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# Positive Impact of Pandemic on E-Learning: A Progressive Narrative

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**Abstract**: The pandemic environment impacted almost all walks of life; it stressed the education sector more, compared to others. Face-to-face (F2F) method of teaching quickly transformed into distant/E-learning. Institutions around the globe faced surmounting challenges in implementation and assessment during this transition, which developed a negative narrative for such learning. Teachers and students were familiarized with the requirements through state-of-the-art technologies, to ensure that the learning process continues. Some specializations did struggle due to numerous reasons, including a shortage of transition time, whereas others felt that practical work competencies could not be developed through the E-learning mode of education. Despite the major success of the E-learning system, which let the learning process advanced nearly at the same level as before, still the narrative of learning loss, was over propagated through publications. This paper provides an overview of the gains and benefits from this unique experience of the generation that went through the process of E-learning or distance learning. Thus, a progressive narrative is being established, as the over emphasis of the propagated narrative is damaging and may result in low self-esteem and lost hope among learners of this generation.

**Keywords:** E-Learning, Online Education, Program Delivery, Graduate Attributes, Impact of Pandemic.

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## Introduction

With the start of the pandemic in 2020, all the academic institutions were confronted with an unanticipated and challenging situation. In order to control the spread of disease and avoid gatherings, a unanimous decision of closing face-to-face classes was taken around the globe. The educational institutions around the world transformed from conventional delivery of their programs to online delivery or E-learning. The academic programs were later delivered in a blended mode i.e., a combination of both face-to-face and E-learning. The solutions were evolved based on their suitability to the pandemic environment where health issues were the main priority, but education could not be halted like some other sectors of life. Ideally the SAMR (Substitution-Augmentation-Modification and Redefinition) model required a longer transition time for a smooth conversion (Romrell, Kidder, & Wood, 2014). The transformation was rapid, and it did not allow the required readiness time for institutional administration, learners, and teaching staff.

In general, educational practices were categorized based on theory of learning into two types namely: teacher-centered or student centered learning (Mayer, 2003). Although the third category was envisioned by educational psychologists but was not very famous. Before the pandemic distance learning and E-learning had partial usage with education institutions. During the pandemic environment, this third category "technology-centered" learning not only became famous but played a pivotal role. The process was highly dependent on technology, and in case of any issues with technology or its failure results in the halting of the teaching process. The detail of three approaches is shown in Figure 1.

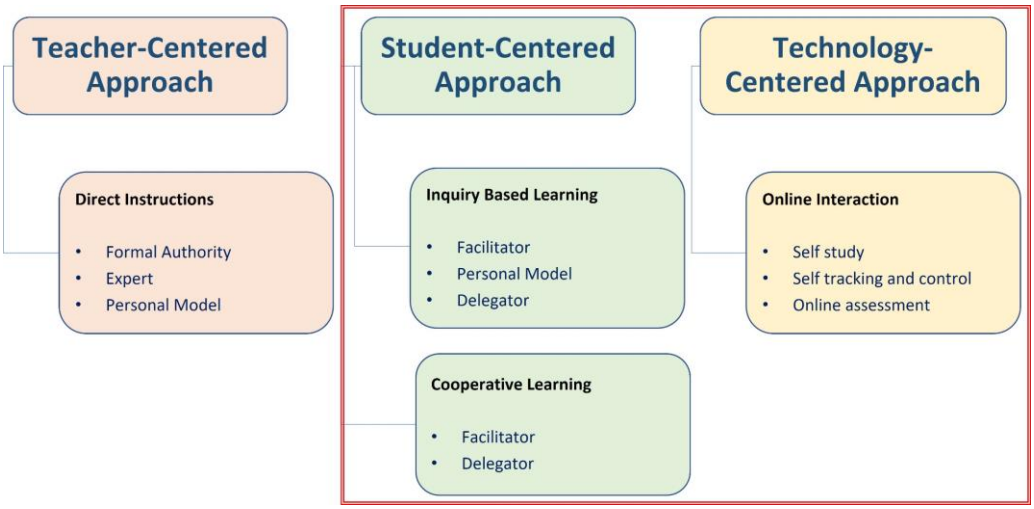


Figure 1. Three Teaching Approaches

The E-learning evolved over several decades. Its first evidence dates back to 1925 when first testing machine was invented. Later, after three decades in 1950's a Harvard professor BF Skinner invented the teaching machine (Skinner, 1958). Programmed Logic for Automated Teaching Operations (PLATO) emerged as first ever computer-based training program (CBT) in 1960 with the purpose to deliver the information to students. In

1970's interactive learning was started by the UK open university where the material was delivered to students by post and correspondence with tutors was done through the mail.

With the invention of first MAC in the decade of 1980's the computers started finding their place at homes and following decades provided the access to wealth of knowledge to these computer owners through net. In 2020 the businesses vastly started using the E-learning concept for the training of their employers. The workers thus got opportunities to improve their industrial knowledge base and skill sets through the use of technology. Individuals are granted access to different programs to earn online degrees to enrich their lives through expanded knowledge.

Educational solutions during pandemic forced quick transformation online or blended learning. Various innovative teaching, learning and assessment techniques along with other processes were developed to meet the requirements of new environment which was overwhelmed by the use technology.

## A Successful Graduate

It is commonly said that "world is not interested in what the graduates know but it is more interested in what they can do with what ever they know". The graduates are expected to acquire multiple skills such as communication, lifelong learning, multidisciplinary teamwork, awareness of ethical and social considerations related to their profession ((Rugarcia, Felder, Woods, & Stice, 2000). Therefore, educational institutions are responsible to teach knowledge, skills, and cultural values through a structured program. This era of global interdependence or globalization has been recognized as an era of graduate attributes (Barrie, 2005; Barrie, 2007). Although each faculty has taken the responsibility of developing their graduate attribute statements however, several desirable attributes consented by most of the academic programs area as shown in Figure 2.

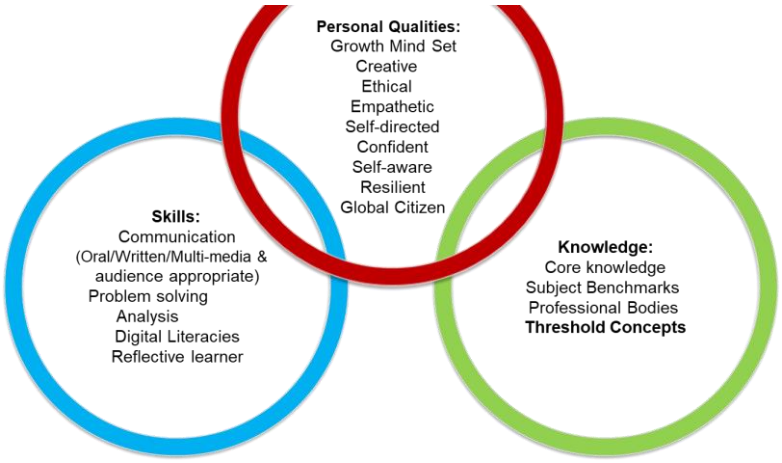


Figure 2. Desirable Graduate Attributes

Even most American engineering programs grasp science, mathematics, engineering fundamentals,

communication, multidisciplinary teamwork, and lifelong learning skills. In addition, the programs also emphasize on awareness of associated social and ethical considerations. Any graduate who has developed these required competencies or skills along with knowledge in his specialization is considered to be a successful graduate with higher probability of employability.

**E-Learning Delivery**

*Interesting Predictions and Advancements*

Science is always busy addressing world challenges through innovative approaches that influence humanity. Science will always continue to surprise us with its breakthroughs and innovations. The core of its modification is the development of new technology which has proven to be growing exponentially. At the beginning of the current century, it was projected that fast evolution of technology will raise us to new heights but with its adverse consequences. As a result of these speedy high-tech developments, a list of achievements in the next few decades has been forecasted (Khan & Ashraf, 2017). A number of these are tabulated in Table 1.

Table 1. Interesting Predictions and Advancements

| Prediction | Advancement |
|---|---|
| Shopping malls will wipeout | Online shopping |
| TV transmission becomes extinct | Video on demand |
| Large offices will not be required | Work from home |
| Restaurant eating reduces | Home delivery |
| Education on convenience | Online program delivery |

Some of these have been recently realized as the human response to the recent pandemic. The last item in the table is related to the education delivery on convenience which was expected to become a reality in a decade or half therefore, most of the educational institutions were progressing in this area but at their pact. The pandemic environment compelled the education sector to take a giant leap for implementation in weeks. The transition from a conventional to E-learning process had varied effects in different parts of the world. It is evident that underdeveloped world had comparatively severe impact than the developed world.

*Advantages and Dis-Advantages*

It has been discussed that intrinsic motivation is mainly desired from the learner to accrue full benefits from E-learning process. The intrinsic learner respects learning while the extrinsic learner remains keen on getting grades. In addition to this major factor, there are numerous other benefits and challenges that have been reported and tabulated in Table 2. Different researchers have emphasized the varied effects of E-learning in different regions of globe during period of transition from conventional to E-learning (Siyabi, Khan, Hussain, & Rashdi, 2020)

Table 2. Advantages and Disadvantages

| Advantages | Disadvantages |
|---|---|
| **Safe and comfortable environment** | Student feedback is limited |
| **Variety of courses / Material availability 24 hours** | Can cause social isolation |
| **Access to best educators around the world** | Requires self-motivation |
| **Affordable fees** | Requires time management |
| **Convenient and flexible** | Lack of communication skills development |
| **Learning at own pace** | Reliability of online assessment |
| **Inclusivity – Participation in class discussion** | Focus on thoery rather practice |
| **Better concentration** | Lacs face to face communication |
| **Career advancement and skill development** | Limited to certain disciplines |
| **Global network** | Inaccessible to computer illetrate population |

*Institutional Gains*

Before highlighting the unique experience acquired by the learners during the period of E-learning/blended learning the institutional advances are underlined in this section. It has been observed that full adaption of the E-learning process necessitated development new norms e.g., policies, processes, procedures and alternate/new techniques for assessment and lab work to meet the new environment. Furthermore, all this was done swiftly to safe learner's time and guarantee the continued delivery of programs at all levels. It has also been reported that to stay in business most educational institutions have taken gigantic steps to acquire required technologies through heavy investment. The staff and learners were trained and have also gained unique experiences in handling the E-learning processes. In technical programs, the negative impact of E-learning on development of some competencies was reported (Khan, Hussain, Ashraf, Siaybi, & Shibli, 2021). While some other studies established that blended learning or different alternate methodologies have demonstrated that such drawbacks of practical or laboratory work can been mitigated (Alqahtani & Rajkhan, 2020; Khan, Siyabi, Ashraf, Hussain, & Fakhim, 2021).

Numerous attempts have been made to create online activities such as video demonstrations, online quizzes, simulations, virtual labs, and data analysis techniques. The recently developed alternate practices to overcome these shortcomings and develop practical associated competencies are interactive simulations with smart work sheet, customized smart sheet for data analysis, and dynamic lab simulations, (Francis, Smith, & Turner, 2020). Some of these newly developed alternative techniques are listed in the subsequent part of this section.

**Smart Data Worksheets**: Complex scientific data analysis

- *Graphing*
- *Spectrum analysis*
- *Multi step calculations*

- *Lab or Randomized data*
- *Personalized feedbacks*

**Customized Smart Worksheets**: Integrated to program requirement

- *Tailored to lab requirements*
- *Embedded in VLE*
- *Integrated to gradebook*
- *Interactive Simulation with Smart Worksheet*

**Dynamic Lab Simulations**: 2D key learning outcomes (animations)

- *Active learning and passively watching video*
- *Familiarization (equipment, techniques, health and safety)*
- *Appreciation into intricacies*
- *Economical to avoid wastage of material*
- *Superimposing on same screen*

These innovative methods amicably resolved the issues in achieving the outcomes for arts and science programs without physical laboratories. Programs relying on these alternative techniques are yet to combine the additional skills of creativity, problem solving, and emotional intelligence. In case of engineering, it was reported that full development of some engineering competencies is a major drawback of E-learning. The use of virtual environment and simulation in engineering has somewhat addressed this shortcoming. However, as the virtual reality and augmented reality are the advanced technologies therefore, a lot is still to be done in order to completely mitigate the deficiencies.

**Progressive Narrative**

During and post pandemic environment several studies over emphasizing the fact of learning loss and experiences of E-learning were published (Betebenner & Wenning, 2021; Engzell, Frey, & Verhagen, 2021; M. J. Khan & Ahmed, 2021; Kohli, Wampole, & Kohli, 2021; Moscoviz & Evans, 2022; Zierer, 2021). Over emphasis on such a narrative is damaging for the generation that went through this experience. It is further believed that loss of time in the period of study or change of program delivery cannot be detrimental to the greater intellectual growth in a longer run. The narrative leads to disaster when students start believing that all is lost (Dworkin & Dworkin, 1979; Rosenthal & Jacobson, 1968; Snow, 1969). It is mostly seen that the students staying away from their class due to prolonged sickness or accompanying their families for vacations do cover their lost times in the longer run. Therefore, it is expected that students can recover their lost time during pandemic if any.

Learning for humans is distinguished by the breadth and difficulty of skills that can be acquired and the extent of abstraction that can be attained. Learning science states that it takes place in two levels, firstly, knowledge and skills commonly known as competencies and secondly deep learning which happens at later stages. Therefore, it is known that learning is never linear. The progress of learning is not wholly dependent on time

spent in class but on multiple factors. Learners of this time are expected to be more robust and enduring as compared to any other (Meltzoff, Kuhl, Movellan, & Sejnowski, 2009).

It cannot be contradicted that pandemic learning is unique. The remote learning has taught new knowledge to this generation thus they are privileged to have undergone this experience. This generation has developed attitudes and attributes that are essential for their future success, e.g., they have become independent, developed advanced and high-tech skills and have freed themselves from dependency culture (Yorke & Harvey, 2005). It would be correct to say that with these capabilities these students are better prepared for life and work. This remarkable generation has undergone a crash course and has developed the following characteristics:

a. Persistent – due to their continued exposure to a special environment and difficult times
b. Resilient – as they responded to the difficult conditions to which they were exposed and came out successful against all obstacles which were beyond anyone's control
c. Enterprising – have shown initiative and resourcefulness to address the environmental complexities in continuation of their studies
d. Open-minded – they were always ready to respond and willing to try ideas that were new to learners and teachers

It may be appropriate to emphasize that remote learning was not a waste of time. As a matter of fact, the most important factor, in those difficult times was that students continued their studies and learned new knowledge. The level of knowledge acquisition by different students can come under discussion but it cannot be completely asserted that learning did not take place. Students went through different experiences and thus exposed to real life difficulties and problem-solving. They were vibrant to quickly become accustomed to the new or changing environment and resolve their different problems to stay current with their studies. The "Generation Alpha" who are already considered exceptionally proficient with awareness of technology or excited about it have further and formally mastered the advanced technology. The learners and teachers of this era are fortunate to have used the technology as part of their daily learning environment. This generation learned new platforms and the number of technological gadgets in the household increased manifold. Student not only developed problem solving skills through use of technology, but also became socially competent. The use of social media and several digital technologies such as: Moodle, Email, MS Teams, CLMS, Mirsal, Blackboard, Zoom, BigBlueButton, WhatsApp, Virtual Reality, Augmented Reality and Artificial Intelligence were mastered. Emerging technologies such as, Virtual reality, augmented reality and artificial intelligence were used at length for teaching for the first time. In addition, the learners, and teachers, depending on the situation were exposed to five different technology-centered learning environments e.g., knowledgebase, online support, synchronous, asynchronous and hybrid.

At the onset of the pandemic, the rapid response to continue teaching and learning was to transform conventional delivery to remote or E-learning. While shifting from conventional teaching to E-learning, the administers of educational institutions ensured that teachers are trained on priority to commence the remote

learning. Educators around the world were exposed to different digital technologies (Albó, Beardsley, Martínez-Moreno, Santos, & Hernández-Leo, 2020; Ferri, Grifoni, & Guzzo, 2020). Virtual/digital learning played critical role with quick commissioning and adaptation of the new hardware/software developed by digital industries to strengthen the learning management system. The generation that went through E-learning has got an experience that was not afforded to the earlier generations. Thus, this generation has become more creative and better communicators or listeners, as they were exposed to a unique environment and communicating behind the digital screens. The learners during E-learning environment were well organized and keen to learn as they were on their own to resolve their daily problems. The students were forced to follow a practical approach with regards to the continuation of their studies and accrue maximum benefits from whatever was being offered to them. It would not be wrong to state that pandemic learning has created a generation of lifelong learners, that learned the problem-solving techniques and while completing their academic investigative assignments kept themselves abreast with the latest in their field.

## Conclusion

The article elaborates different positive achievements during challenging time for learners and institutions. It shows that every learner of this generation may attain success and accomplish in their life regardless of their starting point as they are prepared to tackle any future challenges. It stresses that during pandemic environment, education sector faced more challenges than any other sector. Rapid transition of Face to face (F2F) method of teaching to distant/E-learning generated surmounting challenges, that developed a negative narrative among Institutions around the globe. The negative narrative of learning loss was much propagated through publications; therefore, it is felt that over emphasis of such narrative may result in low self-esteem and lost hope among learners of this unique generation. This initiated a demand to negate the narrative of “all is lost” in the academic sector, during this pandemic environment. The article elaborates different positive achievements of the challenging time for learners and institutions. It is known from human learning science that for them the learning is never linear. Learners of this time are expected to be more robust and enduring as compared to other species. Pandemic learning is unique, and it cannot be denied that remote learning has taught new knowledge. This generation has developed attitudes and attributes that are essential for their future success, e.g., they have become independent, developed advanced and high-tech skills and have freed themselves from dependency culture.

## References

Albó, L., Beardsley, M., Martínez-Moreno, J., Santos, P., & Hernández-Leo, D. (2020). *Emergency remote teaching: Capturing teacher experiences in Spain with SELFIE.* Paper presented at the European Conference on Technology Enhanced Learning.

Alqahtani, A. Y., & Rajkhan, A. A. (2020). E-learning critical success factors during the covid-19 pandemic: A comprehensive analysis of e-learning managerial perspectives. *Education Sciences, 10*(9), 216.

Barrie, S. (2005). Rethinking generic graduate attributes. *HERDSA news*, *27*(1).

Barrie, S. C. (2007). A conceptual framework for the teaching and learning of generic graduate attributes. *Studies in higher education*, *32*(4), 439-458.

Betebenner, D. W., & Wenning, R. J. (2021). Understanding Pandemic Learning Loss and Learning Recovery: The Role of Student Growth & Statewide Testing. *National Center for the Improvement of Educational Assessment*.

Dworkin, N., & Dworkin, Y. (1979). The Legacy of" Pygmalion in the Classroom". *The Phi Delta Kappan*, *60*(10), 712-715.

Engzell, P., Frey, A., & Verhagen, M. D. (2021). Learning loss due to school closures during the COVID-19 pandemic. *Proceedings of the National Academy of Sciences*, *118*(17), e2022376118.

Ferri, F., Grifoni, P., & Guzzo, T. (2020). Online learning and emergency remote teaching: Opportunities and challenges in emergency situations. *Societies*, *10*(4), 86.

Francis, N., Smith, D., & Turner, I. (2020). Student Lab Alternatives with Dry Lab Real Science. *Lecturemotely*.

Khan, A. A., & Ashraf, M. A. (2017). *Progress and Challenges of Mankind Dream's for 21st Century*. Paper presented at the Fifth International Conference on Aerospace Science and Engineering (ICASE 2017), Islamabad, Pakistan.

Khan, A. A., Hussain, T., Ashraf, M. A., Siaybi, M. A., & Shibli, A. A. (2021). *Refined Norms in Education and Their Impact on Engineering Competencies* Paper presented at the International Conference on Studies in Engineering, Sciences and Technology, Antalya, Turkey.

Khan, A. A., Siyabi, M. A., Ashraf, M. A., Hussain, T., & Fakhim, B. (2021). *Hands-On Learning Without Laboratory*. Paper presented at the Teaching and Learning Innovation Festival 2021, Universiti Teknologi PETRONAS, Malaysia.

Khan, M. J., & Ahmed, J. (2021). Child education in the time of pandemic: Learning loss and dropout. *Children and Youth Services Review*, *127*, 106065.

Kohli, H., Wampole, D., & Kohli, A. (2021). Impact of online education on student learning during the pandemic. *Studies in Learning and Teaching*, *2*(2), 1-11.

Mayer, R. E. (2003). Theories of learning and their application to technology.

Meltzoff, A. N., Kuhl, P. K., Movellan, J., & Sejnowski, T. J. (2009). Foundations for a new science of learning. *Science*, *325*(5938), 284-288.

Moscoviz, L., & Evans, D. K. (2022). Learning loss and student dropouts during the covid-19 pandemic: A review of the evidence two years after schools shut down. *Center for Global Development, Working Paper*, *609*.

Romrell, D., Kidder, L., & Wood, E. (2014). The SAMR model as a framework for evaluating mLearning. *Online Learning Journal*, *18*(2).

Rosenthal, R., & Jacobson, L. (1968). Pygmalion in the classroom. *The urban review*, *3*(1), 16-20.

Rugarcia, A., Felder, R. M., Woods, D. R., & Stice, J. E. (2000). The future of engineering education: Part 1. A vision for a new century. *Chemical Engineering Education*, *34*(1), 16-25.

Siyabi, M. A., Khan, A. A., Hussain, T., & Rashdi, H. A. (2020). *A Study of the E-Learning System Efficiency during the Covid-19 Pandemic in a Higher Education Context in Oman*. Retrieved from Muscat Oman:

Skinner, B. F. (1958). Teaching Machines: From the experimental study of learning come devices which arrange optimal conditions for self-instruction. *Science*, *128*(3330), 969-977.

Snow, R. E. (1969). Unfinished pygmalion.

Yorke, M., & Harvey, L. (2005). Graduate attributes and their development. *New directions for institutional research*, *2005*(128), 41-58.

Zierer, K. (2021). Effects of pandemic-related school closures on pupils' performance and learning in selected countries: A rapid review. *Education Sciences*, *11*(6), 252.

Frascari defines synaesthesia as the 'crossing of the senses' [4] and in Eleven Exercises he writes, 'It occurs

# The Potential Use of Quick Response Indonesian Standard (QRIS) to Increase Small Medium Enterprises (SMEs) Productivity in Jambi City Seberang

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**Abstract:** QRIS is a standard QR code for digital payments through served-based electronic money applications, mobile banking, or electronic wallets. QRIS is a payment system that is often used today. It makes payments easier, faster, and safer and does not require cash. SMEs have widely used QRIS. This study aims to determine how the potential and what factors affect the use of QRIS in Jambi City Seberang. The research method used in this study is a qualitative method with the type of phenomenological research. The result showed that the use of QRIS in the Jambi City Seberang is quite potential to be used and influenced by several factors including the understanding factor, interest factor, benefit factor, convenience factor, and obstacle factor. Furthermore, based on the explanation of participants who clearly stated that they wanted or were interested in using the QRIS because they already understood it well enough. In addition, QRIS will provide many benefits and ease of use. Even though it has some obstacles, QRIS can still be used and implemented in Jambi City Seberang.

**Keywords:** Potential, QRIS, SMEs.

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## Introduction

The digital economy was first introduced by Tapscott. According to him, the digital economy is a social phenomenon, including information, information processing, information capacity, and various information

instruments affecting the economic system. Some of the digital components that were first identified were the ICT industry, e-commerce activities, and digital distribution of goods and services (Tapscott, 1997). Meanwhile, Zimmerman stated that the concept of the digital economy is a concept used to explain the global impact of the rapid development of Information and Communication Technology which has an impact on the socio-economic conditions of society (Zimmerman, 2000).

The digital economy itself can be interpreted as all economic activities using the help of the internet and also artificial intelligence or AI (Artificial Intelligence). The digital economy is also an economy based on goods and services produced by electronic businesses and traded through electronic commerce (Musafak, 2012). This digital economy is able to change the economic activities of people from being manual to automatic so that every daily activity and business can be done easily and quickly. Several types of the digital economy include the financial sector, the cultural sector, the tourism, and creative economy, and the agricultural sector (Latifah, 2019).

An example of a digital economy that is increasingly being used today is the financial sector or known as financial technology (fintech). Financial technology itself can be interpreted as a combination of financial services with information technology and this merger makes the financial system easier and more effective (Irawan & Affan, 2020). Financial technology has several types, including funding, financial payments (payments), banking (digital banking), insurance (insurtech), capital markets (capital market), and other financial sector support services. For example, financial payment is one of the most used sectors today. Payment is a technology using a non-cash payment system such as a digital wallet or cellphone money that can be used to pay transactions that have already been available (Puspita, 2019). The form of payment can be Go-pay, Shopee Pay, OVO, and QRIS (Quick Response Indonesia Standard). Currently, one of the most frequently used payment systems is QRIS. QRIS is the unification of various types of QR from various Payment System Service Providers (PJSP) using a QR code. QRIS was developed by the payment system industry together with Bank Indonesia so that the transaction process with the QR code can be easier, faster, and safer. As a result, all PJSPs that will use QR code payments are required to implement QRIS (Bank Indonesia).

QRIS one of the payments that has started to be widely used by SMEs as a non-cash payment system is more efficient because it has advantages such as the capability to accept switching and various types of different merchants (Mahyuni & Setiawan, 2021). By 2021, usage has reached 10.4 million merchants already integrated with QRIS, increasing 120.22% from the previous year. It is because Bank Indonesia efforts and hard work to increase the number of merchants integrating or using QRIS (Elena, 2021).

Currently in Jambi City, in particular, Jambi City Seberang which consists of 2 sub-districts in Jambi City is geographically separated by a river from the city center. Even though rivers separate them, the community's economic activities continue to run well with local community businesses selling local products and other forms of goods and services. Jambi City Seberang has a lot of SMEs or small businesses such as batik craftsmen businesses, food, and beverage businesses, transportation services, grocery stores, and so on that play a role in

advancing the regional economy. Today, the number of SMEs in Jambi City Seberang is more than 250 SMEs consisting of 2 sub-districts and 11 existing urban villages. With this large number of SMEs, many of them still use traditional sales transactions, even though as part of Jambi City and the advancement of the current buying and selling system, SMEs in Jambi City Seberang have the potential to use the QRIS. It is because using QRIS will provide many benefits for SMEs, including potentially increasing sales, improving branding, being up to date, and more convenient, avoiding counterfeit money, automatically recording transactions, no need to provide change, and other benefits (Bank Indonesia). The use of QRIS is good enough to be understood by the public, especially in urban areas (Setiawan & Mahyuni, 2020). In addition, the use of QRIS transactions more priceless, comfortable, and safer and increase market potential and transaction intensity. Furthermore, the implementation of the use of QRIS will open wider potential (Pracoyo et al., 2022). As a result, using QRIS will increase the productivity level of SMEs significantly.

This study aims to determine how the potential and what factors affect the use of QRIS in Jambi City Seberang.

## Theoretical Review

Since it was inaugurated on January 1, 2020, until now the use of QRIS has been widely used by the public as consumers and SMEs. The launch of QRIS as a form of payment media using electronic money. The presence of QRIS is also a form of support from the Indonesian government in the current digital economy era. As the person in charge of this program, Bank Indonesia continues to strive to encourage the public to use the QRIS because it already has a good level of security and the ease and speed of its use. In addition, all payment system service providers that will use QR code payments are required to implement QRIS.

QRIS itself is a standard QR code for digital payments through served-based electronic money applications, mobile banking, or electronic wallets (Hutami A et al., 2020). The QR code can be read and translated at high speed (Rouillard, 2008).

One of the supporting factors or benefits of using QRIS is reducing physical contact and as an alternative form of payment method (Natalina et al., 2021). QRIS is very easy to use by simply scanning a QR code and does not require many payment applications. QRIS is also very useful because it makes payments easier, faster, and safer and does not require cash (Putu et al., 2021). In addition, in its use, SMEs will consider factors in terms of usage intentions, understanding, benefits, convenience, and obstacles (Mahyuni & Setiawan, 2021). Meanwhile, consumers will also consider in terms of convenience, trust, benefit, and risk (Saputri, 2020).

Research conducted by Silaen et al. shows that both perceived convenience has a positive and significant effect on increasing sales, and perceptions of benefits and convenience are also moderately correlated with increasing sales (Silaen et al., 2021). Meanwhile, the results of the second study from Silaen et al. showed that the perception of benefits and convenience had no significant effect, but the perception of security and risk had a

significant effect on interest in using QRIS (Musa F. Silaen et al., 2021).

The results of research conducted by Pracoyo (2022) that the use of QRIS will increase the productivity of SMEs and can compete with other economic actors. To be competitive, SMEs need to provide more value for customers, build synergies and be able to provide the best service (Daft, 2010). Using QRIS will be one of the added values and the best services that SMEs can provide to the community. In addition, the perception of SMEs to use QRIS also shows a positive response (Setiawan & Mahyuni, 2020).

Based on the results of existing research, it can be concluded that using QRIS will increase SMEs productivity, create competitive SMEs and provide the best service SMEs to the community. In addition, the factors that influence the use of QRIS are understanding, intention to use, benefits, convenience, and obstacles to QRIS use.

## Method

The research method used in this study is a qualitative method with the type of phenomenological research. The sample in this study uses the rules of thumb with a total of 5 people as key informants (Januraga et al., 2019). The sampling strategy uses maximal variation sampling which is useful for developing a series of perspectives. İn addition, this study also used the triangulation technique to check the validity of respondents' answers where the respondents who act as validation respondents are several consumers and the Jambi City Cooperative and SMEs Office.

The list of interview questions is built on the theory of planned behavior (Ajzen, 1991). and technology acceptance model theory (Davis, 1989). Some of the questions in this study include: 1. Do you know about QRIS? If yes, please explain? (understanding) 2. Do you use QRIS in business transactions? If yes, can you explain in more detail how to use it? If not, are you interested in using QRIS? (interest/intention) 3. Is QRIS useful in supporting your business? If yes, please mention & explain what the uses are? If not, please explain why? (benefits) 4. Do you think it is easy to use QRIS? If yes, please explain. If not, why? Please explain (convenience) 5. Is there anything that might prevent you from using QRIS? If yes, please mention & explain (obstacles).

## Result and Discussion

I took five SMEs participants in Jambi City Seberang, the five SMEs were accessories and toy seller, mini market, beverage seller, food seller, and batik seller. Of the five, they have more consumers than similar SMEs and can represent similar SMEs as well.

In terms of overall understanding, participants know about QRIS as a payment instrument issued by Bank Indonesia to conduct digital payment transactions. In addition, QRIS is used to replace payment systems made

in cash. As S1 stated that "QRIS stands for Quick Response Indonesia Standard which is a digital payment instrument issued by Bank Indonesia". S2 has similar statement that "buying and selling transactions that process payments through digital". The study shows the same result as the previous research explaining that the QRIS payment method is seen as an innovation in the digital payment system (Jenkins, 2008). The understanding of QRIS by the community, especially in urban areas is quite good (Setiawan & Mahyuni, 2020).

In terms of overall interest or intention, participants explained that they had not used QRIS for their business or business purposes, but only for personal purposes, and some participants had used it because it provided many benefits. In addition, for their own interest, all participants explained that they were interested in using QRIS in running their business but in the process of implementing it, they still had to be directed or guided by the QRIS organizer itself, namely Bank Indonesia. as stated by S3 "interested, there is a desire to use it". The next statement S4 "I want to use QRIS because it is very profitable". This is in line with previous research which explains that the better the use of QRIS, the greater the perception of benefits, and the easier it is to use, the greater the interest or intention to use the QRIS (Mahyuni & Setiawan, 2021).

In terms of benefits, all participants explained that QRIS would provide many benefits in using it, such as making payments easier, saving time and costs, and being more modern. As stated by S1 "it is very useful because it makes transactions easier and is more efficient and modern". In line with S3's statement "of course, it makes payments easier, saves time and costs". This is in line with previous research which explains that the use of QRIS provides advantages in transactions where there is an increase in service quality, a reduction in transaction costs, and a varied and stable service design (Lee & Shin, 2018). The use of QR or barcodes provides convenience and security (Li, 2016). The use of QRIS can provide benefits for SMEs traders (Sihaloho et al., 2020).

In terms of convenience, participants explained that although QRIS has not been implemented, it will provide convenience in making payment transactions because there is no need to use cash or cash in making payments, as stated by S4 "quite easy, just need to move the QR code and transaction can be completed". The next statement S5 "easy because there is no need to use cash to make payments", is in line with previous research which explains that the use of QRIS has the characteristics of ease and efficiency to use (Ferdiana & Darma, 2019). Just need to scan the QR code and make the payment transaction (Arianti et al., 2019).

In terms of obstacles, all participants explained that using QRIS would provide several obstacles including knowledge about the use of QRIS itself, cellphones must be at least in the form of Android, there must be a quota and most consumers still use direct or cash payment methods. As S2 stated that "knowledge about QRIS itself and there are still many consumers who make payments in cash". S3's said that "The cellphone must be android and there must be a quota to operate it". This result is in line with previous research which explains that obstacles to using QRIS can be in the form of an unstable internet connection, internet quota problems, and usage fees (Natalina et al., 2021). Barriers experienced to using QRIS such as the understanding of traders who are still lacking, and consumers cannot scan QR codes (Sekarsari et al., n.d.).

The results of interviews through questionnaires showed that most of the interviewed participants stated that they knew about QRIS (Quick Responses Indonesia Standard) only that in its application it had not been applied by the SMEs. SMEs can also answer and explain well each factor in the use of QRIS such as the understanding factor, interest, benefit, convenience, and obstacle factor. İn addition, the result of interviews with several consumers and the Jambi City Cooperative and SMEs Office as a validation of answers from SMEs also showed that their level of knowledge about QRIS is also quite good. Even though there are SMEs and consumers who don't know about QRIS can still be socialized in the future. Furthermore, their opinion about the use of QRIS in Jambi City Seberang is quite feasible and has the potential because it has to keep up with the times. As stated by consumer C2 "it's worth it, because we have to keep up with the times". Next statement C6 "with the modern condition now, it is very good to be applied in Jambi City Seberang". Meanwhile, other opinions stated that it could be implemented, it was just that there was a need for socialization of the use of QRIS for SMEs and consumers. As stated by C5 "worthy. As long as there is socialization about QRIS and how to use or transact with QRIS". This is also supported by the opinion of the Jambi City Cooperative and SMEs Office which states that most of the SMEs in Jambi City Seberang are able to use QRIS, only that there must be the socialization of the use of QRIS.

## Summary and Recommendation

It can be concluded that the factors that influence the use of QRIS are the understanding factor, interest factor, benefit factor, convenience factor, and obstacle factor. Furthermore, some of these factors can explain the use of QRIS in Jambi City Seberang is quite potential to be used. This is based on the explanation of participants who clearly stated that they wanted or were interested in using the QRIS because they already understood it well enough. In addition, QRIS will provide many benefits and ease of use. Even though it has some obstacles, QRIS can still be used and implemented in Jambi City Seberang. The recommendation given is that even though business actors or SMEs already know about QRIS, but in using they still need direction and guidance from Bank Indonesia as the organizer of QRIS so there is a need for socialization of the use of QRIS for SMEs actors. With many SMEs understanding the use of QRIS more widely used and becoming a payment transaction tool for the Jambi City Seberang community, it has an impact on increasing the productivity of these SMEs.

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## References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211.

Arianti, N. L. N., Darma, G. S., & Mahyuni, L. P. (2019). Menakar keraguan penggunaan QR Code dalam transaksi bisnis. *Jurnal Manajemen Bisnis*, *16*(2), 67–78.

Daft, R. L. (2010). *Era baru manajemen*.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 319–340.

Ferdiana, A. M. K., & Darma, G. S. (2019). Understanding Fintech through Go-Pay. *International Journal of Innovative Science and Research Technology*, *4*(2), 257–260. https://www.bi.go.id/id/default.aspx

Hutami A, N., Endang Maskan, S., & Bida, S. (2020). Analisis Pengaruh Persepsi Manfaat, Persepsi Kemudahan Penggunaan, Dan Persepsi Risiko Terhadap Keputusan Menggunakan Uang Elektronik Berbasis Quick Response Code Indonesian Standard (Qris) Di Kalangan Mahasiswa Upi Yai. *Journal IKRAITH IV*, *2*.

Irawan, D., & Affan, M. W. (2020). Pengaruh Privasi dan Keamanan Terhadap Niat Menggunakan Payment Fintech. *Jurnal Kajian Akuntansi*, *4*(1), 52. https://doi.org/10.33603/jka.v4i1.3322

Januraga, P., Ikm, P. S., & Unud, F. K. (2019). Penentuan sampel penelitian kualitatif , rules of thumbs. *Qualitative Research*, *1*(1), 40.

Jenkins, B. (2008). Developing mobile money ecosystems. *Washington, DC: International Finance Corporation and Harvard Kennedy School*.

Latifah, E. (2019). Perkembangan Ekonomi Digital di. *Jurnal Ekonomi Digital*, *3*(2), 21–27.

Lee, I., & Shin, Y. J. (2018). Fintech: Ecosystem, business models, investment decisions, and challenges. *Business Horizons*, *61*(1), 35–46.

Li, P. (2016). Current and future years of e-commerce. In *Encyclopedia of e-commerce development, implementation, and management* (pp. 1031–1044). IGI Global.

Mahyuni, L. P., & Setiawan, I. W. A. (2021). *Bagaimana QRIS menarik minat UMKM ? sebuah model untuk memahani intensi UMKM menggunakan QRIS How does QRIS attract UMKM ? a model to understand the intentions of UMKM using QRIS*. *23*(4), 735–747.

Musa F. Silaen, Sepbeariska Manurung, & Christine D. Nainggolan. (2021). Effect Analysis Of Benefit Perception, Ease Perception, Security And Risk Perception Of Merchant Interest In Using Quick Response Indonesia Standard (Qris). *International Journal of Science, Technology & Management*, *2*(5), 1574–1581. https://doi.org/10.46729/ijstm.v2i5.313

Musafak. (2012). *Budaya Ekonomi Digital*.

Natalina, S. A., Zunaidi, A., & Rahmah, R. (2021). Quick Response Code Indonesia Standard (QRIS) Sebagai Strategi Survive UMKM Di Masa Pandemi di Kota Kediri. *ISTITHMAR : Jurnal Pengembangan Ekonomi Islam*, *5*(2), 43–62. https://doi.org/10.30762/itr.v5i2.3376

Pracoyo, A., Wijaya, E., Bagasworo, W., Rofianto, W., Budhijana, B., Novita, N., Wardani, D., Sadikin, D. D.

S., Khairani, Z., & Ramadhan, M. (2022). *Sosialisasi QRIS Dalam Upaya Peningkatan Produktivitas UMKM Provinsi DKI Jakarta*, *4*, 11–20. https://doi.org/10.36407/berdaya.v4i1.534

Puspita, Y. C. (2019). Penggunaan Digital Payment Pada Aplikasi Ovo. *Jurnal Manajemen Informatika*, *09*(02), 121–128.

Putu, N., Karniawati, A., Sri Darma, G., Mahyuni, L. P., Sanica, G., Darma, G. S., Luh, P., Mahyuni, I., & Gede, S. (2021). Community Perception of Using Qr Code Payment in Era New Normal. *Pjaee*, *18*(1), 3986–3999.

Rouillard, J. (2008). Contextual QR codes. *2008 The Third International Multi-Conference on Computing in the Global Information Technology (Iccgi 2008)*, 50–55.

Saputri, O. B. (2020). Preferensi konsumen dalam menggunakan quick response code indonesia standard (qris) sebagai alat pembayaran digital. *KINERJA*, *17*(2), 237–247.

Sekarsari, K. A. D., Sulistyaningrum, C. D., Subarno, A., & others. (n.d.). Optimalisasi Penerapan Quick Response Code Indonesia Standard (QRIS) Pada Merchant Di Wilayah Surakarta. *JIKAP (Jurnal Informasi Dan Komunikasi Administrasi Perkantoran)*, *5*(2), 42–57.

Setiawan, I. W. A., & Mahyuni, L. P. (2020). Qris Di Mata UMKM: Eksplorasi Persepsi Dan Intensi UMKM Menggunakan Qris. *E-Jurnal Ekonomi Dan Bisnis Universitas Udayana*, *10*, 921. https://doi.org/10.24843/eeb.2020.v09.i10.p01

Sihaloho, J. E., Ramadani, A., & Rahmayanti, S. (2020). Implementasi Sistem Pembayaran Quick Response Indonesia Standard Bagi Perkembangan UMKM di Medan. *Jurnal Manajemen Bisnis*, *17*(2), 287–297.

Silaen, M. F., Manurung, S., & Nainggolan, C. D. (2021). The Effect of Using Indonesian Standard Quick Response Code (QRIS) on Increasing Sales to Merchants in Pematangsiantar City. *Budapest International Research and Critics Institute (BIRCI-Journal): Humanities and Social Sciences*, *4*(4), 11140–11148.

Zimmerman, H. (2000). *Understanding the Digital Economy: Challengers for New Business Models*.

# Comparative Study of Ecological Metaphors in the Educational Speeches of Chinese, American, and British Leaders

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**Abstract:** Following the metaphor research transforming from cognitive to social-context analysis, Critical Metaphorical Analysis is developed to interpret the speakers' pragmatic intention, attitude, and values. Since ecological theories with harmonious co-existence values is a common identity in intercultural communication, educational speeches also instruct the ecological values for boosting quality lifelong learning in a sustainable educational system. The study selects educational speeches by Chinese, American, and British leaders in the last decade, and conducts a corpus-assisted Critical Metaphor Analysis with the semantic tags in the tool Wmatrix following the Metaphor Identification Procedure, so that the ecological metaphors are identified through the cross-analysis of the semantic domains about "education" and "ecology". Firstly, the study examines the ecological metaphors' frequency, proportion, types, and tokens. According to the four elements in Ecology and tag rules, the most frequent ecological conceptual metaphors in the three countries' sample are categorized into 'organisms, environment, relationship, and human' with expressions like 'gardening', 'journey', 'ecosystem', and 'health'. Furthermore, via concordances, and semantic prosody, the study finds the three countries commonly emphasize a sustainable educational ecosystem with harmonious relationships among educational stakeholders. Additionally, the study analyzes differences with intercultural comparison. The 'education is fluid' with 'water', and 'food' metaphors with 'pie' and 'cake' only appear in the Chinese leaders' educational speeches. The 'fire' metaphors of 'spark' and 'light' only exist in the American expressions, while the 'geographical' metaphor of 'island' only appears in the British discourse. The ecological metaphors on educational issues like technical support, gender, race equality, and social stratification show distinctive ecological values in Chinese Confucianism and Taoism, the reverence for nature in Greek philosophy, and the island identity in globalized Britain. Finally, the study proposed ecological-valued educational objectives, inner connection in the educational system, sustainable education development, and a lifelong learning process of 'learning to become'.

**Keywords:** Critical Metaphorical Analysis; Wmatrix; ecological metaphor; educational speeches; intercultural comparative analysis.

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## Introduction

Since the boosting of modern industrialization and urbanization in the 20th century, human beings have continuously formed an awareness of environmental protection, and the ecological development values have become a heated research focus of scholars worldwide. Biologist Ernst Haeckel in Germany originally gave the definition to ecology in 1866, who proposes that ecology is "the science of studying the relationship between biological organisms and their surrounding environment" and regards organisms and the external environment as a whole system with reciprocal interaction. Zhao Guishen (2009, p.178) holds the view that ecology is a science that studies the relationship between organisms and their surroundings (including abiotic environment and biological environment). Ecology is a natural science, but with the nature of sub-philosophy, it can also be called science philosophy. Since then, ecology has undergone a process of discipline crossing and definition evolution. The combination of ecology and linguistics gives rise to ecolinguistics, which is developed based on the Halliday model and emphasizes the role of language use in protecting the ecological environment.

The concept of "conceptual metaphor theory" was initially proposed by Aristotle in *Rhetoric and Poetics. The Metaphors We Live By* published by Lakoff and Johnson in 1980 has transformed the metaphor analysis from a technique of rhetoric to a method of cognition. Therefore, following the trends in cognitive linguistics is "empirical turn" and "social turn," that is, applying empirical methods like corpus and interpreting the discourse in social and cultural contexts. Metaphors can be regarded as an innovative perspective of interpreting the deep meaning of discourse, which is an interplay between literal context and thinking modes.

Moreover, education facilitates economic progress, human civilization, and technological innovation, with a huge impact on stakeholders in all sectors of society. Thus, it is of vital practical significance to explore educational discourse from the semantic level. Therefore, this study aims at illustrating the profound purpose of the ecological metaphors in educational discourse, and cognitive interpretation could disclose the message both on a linguistic level and an ideological stage, which embodies both theoretical and realistic significance.

### Significance and Purpose

On the one hand, for the theoretical significance, Critical Metaphor Analysis (CMA) is an innovative theory in comparison to other processes of interpreting metaphors. Additionally, most metaphor studies domestic are approximately political and financial discourses, and the other types of metaphorical texts are not abundant, not to mention the metaphorical research of educational discourses. Even though there are a few types of research on educational discourse metaphors, besides the brief discussion of frequency and patterns of metaphor on the surface level, the thinking modes, socio-political conditions, national ideologies, and traditional values lack in-depth analysis. In terms of the theoretical framework of CMA, this study analysis educational discourses from the innovative angle of ecological metaphors, which enlarges the area of metaphorical research topics and the utility perspectives of CMA.

On the other hand, for the practical significance, this study takes the macroscopic context of globalization into consideration, China, Britain, and America are pivotal nations for the global financial system, technological improvement, geopolitical relations, academic exchange, and human civilization. However, there are cultural differences resulting from diverse socio-economic situations, social norms, cultural traditions, and intellectual values amongst these three nations, which may additionally lead to cultural shocks in academic exchange and cross-border educational cooperation. Via the evaluation of the values and ideologies embodied within the metaphors, it is going to be rewarding to increase the intercultural understanding of the Eastern and Western societies, and then boost China's cooperation with Britain and America. Consequently, this research compares the differences among the ecological metaphors inside the educational discourses among the three countries to attain a comprehensive result with an intercultural attitude, which could boost a better comprehension of multiple educational ideas in western and eastern countries that instruct the country leaders, educators, and residents in a certain cultural community.

Furthermore, attributing to the restricted "metaphoric competence" to interpret metaphors and only understand or express words to the literal degree the second-language learners could not grow to be authentic. Thus, this study could additionally assist the second-language learners to have a good command of the functional mechanism of metaphor and eventually authentically master English with a native language user's thinking pattern. Therefore, in terms of the comparative perspective of critical metaphorical analysis between eastern and western countries, the author aims to contribute to intercultural communication in worldwide exchange and equip more English learners with a comprehensive grasp of both lexical and psychological intentions. Meanwhile, this comparative study of ecological metaphors in the educational keynote speeches of Chinese, American and British leaders is of vital significance to promote the development of educational theory in the 21st century within the mutual movement of transformative quality education, environmental protection and a sustainable development vision of social progress regardless of the nation barriers.

**Structure of the Thesis**

This paper interprets the ecological metaphor of education, analyzes the holistic view of educational goals, and makes a literature review on the sustainable development vision and ecological philosophy in educational development and a harmonious view of ecological relations among multiple stakeholders from multiple dimensions in the complex education system. The first chapter conducts a background investigation of the research background about the social turn, significance and purpose, and the structures of the paper. The second chapter provides the literature review informed by a wide range of research at home and abroad, which include the previous research achievements and analysis for shortcomings of the studies in three aspects: critical metaphor analysis, ecological metaphors and ecological metaphors in disciplinary studies to analyze the research status and shortcomings at home and abroad. Then following the research gaps concluded from the previous studies, the research questions of this study are proposed at the end of the second chapter. The third chapter introduces the theoretical framework of the critical metaphor analysis to boost the in-depth analysis of the application of ecological metaphor in educational discourse, and to explore the values and ideology hidden

in metaphor. The fourth chapter illustrates the research methodology including the research tool Wmatrix, metaphor identification procedure, research procedure, and the wide-scale data collection of education-themed speeches of Chinese, American and British leaders in the recent ten years with over 100,000 words in each country to construct a corpus. The fifth chapter expounds on the results after using Wmatrix to attain the semantic coding and identify ecological metaphors by interpreting the semantic domains concentrated on "education" and "ecology". Then this chapter compares and categorizes the similarities and differences of the ecological metaphors that appear most frequently in the educational speeches of Chinese, American, and British leaders. The results are shown via clear figures, tables, and detailed examples in the discourse materials with both qualitative interpretation and quantitative results, aiming to provide a reliable and credible analysis of conceptual metaphors in educational discourses. The sixth chapter illustrates comes to a conclusion about major findings, significance and implications to further discuss the different ideologies and values reflected by metaphorical thinking from the perspective of cognition, education and culture of the three countries from an intercultural vision. Also, this chapter proposes holding a sustainable developmental view in educational reform, constructing harmonious relationships in the education system for co-existence, and striking ecological balance in the academic ecology. Finally, this chapter critically analyses the limitations of the research and proposes further suggestions for further improvement in future studies.

## Literature Review

### Previous Studies on Critical Metaphor Analysis (CMA)

Firstly, the metaphor analysis is effective and efficient to disclose the truth behind the surface. The metaphor could be utilized as a tool to spread power. In *Metaphor and Political Discourse* (2004), Mulsoff holds the view that the influence of metaphors as rhetorical devices is so huge that metaphors have the potential of being perilous catalyzers once they have suddenly transformed and enlightened the individual's common consciousness to resistant and conflicting chaos instead of the mass obeying original long-term choices. Therefore, the research of metaphor would have a significant and rewarding effect on the public's recognition and sustainable society by instructing an appropriate understanding of the discourse about the surroundings.

Moreover, Lakoff and Johnson (1980) are the pioneers who regard the metaphor as a component of human cognition, which inspires mind cognition instead of only a rhetorical technique. In order to make further interpretation of discourses from the cognitive perspective, the studies utilizing the conceptual metaphor theory as a tool have been conducted by a large number of experts (Fauconnier & Turner, 2002). Nevertheless, due to the lack of interpretations of the conscious intentions of the discourses, the conceptual metaphor theory could not be tenable or persuasive enough as its excessive reliance on subjective experience-based interpretation. At the same time, the contextual diversity in discourse analysis is increasingly emphasized from the cognitive perspective, which shows a tendency towards socio-linguistics and forms a close connection with critical discourse analysis (Kristiansen & Dirven, 2008).

Fortunately, in this trend of an interdisciplinary approach as described above, Charteris-Black (2004), a prominent scholar of linguistics, firstly proposed the Critical Metaphor Analysis (CMA) theory in his *Corpus Approaches to Critical Metaphor Analysis.* As a creative approach, CMA integrates corpus and cognitive linguistics and critical semantic analysis together, which has gained great achievements in the past decade. In this part, the author examines and concludes the previous CMA studies of scholars from home and abroad.

CMA has emerged earliest and shows high effectiveness and efficiency with a focus on pragmatics and ideology below the literal surface. The CMA theory makes a breakthrough in discourse analysis, especially in the interpretation of unobvious purposes of language users. Charteris-Black (2004) illustrates that corpus can supplement the contextual analysis of the unique idea metaphor principle and display the critical function of metaphor performed in ideology establishment. Besides, he (2004) additionally proposes a clear three-step procedure for CMA studies: metaphor identification, metaphor interpretation, and metaphor explanation. These steps strike the stability among qualitative and quantitative techniques and will become the mainstream version of empirical studies of modern-day CMA.

Therefore, CMA is utilized in a wide scale of research both at home and abroad. For instance, Russill (2010) and Cohen (2011) conduct a critical metaphor analysis on climate change discourse about the conditions, factors, and impacts. Lee (2015) explores metaphoric themes of Singapore leaders' speeches on the significance of education competence for national development. Via critical metaphor analysis, Kelly (2016) reveals the public's recognition, values, and emotions about local-thought embedded cosmetics advertisement discourse. Furthermore, many scholars at home also lay emphasis on the political speeches of the state leaders, involving the critical metaphor analysis of political speeches delivered by American and British politicians with intercultural comparative analysis, like the American presidents Reagan, Bush, Obama, etc. speeches on education reforms and school governance (Hu and Li, 2013; Feng 2013). The common focus of the previous research is the interpretation of the political and public incentives conveyed through metaphors, which play a role of a driver in instructing public opinion.

Thus, it is obvious that the CMA theory could reveal the ideological values, cultural roots, religious beliefs, and social background behind the literal meaning of the linguistic texts. However, there is still a research gap that the most former research of using CMA as a theoretical foundation are applied on the qualitative analysis. The former scholars tend to interpret the discourse through subjective understanding and individual perceptions but lack solidified quantitative data like gained from corpus-assisted analysis to make the research results and assumptions of the disclosure of the speakers' intentions more warrantable.

**Previous Studies on Ecolinguistics**

First of all, the improvement trend of cognitive linguistics today includes two major focuses. The first is stressing the cultural diversity and social background in discourse analysis, instead of purely analyzing the simplest cognitive phenomenon, which integrates the interdisciplinary perspectives of sociolinguistics and

critical discourse analysis. Besides, the other is to boost the validity of the research findings through experiment-based or corpus-assisted empirical research.

Besides, the rhetorical technique of ecological metaphor can also be regarded as a metaphorical analogy. Mapping the concepts and information of ecology to some other research subjects is an approach that can convey novel enlightenment to new study topics. The ecological metaphor technique has come to be a particular paradigm of the systematic and scientific method that can be applied on a broad scale.

Moreover, it is human beings' natural consciousness of thinking about daily activities from an ecological-rule perspective, and that is the reason why people would select the components and concepts of ecology to be the rhetorical sources of ecological analogy. In the long-term formation process of the earth, biological systems have experienced holistic transformative tipping points. Human beings are as the same as fauna and flora, as a composition of the biological system, which interact with the ecological system by following the evolution and changes in the environment.

Following the humans' perception to the ecological activities and sustainable development philosophy as illustrated above, Ecolinguistics came into being. Ecolinguistics is created on the interdisciplinary basis of linguistics and ecology (Wang and Zhao, 2020). American linguist Haugen (1972) proposed the theory about "ecology of language", regarding the ecological study in linguistics as the study of the relationship between any language and its environment. Later, Makkai (1993) formally put forward the term "Ecolinguistics", which concerns language as a relatively independent ecosystem. It is of great necessity to study language as a symbol, but it has more practical significance to connect with the people who create and use these symbols and to focus on the environment in which language is used. After that, the British linguist Halliday (1990) proposed Ecolinguistics, a branch of linguistics. As a result, two models of Ecolinguistics research have emerged, namely the "Haugen model" and the "Halliday model (1993)", and ecological discourse analysis has gradually developed. Among them, the one who understands and describes events and experiences is the source domain, and the one that is understood and described is the target domain. Through the cognitive understanding of the source domain and the target domain, people constantly construct the relationship between the two, which is called cross-domain mapping. In the process of constructing discourse, the metaphor will gradually become natural and become a part of human language, so we should advocate beneficial metaphor construction. Appropriate use of metaphors can not only enhance the image of the expression, but also express the speaker's standpoint, viewpoint and ideology in a natural and legalized manner.

Also, the Chinese researchers mostly keep the view that Ecolinguistics studies ought to root in the social context of linguistic usage formed in a long term by the wisdom of traditional Chinese philosophy about keeping harmonious relationships with the ecosystem and obeying the natural rules rather than conquering nature. Therefore, there is a general tendency of recognizing Ecolinguistics as a non-metaphorical paradigm (Huang 2016).

Therefore, because of the variant factors creating metaphors, the studies exemplified above have transformed the perspectives from conventional rhetorical analysis to cognitive conceptual research. Nevertheless, another research gap still exists in terms of the analysis of the former studies on Ecolinguistics, which is the lack of intercultural research. Different countries with variant cultural, linguistic and historical background must have multiple perceptions about the ecological values. Therefore, it is of great necessity to examine and understand the cultural differences and similarities as a common identity in the ecological comprehension of people in diverse cultures in order to grasp an intercultural and holistic interpretation of Ecolinguistics.

**Previous Studies on Ecological Metaphors**

Ecological metaphors are increasingly widely applied as a medium to gain vivid rhetorical effects. From the former discourse studies about ecological metaphors, abundant ecological terms can be found in variant discourse analysis.

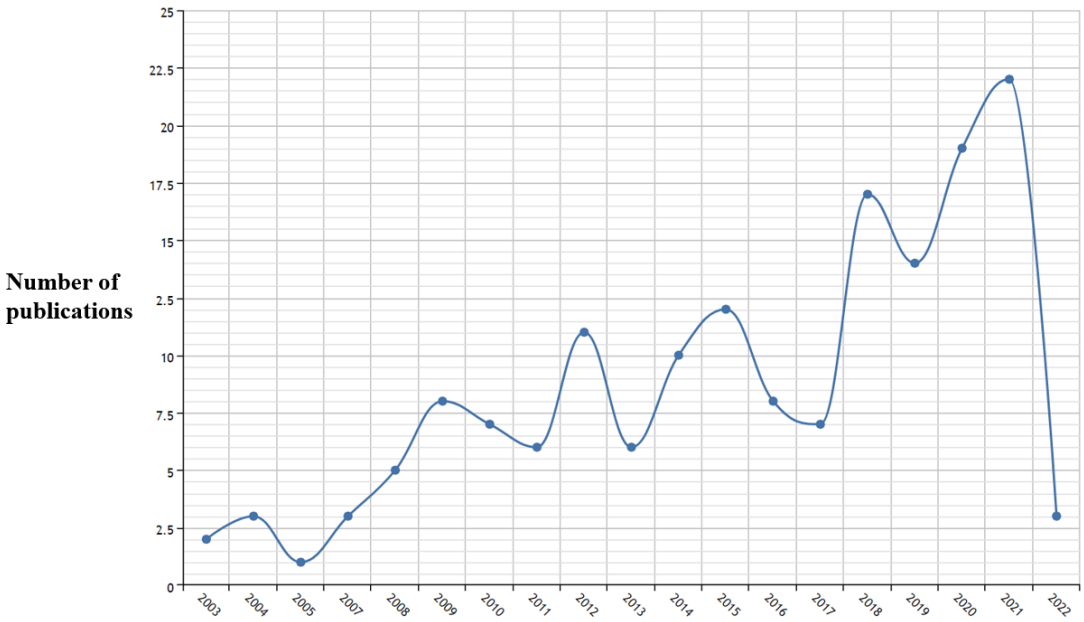



Figure 1. The Number of Articles Published on Ecological Metaphor on CNKI from 2003 to 2022

Firstly, from examining the number of the published articles with the keywords of “ecological metaphors” on China’s National Knowledge Infrastructure (CNKI) from 2003 to 2022 as shown in the above Figure 1, it can be found that the holistic trend of ecological metaphoric study has experiencing a fluctuation rise in the past two decades, especially growing significantly in the past five years. Thus, it can be concluded that the ecological metaphor research is increasingly become an important focus in various fields.

In Tang Jianmin (2008)’s study, the researcher gives a definition to the connotation of ecological metaphor as a methodology for academic research and illustrates the similarities between ecosystem and human society. Also, the enhancement of interdisciplinary studies in ecology facilitates the development of ecological metaphors.

Zheng Liang and Zhu Yali (2017) study the ecological metaphors in the literature *Kalabu Storm* to interpret the ecological identity construction of heterogeneous space, which also explains the ecological relationship with the modern humans' anxiety. Ai Lin (2020) applies ecological metaphor analysis to Chinese President Xi's news discourse by categorizing ecological metaphors into destructive, neutral metaphors, and beneficial types, and discloses the positive and negative impacts of the three kinds of metaphors in ecosystem.

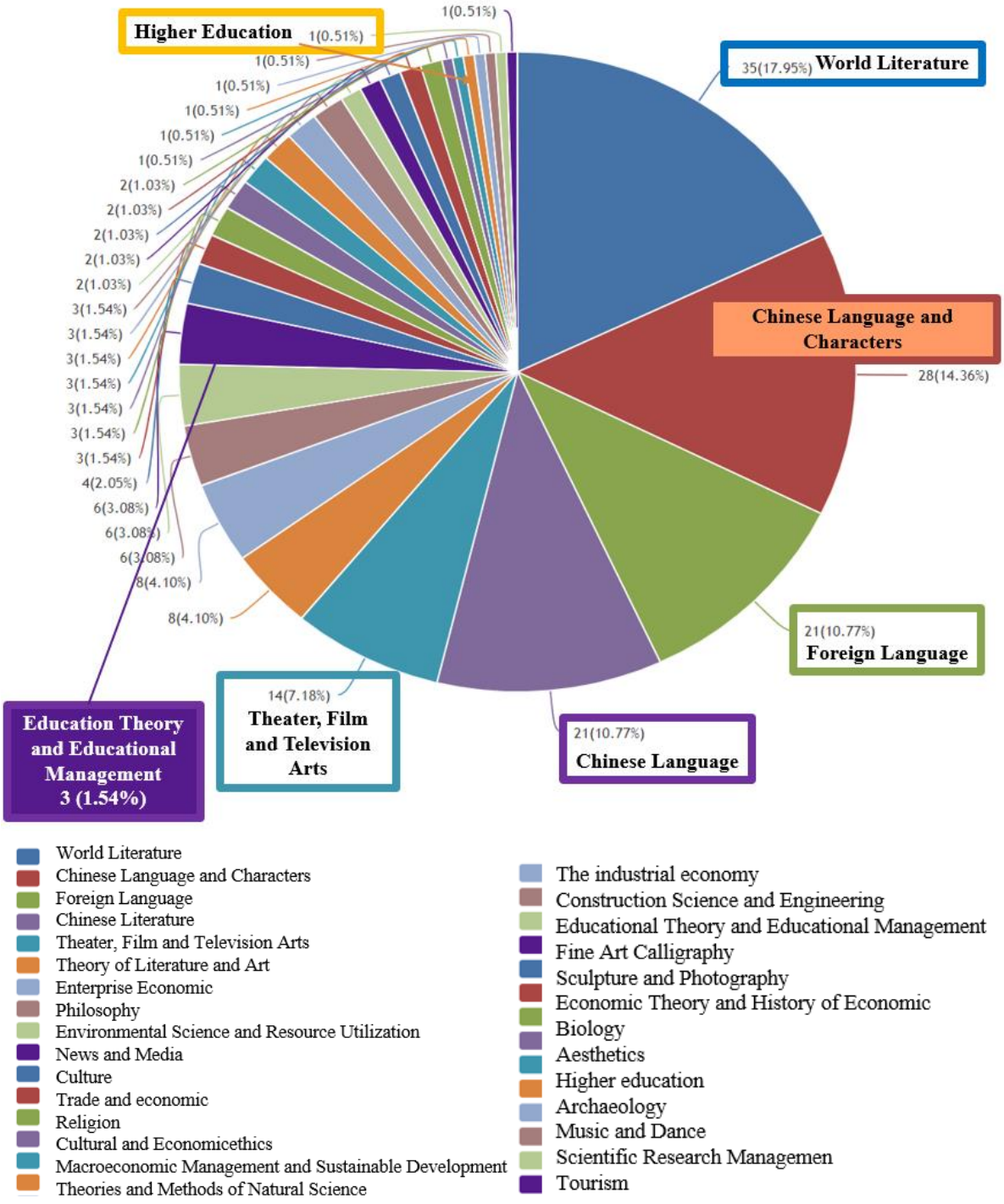



Figure 2. The Themes of Articles Published on Ecological Metaphor on CNKI

Besides, a wide range of scholars abroad also conducted diverse analysis on ecological metaphors. Gibbs (2019) adopts the angle of ecology to disclose the ecologically metaphorical implications in the speakers' expressions of their body perceptions in ecological surroundings, which are named metaphorical expressions. Jensen and Greve (2019) hold the view that ecological metaphor implies ecological cognition attributing to the interaction between living organisms and ecosystem. Ekanem Edet, David Wright, and Graham Street (2007) analyzed the significant role of ecological metaphor in boosting ecological industry. Besides, in terms of the ecological psychology theory, Agnes Szokolszky (2019) conducts field research on ecological metaphors in children' discourse based on developmental ecological approach. Mark E. Olson and other scholars (2019) propose the necessity for biologists to take advantages of metaphors in ecological studies.

Besides, from examining the published articles with the keywords of "ecological metaphors" on CNKI (Figure 2), it can be found that the most heated five research themes focus on the subjects like World Literature, Chinese Language and Characters, Foreign Language, Chinese Literature, Theater, Film and Television Arts, while the ecological metaphor research in higher education, education theory and educational management only take up about 2% of the total publications.

Among these themes as above, ecological metaphors are widely used to compare the rules of the ecosystem with human society, as well as "individual", "population", and "community" describing the intimate connection and interplay between living organisms, social environment, and natural surroundings, and there are also many other ecological keywords appeared as ecological metaphors like "sustainability", "carrying capacity", "mutation", "gene", "competition", "evolution", "selection", "transmission", "variation", etc. Meanwhile, there are also some pessimistic linguistics expression implying the damage to ecological environment. For instance, Halliday delivered a remarkable speech at the International Conference on Applied Linguistics, which symbolizes the start of Ecolinguistics as a linguistics branch to receive wide attention in 1990. Halliday holds the view that there are multiple non-ecological factors utilized via the language in the modern society, like "growthism", "classism" and "anthropocentrism", which could aggravate the deterioration of the ecological system, which is in contrast to the view that human beings are an essential part of nature (Halliday, 1990, p. 172).

Moreover, research in ecology and other related disciplines like Humanities and Social Sciences are gradually intersecting and integrating with each other. Several disciplines have features in common with ecology, and some newly emerging disciplines have been established informed by the basic theories and research methods of ecology, and some of them also apply the thinking patterns of ecological metaphor to interpret their disciplines' complicated insights with an analogical and interdisciplinary heuristic.

To take educational ecology as an example, it is a newly established discipline that takes advantage of ecological methods to study the interaction between the stakeholders in education and other social sectors. For instance, Yuan Li (2019) proposed that the construction strategy of English ecological classroom in the "Internet+" era ought to include the establishment of an effective teacher-student niche, the coordinated development of classroom subjects, the creation of ecological teaching content and methods, the creation of an

ecological teaching environment, and the implementation of scientific and ecological teaching evaluation. Thus, the term "ecology", as a prior naming component of this interdisciplinary field connected with education and sociology, reflects the ecological evolution rules are not limited in biology, but also are in line with the basic logic in many other disciplines.

Thus, adopting an interdisciplinary research view of linguistics, ecology, and education, this paper explores the ecological metaphors expressed in educational discourses delivered by national leaders as an effective, thought-provoking, powerful and influential agent of heuristic. However, there is still an obvious gap, which is the need for further interpretation of the critical understanding of a certain ecological metaphor in a certain discipline based on the speakers' socio-economic status, and their cultural identity. This problem can be found apparently, especially for the former ecological analysis in educational themed research, which mainly focus on interpreting the literal understanding of ecological expressions based on the common comprehension instead of taking the speakers' social status, cultural background, obscure purpose, and potential intentions into further consideration.

**Research Questions**

Above all, in order to make up for the three research gaps concluded at the end of each section in the literature review as above. The three proposed research questions involve:

(1) What specific types of ecological metaphors appear with high frequencies in the educational discourse of China, Britain, and America?
(2) What are the comparative study results about the common metaphorical words and variant expressions among the conceptual metaphors used in the three national leaders' educational speeches?
(3) What are the three national leaders' further intentions by employing these metaphors? And what are the influencing factors of these cognitive attitudes resulting from a certain nation's culture, history, economies, etc.?

## Theoretical Framework

The definition of the theoretical framework Critical Metaphor Analysis (CMA) will be introduced in this part from two aspects. On the one hand, it will firstly introduce CMA theory and then explain the closely intertwined connection among metaphor, thinking patterns, and ideology. On the other hand, it will clearly illustrate the three basic elements for analyzing metaphors, including the identification, interpretation and explanation of metaphors.

**Benefits and Challenges of CMA**

The section in the Chapter II has introduced the origin, definition and development of Critical Metaphor Analysis (CMA) in detail. Thus, this part will illustrate the cognitive benefits and subjective challenges of using

CMA as the theoretical framework and will explain the reasonable solutions to the potentially subjective problems of CMA by conducting a quantitative corpus-assisted analysis.

Through the cognitive understanding of the source domain and the target domain, people constantly construct the relationship between the two, which is called cross-domain mapping. In the process of constructing discourse, metaphors will gradually become natural and become a part of human language, so we should advocate beneficial metaphor construction. Moreover, the appropriate use of metaphors can not only enhance the image of the expression, but also express the speaker's standpoint, viewpoint and ideology in a natural and legalized manner (Li 2019).

Nevertheless, a few shortcomings also can be discovered within the literature review about the CMA studies as above. Also, notably, conceptual metaphor theory brings great changes as a guide to critical metaphor research for discourse analysis. Generally speaking, CMA researchers, firstly, seize the holistic macroscopic context of the textual content, then map the domain metaphor, and eventually further explore the ideological intentions behind the metaphor mapping. Thus, this process of discourse analysis is short of the focus on the diversity and complexity of the metaphorical meanings and excessively depends on the speculative impacting factors from the subjective views of the author rather than being warrantable and tenable on the basis of rigorous data analysis resulting from empirical studies.

Fortunately, the introduction of the corpus-assisted method can be viewed as a historic transformation to the critical metaphor analysis, which tackles the criticism of conceptual metaphor overly depending on the researchers' intuition and isolating from the language user's social context, which may lead to untenable and subjective analysis results (Dong 2019). Consequently, the research of critical metaphor bridges the gap of the former studies to some degree by examining the in-depth cognitive interpretation of the textual surroundings factors via interpreting conceptual metaphor and taking into account the language users' cultural identity, thinking patterns, and social standpoint to comprehensively conduct critical discourse analysis.

Furthermore, mixed with the quantitative studies with the assistance of the corpus, cognitive linguistics can be broadly integrated with different research fields and extend its own application content. Thus, an advanced corpus tool makes it possible to analyze the textual structure and linguistic semantics based on an objectively evaluated procedure in order to solve the potential problems of utilizing CMA as a theoretical framework for metaphorical analysis.

**Procedure of CMA**

The process of metaphor analysis is to identify, explain and interpret conceptual metaphors (Charteris-Black, 2004). First, metaphor recognition requires reading closely of text discourse to select potential research metaphors. The interpretation of metaphor refers to the degree to which metaphor is influenced by the complicated traits of pragmatics and cognition (Charteris-Black, 2004). Thus, that is the reason why it is

necessary for researchers to identity the conceptual metaphors with the assurance that the selected metaphor fully represents the research topic in a certain field. Last but not the least, researchers ought to explain their reasons for selecting the metaphors as research objectives as long as they have finished making their decision of choosing the certain research metaphors.

Also, researchers should consider the assumptions of this metaphorical analysis to explain their reasons for the selection, and investigate the speakers' discourse intentions, and the ideological context of the metaphors (Akman, & Açıkgöz, 2022; Akman, Ekici, Koçak, & Erdem, 2022; Akman, Sevim, Demirel, & Yılmaz, 2022; Aydın, Somuncu Demir, & Aksut, 2021; Bulut & Kirbas, 2022a, 2022b; Bulut, 2021a, 2021b; Charteris-Black 2011; Kaban, 2021a, 2021b; Onal, 2019; Palic Sadoglu & Durukan, 2018).

## Research Methodology

### Research Tool Wmatrix

The research tool Wmatrix utilized in this analysis is developed by scholar Paul Rayson (2008) and other scholars at Lancaster University. Similar to other corpus-assisted analysis software, Wmatrix could generate index, develop collocation, and generate thesaurus. While notably, the semantic domain can also be automatically generated with tags in order to get a comprehensive and complete selection of metaphors. Thus, Wmatrix is unique and superior to other software because its embedded tool USAS (UCREL semantic annotation system) can automatically code the semantic domain of text.

Also, the semantic tag set of USAS is based on the Longman lexicon of Contemporary English list and includes 21 semantic domains, such as "emotion", "food and agriculture", "government and the public", "architecture and housing", "education", "time", etc. these semantic domains can also be subdivided into 232 sub-semantic domains and labeled respectively. For example, the semantic domain E (emotion) includes six sub-semantic domains: E1 (general emotion), E2 (like), E3 (calm and angry), E4 (happy and sad). In addition, Wmatrix can compare the research corpus with the reference corpus to generate a key semantic domain, that is, compared with the reference corpus, there is an overused or overused semantic domain in the research corpus. The reference corpus is BNC sampler, including BNC sampler spoke (982,712 words) and BNC sampler written (968,267 words).

Moreover, the semantic domain coding function of Wmatrix provides a convenient basis for extracting metaphor. Wmatrix can make the semantic domain be automatically marked by words in the text, which is in concordance with the source domain. On the basis of determining which semantic domain is the source domain or target domain, all lemmas and tokens of the semantic domain can be extracted. Compared with the previous lexical based index analysis, this semantic domain based index analysis can extract the possible metaphorical terms and symbols in large-scale corpus to the greatest extent (Dong and Wang, 2019).

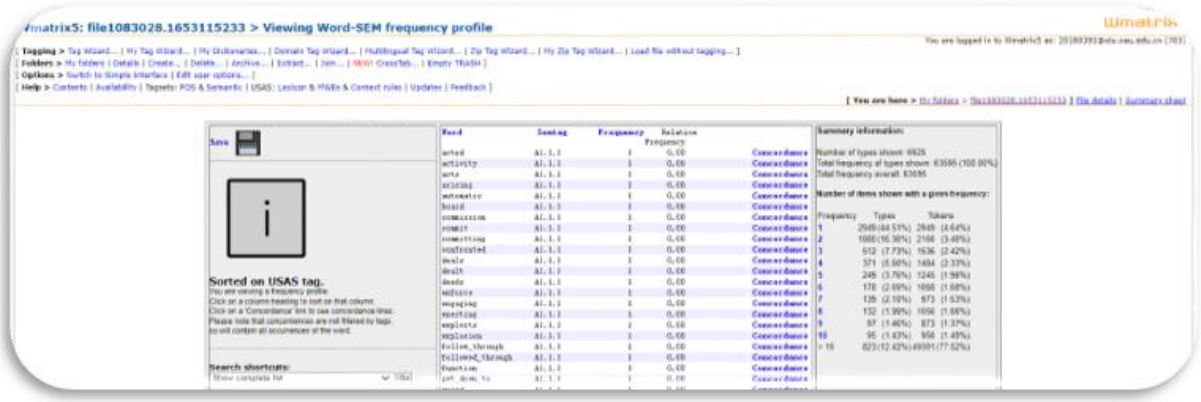



Figure 3. Operational website of Wmatrix

The website can automatically assign codes to parts of speech and semantic domain, and obtain word frequency list, part of speech frequency list and semantic domain frequency list. (Figure 4).

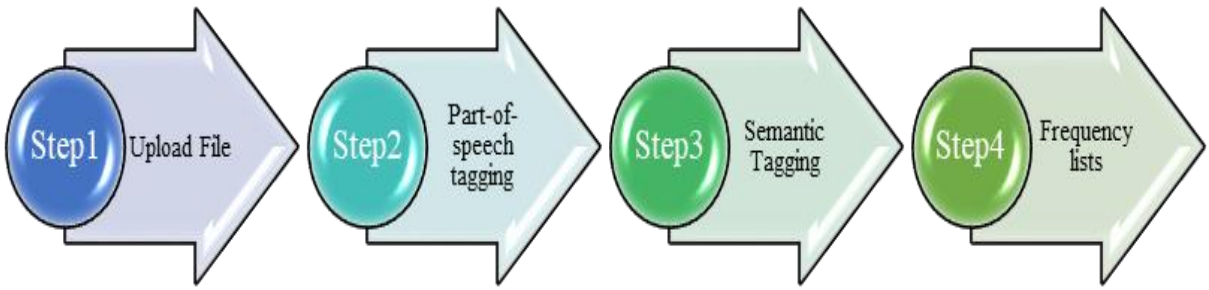



Figure 4. Wmatrix Tag Wizard Automatic Analysis Process

In conclusion, this thesis tries to take advantage of the semantic tool USAS of the corpus-assisted research software Wmatrix to connect semantic tags to certain categories of words accordingly (Dong 2019). This type of semantic domain-based index can extract the metaphors in massive-scale corpus to an extra volume, fending off missing alternative metaphors due to manual selective process, as a consequence enabling the research findings to be warrantable.

**Data Collection**

The text sample of this study is discourse of nation leaders' educational speeches in the last decade from 2012 to 2021, collected from the official websites of the national education administrations of China, Britain and America with almost 10,000 words from each country.

The detailed compositions of the corpus content, including the speech time, word count, word token, and word types in each country are shown in Table 1.

Table 1. Composition of Corpus

| China | | | Britain | | | America | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Token** | **Type** | **Year** | **Token** | **Type** | **Year** | **Token** | **Type** |
| **2012** | 9465 | 9142 | **2012** | 9024 | 8324 | **2012** | 10432 | 9634 |
| **2013** | 9947 | 7946 | **2013** | 10173 | 9349 | **2013** | 9598 | 8924 |
| **2014** | 9912 | 9443 | **2014** | 9853 | 9243 | **2014** | 10024 | 9467 |
| **2015** | 10962 | 9451 | **2015** | 11173 | 9827 | **2015** | 9923 | 9364 |
| **2016** | 11318 | 9478 | **2016** | 10425 | 9973 | **2016** | 11271 | 9836 |
| **2017** | 10127 | 9451 | **2017** | 9398 | 8636 | **2017** | 9829 | 9320 |
| **2018** | 11273 | 9624 | **2018** | 9527 | 9067 | **2018** | 10729 | 9673 |
| **2019** | 9798 | 9104 | **2019** | 12026 | 9845 | **2019** | 12002 | 9839 |
| **2020** | 10745 | 9623 | **2020** | 11262 | 9532 | **2020** | 9347 | 8941 |
| **2021** | 9725 | 9007 | **2021** | 9632 | 9183 | **2021** | 9941 | 9341 |
| **Sum** | 103272 | 92269 | **Sum** | 102493 | 92979 | **Sum** | 103096 | 94339 |

**Research Procedure**

The research procedure is shown in the flow chart (Figure 5) above. Firstly, based on the corpus-assisted methodology, the study constructs three corpora consisting of the three countries' sample discourse respectively.

Secondly, this paper utilizes the Metaphor Identification Procedure (MIP) to identify the words expressed as metaphors in the educational speeches (Pragglejaz Group 2007), which focuses on the implied meaning, which is attained via comparative analysis.

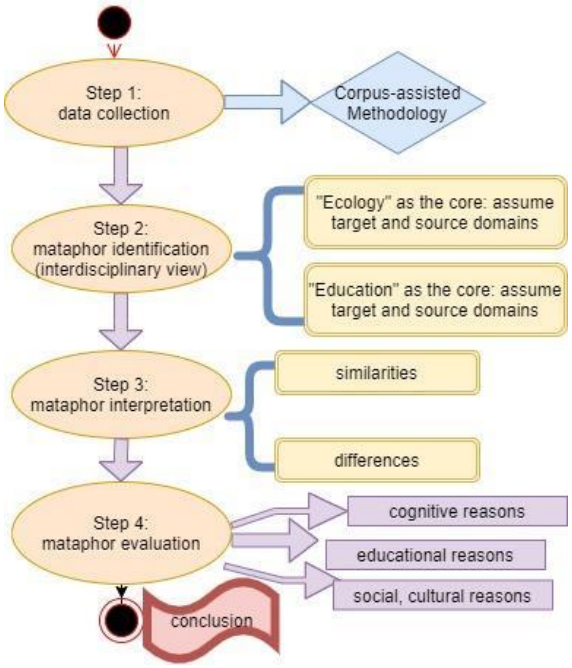



Figure 5. Flowchart of the Research Procedure

The specific metaphor recognition procedures of MIP (Pragglejaz Group 2007) are as follows:

(1) Read the text or discourse as a whole and understand its general meaning.

(2) Define the word set in the discourse sample

(3) Interpret the meaning and implications of the word set in the discourse sample

In view of the research purpose, the basic meaning of vocabulary should be relatively more specific and accurate. At the same time, it has a long history of use and is related to physical behavior. It is necessary to judge whether there can be a sharp contrast between contextual meaning and original meaning, and understand contextual meaning through comparison.
(4) If the answer to the above question is yes, the contextual meaning of the word is metaphorical.

Thirdly, on one hand, the study analyses the similarities of the most frequently used metaphors in the leaders' educational speeches in China, America, and Britain by examining the ecological metaphors' frequency, proportion, types, and tokens. In terms of the four elements in Ecology and tag rules, the most frequent ecological conceptual metaphors in the three countries' samples are accordingly categorized into 'organisms, environment, relationship, and human'. Furthermore, via concordances, and semantic prosody, the study investigates the commonly emphasized educational ideas expressed via ecological metaphors among the three countries. On the other hand, the study examines the differences in the distinctively used ecological metaphors of the three countries respectively with the analysis of certain real examples in the language use.

Finally, the study will evaluate the unique ecological metaphors in the three countries' educational speeches by exploring the reasons of cognition, education, social context, culture, geographical position, etc. to interpret the cultural and educational differences in terms of variant ecological values expressed via ecological metaphors.

## Results and Discussions

### 5.1 Metaphor Identification

Ecology is a branch of science, including human science, population, community, ecosystem and biosphere, which is the study of living organisms, including humans, plants, and animals, etc., and how they interact with the physical environment around them. According to the *Oxford English Dictionary*, an ecosystem is defined as "a complex network or interconnected system". Others define it as a system or network of interacting parts, or in other words, things or objects that must interact and connect in the environment. In detail, relationships among organisms include intraspecific relationships and interspecific relationships. Intraspecific relationships are divided into intraspecific mutual assistance (cooperative relationships) and intraspecific competition; Interspecific relationships include: ①symbiosis, ②parasitism, ③predation and ④interspecific competition. A complete ecosystem includes biological and abiotic parts. Plants are producers and can produce organic matter through photosynthesis. Animals are consumers and cannot produce organic matter through photosynthesis, and they feed directly or indirectly on plants. Consumers eat producers, producers are eaten by consumers, and the relationship between producers and consumers, that is, the relationship between eating and being eaten, constitutes the food chain, which is intertwined with each other to form the food web. The remains of animals and plants after death are decomposed into carbon dioxide, water and inorganic salts by bacteria and fungi, and

carbon dioxide, water and inorganic salts are used by plants. Various organisms in the ecosystem are connected with each other through various relationships, the most important of which is the food relationship (Figure 6).

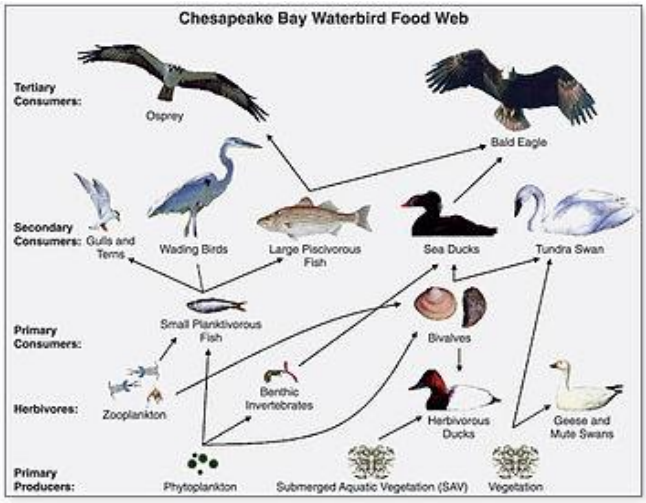



Figure 6. Matthew C. Perry -Diagram of a food chain for waterbirds of the Chesapeake Bay, United States.

More significantly, the interrelation traits in the ecosystem also go for the analysis of the interdependent relationships among human beings in society, along with social activities continuously exert an impact on the environment, which meanwhile changes human's daily life and brings challenges to the sustainable development of ecosystem which supports social life.

Thus, according to the ecological environment, food chain, and interactions between living organisms and the physical surroundings, it can be concluded that ecology is composed of four fundamental elements: (1) organism; (2) relationship; (3) human; (4) the environment, which are analyzed with Wmatrix's USAS tag set (Table 2.) as follows:

Table 2. Semantic Tags with Ecological Metaphors Appear in this Research

| Ecological elements | Semantic tags |
|---|---|
| **Organism** | F1 Food, F4 Gardening (Farming & Horticulture), L3 Plants. |
| **Environment** | O1.2 Substances and materials generally: Fluid, W1 the universe, W2 Light, W3 Geographical terms, W4 Weather, W5 Green issues, M6 Location and direction |
| **Relationships** | S1.1.2 Reciprocity, S1.1.3 Participation, S5 Groups and affiliation, S8 Helping or hindering |
| **Human** | B1 Anatomy and physiology, B2 Health and disease, B4 Cleaning and personal care |

**Metaphor Distribution**

First of all, the distribution of dominant ecological metaphors can be analyzed in terms of the four main

ecological categories. The source semantic tags are demonstrated in four categories, including "the environment", "organism", "relationships", and "human", which in accordance with the four fundamental components of the ecological system. The comparison of ecological metaphor distribution in the three corpora is shown in the following Table 3.

The most frequent used ecological metaphors in the three countries are metaphorical types "cultivation, growth" belonging to the "organism category"; metaphorical types "cooperation, community, relation" in the "relationships category" and metaphorical types "health, body" in the "human category".

Moreover, the "growth" ecological metaphors appear most frequently in Chinese leaders' educational speeches, with a high frequency of 322 times, taking a proportion of 19% of all the representative ecological metaphors in China's discourse, implying the China's efforts in transforming education with continuous progress in the long run, just like the natural rules of plant growth. While the ecological metaphor type "relation" is expressed most with 249 and 135 times in American's and British's sample, which takes up 28.91% and 27.16% respectively, implying American and British leaders' emphasis on building communities in the educational system as a whole to confront challenges with connected relations among multiple stakeholders at variant dimensions, just like the interdependent and co-existing relations between living organisms and physical environment in the ecosystem. Notably, the distinctive ecological metaphors in the three corpora, includes the "fluid" and "food" metaphors in China, the "fire" metaphors in America, and the "island" metaphor in Britain.

Table 3. Comparison of Ecological Metaphor Distribution in the Three Corpora

| Ecological category | Metaphor | China's corpus | | | USA's corpus | | | UK's corpus | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | types | Proportion | tokens | types | Proportion | tokens | types | Proportion | tokens |
| Organism | cultivation | 148 | 10% | 217 | 46 | 6.49% | 59 | 54 | 10.87% | 74 |
| | growth | 264 | 19% | 322 | 93 | 13.12% | 132 | 31 | 6.24% | 39 |
| | plant | 33 | 2% | 58 | 17 | 2.40% | 25 | 1 | 0.20% | 6 |
| | food | 36 | 3% | 71 | 1 | 0.14% | 1 | 0 | 0 | 0 |
| Relationships | cooperation | 196 | 14% | 263 | 125 | 17.63% | 177 | 113 | 22.74% | 145 |
| | reciprocal | 24 | 2% | 36 | 9 | 1.27% | 22 | 24 | 4.83% | 33 |
| | community | 185 | 13% | 256 | 155 | 21.86% | 198 | 92 | 18.51% | 132 |
| | relation | 194 | 14% | 237 | 205 | 28.91% | 249 | 135 | 27.16% | 174 |
| Human | disease | 8 | 1% | 24 | 1 | 0.14% | 4 | 2 | 0.40% | 9 |
| | health | 239 | 17% | 351 | 5 | 0.71% | 12 | 9 | 1.81% | 25 |
| | body | 62 | 4% | 67 | 50 | 7.05% | 71 | 33 | 6.64% | 42 |
| Environment | fluid | 37 | 3% | 69 | 2 | 0.28% | 5 | 2 | 0.40% | 3 |
| | fire | 0 | 0 | 0 | 27 | 6.49% | 56 | 0 | 0 | 0 |
| | island | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.20% | 2 |

In addition, the mLFR (metaphorical lemma-formation ratio) can be calculated from the ratio of the types and tokens of the metaphors. The mLFR is directly proportional to the novelty of the metaphor pattern and inversely

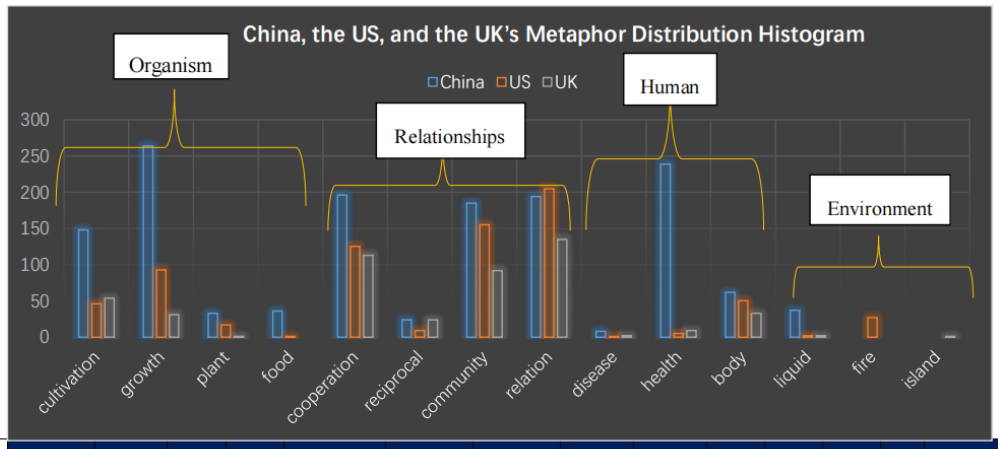
proportional to its conventionality. The higher the mLFR, the m novel ore the metaphor is, and the lower the mLFR, the more conventional the metaphor is. According to the echo value, we can find the rules and conditions of metaphor use in a certain corpus. By comparing the mLFR values, the study can find the conventional metaphor patterns and novel metaphor patterns used in the three-countries leaders' educational speeches.

Therefore, from the Table 4 as follows, it can be found that the top-two most innovative metaphors with the highest mLFR as the highest novelty in China's and Britain's discourse sample are the same, which are "body (mLFR=92.54% in China, mLFR=78.57 in Britain)" and "growth (mLFR=81.99% in China, mLFR=79.49% in Britain)", while the top-two metaphors with the highest novelty in America are "relation (mLFR=82.33%)" and "community (mLFR=78.28%)", belonging to the "relationship category".

Table 4. The mLFR of the Three Nations' Discourse-sample

| Ecological category | Metaphor | China's corpus | | | USA's corpus | | | UK's corpus | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | types | tokens | mLFR | types | tokens | mLFR | types | tokens | mLFR |
| Organism | cultivation | 148 | 217 | 68.20% | 46 | 59 | 77.97% | 54 | 74 | 72.97% |
| | growth | 264 | 322 | 81.99% | 93 | 132 | 70.45% | 31 | 39 | 79.49% |
| | plant | 33 | 58 | 56.90% | 17 | 25 | 68.00% | 1 | 6 | 16.67% |
| | food | 36 | 71 | 50.70% | 1 | 1 | 100.00% | 0 | 0 | 0 |
| Relationships | cooperation | 196 | 263 | 74.52% | 125 | 177 | 70.62% | 113 | 145 | 77.93% |
| | reciprocal | 24 | 36 | 66.67% | 9 | 22 | 40.91% | 24 | 33 | 72.73% |
| | community | 185 | 256 | 72.27% | 155 | 198 | 78.28% | 92 | 132 | 69.70% |
| | relation | 194 | 237 | 81.86% | 205 | 249 | 82.33% | 135 | 174 | 77.59% |
| Human | disease | 8 | 24 | 33.33% | 1 | 4 | 25.00% | 2 | 9 | 22.22% |
| | health | 239 | 351 | 68.09% | 5 | 12 | 41.67% | 9 | 25 | 36.00% |
| | body | 62 | 67 | 92.54% | 50 | 71 | 70.42% | 33 | 42 | 78.57% |
| Environment | fluid | 37 | 69 | 53.62% | 2 | 5 | 40.00% | 2 | 3 | 66.67% |
| | fire | 0 | 0 | 0 | 27 | 56 | 48.21% | 0 | 0 | 0 |
| | island | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 50.00% |

Generally, according to China, the US, and the UK's metaphor distribution histogram as follows, it can be found that the most frequent ecological metaphors appear in China, America, and British leaders' educational speeches belonging to the "relationship" category, while the least used ecological metaphors belong to the "environment" category. Taking the total ecological metaphors count and distribution into consideration, it can be found that there are more ecological metaphors in Chinese discourse than in America and in Britain generally (Figure 7). Thus, the results imply that the ecological values are more prevalent in China's sustainable social production, moderate educational reform and citizen's ecological cultural propaganda with China's long history of farming society rooted in traditional natural philosophy of Confucianism and Taoism.




| | cultivation | growth | plant | food | cooperation | reciprocal | community | relation | disease | health | body | liquid | fire | island |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| China | 148 | 264 | 33 | 36 | 196 | 24 | 185 | 194 | 8 | 239 | 62 | 37 | 0 | 0 |
| US | 46 | 93 | 17 | 1 | 125 | 9 | 155 | 205 | 1 | 5 | 50 | 2 | 27 | 0 |
| UK | 54 | 31 | 1 | 0 | 113 | 24 | 92 | 135 | 2 | 9 | 33 | 2 | 0 | 1 |

Figure 7. China, the US, and the UK's Metaphor Distribution Histogram

Last but not the least, from the Figure 8 as above, the overall distribution of the top 10 metaphorical words in the three countries' educational speeches shows that the ecological metaphors appear most in the concordances related to "growth, health, cooperation, relation, community, and cultivation", which imply that China, the US and the UK all embrace natural values of making continuous progress, cultivating quality talents in a resilient era, overcoming challenges with a solid community, and get along well with other people and countries benefiting from harmonious coexistence.


Figure 8. The Overall Distribution of the Top 10 Metaphorical Words in the Three Countries' Educational Speeches

**Similar Metaphors' Interpretation and Evaluation**

***Improving Education is Gardening (F4, L3 <Organism>)***

Initially, the common ecological metaphor with the highest frequency in the three national leaders' educational

speeches is “education is gardening”, which can be mapped to the ecological category of “organism” with the coding tag of “F4” in the Wmatrix. The gardening metaphors are used to describe the continuous process of talent cultivation and lifelong education just like facilitating the natural rules of plants’ growth. Also, plant metaphors in the gardening category also describe the inner element of striking the balance of the natural system just like the significant role of every stakeholder in keeping the normal running of the educational system. In addition, plants are fundamental components of the ecosystem, which is the common sense of human beings. Consequently, plants widely become the source domain for describing abstract educational concepts. Thus, it is comprehensible that lifelong learning is just like gardening and planting the plants for keeping a balanced environment is as the same as empowering every single sector in the educational community.

The similarity between gardening and continuous education maps the source domain to the target domain. By calculating the gardening metaphorical words in three nations’ educational discourse corpus, the frequent gardening metaphors to describe education can be found, involving cultivation, plant, and growth. The distribution, semantic tag, metaphorical words, and frequency of the gardening metaphor in each country are illustrated in Table 5,6,7 as follows:

Table 5. Gardening Metaphors in China’s Corpus

| Gardening Metaphor | Semantic Tag | Metaphorical words | Concordances | Frequency | Total |
|---|---|---|---|---|---|
| **cultivation** | F4 | foster, cultivate | Foster a new development paradigm, foster and expand new competitive strengths, foster an innovation-friendly environment, foster a social environment that embraces innovation; foster a community, foster a new development paradigm, foster new growth drivers, foster new technologies;<br><br>cultivate a closer community with a shared future, cultivate green production,<br>cultivate new growth drivers through scientific and technological innovation and digital transformation | 142 | 148 |
| | F4 | thrive | Maintain its diversity and thrive, thrive without a peaceful and stable environment, thrive by spring, thrive in this sector | 6 | |
| **growth** | F4 | grow, growth | Growth rate, economic growth, growing friendship, steady growth, growth driver | 264 | 264 |
| **plant** | L3 | root | Take root in our hearts, root causes, deep roots, original root, rooted in the unique cultural environment, ancestral roots, deeper roots in hearts and minds | 12 | 33 |
| | | seed | Spread the seeds for the idea of peace | 3 | |
| | | fruit, fruitful | Fruits of scientific innovation and development, fruits of human progress;<br><br>diverse and fruitful cooperation, produce more fruitful outcomes in China-Africa cooperation, keep producing fruitful results | 18 | |

In Chinese education discourse, the concordances about "cultivation metaphors" are mainly expressed via the metaphorical words "foster" and "cultivate". The concordances like "foster a new development paradigm, foster and expand new competitive strengths, foster an innovation-friendly environment, foster a social environment that embraces innovation, foster a community, foster a new development paradigm, foster new growth drivers, foster new technologies" show the outcomes that China's technology and innovation develop by leaps and bounds, and the Chinese government highlights the support for building technological innovation community via cooperation and the emphasis on cutting-edge-technology related education enhancement.

Also, the "cultivate"-related metaphorical words are expressed in the concordances like "cultivate a closer community with a shared future, cultivate green production, cultivate new growth drivers through scientific and technological innovation and digital transformation", which emphasizes that the process of building a community or boost new growth drivers for the technological breakthroughs in the digital transformative era ought to be a continuous and tough process, just like the cultivation of organisms in nature, which is a long-term task.

Also, in the Chinese President Xi's educational speech in 2021, Chinese President Xi used a Chinese poem, "Past a fallen ship, one thousand sail onward; for a sick tree, ten thousand thrive by spring." to express his hope for a recovering future of the post-pandemic era in terms of the recycling rules of the organisms like trees in nature following the seasons coming and going. Also, the "thrive" metaphors are expressed in other frequent concordances like "maintain the diversity and thrive, thrive without a peaceful and stable environment, thrive by spring, thrive in this sector". Moreover, the growth metaphors include the concordances of "growth rate, economic growth, growing friendship, steady growth, growth driver", which imply the Chinese active reform for sustainable development and educational reforms. Thus, the "cultivation metaphor" implies the strong vitality and determined spirit of overcoming challenges of the Chinese people.

Also, the "plant" metaphors are expressed in the concordance like "take root in our hearts, root causes, deep roots, original root, rooted in the unique cultural environment, ancestral roots, deeper roots in hearts and minds". Notably, the ecological metaphor "spread the seeds for the idea of peace" shows that China aspires to call for peace just like spreading seeds to construct a harmonious-international-relations "ecosystem" on the world scale. Finally, the ecological metaphor "fruit" is illustrated in the concordances of "fruits of scientific innovation and development, fruits of human progress" which emphasizes China's great achievements in social construction and citizens' welfare. The "fruit" metaphor is also used to emphasize the profound meaning and rewarding outcomes of the global cooperation between China and Africa, which can be reflected in the concordances "diverse and fruitful cooperation, produce more fruitful outcomes in China-Africa promising cooperation, keep producing fruitful results" (Table 5.).

By comparing the differences between the common "gardening" metaphors in the three countries as shown in the Table 5, 6, 7 and the Venn diagram as above, this study also finds that the metaphorical word "thrive" only exist in Chinese discourse, and the expression of "rooting out systemic racism" only appear in American

speeches, which implies the unique social context of American diverse cultures in history. Moreover, the concordance of "growing STEM subjects", showing the British government's emphasis on the role of Science, Technology, Engineering, Mathematics on boosting economic improvement, and technological and innovative breakthroughs.

Table 6. Gardening Metaphors in American Leaders' Educational Speeches Corpus

| Gardening Metaphor | Semantic Tag | Metaphorical words | Concordances | Frequency | Total |
|---|---|---|---|---|---|
| **cultivation** | F4 | foster, cultivate | foster student success, foster home | 85 | 93 |
| | | harvest | help out a friend with his harvest | 8 | |
| **growth** | F4 | grow, growth | grow up, national growth gets a boost, job growth, grow economy, accelerated growth, grow and thrive, grow through this challenging time | 46 | 46 |
| **plant** | L3 | root, seed, branch | the root of our problems, root out systemic racism;<br><br>the seeds have sprouted, the roots are strong, and I just saw more than 500 branches that are ready to grow again | 17 | 17 |

Table 7. "Gardening" Metaphors in the British Leaders' Educational Speeches Corpus

| Gardening Metaphor | Semantic Tag | Metaphorical words | Concordances | Frequency |
|---|---|---|---|---|
| **cultivation** | F4 | foster, cultivate | Foster talents,<br>cultivate the youth | 54 |
| **growth** | F4 | grow | Grow and develop their own accord, economic growth generates is more fairly shared in our society, we need a funding and access system that is fit for the 21st Century and will drive our country's growth in this post-recovery era, grow around long term vision, grow up, grow a high-tech business, the growth of strategically important STEM subjects, stem the growth of low quality courses, growing STEM A Level, support local innovation and growth, Promoting the UK's education sector is not just about jobs and exports growth | 31 |
| **Plant** | L3 | root, seed | Looking forward to seeing a tailored curriculum to those who will benefit from more practical learning take root;<br><br>plant the seed for the idea of the pupil premium | 2 |

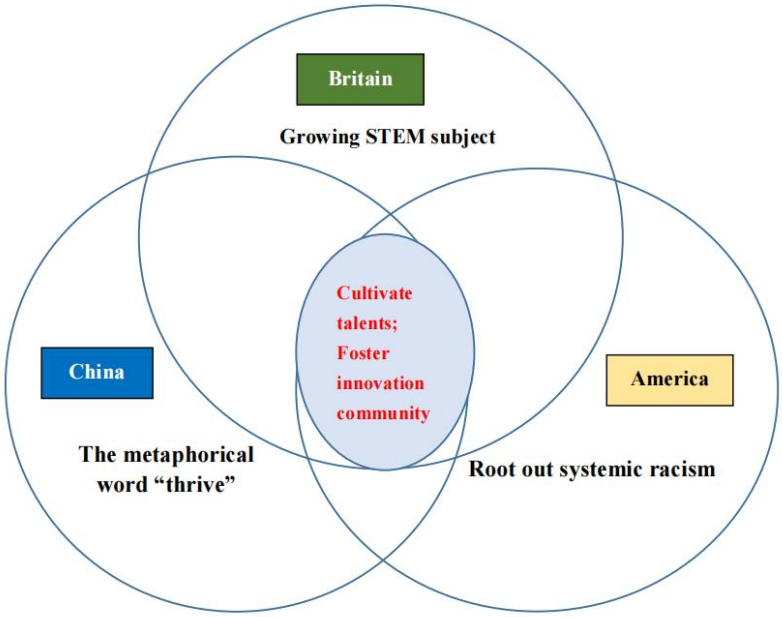



Figure 9. The Venn Diagram on the Similarities and Differences of "Gardening" Metaphors between China, American and Britain

Last but not the least, the "gardening metaphors" are common in the three nation leaders' educational speeches expressed through the metaphorical words like "growth, foster, and cultivate", which implies the ecological view in educational external facilitation and inner improvement. Although the soil fertility and the amount of rain and dew may come from accidental transportation, "external intervention and assistance" such as weeding and deep ploughing, irrigation and fertilization also play a great role in crop growth. Therefore, similar to the ecological phenomenon, educators should try their best to create good conditions in the process of human growth.

When it comes to the plant-related metaphorical words in the research discourse sample, it can be found that the metaphorical words like "root, seed, and fruit" appear with a high frequency, which can be concluded that education is generally regarded as a condition for human growth. Without education, people will not have rational and independent thinking or master the skills of survival and communication, and human beings will not be able to survive in society. Therefore, human growth can be compared to the growth of plants, and education is the sunshine, rain, dew, soil, and other elements required for plant growth.

In addition, the plant metaphor reflects learners' subjective initiative, since it regards education as agriculture with natural rules instead of the industry with excessive intervention. Education is ought to respect the students' nature, character, and interests, just like agriculture needs to respect the growth law of plants. Human beings cannot replace plants to grow, just as teachers cannot replace students to learn. From the perspective of the plant metaphor, learners are not arbitrarily shaped by educators. Educators can only prepare them for their growth, and enhance students' self-efficacy through positive psychology, which is similar to fertilizing plants to provide

nutrition. Just like sowing seeds and watering regularly, they should boost students' learning enthusiasm, promote students' inner motivations and cultivate students' social-emotional skills. Such an educational idea that conforms to the law of natural ecological development reflects the student-centered constructivist educational idea, which abandons the traditional teacher-centered method by instilling knowledge into students with rote memory.

However, on the other hand, the "growth" metaphor in educational discourse has prompted a profound reflection on the industrialization of education today. For instance, in the current industrial market-economy-oriented world, in order to improve learners' grades with high competence, some primary and secondary schools in China continuously increase the length of examination subjects in the curriculum, and try to reduce and occupy the arts, technology, comprehensive practice, career planning, community activities and other courses that have less connections with the examination. This mode of education is in accordance with the metaphor of industrial production, just like adding various courses to products (students) as raw materials, just like processing the food in factories, adding a little more pigment would make the color brighter.

The metaphor of "education is the growth of plants" implies that if educators pay too much attention to achievements and results of academic performance but despise the courses of art, technology, comprehensive extra-curricular practices, career planning, community activities, etc., schools will ignore the holistic education of student's socio-emotional skills and comprehensive competence, which is just like putting plants in an extremely unbalanced and unhealthy growth environment without watering them.

The above practice reflects the problem of using the metaphor of industrial production for education. Students are not machines in industrial production or editable program software, but rich individuals with different personalities and interests. Educators need to respect the unique personality of each student, and set the curriculum content suitable for students' levels according to their understanding and adaptability at different stages. Just as within a reasonable limit, fertilization can increase the yield, but if excessive fertilization exceeds the absorption capacity of plants, it will destroy the self-pace of plant growth, just as educators must respect the self-pace of students' growth.

Therefore, only when education breaks away from the educational concept of being radically eager to obtain results and rewards, but abides by the natural development nature of students' cognitive levels and personal development need, can education cultivate all-around talents with mature minds, prominent morality and rich knowledge.

***Education is a Journey (M6, S8 <Environment>)***

The ecological metaphor "education is a journey" belongs to the "environment category" expressed via the metaphorical words like "routes, destinations, obstacles, etc." by considering the educational development is a process just like "journey, which is a movement with purpose from the starting point to the destination in

physical space within a real environment.

The "Journey" metaphor is a representative metaphorical research in the cognitive linguistics. Lakoff and Johnson (1980, p.44) originally created the metaphorical concordance "love is a journey" in terms of the sentences such as "our marriage is on the rocks" and "we are at the crossroads". A few years later, Lakoff and Turner (1989) expressed the metaphor "life is a journey", which shows that "journey" metaphor is regarded as a purposeful movement from the starting point to the destination in physical space within a real environment, thus, that is the reason why this study also consider the "journey" metaphors in educational speeches as the examples in the "environment category" of "ecological metaphors". Moreover, Lakoff (1993) gave a more detailed cognitive definition to the "journey" metaphor again, with the expressions like "purposeful activity is traveling along a path towards a destination". The route of educational development is by no means an actual road, but an active path chosen by people. It represents the "journey"-like process of seeking interlinkages with multiple stakeholders in a wide range of countries and regions, and aims to boost education as common goods that brings intellectual outcomes to more people, and continuously facilitate the evolution of human civilization.

According to the definition and traits of "journey" metaphors as ecological metaphors, this study examines the "journey metaphors" in the educational speeches delivered by leaders in China, the UK, and the US, and finds the metaphorical words like "journey, start, end, destination, route" with concordances frequently as shown in the Table 8 follows.

Firstly, the metaphorical word "journey" appear frequently in all the three countries' discourse sample. In China, there are expressions "To contain the virus, stabilize the economy and protect livelihood remains a long and arduous journey for all countries; embark on a new journey next year toward fully building a modern socialist country; With a fluid situation, the world economic recovery is an uphill journey; the journey of human progress; The journey ahead will always see twists and turns" which implies the tough and challenging efforts of recovering the education in the post-pandemic era, and the long-term process of boosting the prosperous socialist society. Notably, the Chinese President Xi emphasized the gradual process of social reforms with a traditional Chinese proverb "a thousand-mile journey begins with the first step", which implies a metaphorical meaning of accumulation could contribute to achievements in a long run.

Besides, the metaphorical words like "milestone" and "cornerstone" also becomes the frequent expressions as the symbols of achievements in the "journey" metaphors, like the sentences said by Chinese leaders, "Major milestones were recorded in fields of science and technology and numerous outcomes in innovation were achieved; The Millennium Summit was a call for action to end global poverty and represented a milestone in the endeavor to promote the common development of mankind. China's aid to Africa has never been attached to political strings. All this has constituted a defining cornerstone for the ever-growing friendship between China and Africa."

In America, there are "journey" metaphorical concordances like "twists and turns on your journey, we continue

a never-ending journey to bridge the meaning, as you prepare for the next stage of what I know will be a remarkable journey, the beginning of your journey to find or refine your purpose, America will continue on its journey towards that distant horizon, and a better day", which emphasizes the demanding tasks in the process of achieving quality education and realizing American dreams.".

Table 8. "Journey" Metaphors in the Three Corpora Sample

| Journey Metaphor | Semantic Tag | Metaphorical words | Concordances | Frequency |
|---|---|---|---|---|
| Location and direction | M6 | journey | **China:** To contain the virus, stabilize the economy and protect livelihood remains a long and arduous ***journey*** for all countries; embark on a new ***journey*** next year toward fully building a modern socialist country; With a fluid situation, the world economic recovery is an uphill ***journey***; the journey of human progress; a thousand-mile ***journey*** begins with the first step; The ***journey*** ahead will always see twists and turns;<br>**America:** twists and turns on your journey, we continue a never-ending ***journey*** to bridge the meaning, as you prepare for the next stage of what I know will be a remarkable ***journey***, the beginning of your ***journey*** to find or refine your purpose, America will continue on its ***journey*** towards that distant horizon, and a better day;<br>**Britain:** It is a ***journey*** that can stop and start when you like; We've started this ***journey*** in education already; what's the next step on your ***journey*** once you've completed a T Level or an initial apprenticeship; the school continues its upward ***journey***; We're also thinking about the role that inspection plays in the school leadership ***journey*** | 82 |
| | | Starting point, destination | The ***starting*** point for that is that school leaders; My ***starting point*** for that work is that we have a good education system; My ***starting point*** is always that we should trust our best leaders and teachers to get on with the job; the 13th Five-Year Plan set off to a good ***start*** this year;<br>LLE turns education from a narrow, set ***destination*** into to an accessible, flexible journey; the most appealing ***destination*** for foreign investment; When it comes to our schools and colleges, although we have published performance tables where ***destinations*** to further education, apprenticeships and employment are all counted…; | 47 |
| Helping or Hindering | S8 | Milestone, stone, cornerstone | **China:**<br>● Major ***milestones*** were recorded in fields of science and technology and numerous outcomes in innovation were achieved.<br>● The Millennium Summit was a call for action to end global poverty and represented a ***milestone*** in the endeavor to promote the common development of mankind.<br>● China's aid to Africa has never been attached to political strings. All this has constituted a defining ***cornerstone*** for the ever-growing friendship between China and Africa.<br>**America:** a huge milestone for my family and me;<br>**Britain:**<br>● Education is the ***cornerstone*** of critical thinking, creativity, choice and capital.<br>● English and maths are the foundation ***stones*** for humanities, languages and the sciences and so much else.<br>● This year we hit the ***milestone*** of 50% of pupils taught in academies. | 2 |

In Britain, the "journey" metaphors in educational speeches illustrate the starts and ends in finishing and achieving every stage of education. Also, the speakers compare the education leadership as a long-term journey, which requires continuous transformations to achieve the final goals. In detail, the "journey" concordances in

the text include “It is a journey that can stop and start when you like; We’ve started this journey in education already; what’s the next step on your journey once you’ve completed a T-Level or an initial apprenticeship; the school continues its upward journey; We’re also thinking about the role that inspection plays in the school leadership journey”.

Secondly, the metaphorical words “starting point”, and “destination” of the “journey” metaphors are expressed to describe educational reform and leadership as a journey-like process, and the concordances in the three corpora are “The ***starting*** point for that is that school leaders; My ***starting point*** for that work is that we have a good education system; My ***starting point*** is always that we should trust our best leaders and teachers to get on with the job; the 13th Five-Year Plan set off to a good ***start*** this year” and “LLE turns education from a narrow, set ***destination*** into to an accessible, flexible journey; the most appealing ***destination*** for foreign investment; When it comes to our schools and colleges, although we have published performance tables where ***destinations*** to further education, apprenticeships and employment are all counted”.

Thirdly, the metaphorical words like “milestone” and “cornerstone” also becomes the frequent expressions as the symbols of achievements in the “journey” metaphors, which belonging to the “helping or hindering (tag <S8>)” in all the three countries. Like the sentences said by Chinese leaders, “Major milestones were recorded in fields of science and technology and numerous outcomes in innovation were achieved; The Millennium Summit was a call for action to end global poverty and represented a milestone in the endeavor to promote the common development of mankind. China’s aid to Africa has never been attached to political strings. All this has constituted a defining cornerstone for the ever-growing friendship between China and Africa.”

Similarly, in America, there is also a “milestone” metaphor used to illustrate personal achievement in the concordance like “a huge milestone for my family and me”. Also, even though the process of educational and social reforms is an arduous process in the UK, the British government still makes great breakthroughs. Via the “milestone, stone, cornerstone” metaphorical words in the “journey” metaphors of British discourse sample, education achievements are described in the sentences like “Education is the ***cornerstone*** of critical thinking, creativity, choice and capital; English and maths are the foundation ***stones*** for humanities, languages and the sciences and so much else; This year we hit the ***milestone*** of 50% of pupils taught in academies”.

Therefore, the “journey” metaphor in the three countries’ educational speeches can be understood as viewing learning as the movement of people in space, while the educators achieve a place a little ahead to guide the learners. At first, learners are far from what they must achieve, but through unremitting efforts, eventually, learners will arrive at the destination of the journey, create value, and make their aspirations come true. And then learners follow the order and directions of phased progress when they start learning. At each stage, they should learn what is suitable for that stage in an appropriate way accordingly. For example, in the process of moving in a specific direction, travelers must pass through some places. Similarly, in the journey of education, teachers play a guiding and leading role to the students. When students are unable to get close to the destination or lose their way, they should be encouraged rather than discouraged by their teachers who are their guides.

Students should appreciate the scenery and overcome difficulties in their journey with the support and instruction of their teachers, and get to the destination by themselves finally.

However, compared with the "plant" metaphor, the educational "journey" metaphor does not stress too much the decisive role of learners' subjective initiative and inner-motivation domination. Although the process of travel should be participated by the learners themselves, the destination is pre-selected according to the values of the educational policymakers in the huge social context. The education the learners receive is guided by the road map designed by the educational policymakers set in and guided by the social environment. The curriculum in the school is also considered the road map that the learners need to take on the journey.

In educational practice, although people are born with the possibility and motivation to learn, progress-oriented and grade-dominated schools that fully adhere to "education is journey" would still evoke doubts and criticisms. People are worried about whether the educational purpose that the society is willing to cultivate is also in concordance with the learners' own initiative. Metaphorically speaking, "purpose" is a specific spatial position. Educators should lead learners to a specific place, such as focusing on cultivating students' critical thinking, advanced quality, the consciousness of empathy and social responsibility.

Consequently, on the disadvantaged side, the travel metaphor in educational discourses implies the lack of learners' autonomy in constructivist learning and the inadequate curriculum-design choice of teachers in educational policy-making. Governance-related stakeholders might emphasize too much on the utility of education to serve the social development at a highly progressive speed, but ignores the flexibility of other influencing factors in the learning process, the autonomy of self-paced choice of talent cultivation, as well as take a too strict hold on the dynamic diversity of learning content, which formulates the existing mainstream education methods and talent training goals recognized by the public as the decided route on the "journey" of teaching and learning.

***Education System is Ecosystem (S 1.1.2, S 1.1.3, S5 <Relationships>)***

Besides, another mutually frequent ecological metaphor is "education system is an ecosystem", which belongs to the category of "relationships" with the tag of "S1, S5" in the Wmatrix. The relationship-related metaphors include tag1.1.2 "reciprocity", S1.1.3 "participation", tag "groups and affiliations", etc., which map the interactive and interdependent characteristics of the ecosystem to the complicated education system and academic ecosystem with the interplay and cooperation among diverse stakeholders in multiple dimensions.

Relationships are the fundamental factor in keeping a harmonious and sustainable ecosystem. As the largest ecosystem on earth, the structure and work of the biosphere can maintain a relatively stable state for a long time. First, from the perspective of energy, the continuous flow of solar energy is the driving force for the normal operation of the biosphere. Second, from the material point of view, the atmosphere, hydrosphere and lithosphere provide all kinds of necessary materials for the survival of organisms. Third, the biosphere has

multi-level self-regulation ability. For example, when the content of carbon dioxide in the atmosphere increases, plants will strengthen photosynthesis and increase the absorption of carbon dioxide. When an organism is extinct, other organisms that play the same role in the biosphere will take its place; When the number of a plant-feeding animal increases, the number of relevant plant populations and natural enemy populations also changes, so that the number of this animal population can be controlled. Therefore, although the biosphere has the ability to self-sustaining a steady state, it depends on the dependence of different subjects in the biosphere.

Similarly, the metaphor of "ecosystem" speech in education also shows the significance of a "harmonious, cooperative and reciprocal relationship" in maintaining the stability of the education system and academic ecosystem. In detail, in the Chinese leaders' educational speeches, there are keywords like "educational cooperation within ASEAN universities", "China-ASEAN", "exchanges", and "cooperation" in the "Word Clouds" figure compared to BNC Sampler Spoken (Figure 10).


Figure 10. "Word Clouds" Figure compared to BNC Sampler Spoken in the Chinese Leaders' Educational Speeches

In the American leaders' educational speeches, there are keywords like "belonging to a group", and "personal, relationship" in the "Word Clouds" figure compared to BNC Sampler Spoken (Figure 11).


Figure 11. "Semantic Tag Coulds" Figure compared to BNC Sampler Spoken in the Chinese Leaders' Educational Speeches

In the American speeches, the expressions like “communities”, “society”, “together”, and “group”, imply the reciprocal relationship and co-existence in the educational ecosystem. For instance, the American president proposes that the quality education should be equally obtained by every child living in the community and the nation as equal participants in the social entity, which stresses the equal opportunity in education to strike a balance of diverse socio-economic, gender, or racial learners in the educational ecosystem.

Also, there is a “Semantic Tag Clouds” figure compared to BNC Sampler Spoken in the Chinese leaders’ educational speeches, which includes the tags related to stakeholders’ relationships in the educational system like “belonging to a group”, “causes & effect connection”, “helping”, “reciprocal”, etc. (Figure 12).

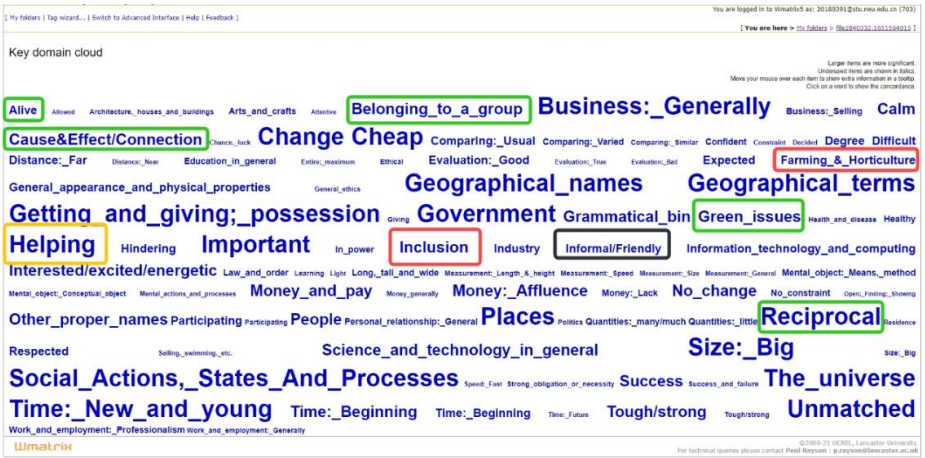



Figure 12. “Word Clouds” Figure compared to BNC Sampler Spoken in the American Leaders’ Educational Speeches


Figure 13. “Word Clouds” Figure compared to BNC Sampler Spoken in the British Leaders’ Educational Speeches

Moreover, in the British leaders’ educational speeches, there are keywords like “education system” in the “Word Clouds” figure compared to British National Corpus (BNC) Sampler Spoken, which has a high frequency and is closely related to ecological consciousness of the ecological system as an implicated entity (Figure 13). For instance, the British leader tends to have an overall strategic view and focus on the inner order and outer harmony and cooperation of the education system, just like the intimate relationship between multiple organisms in the natural ecosystem.

Therefore, from the perspective of politics, economy, technology, and other executive resources, the high-quality development of education essentially involves the coordination of the interests of all subjects in the public sphere. Externally, the high-quality development of education needs the adjustment and optimization of different subjects such as schools, society, and government in policy-making, resource allocation, supervision, and guarantee, etc. Internally, the high-quality development of education depends on the coordinated development and orderly integration of various endogenous factors under the background of reshaping power relations and role orientation. Fully coordinating the “vertical and horizontal relations” inside and outside the education system and realizing the harmonious interaction of "extrapolation and endogenous" forces is an effective way to enhance the top-level design and self-correction ability of the education development system and explore the connotation construction and practical research of high-quality development of basic education.

Moreover, an ‘ecosystem’ can be described as a ‘community network of interactions between organisms and their environment’, which highlights the concept of establishing a ‘network’ that continuously influences and nourish what actually happens in the educational system. For example, students are influenced by their parents, classmates and teachers. The British Prime Minister Teresa May said in her speech, “No teacher teaches in isolation”, as they are also affected by other teachers, their department, school leaders, policymakers, and governments. Thus, just like the relations ships between living organisms and their surroundings in the natural ecosystem, every stakeholder is part of an educational ‘ecosystem’. To form an effective ecosystem, educational resources need to seamlessly work together. Thus, this study concluded the component stakeholders of the education system in the Figure 14 as follows according to the educational speeches delivered by the three nations’ leaders. In detail, on the global level, the stakeholders include international organizations, media and researchers at all sectors. Besides, on the national level, key players involve national government, ministry of education, public media, as well as education experts, government agencies of economy, politics, culture, etc. Finally, on the local level, the main stakeholders include local authorities, school borders, private businesses, children’ parents, local communities, private schooling, and education material providers. All these above sectors are intimately interrelated with each other in the education system.

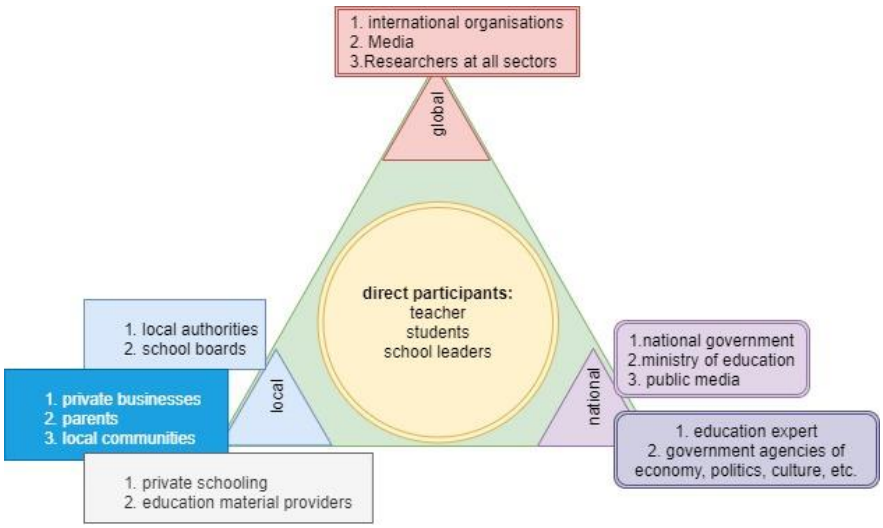



Figure 14. Interaction and Connection among Multiple Stakeholders in the Education System

***Education is a Human (B1, B2, S1.2.5, S4<Human>)***

In this section, the study analyzed the ecological metaphors of "human" with the perspective of three types of semantic prosody. The word "semantic prosody" was about a certain kind of collocation words with the same or similar semantic characteristics, whose semantics infect and penetrate each other, forming a language phenomenon of semantic atmosphere in the context, which is called"semantic prosody". Semantic prosody is divided into positive semantic prosody, neutral semantic prosody, and negative semantic prosody. The detailed tags and concordances are as shown in the Table 9 at the end of this section.

Table 9. Human Metaphors in the Three Corpora

| Human metaphor | Semantic Tag | Metaphorical words | Concordances | Frequency | | | Sum |
|---|---|---|---|---|---|---|---|
| | | | | China | UK | US | |
| Disease | B2 | Ill, illness | Suffer poverty and illness, constant illness, face a sudden illness, costly illness, unexpected illness | 2 | 1 | 2 | 4 |
| | B2 | Weakness, disease | Check out on the weakness, a sign of weakness, identify the strength and weaknesses of teaching across school, weakness in the provision, | 6 | 4 | 7 | 17 |
| Health | B2 | Healthy, Health | Healthy and civilized lifestyles, the healthy development of AI globally, healthy economic and social development, healthy fundamentals of the Chinese economy, healthy and steady growth of Chinese economy, a healthy fiscal balance, credit asset quality at a healthy level, support the development of healthy, happy children, well -educated and healthy, healthy and vibrant return to school, live a healthy lifestyle | 42 | 18 | 14 | 74 |
| | B2+ | sound, Well-being, recover | Sound development of the digital economy, sound legal framework, a sound ecology, a sound global eco-environment, a sound credit guarantee system, sound and stable, a sound business environment, foster a sound environment for people's health, sound development in the long term, preserve the sound momentum of peace and development in Asia; greater investment in people's wellbeing, improve the people's wellbeing, social-emotional wellbeing, support student and educator wellbeing, teacher wellbeing and workload; post-earthquake recovery and reconstruction, the world economic recovery, beat the virus and promote global recovery, a tortuous global recovery, experience slow recovery, recover from the pandemic, national recover, unfair recovery, on the road to recovery, track their recovery, recover from devastation, move beyond recovery, post-recovery era, post-recovery Britain, teachers, students and lecturers are all recover from the impact of the pandemic, recover economically, recover and rebuild the region | 34 | 21 | 42 | 97 |
| | S1.2.5 | robust, strong | A most robustly growing region, robust economic growth, make growth drivers more robust, robust market entities, foster a robust market; have robust access to STEM laboratories, continue robust learning, make our education system as robust as possible, produce robust analysis, build robust processes | 24 | 14 | 21 | 59 |
| | S1.1.1 | treat, nurture | Treat each other as equals, treat the people as nothing more than just simple, treat businesses of all types of ownership equally, treat each other, treat infectious diseases, ownership from both home and abroad are treated as equals and compete on a level playing; everybody deserves to be treated with dignity, treat the uninsured, treat them with respect, women and girls are treated as full and equal citizens, treat vocational a second class, treat them with even more care, not to treat children with SEND as a homogenous group | 13 | 11 | 7 | 31 |
| | S4 | foster | Foster a new development paradigm,<br>Foster and expand new competitive strengths, foster an innovation-friendly environment, foster a social environment that embraces innovation; foster a community, foster a new development paradigm, foster new growth drivers, foster new technologies | 126 | 114 | 97 | 337 |
| Body | B1 | Body, hand, blood, pulse | OECD body, EU, government body | 21 | 13 | 11 | 45 |
| | B2 | Person, personnel | Personal privacy, personal income will rise in tandem with economic, facilitate the flow of personnel and goods, talented personnel, technological personnel, allocate research personnel, facilitate the orderly flow of personnel, young person, reopen schools for in-person learning, the universal rights are the birthright of every person on this planet, full time in-person learning, access to in-person instruction, safe in-person learning, students are back in person | 19 | 41 | 30 | 90 |

Firstly, in the positive semantic prosody, the collocations of lexical items are mostly words with positive semantic characteristics, thus forming a positive semantic atmosphere. Also, in terms of the Wmatrix tag rules, the "+" symbolizes the positive semantic prosody, which implies the hope and confidence of the speaker. Firstly, the most notable result of "human" is the semantic domain [B2+] involving metaphorical words of "sound, well-being, recover". The ecological metaphors with a positive prosody express a the three countries' determined, positive, and optimistic attitudes towards social challenges like public health crisis, education inequality, economic growth, etc. in the concordances like "Sound development of the digital economy, sound legal framework, a sound ecology, a sound global eco-environment, a sound credit guarantee system, sound and stable, a sound business environment, foster a sound environment for people's health, sound development in the long term, preserve the sound momentum of peace and development in Asia; greater investment in people's wellbeing, improve the people's wellbeing, social-emotional wellbeing, support student and educator wellbeing, teacher wellbeing and workload; post-earthquake recovery and reconstruction, the world economic recovery, beat the virus and promote global recovery, a tortuous global recovery, experience slow recovery, recover from the pandemic, national recover, unfair recovery, on the road to recovery, track their recovery, recover from devastation, move beyond recovery, post-recovery era, post-recovery Britain, teachers, students and lecturers are all recover from the impact of the pandemic, recover economically, recover and rebuild the region".

Also, other 'human-category' ecological metaphorical words with implications of positive semantic prosody also include the human-metaphorical words "robust, strong", expressed in the concordances of "a most robustly growing region, robust economic growth, make growth drivers more robust, robust market entities, foster a robust market; have robust access to STEM laboratories, continue robust learning, make our education system as robust as possible, produce robust analysis, build robust processes". Additionally, the ecologically metaphorical words "health" are also expressed similar optimistic developmental ideas like "Healthy and civilized lifestyles, the healthy development of AI globally, healthy economic and social development, healthy fundamentals of the Chinese economy, healthy and steady growth of Chinese economy, a healthy fiscal balance, credit asset quality at a healthy level, support the development of healthy, happy children, well -educated and healthy, healthy and vibrant return to school, live a healthy lifestyle".

Furthermore, in the neutral semantic prosody, keywords attract both negative and positive collocations, showing a complex semantic feature. The neutral semantic prosody with ecological metaphor like "treat" are also frequently expressed to emphasize building harmonious and equal relationships among people just like forming harmonious relations among organisms in the ecosystem, and the discourse includes "treat each other as equals, treat the people as nothing more than just simple, treat businesses of all types of ownership equally, treat each other, treat infectious diseases, ownership from both home and abroad are treated as equals and compete on a level playing; everybody deserves to be treated with dignity, treat the uninsured, treat them with respect, women and girls are treated as full and equal citizens, treat vocational a second class, treat them with even more care, not to treat children with SEND as a homogenous group".

Moreover, another neutral semantic prosody is the "body" metaphor with the expressions like "OECD body;

EU, government body" in the speeches about the international organizations' contributions to facilitating global education, which imply the western and eastern countries' aspirations for participating and collaborating in global affairs to empower the international community. Besides, another neutral semantic prosody is ecological metaphor "person", expressed in the concordances of "personal privacy, personal income will rise in tandem with economic, facilitate the flow of personnel and goods, talented personnel, technological personnel, allocate research personnel, facilitate the orderly flow of personnel, young person, reopen schools for in-person learning, the universal rights are the birthright of every person on this planet, full time in-person learning, access to in-person instruction, safe in-person learning, students are back in person", which shows the three governments' common focus on protecting personal rights and privacy, as well as the efforts in the post-pandemic resilience for in-person education.

Last but not the least, in the negative semantic rhyme, almost all collocations attracted by lexical items have concrete meanings, and in the speeches of the three nations in this study, the common metaphorical words like "ill, weakness, disease" belong to this category, implying the educational and social challenges like coronavirus pandemic, public health crisis communication, inequality in public education, etc. in the three nations. The distinctive negative semantic features make the whole context present a negative and negative semantic atmosphere, including the concordances in Chinese, American, British leaders' educational speeches, like "Suffer poverty and illness, constant illness, face a sudden illness, costly illness, unexpected illness".

**Different Metaphors' Interpretation and Evaluation**

"Water" metaphors with the words like "ocean, pool, stream, sail" and "food" metaphorical words like "cake" and "pie" are important contents of ancient Chinese philosophy and traditional Chinese culture respectively. Moreover, "Fire" metaphors with the words like "spark" and "light" are the core metaphor of western culture, and mainly appear in the American leaders' educational speeches. While the "island" metaphor has become a unique metaphorical expression in British leaders' educational discourse due to Britain's unique geographical location as an island nation.

***Education is Fluid in China's Corpus (M4, O1.2, W3 <Environment>)***

The metaphor of "water" is the most prominent in the educational speeches of Chinese leaders. Water is not only the material for human survival, but also an important material in nature to maintain the life of all things and maintain the balance and stability of the ecosystem. The concept "fluid" as the source domain is mapped to the target domain with the meaning of education, and then the concept "education is fluid" becomes the conceptual metaphor. The author categorizes the "fluid metaphor" into three types, namely: (1) the dynamic action of water flow like the word "wave"; (2) geographical-concept water body, involving "water, ocean, pool, stream"; (3) human beings' water-related activities like the word "sail". The fluid metaphors, semantic tags, metaphorical words, concordances and frequency are as follows:

Table 10. “Fluid” Metaphors in China’s Corpus

| Fluid Metaphor | Semantic Tag | Metaphorical Words | Concordances | Frequency | Total |
|---|---|---|---|---|---|
| **water** | O1.2 | water, ocean, pool, stream | Vast ocean; Talent pool; pool of personnel; Thousands of streams | 28 | 28 |
| **flow** | W3 | wave | Wave of infections | 3 | 3 |
| **other** | M4 | sail | Sail onward; the sail of peace | 6 | 6 |

Mencius, a philosopher of ancient Chinese Confucianism, put forward the metaphor of flowing water in addition to the metaphor of plants, to illustrate that people are not only born with the possibility of learning, but also born with the motivation of learning. No matter where the water is, it will naturally flow downward, and no one can stop it. Some thinkers attach importance to the influence of the environment on people. They say that how people develop depends entirely on how the environment shapes people, just like water flowing along the river. The water must flow there in the direction that people dig the river.

For instance, Chinese President Xi makes an analogy of comparing a drop of water with the formation of the ocean, and explains the accumulation and important role of every drop of water to the huge ocean, which metaphorically implies solidarity and joint contributions are significant in international collaboration to create a promising future as a community of human destiny. For example, Mencius also described the way to obtain learning achievements by comparing two kinds of water: the first is water with a source, which flows day and night. Although it will accumulate temporarily in low-lying areas, once it is full, it will overflow and continue to flow until it finally enters the sea. This is just like the learners who have a long-term and sustained interest as their inner motivations for learning. They may encounter short-term difficulties in learning, but they will eventually overcome them and make progress. On the contrary, those who study out of temporary interests or immediate interests can also study very seriously at the beginning, but it is difficult to persist in the long term. Just like the rain in summer fills the ditches on the ground, it is conceivable that they will soon dry up because there is no source.

Therefore, the “fluid” metaphor well explains the long-term cultivation of learners’ motivation for active learning, and indicates that in educational practice, people who study out of curiosity and thirst for knowledge by interest-driven, which is just like the unstoppable flowing water, can make long-term progress. In the educational speeches of Chinese leaders, the metaphor of “water” and “pool” reflects China's “Taoist” thought. A drop of water wears a stone, and the sea embraces all rivers. Water not only obeys the natural dynamism but also perseveres, running day and night. Therefore, the Chinese leaders utilize the “water” metaphor to inspire educators, teachers, and students to emancipate their minds, renew ideas, keep pace with the times and be brave in innovation, which is just like the spirit of water. For example, President Xi use the “fluid” metaphorical word “pool” to propose that the government and administrators should enable all talents to apply their potential, pool their talents and strength, and raise the efficiency of the innovation, and should help both professionals to make

new innovations and the common people to explore their creativity, and encourage overseas talents and foreign professionals to pursue start-ups and innovation in China. And finally, China aims at pooling and upgrading factors of innovation and raising the efficiency of commercialization of innovation and research outcomes.

Also, the water metaphors like "sail" with the sample's concordance of "set a sail to move forward" have the power of moral education, reflecting the traditional Chinese philosophical wisdom in Confucianism and Taoism, and which are used frequently by Chinese leaders in the educational speeches sample in this research. For instance, Chinese President Xi proposes that Taoism's most prominent masterpiece *Tao Te Ching* says, "The best virtue is like water." in his educational speech at a national education-themed conference. He emphasizes that water always finds the lowest level and then stops. This could be a symbol of a source of moral education. Also, by looking for the lowest point, water shows its humility. As Lao Tzu said: the river and sea can become the place where many rivers converge. Because it is good at being in a low position, it can become the place where many rivers converge. Thus, For Mencius, environmental factors (such as the lack of materials, and the order of the monarch) can briefly force people to do certain behaviors, but that is not what people love and pursue in their inner nature. No matter how the environment forces people, people always maintain a good nature, just as water maintains a downward nature. Once people hear virtual words and see kind deeds, they will feel a sense of beauty and happiness. A good thing has an attraction, just as the gravity of the earth has an attraction for water.

Therefore, the "Education is fluid" metaphor also well answers the famous "nature" and "nurture" in educational philosophy concerning the relationship between human beings and nature. This involves two main insights: Firstly, nature endows people with the desire for good, but not the good itself. Secondly, quality education, on the other hand, creates moral human beings and a harmonious environment, so that learners can appreciate virtual personalities and excellent actions happening around them. A person who has never seen moral people and kind deeds is like a river that has been surrounded by dams for a long time. The water in the river is not without gravitational potential energy but has not yet had the opportunity to release it. One day, when the gate was suddenly opened, the river would surely pour down. Mencius used the "education is fluid" metaphor to describe the great soul-soaked shock people received when witnessing beautiful words and deeds.

***Food Metaphor in China's Corpus (F1 <Organism>)***

In ancient China, due to low productivity, natural and man-made disasters and other reasons, the problem of food shortage has always been a problem for people. In order to keep the country stable, the ancient governors took the people as the foundation of governing the country, and the first thing was to ensure that the people had enough food. Chinese food culture originated from the long history of agricultural civilization, and in turn, food culture permeates all aspects of people's social life. China's unique culture in the diet has created a large number of metaphors and proverbs related to food. These metaphors and proverbs in turn enrich the food culture, thus, making the food culture inherited for thousands of years. The food metaphor is unique in China's corpus with expressions as follows.

Table 11. "Food" Metaphor in China's Corpus

| Food Metaphor | Semantic Tag | Metaphorical Words | Concordances | Frequency | Total |
|---|---|---|---|---|---|
| Food | F1 | fruit | fruits of development, fruits of human progress, fruits of scientific innovation and ecological development, fruits of reform and development | 28 | 36 |
| | | pie | make the pie of cooperation even bigger for all our people, make the pie of our trade and economic cooperation bigger | 8 | |

"Pie" and "fruit" are widely used in Chinese leaders' educational speeches, which implies intense cooperative interest for rewarding outcomes, education equality and shared benefits of talent cultivation. For example, the metaphorical words "pie" the "fruit" expressed in the concordances in the Chinese leaders' educational speeches like "fruits of development, fruits of human progress, fruits of scientific innovation and ecological development, fruits of reform and development", and "make the pie of cooperation even bigger for all our people, make the pie of our trade and economic cooperation bigger" refer to the metaphor of economic development and income redistribution in political terms. If economic development is likened to baking a pie, one side of the debate believes that development should focus on "more equitable distribution of the pie", while the other side believes that development should focus on "making the pie bigger". Taking the Chinese context into consideration, over the past 40 years of reform and opening-up, China's economic growth, continuous development of education, and substantial improvement of national living standards have also led to a widening gap between the rich and the poor and a series of related social problems. All kinds of affluent classes either rely on hard work and enterprising character to become beneficiaries under the new market economy or take advantage of institutional loopholes to inherit unfair privileges. Therefore, the Chinese leaders use the metaphorical word "pie" frequently as an emphasis on reduce social injustice, and bringing affluent life to more people at home and abroad as a community of human destiny.

***Fire (Spark/Light) Metaphor (O4.6 <environment>) in America's Corpus***

The American presidents have mentioned the fire metaphors with the metaphorical words like "spark" and "light", expressed in the concordances like "precious light of freedom, light the spark in the minds of innovators, spark innovation at businesses, spark complete reform" in order to encourage the students to boost their consciousness and ability of innovation, and call on America to keep the spirits of freedom and democracy as fundamental and inalienable human rights.

American leaders use the metaphor of "fire" in their educational speeches, which has been influenced by ancient western philosophy. Since human beings learned to make cooked food with fire, fire has always been regarded as a symbol of life. Prometheus stealing fire in Greek mythology is the most typical example, and ancient Greek

philosophy emerged from early Greek mythology and sought the origin of the world from fire. In the process of fire generation, change is eternal, so from then on to the opposite transformation, that is, eternal. Here Heraclitus touched on the most superficial unity of opposites. For example, American presidents implied that the educational community is similar to the ecological community in nature, which needs the same powerful elements as "fire" to provide support for the sustainable development of education, so as to lay the foundation for the promising future of lifelong education.

Table12. Spark/Light Metaphors in the USA's Corpus

| Fire Metaphor | Semantic Tag | Metaphorical Words | Concordances | Frequency |
|---|---|---|---|---|
| **Fire (spark, light)** | **O4.6+** | **spark, light** | precious light of freedom, light the spark in the minds of innovators, spark innovation at businesses, spark complete reform | 27 |

***Geopolitical (Island) Metaphor (W3 <environment>) in Britain's Corpus***

The geopolitical metaphor expressed by the metaphorical word "island" has only appeared in the British leader's educational speeches. For example, the British Prime Minister Theresa May proposes her view about building networks in her speech that "Schools should not exist as island", and the schools ought to open to exchanges and embrace diversity, so that Britain can build a self-improving education system with collaborative innovation worldwide, and will stimulate the potential and enthusiasm of teachers, educators, and school leaders, which implies that similar to the ecological system with interdependence among living organisms and physical environment just like islands and ocean, human society is also an interconnected entity with unalienable relationships among each other. Every stakeholder in the educational system should not be isolated, so that the British educational system could gain long-lasting achievements. In the education system, multiple stakeholders at all levels cooperate and close linked with each other, as well as jointly boost educational exchanges, and facilitate the flow of academic resources, visiting scholars, and international students across countries.

In history, Britain's special island geography and environment created favorable conditions for the development of navigation, the Navy, foreign expansion and the establishment of a strong empire. The geographical environment of a country or nation has a profound impact on the development history and national character of the country or nation. Therefore, the geography and glorious history of the island have created the national character of the British who are willing to be independent. However, with the continuous development of economic globalization and political multi-polarization, the British government began to emphasize strengthening the communication and integration with the world in education, economy, and culture, so as to obtain more open and diverse ideas to promote the sustainable and innovative development of British education.

Also, just like the "Butterfly Effect Theory" in nature, that is, all things are closely related and all natures are closely connected: a butterfly in the Amazon tropical rain forest in South America may cause a tornado in Texas

in the United States two weeks later with an occasional flap of its wings. Therefore, the fate of individuals is closely connected with the fate of others. At the same time, the close relationship between the whole and parts is close, and the loss of the whole naturally affects the interests of individuals. The fate of all people is an inseparable or closely related "small land". Therefore, the "island" metaphor illustrates the truth that the education system supports each other internally and externally, countries cooperate with each other, and humans' and nations' destiny is connected intimately with their neighbors and their surroundings.

## Chapter VI - Conclusion

### Major Findings of the Study

This paper studies the ecological metaphor in educational discourse. Additionally, the metaphorical expressions in Chinese, American, and British leaders' speeches have been compared systematically, showing the differences and similarities between the three countries. The major findings obtained through the comparative study can be summarized as follows:

First of all, the metaphors in the educational speeches of leaders of China, the United States, and Britain all share a common feature, that is, the mapping process is from concrete and literal discourse to abstract and complex educational concepts. The abundance of conceptual metaphors in all corpus corresponds to the universality of conceptual metaphors.

Secondly, in all American, Chinese, and British leaders' educational speeches, there are four dominant types of metaphors in common, which includes the metaphors regarding education as gardening, journey, ecosystem, and human. It is evident that these conceptual metaphors share similar mapping relationships.

Last but not least, the reason for these differences lies in variant aspects, such as the different historical backgrounds, cultural traditions, geographical positions, and socio-economic conditions of different countries. It is worth mentioning that both cognitive and contextual analysis is significant to the research results. On one hand, cognitive factors are crucial to the metaphor choice of educational discourses. On the other hand, external social factors such as cultural, economic, and political differences influence the way of thinking, at the same time, cognitive factors even determine the way people understand the world. Therefore, taking the two sides into consideration, the cross-cultural comparative analysis is applied to examine the differences and influencing factors among the three countries' corpora.

### Significance and Implications of the Study

In terms of the further implications of the ecological metaphors in the three countries' educational speeches, the ecological metaphors' relationship with educational ideas can be concluded and categorized in three aspects as follows:

***Establish a Holistic View of Educational Objectives***

First of all, we should consider education as a whole. According to the theory of ecology, the ecological environment is a unified whole. The destruction of any local ecology will lead to the deterioration of the whole ecological situation. Ignoring the integrity of educational objectives will make all links of education isolated and disconnected from each other, resulting in the fragmentation of education. Exam-oriented education is to pay too much attention to one aspect of Education - the improvement of examination results. In addition, the single pursuit of efficiency, fairness, and quality of education is also an important manifestation of this way of thinking.

Besides, we should take the common well-being of the whole universe as the goal and ultimate concern of education. To consider the issue of education in the context of the whole society, we should go beyond talking about education on education and restore the sense of responsibility of education to the whole world.

***Educational System View of Paying Attention to the Internal Connection***

The ecological worldview holds that all units, in reality, are intrinsically interrelated, and all units and individuals are composed of relationships. Every individual (whether teachers or students) should be aware of the impact on others and the environment, which has a potential impact on their own future. Education should not only give full play to people's subjective initiative, and respect human nature, but also treat the other, knowledge, media, and even the whole living environment of mankind in education with an "open attitude to the other", so that each individual in the educational field can participate in the future related to himself by means of internal contact and constantly generate each other.

Last but not the least, in terms of the research results in the last chapter, the author concluded the stakeholders in education system in the following Table 13. There are three dimensions in the educational system, involving global, national and local layers. Also, three major spheres in educational system gathering multiple stakeholders, including, (1) public sphere: non-governmental organizations, government, education policy-makers, society's multiple sectors (economy, politics, cultural exchanges, public health, etc.), and mass media. (2) personal sphere: leaners, and parents (3) technical sphere: teachers.

In detail, on the global level, non-governmental organizations shoulder the responsibility of boosting quality education as a sustainable development goal, and ought to do research on global education and establish global education policies. On the national level, government and education policy-makers launch education reforms, establish policies, and intervene in education's autonomy and should bridge the gap of educational equity. Also, society's multiple sectors of economy, politics, cultural exchanges and public health should jointly to assist to cultivate talents with international employability as global citizens; try to bridge the gap between economic and educational stratifications; and practice the talent supportive policy in the labor market for transformative industries, and technological innovation. Besides, mass media can provide learners with open education

resources, play a role in public values guidance, enhance community exchange, and boost information diversity, along with obey the transparency of information, open policy for publication, and mature censorship policy.

Table 13. Roles and Interactions among Multiple Stakeholders within the Educational System

| Dimension | Sphere | Stakeholder | Responsibility | Empowered required from other sectors |
|---|---|---|---|---|
| **global** | **public** | Non-governmental Organization (NGO) | Boost quality education as a sustainable development goal | Do research on global education and establish global education policies |
| **national** | **public** | **Government, education policy-makers** | Launch education reforms, establish policies, and intervene in education's autonomy | Bridge the gap of education, and realize UNESCO 2050 *Futurex of Education* |
| **national** | **public** | **Society's multiple sectors (economy, politics, cultural exchanges, public health, etc.)** | Cultivate talents with international employability as global citizens; bridge the gap between economic and educational stratifications | The talent supportive policy in the labor market, transformative industries, technological innovation |
| **national** | **Public** | **Mass media** | Open education resources, crisis communication, values guidance, community exchange, information diversity, | Transparency of information, open policy for publication, mature censorship policy |
| **Local (direct participants)** | **Technical** | **Teachers** | Command of profession and Pedagogy, Synergy with parents, cooperation with education administrators, obeying official education policy and curriculum, constructivism pedagogy | Transformation of teacher education, continuous technical empowerment, and welfare support; Making education policies in terms of teachers' classroom practices, following the post-pandemic digital transformation of education |
| **Local (direct participants)** | **Personal** | **Learners** | Self-learning ability, inner motivations, have global employability, transferable skills and future global leadership | Adapt to the social requirements and labor market, engage in the global exchange and cross-cultural communication for being global citizens |
| **Local (direct participants)** | **Personal** | **Parents** | Well-fostered children, family education for psychological support and characteristic cultivation, feedback, synergy with teachers | Communications with teachers and children, family teaching methods, adapting to the post-pandemic distance learning mode together with their children |

On the local level, teachers should have a good command of profession and pedagogy, synergy with parents, cooperation with education administrators, obey official education policy and curriculum and adopt constructivism pedagogy for student-centered learning. Also, especially in a post-pandemic era, digital transformation of teacher education should be combined with the government's continuous technical empowerment to create an active circulation in the educational system. Meanwhile, the realization of education

policies also depends on teachers' real classroom practices. Furthermore, learners should form self-learning ability, enhance inner motivations and global employability with transferable skills for future global leadership. Moreover, they should adapt to the social requirements and labor market, and engage in the global exchange and cross-cultural communication for being global citizens. Finally, parents should provide family education for psychological support and characteristic cultivation, feedback, synergy with teachers. Communications with teachers and children, family teaching methods, and the adaptation to the post-pandemic distance learning mode together with their children are of vital significance for parents.

***Constructing a sustainable view of educational development***

Education emphasizes the process of gradual growth, accumulation and generation of all creatures and contents. From the perspective of cultivating people, the understanding of "sustainable development education" by the presidential Advisory Committee on sustainable development of the United States is "a process of lifelong learning", that is, not only to make students meet academic standards and achieve excellent results but also to take care of students' enthusiasm and wonder for knowledge and lay the seeds of lifelong learning for students. As far as education itself is concerned, the setting of educational objectives should not only pay attention to the explicit standards, but also point to the eternal value and virtue; The evaluation of education should not only pay attention to the results of education but also pay attention to the process of education. Teachers should not only pay attention to the "input" and "output" of education but also pay attention to the impact on the future. Educational policy makers should not only pay attention to the external needs but also respect the internal logic of education. From the perspective of social development, education should not only provide power and cultivate talents for social development but also reflect and criticize social development. Last but not the least, education should not only meet the needs of social development and adapt to the spirit of the development of the times, but also appropriately surpass the current social development and lead the progress of the society.

***UNESCO Futures of Education 2050: "Learning to become." (life-long learning)***

The sustainable view of the ecological system implies the sustainable development of education as a lifelong learning process, which is also the 2050 goal proposed by the report UNESCO "Futures of Education" (McGuire 2022). When considering UNESCO Futures of Education 2050, the concept of "Learning to Become" allows for innovation and ownership of the future to be considered both locally and globally. "Learning to Become" points to a philosophy of education and an approach to pedagogy that views learning as a process of continual unfolding that is ongoing and life-long, and invokes the need to develop the capacity to imagine a good and fulfilling life. Besides, with the sustainable educational development goal, every stakeholder is a unique and complementary element in the education system. For instance, teachers are supposed to play their role in promoting the internal value and complementarity of each element of the education system, like supporting the management of education institutions' leadership, boosting the intellectual and psychological development of learners, and providing the educational policy-makers with constructive suggestions and classroom practices experiences for educational reforms, so that with the interaction and collaboration, can the

educational system can be empowered by the stakeholders at all sectors to realize lifelong benefits. The future era will be an era rooted in ecological ideas and holistic thinking patterns for realizing sustainable improvement in all fields. Therefore, the implication of ecological civilization can be continuously shown to education in a metaphorical way, thinking and understanding in a humble and imaginative way to interpret the educational implication of ecological civilization.

**Limitations of the Study and Suggestions for Further Research**

Attributed to the complicated comprehension of metaphorical rhetoric, this paper still has several limitations. Thus, a few pieces of advice are proposed for future studies. Firstly, the research data for constructing a corpus does not cover all the international education-related speeches made by certain national leaders. Because of the time limitation, it is challenging to find all the published speeches in all the index resources, thus, which might influence the diversity of discourse content and the richness of research results. Therefore, future research is hoped to expand the corpora size to gain a more comprehensive view of the multi-national discourse. In addition, although the Wmatrix tool assists conceptual metaphor identification initially, the in-advanced proposed metaphors may still be manually located by carefully reading the texts in the corpus, which may lead to the individual influence of the study. Therefore, future research ought to adopt a more scientific method of conceptual metaphor recognition. Finally, another deficiency is that the paper involves many angles, resulting in insufficient exploration. Future research can further reflect on a certain direction or angle.

In conclusion, even there are large space to make improvement in the future studies, this study obeys the heated world trend of sustainable development ideas and the focus on futures of post-pandemic transformative education, combined with the intercultural comparative analysis based on the variant social context of the east and the west to examine the common identity and different cultural understandings. Thus, apart from conducting a corpus-assisted critical discourse analysis, this study also aims at facilitating the aspirations of building a community of shared future for mankind to realize the Sustainable Development Goals of the United Nations. The ecological values of development is no longer confine the ecological concept of sustainable development to environmental protection, but empower the sustainable development of quality education, gender equality, poverty eradication, public health, etc.

## Refences

Szokolszky, A. (2019). Perceiving Metaphors: An Approach from Developmental Ecological Psychology. *Metaphor and Symbol*, *34*(1).

Lin, A.I. (2020). Ecological Metaphor in News Discourse. *Journal of Culture*, *4*, 121-123.

Akman, Ö., & Açıkgöz, B. (2022). Classroom Teachers' Metaphorical Perceptions Regarding the Concepts of Independence and Struggle. In M. Shelley, H. Akcay, & O. T. Ozturk (Eds.), *Proceedings of ICRES 2022-- International Conference on Research in Education and Science* (pp. 52-70), Antalya, Turkey.

ISTES Organization.

Akman, Ö., Ekici, K., Koçak, Z., & Erdem, C.C. (2022). Metaphor Perceptions of Social Studies Teachers Regarding the Conceptions of Freedom and Justice. In M. Shelley, H. Akcay, & O. T. Ozturk (Eds.), *Proceedings of ICRES 2022-- International Conference on Research in Education and Science* (pp. 137-152), Antalya, TURKEY. ISTES Organization.

Akman, Ö., Sevim, A. N., Demirel, S., & Yılmaz, H. (2022). Metaphorical Perceptions of Social Studies and Classroom Teachers on the Concepts of Non-Governmental Organizations and Global Citizenship. In P. Dankers, M. Koc, & M.L. Ciddi (Eds.), *Proceedings of ICEMST 2022-- International Conference on Education in Mathematics, Science and Technology* (pp. 52-67), Antalya, Turkey. ISTES Organization.

Aydın, F., Somuncu Demir, N., & Aksut, P. (2021). Metaphoric Perceptions of Preservice Teachers Regarding Technological Change. *International Journal of Technology in Education and Science (IJTES), 5*(3), 336-361. https://doi.org/10.46328/ijtes.177

Bulut, A. (2021a). Investigation of Metaphorical Perceptions of Preschool Teachers on the Concept of Language Development. *International Journal of Research in Education and Science (IJRES), 7*(2), 351-366. https://doi.org/10.46328/ijres.2126

Bulut, A. (2021b). Metaphorical Perceptions of Preschool Teachers on the Concept of Nature. *International Journal on Social and Education Sciences (IJonSES), 3*(2), 237-251. https://doi.org/10.46328/ijonses.142

Bulut, M. & Kirbas, A. (2022a). Pre-service Teachers' Perceptions on the Concept of Oral Communication: A Metaphor Research. *International Journal of Research in Education and Science (IJRES), 8*(4), 765-782. https://doi.org/10.46328/ijres.3070

Bulut, M. & Kirbas, A. (2022b). An Examination of Pre-Service Teachers' Metaphorical Perceptions about Turkish Language Lessons Taught through Distance Education. *International Journal of Technology in Education and Science (IJTES), 6*(4), 633-659. https://doi.org/10.46328/ijtes.427

Charteris-Black, J. (2004).*Corpus approaches to critical metaphor analysis*. Basingstoke: Palgrave Macmillan Press.

Charteris-Black, J. (2011). *Politicians and rhetoric: The persuasive power of metaphor* (2nd ed.). Basingstoke: Palgrave Macmillan Press.

Charteris-Black, J., & Ennis, T. (2001). A comparative study of metaphor in Spanish and English financial reporting. *English for Specific Purposes*, *20*(3), 221-232.

Cohen, M. J. (2011). Is the UK preparing for "war"? Military metaphors, personal carbon allowances, and consumption rationing in historical perspective. *Climatic Change*, *104*, 199-212.

Gefei, D. & Qianqian, W. (2019). A Wmatrix-based study of metaphorical patterns in American educational discourse: a case study of Bush and Obama's educational speeches. *Journal of Northeast University (Social Science Edition), 21*(1), 96-103.

Edet, E., Wright, D. & Street, G. (2007). The Importance of the Ecological Metaphor in Understanding Industrial Sustainability. *Measurement and Control*, *40*(8), 235-238.

Guangyi, F. (2013). *Introduction to Linguistic Ecology.* Beijing People's publishing house.

Gibbs, R. W. (2019). Metaphor as Dynamical–Ecological Performance. *Metaphor and Symbol*, *34*(1), 33-44.

Haeckel, E. (1866). *Generelle Morphologie der Organismen: Vols I and II*. Berlin: Verlag Von Georg Reimer.

Halliday, M. A. K. (1990). New ways of meaning: The challenge to applied linguistics. *Journal of Applied Linguistics*, *6*, 7-11.

Halliday, M. A. K., & Martin, J. R. (1993). Writing science: *Literacy and discursive power*. Pittsburgh: University of Pittsburgh Press.

Haugen, E. (1972). *The ecology of language*. Redwood City, CA: Stanford University Press.

Guowen, H. (2016). Life is Full of Choices. *Contemporary foreign language studies, 1,* 1-11.

Jensen, T. W., & Greve, L. (2019). Ecological cognition and metaphor. *Metaphor and Symbol, 34*(1), 1-16.

Ji Yuhua, Chen Yan. A new approach to critical discourse analysis: critical metaphor analysis. *Journal of Xiamen University: Philosophy and Social Sciences Edition*, 2007, (6), 42-46.

Kaban, A. (2021a). Determining Teachers', Students', and Parents' Perceptions of Distance Education through Metaphors. *International Journal of Research in Education and Science (IJRES), 7*(1), 245-264. https://doi.org/10.46328/ijres.1316

Kaban, A. (2021b). Metaphoric Perceptions of Teachers, Students, and Parents towards Social Media. *International Journal on Social and Education Sciences (IJonSES), 3*(3), 489-503. https://doi.org/10.46328/ijonses.192

Kelly, L. H. Critical metaphor analysis of cosmetics metaphorical advertising slogans: A cross-cultural perspective. *Cognitive Linguistic Studies*, *3*(1) (2016):134-150.

Kristiansen, G., & Driven, R. (Eds.). (2008). *Cognitive sociolinguistics: Language variation, cultural models, social systems*. Berlin & New York, NY: Mount de Gruyter.

Lakoff, G. (1993). *The contemporary theory of metaphor*. In A. Ortony (Ed.), Metaphor and thought. Cambridge: Cambridge University Press.: 202-251.

Lakoff, G., & Johnson, M. (1980). *Metaphors we live by*. Chicago, IL: The University of Chicago Press.

Lakoff, G., & Turner, M. (1989). *More than cool reason: A field guide to poetic metaphor.* Chicago, IL: The University of Chicago Press.

Lee, M. (2015). Critical metaphor analysis of citizenship education discourse. *Public Relations Inquiry, 4*(1), 99-123.

Shurong, L. (2019). *Comparative study on Ecological metaphor in economic keynote speeches of Chinese, American and Russian leaders*. Xi'an Foreign Studies University, master's thesis.

Makkai, A. (1993). *Ecolinguistics: Toward a New "Paradigm" for the Science of Language*. New York: Printers Publishers.

Perry, M. C. (2007). *US Geological Survey* (USGS). *"Chapter 14: Changes in Food and Habitats of Waterbirds." Figure 14.1. Synthesis of U.S. Geological Survey Science for the Chesapeake Bay Ecosystem and Implications for Environmental Management*. USGS Circular 1316.

Claire, M. (2022). *UNESCO Futures of Education Report Brief.* Retrieved from http://repository.ifla.org/bitstream/123456789/1856/1/UNESCO%20Futures%20of%20Education%20Brief.pdf

Mulsoff, A. (2004). *Metaphor and political discourse.* New York: Palgrave Macmillan.

Olson, M. E., Arroyo-Santos, A., & Vergara-Silva, F. (2019). A User's Guide to Metaphors in Ecology and

Evolution. *Trends in Ecology & Evolution*, *34*(7), 605-615.

Onal, N. (2019). Metaphoric Perceptions of High School Students about Nomophobia. *International Journal of Research in Education and Science (IJRES)*, *5*(2), 437-449.

Palic Sadoglu, G. & Durukan, U.G. (2018). Determining the Perceptions of Teacher Candidates on the Concepts of Science Course, Science Laboratory, Science Teacher and Science Student via Metaphors. *International Journal of Research in Education and Science (IJRES)*, *4*(2), 436-453. DOI:10.21890/ijres.428260

Pragglejaz Group. (2007). MIP: A method for identifying metaphorically used words in discourse. *Metaphor and Symbol*, *22*(1), 1-39.

Rayson, P. (2008). From key words to key semantic domains. *International Journal of Corpus Linguistics*, *13*(4), 529-545.

Russill, C. (2010). Temporal metaphor in abrupt climate change communication: An initial effort at clarification. In W. Leal Filho (Ed.), *the economic, social, and political elements of climate change.* New York: Springer.

Jianmin, T. (2008). Ecological Metaphor Methodology. *Journal of Chongqing University of Posts and Telecommunications (Social Science Edition)*, *2*, 68-72.

Boran, W. & Wen, Z. (2020). Ecological construction of College English online open course teaching from the perspective of eco linguistics. *Foreign Languages*, *36*(6), 134-140.

Li, Y. (2019). Construction of English ecological classroom in the “Internet +” era. *Teaching and management*, *2*, 105-107.

Liang, Z. & Yali, Z. (2017). Ecological and cultural metaphor in Hong Ke’s novel Kalab Storm. *Novel review*, *2*, 196-201.

# The Impact of COVID-19 on the Education of Children of Indonesian Migrant Workers at the Community Learning Center for Junior High School in Sabah, Malaysia

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**Abstract**: The existence of COVID-19 prompted the Malaysian government to issue regulations for learning from home, including the community learning center in Sabah, Malaysia**.** This study aims to determine the impact of COVID-19 on the education of children of Indonesian migrant workers at the community learning center for junior high school in Sabah, Malaysia by using exploratory methods and descriptive data analysis using quantitative and qualitative approaches. The survey results showed that the respondents were 160 students, all students learned to use mobile phone when online learning, the media used were quite diverse, but most used whatsapp groups because they were quite easy to use and familiar among students and did not take up too much internet quota. More than 50% of students understand when carrying out online learning, but there are still many students who moderately understand due to demographic factors so they have difficulty connecting to the internet. The existence of this COVID-19 pandemic not only has a negative impact but also has a positive impact, students are required to keep up with the times by being able to use technology optimally.

**Keywords:** COVID-19, education, education technology, online learning, junior high school

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## Introduction

Education is able to shape the character and civilization of a dignified nation in order to educate the nation's life, this is in line with Undang-Undang Republik Indonesia No. 20 of 2003 concerning the National Education

System. The government's efforts in terms of equal distribution of education continue to Malaysia. One of the efforts made by the government is to build a Community Learning Center (CLC), an educational service for the children of Indonesian Migrant Workers, especially in the areas of Sabah and Sarawak, Malaysia. However, in December 2019 the world was shocked by the novel coronavirus (2019-ncoV) originating from Wuhan, China which quickly spread to all around of the world, including Malaysia. The existence of COVID-19 has an impact on all aspects of people's lives, including education (Abidin, Alkaabi, & Razak, 2021; Carter, Akerson, & Cesljarev, 2021; ElSaheli-Elhage, 2021; Johar, Amat, & Raja Ibrahim, 2021; Liu & Cheng, 2021; Onuralp, 2021; Tsai, 2022; Ye, 2021). The impact in the oil palm plantations of education is also experienced by the children of Indonesian migrant workers who are in the Community Learning Center (CLC) Sabah, Malaysia.

However, the Malaysian government continues to strive for the ongoing education process during the pandemic by implementing Work From Home (WFH). The application of Work From Home (WFH) is not easy, it needs adaptation to all aspects, especially online learning requires technological devices such as mobile phones and internet networks. After the implementation Work From Home (WFH) it was found that many students were not active in online learning, they did not collect assignments, complained about the difficulty of getting an internet network, limited internet quota and also helping their parents in the oil palm plantations.

This problem is in line with various studies that have been carried out in Indonesia. The students in the city of Malang were not ready to take online lectures due to decreased concentration and lack of internet access. However, there is also a positive impact, namely that learning can be carried out flexibly without being limited by space, saving time and costs (Ramadanti et al., 2021).

Meanwhile, according to Syah (2020) there are various disturbances during online learning including learning disorders, disturbances in assessment, cancellation of assessments, opportunities to get a job after graduation. Meanwhile, according to Mansyur (2020) the disruption of learning dynamics during the COVID-19 outbreak was due to a transformation in the use of technology-based learning media, adjustments to learning methods and evaluation of learning by teachers, and demands for collaboration with parents.

This research identified the research problem and developed research questions: How is the Indonesian migrant workers' children at the community learning center on doing online learning? What are the advantages and disadvantages of participating in online learning at the community learning center? What are the obstacles on doing online learning from the perspective of the students? This research was conducted with the aim of knowing the impact of COVID-19 on the education of children of Indonesian Migrant Workers at the Community Learning Center (CLC) for junior high school in Sabah, Malaysia.

## Theoretical Review

Undang-Undang Republik Indonesia No. 20 of 2003 concerning National Education System explains the

meaning of education as a conscious and planned effort that must be owned to create a learning atmosphere and learning process so that students actively develop their potential to have religious spiritual strength, be able to control themselves, has personality, intelligence, and noble character, as well as skills that a person must possess. In addition, it is also stated that every citizen has the same rights in obtaining education regardless of physical, intellectual or regional conditions according to their respective talents, interests and abilities. Permendikbud Nomor 19 Tahun 2006 concerning Program Indonesia Pintar states that the purpose of this program is to increase access for children aged 6 to 21 years to obtain educational services until they graduate from secondary education units or 12 (twelve) years of compulsory education.

**Online Learning**

Online learning is an ICT-based learning model. The supporting capacity of this program is ICT facilities in the form of a web LMS, monitoring program, modular and supplements in the form of multimedia (Bilfaqih & Qomarudin, 2015). The success of online teaching colleges in Malaysia is still in its early stages as many universities in Malaysia are just getting started since the government's announcement of the closure of face-to-face colleges. Although online teaching has many significant benefits, there are disadvantages including the lack of student involvement, more time consumption and technical difficulties are the main problems faced by lecturers at universities in Malaysia (Ramayah & Kumar, 2020).

Higher education in Russia during the COVID-19 period is the most important, namely preparing lecturers and students readiness in implementing online learning. Lecturers must be ready to carry out distance learning activities, implement LMS, use ICT, control and evaluate online lecture activities and conduct webinars and online conferences (Almazova et al., 2020). Analysis of various strategic issues related to the impact of COVID-19 on disparities Indonesian education, including limited internet access and limited capacity of teaching staff, are the main problems in the effectiveness of distance learning (Santosa, 2020). Meanwhile, research conducted by Aswan and Amir (2021) can be concluded that the COVID-19 pandemic does not prevent literacy activities at the Community Learning Center (CLC) as evidenced by the existence of letter writing activities that are able to have a positive impact in the form of generating imagination, filling spare time, increasing self-confidence in students and able to create communication between students and teachers.

**Operational Process of Online Learning**

Research conducted by Yohana et al (2020) states the process of operating online learning includes administrative processes and learning processes, starting from learning planning, implementation of learning, learning processes, assessment of results to supervision of learning, the process of operating online learning are:

- Administration: operation of online learning for administrative purposes (learning registration, participant registration, scheduling and other administration).
- Lesson planning: operation of online learning for lesson planning purposes.
- Implementation of Learning: operation of online learning for the purposes of implementing learning.

- Assessment of learning outcomes and processes: operation of online learning for the purposes of assessing learning outcomes and processes.
- Supervision of learning process: operation of online learning for the purposes of supervising learning process.

**General Conditions of the Community Learning Center (CLC) in Malaysia**

Community Learning Center (CLC) is an educational service for the children of Indonesian migrant workers, especially in the Sabah and Sarawak regions, Malaysia as a result of the joint statement on annual consultations between the Indonesian and Malaysian governments in 2009. CLC is a learning activity center under the Indonesian School of Kota Kinabalu (SIKK) located in the middle of an oil palm plantation. CLC gets funding from the Indonesian government, its students are officially registered in the dapodik, so the curriculum used is the same as the curriculum in Indonesia. There are 115 primary school CLCs and 45 junior secondary school CLCs. Meanwhile, the number of student CLC of junior high schoool in Sabah, Malaysia can be seen in the table below:

Table 1. Number of Student CLC of Junior High School Students in Sabah, Malaysia in 2021

| Wilayah Kerja | Gugus | CLC SMP | Total Per Wilker |
|---|---|---|---|
| KJRI Kota Kinabalu | Pedalaman Nabawan | 125 | |
| KJRI Kota Kinabalu | Pedalaman Beaufort | 154 | |
| KJRI Kota Kinabalu | Keningau | 488 | |
| KJRI Kota Kinabalu | Pantai Barat | 629 | |
| KJRI Kota Kinabalu | Kundasang Ranau | 183 | **3.084** |
| KJRI Kota Kinabalu | Kinabatangan 1 | 314 | |
| KJRI Kota Kinabalu | Kinabatangan 2 | 253 | |
| KJRI Kota Kinabalu | Kinabatangan 3 | 326 | |
| KJRI Kota Kinabalu | Sandakan | 612 | |
| KRI Tawau | Lahad Datu | 529 | |
| KRI Tawau | Kunak | 297 | **1.759** |
| KRI Tawau | Semporna Balung | 381 | |
| KRI Tawau | Tawau | 552 | |
| **Total** | | **4843** | **4843** |

## Method

This research was conducted in Sabah, Malaysia because the children of Indonesian migrant workers also have the right to proper and equal education rights as students of Indonesia, so it is necessary to analyze the impact of COVID-19 to their educational development. This research is a type of exploratory descriptive research using quantitative approaches to describe an ongoing phenomenon either variables, symptoms or circumstances without the need to test certain hypotheses (Arikunto, 2010). The sampling technique in this study used a

purposive sampling technique where there were limits to participants on certain criteria. The data collection technique are the observation method carried out in 2020-2021 when the first author being the teacher of community learning center, the literature study method, interviews and questionnaires.

## Results and Discussion

### Description of Research Subjects

The criteria sets before distributing the questionnaire is taking grade 9 because the students at the junior high school level have carried out learning from the beginning of COVID-19 until now, it is hoped that the results of this survey are representative from 1382 students in the 9th grade junior high school level. Based on the questionnaire distributed among 160 students, 66 students in the working area of the Consulate General in Kota Kinabalu who filled out the survey and the remaining 94 students junior high school level in the work area of Consulate Republic Indonesia in Tawau.

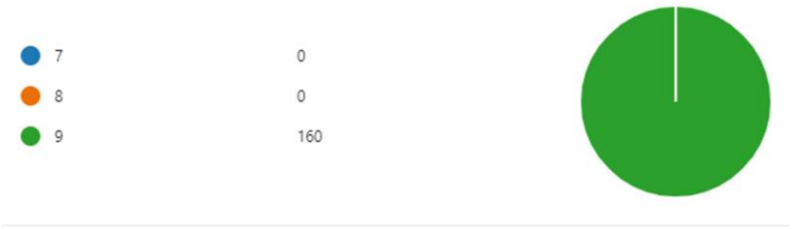


Figure 1. Class of Respondent at the Community Learning Center

### Online Learning at the Community Learning Center (CLC)

The existence of COVID-19 has made the Malaysian Ministry of Education issue a policy following the directions of the State Safety Council. At the beginning of the COVID-19 outbreak, all education, both public and private, carried out online learning, but after the COVID-19 conditions began to improve, schools held limited offline or face-to-face learning especially for the Community Learning Center (CLC) area which is in the middle of an oil palm plantation. The teacher of CLC must ask permission from the oil palm plantations manager to open a school. If the school is ready but the oil palm plantations manager does not allow it, the learning will still be done online, but if the manager allows it, the school must follow the Standard Operating Procedure (SOP) that was in effect at that time.

In the process, each school must arrange a study room for a maximum of 50% of the number of students, schools must provide hand washing soap, sinks, thermos guns, student body temperature records and the entire school community must wear masks. But gradually after the COVID-19 vaccine, students have started to be vaccinated, so the opening of schools can now be 100%. When carrying out online learning, all students use mobile phone. None of the students use laptops due to the limited economic situation of Indonesian migrant workers.

Most of learning process carried out using WhatsApp group media because the media is quite easy to use and familiar among students. In addition, WhatsApp groups don't take up too much internet quota. In line with research (Mulyono et al., 2021) students use WhatsApp media because there is the use of technology in learning, the perceived usefulness in learning to the ease of use. Participant in WhatsApp group also gaining a lot of practical knowledge, enacting connectedness and belonging, obtaining informational benefits, leadership capacity and motivation (Pimmer et al., 2021).

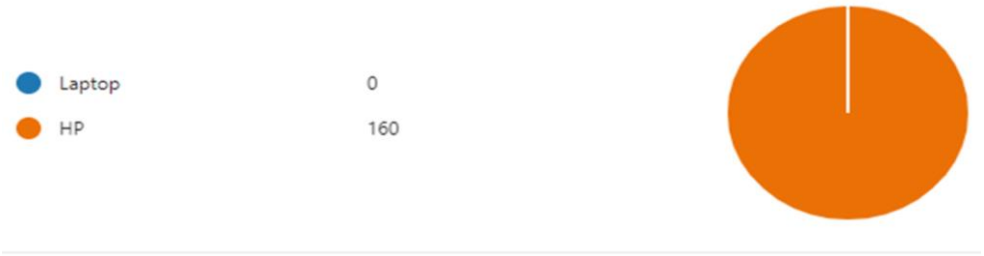


Figure 2. The Tools used in Online Learning

Besides WhatsApp group, there are other learning media such as zoom meeting that effectively improve student learning outcomes (Syaharuddin et al., 2021) and google meet can support the implementation of online learning. Applied among students teacher must be smart in varying online learning so that students do not get bored easily, support students to be interactive during learning, and the knowledge provided can be conveyed properly. However, occasionally it is necessary to hold games in learning, the gamification make the students being not only motivating but also enhancing learning process than non-gamified course (Barata et al., 2015; Zainuddin et al., 2020) . The example for the gamification is quizzes, where the applications' score can be set to appear automatically so that it add to the challenge for the students to stay competitive, and the user can be rewarded based on their point.

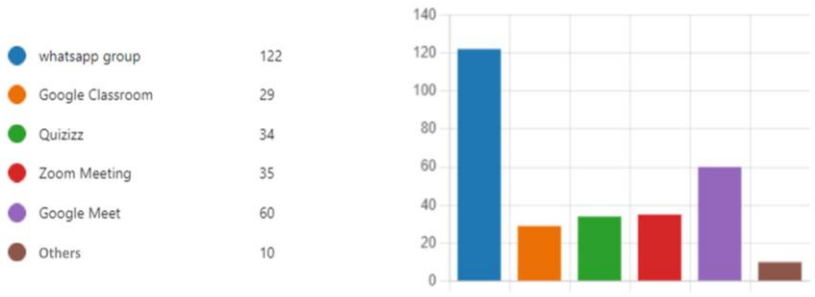


Figure 3. The Media used in Participating Online Learning

Based on the survey, it is known that more than 50% of students understand online learning, this is in line with research (Abdullah et al., 2021) the respondents has thorough knowledge and understanding on online learning. However, there are still 41.25% (66 students) who moderately understand online learning and 1 student feels very clueless. One of the factors supporting the level of student understanding is in line with the survey results

that teachers when carrying out online learning also provide additional information or explanations to students, not just giving assignments without material explanations. Because after all, the teachers' position cannot be replaced with just the assignments.


Figure 4. Level of Understanding Students taking Online Learning

**The Advantages and Disadvantages of Participating in Online Learning at the Community Learning Center**

There are the advantages of online learning. First the students can prevent from getting COVID-19 disease because safety and health must come first. Then, from home they are starting to learn to take full advantage of technological features (De Paepe et al., 2018) like recording, videoconferencing tools, searching function and also learn more phone app like editing photo, video, google classroom, quizzes, google meet, zoom meeting, etc. It is undeniable that at that time each of student is required to keep up with the times by being able to use existing technology optimally, it can be seen from the survey below most of respondents (N=107) agreed so. In addition, learning activities can be carried out anywhere and easily manageable (Mukhtar et al., 2020; Mustapha et al., 2021; Ramadanti et al., 2021) without the need to come to school so the students can save time, money and energy. Besides studying, students can help their parents in the oil palm plantations or in the home like doing some chores that make them more independent and dependable. The time for completing assignments tends to be longer because all the subjects almost has a task so the teacher gives more time to submit the tasks.


Figure 5. The Advantages of Participating in Online Learning

Even though it has the advantages, there are disadvantages when participating in online learning such as technical issues. At first they were very slow when using new technology, it takes more time to operate zoom meeting or google meet especially connecting to signal because the students have difficulty finding signal in the oil palm plantations. Then the lack of interaction between teachers and students (Coman et al., 2020), lower

collaborative learning among students (Dumford & Miller, 2018) can become worsen when the students tend to close the screen when participating zoom meeting or google meet because they may absent in person from online learning. Furthermore, when the students dislike group engagement or has introvert side, they prefer to work individually than a group so collaborative interaction will not work. Afterward, the result of level understanding students about online learning on figure 4 shows 66 participant among 160 students moderately understand. It means the students not extremely understand, but still can grab the information and knowledge quite well, if this is kept for a long time there will be loss learning as well.

**The Obstacles on doing Online Learning from the Perspective of the Students**

The result of the survey for the obstacles in doing online learning most of participants have unstable internet network. It is caused by demographic factors, the majority of students' houses are in the middle of oil palm plantations so that they have difficulty connecting to the internet. There are many other problems beside unstable internet network such as lack of internet quota because of limited money to buy internet quota dan lack of concentration or focus during online learning because of the boredom (Derakhshan et al., 2021) experienced by the students. The boredom caused by sitting too long when doing online learning, the teacher explains too monotonously, lack of feed back and less interactive in class. The busyness of helping their parents in the oil palm plantations also become the obstacle, because of that matter students prefer to work than study. Furthermore, students have difficulty capturing material if not explained directly face to face by the teacher for mathematic subject.

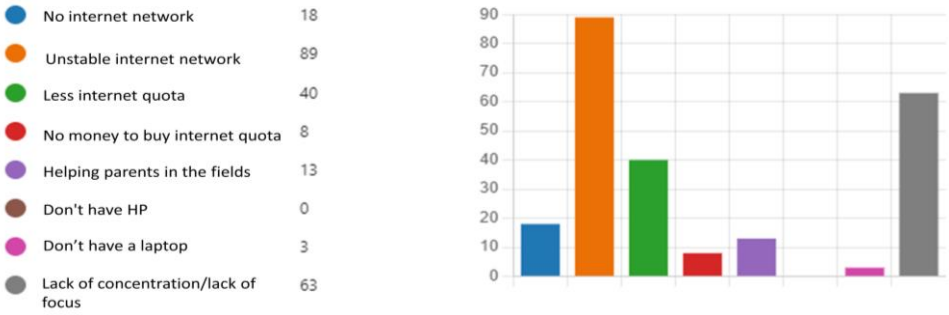


Figure 6. The Obstacles in doing Online Learning

## Conclusion

COVID-19 has an impact on all sectors of human life, including education in the oil palm plantations. In order for learning to continue, various efforts have been made by the government including online learning. Learning is carried out in various stages starting from doing full online learning, blended learning, then limited face-to-face learning is carried out by applying 50% of the number of students in classroom or a shift system is applied and recently has been carried out comprehensive offline learning. In the process of opening the school, a teacher from Community Learning Center (CLC) must first coordinate with the oil palm plantations manager. If they

get permission, the school will be opened, but if they do not get permission, learning must remain online. The results of the survey show that online learning at the Community Learning Center (CLC) for junior high school in Sabah, Malaysia use mobile phones. Among various applications, WhatsApp group is the most widely used because it is easy, familiar and takes up less quota. The biggest obstacle experienced by students is the lack of stable internet signal due to geographical conditions in the middle of an oil palm plantation. Online learning not only has a negative impact like the lack of collaborative learning but also has positive impact such as students are required to keep up with technology advances.

## Recommendations

The teachers are needed to create beneficial and useful online learning such as choose the most optimal online learning system for the students, manage online learning become more interesting and not monotonous, give more feed back and support the students to join collaborative interaction. The students needed prepare all the equipment before learning activities start, such as the mobile phone has been charged and looks for a more stable internet signal so that learning can run smoothly.

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## References

Abdullah, M. B., Daril, M. A. B. M., Wahab, M. I. B. A., Subari, K. B., & Abdullah, S. M. Bin. (2021). Exploratory Study on the Online Learning Understanding Based on Movement and Condition in Sitting Position. *International Journal of Interactive Mobile Technologies*, *15*(18). https://doi.org/10.3991/ijim.v15i18.24731

Abidin, M. I. Z, Alkaabi, E., & Razak, A. (2021). Proof of concept: Effectiveness of photography training simulator during COVID-19. In M. Shelley, I. Chiang, & O. T. Ozturk (Eds.), *Proceedings of ICRES 2021-- International Conference on Research in Education and Science* (pp. 185-193), Antalya, Turkey. ISTES Organization.

Almazova, N., Krylova, E., Rubtsova, A., & Odinokaya, M. (2020). Challenges and opportunities for Russian higher education amid COVID-19: Teachers' perspective. *Education Sciences*, *10*(12).

Arikunto. (2010). Prosedur Pengantar Suatu pendekatan Praktek. *Rineka Cipta*, *2006*(2006), 30–32. http://library.um.ac.id/free-contents/index.php/buku/detail/prosedur-penelitian-suatu-pendekatan-praktek-suharsimi-arikunto-19157.html

Aswan, A. & Amir, A. (2021). Kegiatan Literasi Di Masa Pandemi COVID-19: Studi Kasus Pada Anak Pekerja Migran Indonesia Di Sabah Malaysia. *Seminar Internasional Riksa Bahasa XIV*, (e-ISSN: 2655-1780),

pp. 268-275. http://proceedings.upi.edu/index.php/riksaBahasa

Barata, G., Gama, S., Jorge, J., & Gonçalves, D. (2015). Gamification for smarter learning: tales from the trenches. *Smart Learning Environments*, *2*(1). https://doi.org/10.1186/s40561-015-0017-8

Bilfaqih, Y., & Qomarudin, M. N. (2015). Esensi Pengembangan Pembelajaran Daring. In *Deepublish* (Vol. 1, Issue 1).

Carter, I., Akerson, V., & Cesljarev, C. (2021). Reflections on teaching fully asynchronously: A self-study of elementary science and health methods during the COVID-19 pandemic. In V. L. Akerson & I. S. Carter (Eds.), *Science Education during the COVID-19 Pandemic: Tales from the Front Lines* (pp. 165-190). ISTES Organization.

Coman, C., Țîru, L. G., Meseșan-Schmitz, L., Stanciu, C., & Bularca, M. C. (2020). Online teaching and learning in higher education during the coronavirus pandemic: Students' perspective. *Sustainability (Switzerland)*, *12*(24). https://doi.org/10.3390/su122410367

De Paepe, L., Zhu, C., & Depryck, K. (2018). Online Dutch L2 learning in adult education: educators' and providers' viewpoints on needs, advantages and disadvantages. *Open Learning*, *33*(1).

Derakhshan, A., Kruk, M., Mehdizadeh, M., & Pawlak, M. (2021). Boredom in online classes in the Iranian EFL context: Sources and solutions. *System*, *101*. https://doi.org/10.1016/j.system.2021.102556

Dumford, A. D., & Miller, A. L. (2018). Online learning in higher education: exploring advantages and disadvantages for engagement. *Journal of Computing in Higher Education*, *30*(3).

ElSaheli-Elhage, R. (2021). Access to Students and Parents and Levels of Preparedness of Educators during the COVID-19 Emergency Transition to e-Learning. *International Journal on Studies in Education (IJonSE)*, *3*(2), 61-69.

Johar, S. S., Amat, M. I., & Raja Ibrahim, R. Z. A. (2021). Emotional Intelligence, Depression, Anxiety and Stress of Civil Servants in COVID-19 Pandemic. In S. Jackowicz & O. T. Ozturk (Eds.), *Proceedings of ICSES 2021-- International Conference on Studies in Education and Social Sciences* (pp. 1-10), Antalya, Turkey. ISTES Organization.

Liu, X. & Cheng, P. (2021). Virtual teaching/learning on engineering graphics course in COVID-19 pandemic. In M. Shelley & V. Akerson (Eds.), *Proceedings of IConEST 2021-- International Conference on Engineering, Science and Technology* (pp. 1-11), Chicago, USA. ISTES Organization.

Majlis Keselamatan Negara. (2020). Soalan Lazim (FAQ's)-Bil.1 (Dikemaskini) Perintah Kawalan Pergerakan (Movement Control Order) 18-31 Mac 2020.

Mansyur, A. R. (2020). Dampak COVID-19 Terhadap Dinamika Pembelajaran Di Indonesia. *Education and Learning Journal*, *1*(2). https://doi.org/10.33096/eljour.v1i2.55

Mulyono, H., Suryoputro, G., & Jamil, S. R. (2021). The application of WhatsApp to support online learning during the COVID-19 pandemic in Indonesia. *Heliyon*, *7*(8). https://doi.org/10.1016/j.heliyon.2021.e07853

Mustapha, I., Van, N. T., Shahverdi, M., Qureshi, M. I., & Khan, N. (2021). Effectiveness of Digital Technology in Education During COVID-19 Pandemic. A Bibliometric Analysis. *International Journal of Interactive Mobile Technologies*, *15*(8). https://doi.org/10.3991/ijim.v15i08.20415

Onuralp, E. (2021). Providing Health Security against COVID-19 Pandemic in the Office Spaces of European

Programme Support Office in North Cyprus: An Architectural Aspect as a Different Approach to Ventilation of Spaces with Fresh Air. In S. Jackowicz & M. Al-Jabari (Eds.), *Proceedings of ICSEST 2021-- International Conference on Studies in Engineering, Science, and Technology* (pp. 23-60), Antalya, Turkey. ISTES Organization.

Permendikbud Nomor 19 Tahun 2006 Tentang Program Indonesia Pintar

Pimmer, C., Brühlmann, F., Odetola, T. D., Dipeolu, O., Oluwasola, O., Jäger, J., & Ajuwon, A. J. (2021). WhatsApp for mobile learning. Effects on knowledge, resilience and isolation in the school-to-work transition. *Internet and Higher Education*, *50*. https://doi.org/10.1016/j.iheduc.2021.100809

Ramadanti, E., Mukhlis, I., & Hadi Utomo, S. (2021). Dampak pandemi COVID-19 terhadap pendidikan tinggi di Kota Malang. *Jurnal Ekonomi, Bisnis Dan Pendidikan*, *1*(3). https://doi.org/10.17977/um066v1i32021p209-218

Ramayah, B., & Kumar, R. (2020). Challenges Towards Online Teaching During COVID 19 Pandemic In Malaysia: University Lecturers' Perspective. *ICERI2020 Proceedings*, *1*. https://doi.org/10.21125/iceri.2020.0132

Santosa, A. B. (2020). Potret Pendidikan di Tahun Pandemi : Dampak COVID-19 Terhadap Disparitas Pendidikan di Indonesia. *CSIS Commentaries*.

Syah, R. H. (2020). Dampak COVID-19 pada Pendidikan di Indonesia: Sekolah, Keterampilan, dan Proses Pembelajaran. *SALAM: Jurnal Sosial Dan Budaya Syar-I*, *7*(5). https://doi.org/10.15408/sjsbs.v7i5.15314

Syaharuddin, Husain, H., Herianto, H., & Jusmiana, A. (2021). The effectiveness of advance organiser learning model assisted by Zoom Meeting application. *Cypriot Journal of Educational Sciences*, *16*(3), 952–966. https://doi.org/10.18844/CJES.V16I3.5769

Tsai, K.L. (2022). The effects of university communication on student resilience and engagement during the COVID-19 pandemic. In O. Noroozi & I. Sahin (Eds.), *Proceedings of IHSES 2022-- International Conference on Humanities, Social and Education Sciences* (pp. 230-237), Los Angeles, USA. ISTES Organization.

Undang-Undang Republik Indonesia Nomor 20 Tahun 2003 Tentang Sistem Pendidikan Nasional

Ye, Z. (2021). Comparing the distributions of attitudinal resources of news discourses on London and Wuhan lockdown during COVID-19 outbreak based on Appraisal Theory. In V. Akerson & M. Shelley (Eds.), *Proceedings of IConSES 2021-- International Conference on Social and Education Sciences* (pp. 160-169), Chicago, USA. ISTES Organization.

Yohana, Muzakir, & Hardianti, D. (2020). Efektivitas Pembelajaran Daring pada Program Studi Pendidikan Ekonomi Koperasi Fakultas Keguruan dan Ilmu Pendidikan Universitas Qamarul Huda Badaruddin. *Jurnal Tirai Edukasi*, *1*(4).

Zainuddin, Z., Shujahat, M., Haruna, H., & Chu, S. K. W. (2020). The role of gamified e-quizzes on student learning and engagement: An interactive gamification solution for a formative assessment system. *Computers and Education*, *145*. https://doi.org/10.1016/j.compedu.2019.103729

# The Relation between Petroleum and Environment: Current Situation in Turkey

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**Abstract**: Petroleum and petroleum products are used in many areas from heating of houses to use as fuel in cars and aircraft, as well as pharmaceuticals, paints, plastics and tires. It causes environmental pollution during transportation, processing, exploration and use of petroleum. In addition, petroleum pollutes the air when it is used as fuel. For this reason, there are various protocols and legal requirements based on environmental protection around the world. In petroleum-related facilities in Turkey, to minimize environmental impact and importance is given to work towards reducing pollution. The major impacts of these facilities on the environment are emissions to the atmosphere and water, as well as waste generation. The environment and natural habitats are protected, when necessary, measures are taken on these issues. In this study, petroleum production, transportation and petroleum refineries, petroleum and the environment, taking into consideration the current situation in terms of Turkey are given and received detailed information on the measures to be taken.

**Keywords:** Environment, mining, petroleum, pollution, Turkey

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## Introduction

Oil, metaphorically called by some "black gold", is a hydrocarbon whose composition will be explained later that it is found in the subsoil, oil has many different uses, the main and most important is the production of fuels, everything that whether powered by gasoline, automobiles, planes, ships, etc. in addition to power generating industries; This is why it is said that oil moves the world, since it plays a very important role in the industry, and consequently also in the economy and finances of the world, all countries need oil to achieve optimal development, because although the main use is the production of fuels, it is not the only one, many

products of daily life are made up of petroleum, from clothing to makeup, kitchen utensils, school supplies, car tires, footwear, in short, we will find oil in the composition of many things, another reason to consider it a resource of vital importance worldwide (Ionel-Alin et al., 2012).

This is one of the reasons why the oil levels in the deposits where they are located are under constant observation, since there is a belief that the higher the oil level the country will be a richer country, so strong is the belief that Over time it has even been the reason for wars between countries.

However, oil has many areas to explore, in addition to the economic impact, an issue of vital importance is the environmental impact generated by the extraction and refining of this hydrocarbon, since we often lose sight of the basics of the environment, and of the planet where we live, we do not stop to reflect on the damage we are causing by being blinded by economic interests.

Substantial quantities of toxic and non-toxic waste are generated during the extraction, refinement, and transportation stages of oil and gas. Some industry by-products, such as volatile organic compounds, nitrogen & sulfur compounds, and spilled oil can pollute air, water, and soil at levels that are harmful to life where improperly managed (Bautista and Rahman, 2016). Climate warming, ocean acidification, and sea level rise are global changes enhanced by the industry's emissions of greenhouse gases like carbon dioxide (CO2) and methane, and micro-particulate aerosols like black carbon (Stohl et al., 2013).

Among all human activities, fossil fuel combustion is the largest contributor to the ongoing buildup of carbon in the earth's biosphere. The International Energy Agency and others report that oil & gas use comprised over 55% (18 Billion Tons) of the record 32.8 Billion Tons (BT) of $CO_2$ released into the atmosphere from all energy sources during year 2017 (Ritchie, H. and Roser, 2020). Coal use comprised most of the remaining 45%. Total emissions continue to rise nearly every year: up another 1.7% to 33.1 BT in 2018 (GESR, 2019).

Through its own operations, the petroleum industry directly contributed about 8% (2.7 BT) of the 32.8 BT in 2017. Also, due to its intentional and other releases of natural gas, the industry directly contributed at least 79 million tons of methane (2.4 BT $CO_2$-equivalent) that same year; an amount equal to about 14% of all known anthropogenic and natural emissions of the potent warming gas (TFS, 2019).

Along with fuels like gasoline and liquified natural gas, petroleum enables many consumer chemicals and products, such as fertilizers and plastics. Most alternative technologies for energy generation, transportation, and storage can only be realized at this time because of its diverse usefulness. Conservation, efficiency, and minimizing waste impacts of petroleum products are effective industry and consumer actions toward achieving better environmental sustainability (Lovins, 2018).

Some harmful impacts of petroleum can be limited to the geographic locations where it is produced, consumed, and/or disposed. In many cases, the impacts may be reduced to safe levels when consumers practice responsible

use and disposal. Producers of specific products can further reduce the impacts through life cycle assessment and environmental design practices.

Local and Regional Impacts;

- Air pollution,
- Acid rain,
- Oil spills,
- Waste oil,
- Produced water and drilling waste discharges.

Global Impacts;

- Climate change,
- Ocean acidification.

## Sources of Petroleum-Related Environmental Pollution

We can collect the pollution caused by petroleum in three groups: pollution that occurs during the operation of the facilities, accidents and pollution caused by the end user. Among them, although it is continuous, it is the pollution that occurs during the operation of the facilities that does not reflect much on the public. Turkish Marine Research Foundation (TÜDAV) deals with the pollution related to the facilities under 5 headings. These are environmental problems caused by oil loading/unloading facilities, refineries, oil production facilities, and traffic and ballast water discharge from oil-laden tankers.

Accidents also have an important place in petroleum-related pollution. It is stated that tanker accidents and accidents in oil production facilities at sea cause irreparable environmental problems. The accident that occurred as a result of the super tanker named Exxon Valdez landing on the rocks in Alaska in 1989 and the Deepwater Horizon Oil Spill that took place on April 20, 2010 are important examples of this.

End-user pollution, on the other hand, covers the pollution caused by the use of petroleum products, industrial facilities, transportation vehicles and petro-chemical products. This dimension of the pollution caused by petroleum products is mostly on the agenda in the field of greenhouse gas emissions and climate change. Air pollution resulting from the combustion of hydrocarbons in end-user pollution, and climate change and global warming, which are believed to be the result of this, are discussed. Daniel Yergin lists the possible consequences of hydrocarbon combustion as “smoke and air pollution, ozone depletion, acid rain and global warming”. Global warming is seen as the most important among the possible risks (TÜPRAŞ, 2022).

Considering the increase in greenhouse gas emissions and the environmental problems caused by accidents, various solutions have been proposed for the pollution created by petroleum. One of them is isolating the petroleum and production business, but this is not very easy to implement. The transition from fuel-oil to natural

gas in industry and residences is also a product of these discussions. At this stage, the main limitation of natural gas is the interdependence of countries.

The use of natural gas brings with it important risks in terms of international relations due to transportation methods and limited resources. Conservation of energy and increasing energy efficiency also emerges as a solution for less consumption of petroleum, like other polluting energy sources. On the other hand, there is an effort to put “green gasoline” on the market as an alternative to gasoline and diesel consumption in transportation vehicles, which is one of the most important issues in terms of carbon footprint.

## Petroleum and Environment in Turkey

There are 4 oil refineries operating actively in Turkey and these refineries are located in Batman, İzmir, Kırıkkale and İzmir. All of them are operated by TÜPRAŞ. TÜPRAŞ is a well-established and large company of our country working with energy systems and which has made sustainability a focal point as of 2021, has adopted a much more transparent working principle in environmental issues.

### İzmir Refinery

The İzmir Refinery was put into operation in 1972 with the aim of meeting Turkey's increasing demand for petroleum products. Starting production with a crude oil processing capacity of 3 million tons/year, the refinery's crude oil operating capacity was registered as 11.9 million tons/year as a result of significant capacity increases and unit modernizations over time (Fig. 1).

Figure 1. İzmir Refinery

### Batman Refinery

Batman Refinery, which is the first refinery of Turkey, was established in Batman in 1955 with an annual crude oil processing capacity of 330 thousand tons. As a result of the commissioning of a new crude oil processing unit in 1972, the annual crude oil processing capacity of the Batman Refinery increased to 1.4 million tons/year (Fig. 2).

Figure 2. Batman Refinery

**İzmit Refinery**

İzmit Refinery started production in 1961 with a crude oil processing capacity of 1 million tons/year. As a result of significant capacity increases and conversion unit investments realized over the years, the design capacity of the refinery was registered as 11.3 million tons/year. The Izmit Refinery, which produces at Euro V standards, is at the center of the consumption center, where approximately 33% of Turkey's petroleum products are consumed (Fig. 3).

Figure 3. İzmit Refinery

**Kırıkkale Refinery**

The Kırıkkale Refinery, which was established in 1986 to meet the oil demand of many cities in the Central Anatolia, Eastern Mediterranean and Eastern Black Sea regions, especially Ankara, was expanded with the addition of hydrocracker, isomerization, diesel desulfurization and CCR reformer units, and became a refinery with medium complexity according to Mediterranean standards. The Refinery, which has an annual crude oil processing capacity of 5.4 million tons, is supplied with crude oil from Botaş's Ceyhan Terminal using the Ceyhan-Kırıkkale pipeline (Fig. 4).

Figure 4. Kırıkkale Refinery

## Conclusions

There are various regulations in current rail, road and maritime transport in Turkey. With these regulations, oil transportation has been taken to a safe border for our country. With each passing day, it is supported by sustainable environmental action decisions taken as a country. In addition, as stated in the 11th Development Plan of the Presidency of the Turkish Presidency of Strategy and Budget, the sustainable use of soil and water resources, which are becoming increasingly important due to climate change and urbanization, and the protection of the environment and biological diversity gain importance. Oil refineries in our country are operated with high security measures. In addition, emergency plans are available for unexpected oil accidents. Likewise, high security measures have been taken in sea or road transport and are supported by regulations throughout the country. There are high fines or sanctions for non-compliance with regulation requirements. In this context, sustainability is very important in the operation of oil, which is an important energy source for Turkey. The environmental targets of TÜPRAŞ are 27% emission reduction in 2030, 35% emission reduction in 2035 and carbon neutral target in 2050. Various measures are taken to achieve these goals and rapidly developing studies are carried out.

## References

Bautista, H. and Rahman, K.M.M. (2016). Review on the sundarbans delta oil spill: effects on wildlife and habitats, *International Research Journal*, *1*(43), 93–96.

GESR, (2019). Global Energy & $CO_2$ Status Report 2019: *The latest trends in energy and emissions in 2018*, *International Energy Agency* (Paris), https://www.iea.org/reports/global-energy-co2-status-report-2019

Ionel-Alin, I., Emil, P.I. and Maria, I.N. (2012). Environmental reporting and good practice of corporate governance: petroleum industry case study, *Procedia economics and finance*, *3*, 961 – 967.

Lovins, A. (2018). How big is the energy efficiency resource?, *Environmental Research Letters*, *13*(9), 090401.

Ritchie, H. and Roser, M. (2020). $CO_2$ and greenhouse gas emissions: $CO_2$ emissions by fuel, 15.10.2022, https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions#co2-emissions-by-fuel

Stohl, A., Klimont, Z., Eckhardt, S., Kupiainen, K., Chevchenko, V.P., Kopeikin, V.M. and Novigatsky, A.N. (2013), Black carbon in the Arctic: the underestimated role of gas flaring and residential combustion emissions, *Atmospheric Chemistry and Physics*, *13*(17), 8833–8855.

TFS, (2019). *Tracking fuel supply - methane emissions from oil and gas, International Energy Agency (Paris),* https://www.iea.org/reports/tracking-fuel-supply-2019/methane-emissions-from-oil-and-gas

TÜPRAŞ, (2022). 2021 sürdürülebilirlik raporu, 15.10.2022, https://tprstaticfilessa.blob.core.windows.net/assets/uploads/srrapor/2021_tupras_surdurulebilirlik_raporu.pdf

# A Step Forward in Learning during Pandemic: Emerging Technologies and Innovative Pedagogies

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**Abstract**: Pre-COVID technologies used for teaching and learning were mixed for adapting full or partial online learning. However, during the pandemic, the only available choice for continuation of teaching and learning was online education. Globally, students of all ages and levels of education were forced to familiarize themselves with the latest technologies. As a result, advancement and familiarization with technologies have opened new possibilities in the E-learning teaching and learning process. Digital learning in the shape of blended learning has grown rapidly at different levels especially at the postgraduate level. Some of the new concepts have been adopted in higher education although concerns are still haunting. HEIs (Higher education institutions) sought an opportunity to transform from traditional learning which had attracted growing traction as a flexible and affordable means to complement traditional higher education pre – COVID. Virtual/digital learning departments are now playing a key role along with the digital industries to help them develop and strengthen the learning management system. Using bitesize knowledge in module materials improved the learning experience. This research focuses on the positive influence that appeared as a result of E-learning. The new technologies and pedagogical advancements develop to address the gaps between conventional and online

learning are being discussed here.

**Keywords**: Emerging Technologies, Smart Learning, Learning Environment, Digital Skills, Innovative Pedagogies

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## Introduction

The spread of the COVID-19 pandemic in early 2020 compelled the world to change their day-to-day life matters and hence it impacted almost all walks of life. Different industries and institutions received this impact from minor to major. School, colleges and universities all over the world suspended their conventional (face-to-face) classes and shifted them to E-learning. All types of education whether it is Student-Centred or Teacher-Centred shifted to Technology-Centred as shown in Figure 1.

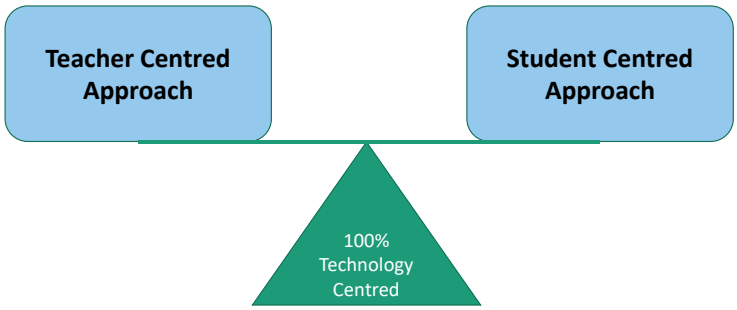


Figure 3. Shift of Teaching and Learning to Technology-centred

Most of the teachers and students were reluctant to shift their teaching and learning to the computer (Alshehri, 2022; Atak, Yaşar, & Purzer, 2022; Bruun & Zachariassen 2020; El-aasar & Farghali, 2022; Hebebci, 2021; Kibici & Sarıkaya, 2021; Kilincer, 2021; Korkmaz & Toraman, 2020; Nnebedum, Obuegbe, & Nwafor, 2021; Sarikaya, 2021). However, distance / online learning is not a novel concept, from a historical perspective major change started towards distance learning around the 1970s. Distance learning continuously changing its shape rapidly with the advancement of information and communication technologies. The internet since the ’90s and WWW (world wide web) proved itself a most reliable rapid medium of information sharing (Feldmann 2014). Further development in the technologies improved the internet infrastructure with the integration of simple but powerful interactive tools (Akturk & Saka Ozturk, 2019; Ozturk & Ozturk, 2022; Simamora, De Fretes et al. 2020). Today with the help of advancement and familiarization with technologies have opened new possibilities in the E-learning teaching and learning process (Simamora, De Fretes et al. 2020). The lack of interest or time in

getting technologies awareness with teachers and students was the main obstacle to the adaption of E-learning (Abualhaija, 2022; Dagnino, Dimitriadis et al. 2018; Pangayan, 2021; Qi, 2021) prior to COVID-19.

At the onset of the COVID-19 period, the rapid response to continuing teaching and learning was to shift conventional teaching to remote or E-learning (Beardsley, Albó et al. 2021). The rapid shift exposed the challenges of technology awareness and left no choice for teachers and students to enhance their digital competencies (Gewerc, Persico et al. 2020). While shifting conventional teaching to E-learning, the administrations in the universities provided remote teaching training to educators on a priority basis which resulted in almost all educators around the world exposing themselves to digital technologies (Albó, Beardsley et al. 2020, Beardsley, Albó et al. 2021). Virtual/digital learning departments are now playing a key role along with the digital industries to help them develop and strengthen the learning management system. The growth in online teaching and learning needs innovation in transferring knowledge by changing the strategies in engaging students, and motivation and overcome the technical challenges of accessing IT resources (Archambault, Leary et al. 2022). Module materials are tailored according to the bitesize knowledge which certainly improves the quality of learning. In the future, digital technology skills will simplify the process of finding, evaluating, using, and sharing knowledge in an effective way, which will enhance the learning and teaching (Grimus and curriculum 2020).

This research is conducted to highlight the positive impact that appeared because of E-learning. A mixed method of quantitative and qualitative research method was used to analyse the digital skills educators obtained during the COVID-19 period. The results showed that there were different 12 different digital technologies tools teachers and students used during the forced E-learning period. The faculty members acquired new technological skills and pedagogical advancements developed to address the gaps between conventional and online learning.

**Research Motivation**

A research study was conducted to illustrate the contribution of the COVID period in terms of technology awareness and innovative teaching pedagogies. To accomplish the purpose of this research, we focused on two research questions:

- Developing an awareness of technology
- Online teaching pedagogies and challenges

## Methodology

The mixed research method qualitative and quantitative research was used to handle numeric and non-numeric data (Popa, Repanovici et al. 2020). Van outlined the different phases of data collection and analysis for conducting mixed research methods in detail (van den Akker 2013) (Cannon 2004). For quantitative analysis,

the study sample consists of 589 students enrolled at MTC (Military Technological College). Three different types of questions were used (Multiple-choice/Likert scale/Open-ended questions); to find out how user developed their digital skills during the COVID-19 period and what challenges they faced. The quantitative data was analyzed using descriptive statistics, for example, mean, percentage and correlation. For qualitative research 12 participants were randomly selected faculty members (those who never used digital technologies before COVID) in different departments of MTC. Qualitative data was collected through interviews with open-ended questions to analyse their interaction with the usage of digital technologies during the COVID period.

## Results and Discussion

For quantitative research, 12 questions in multiple grid types of question and one open-ended question were asked from students to investigate how they have used/developed their digital skills during the COVID period. In this research 12 different digital technologies (Moodle, Email, MS Teams, CLMS, Mirsal, Blackboard, Zoom, BigBlueButton, WhatsApp, Virtual Reality, Augmented Reality and Artificial Intelligence) were presented to the students by giving them the option to choose which technology they have learned and used during the COVID period. In addition, the researcher used five different purposes of using technology (knowledgebase, online support, synchronous, asynchronous and hybrid) which was mentioned and described in the literature review by many scholars and academics (Basilaia and Kvavadze, 2020). The open-ended question was used to give participants a chance or more space to comment on other possible technologies that are used in their institutions and the way they utilize them.

Figure 2 shows the use of 12 different digital tools (that have been selected based on the E-learning digital tools available in the research site – the four HEIs), with the five major E-learning purposes described by Basilaia and Kvavadze, 2020. As it is shown in Figure 2, all 12 chosen digital tools were used at different frequencies. The most used digital tool was Moodle with an 826-response frequency number (23.97% of the total responses) while the least was Blackboard with a 71-response frequency number (2.06% of the total responses).

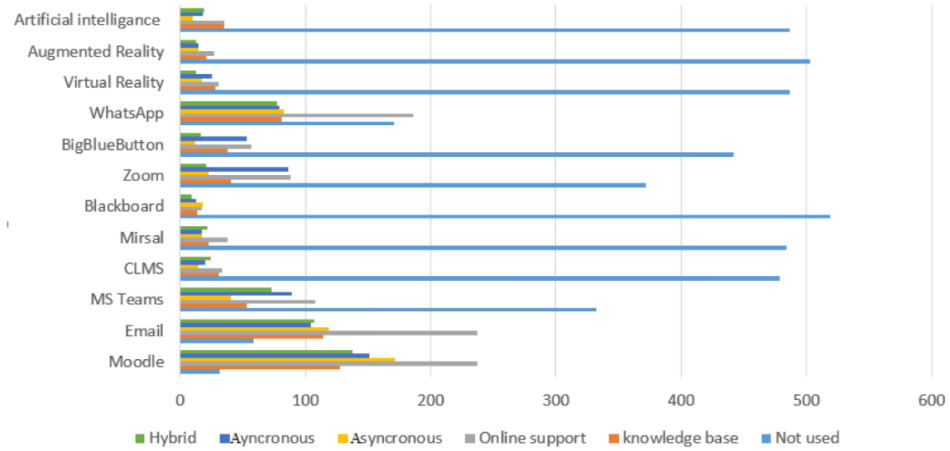


Figure 4. Digital Technologies used during COVID Period

Besides this, the 12 digital tools were used for all 5 purposes, but with different percentages. The most frequent purpose was online support with a 1094-response frequency number (31.75% of the total responses) while the least was hybrid with a 532-response frequency number (15.44% of the total responses).

Figure 3 shows that responses to an open-ended question regarding any other technologies that have been used are as follow: 46% G Suite, 23% Go to the meeting and 5% YouTube. While 25% of the responses were for other digital tools.

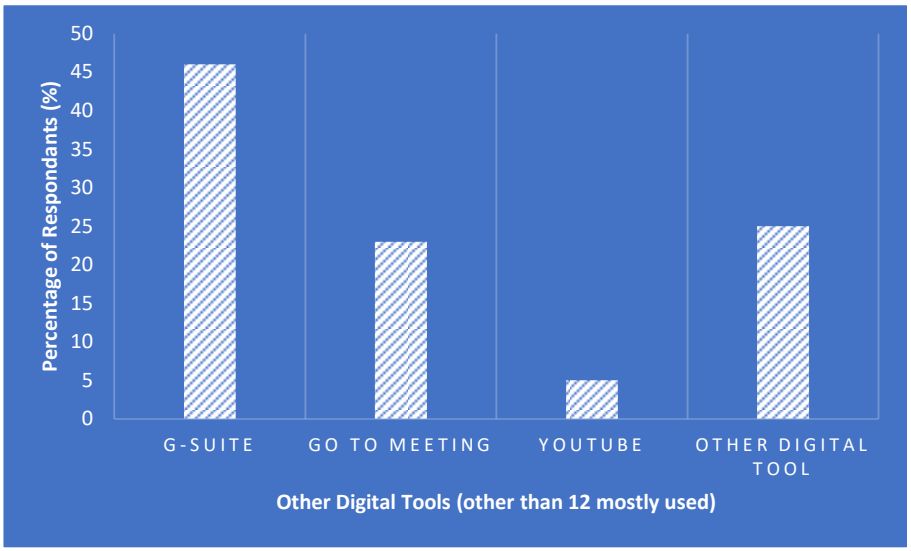


Figure 5. Other than 12 Digital Tools for E-learning

For qualitative research, members of the faculty were interviewed to share their experience of interaction with digital technologies and their teaching experience. Only those members of the faculty were selected who didn't have any experience with E-learning prior to COVID. The following are the outcomes of the analysis:

- **Teaching online**: The collected data highlighted that at the onset of COVID-19 most of the faculty members who were never involved in E-learning activities started to update their knowledge of the latest digital communication technologies.
- **VLE**: Virtual Learning Environment was a completely new idea for the interviewee and hence with their conventional teaching pedagogies faculty member faced it was challenging to engage students during the lesson.
- **Innovation in pedagogies**: As a part of continuous professional development faculty members started modifying their lesson plans and preparing a bitesize lesson for students.
- **Lack of interest**: Faculty members expressed their challenge to incorporate active participation during the learning process and emphasized the need for digital pedagogies, especially for undergraduate and lower-level students.
- **ICT challenges and learning opportunities**: Qualitative analysis revealed that despite ICT challenges faculty advanced and familiarized themselves with technologies with the option of E-learning teaching

and learning process

Results have shown the positive influence of E-learning on the faculty member who previously had no experience with E-learning because of either time or lack of interest or trust. Informal discussions with those faculty members who had previous experience with E-learning further polished their advancement and a few of them created YOUTUBE channels so their students can get more benefits from education anywhere and anytime.

**Impact of E-learning**

Human being learns through various sources throughout their lifespan. Learning is the process to acquire skills and knowledge. The skills and knowledge that can be utilized for the betterment of society are worthy. Different education systems have been developed to inculcate knowledge and skills in students. The distance education system was introduced to address the masses in general and especially to those who cannot approach the conventional education system. The distance education system with many benefits has some shortcomings in its nature, including interactivity, individual assistance, activity-based learning, context-based learning, and so on. Learning using electronic media (E-Learning) is one of the forms of distance learning.

Emerging technologies, including Augmented Reality (AR), Virtual Reality (VR), Artificial Intelligence (AI), Big Data, Machine Learning (ML), Wearable Devices, etc., have paved the way toward the future of E-learning. AR is to augment or superimpose computer-generated information on the real-world view of the user that can benefit a lot in the learning process of a student. VR is an environment where the user delves into the virtual atmosphere by using gadgets. Using this technology, the students can feel themselves in a university environment while sitting at home. AI is the field where researchers are trying to make machines intelligent and without a doubt, this area is the future of E-learning.

Big Data can be considered as large sets of data having valuable patterns that can be utilized to improve the learning of students by extracting those patterns using advanced computational techniques. ML is the subfield of AI where machines learn by experience without being directly programmed and this quality can be utilized to provide custom learning solutions to E-Learners. E-learning truly is the type of learning where students can learn anywhere & any time, and smart wearable devices are one of the good solutions for this type of learning. Mentioning a few, there are a lot number of emerging technologies that are contributing too much nowadays and will be part of E-learning in the future.

## Conclusion

This study examined and highlighted the impact of emerging technologies on E-learning and evolved teaching pedagogies that began at the mass level when COVID struck. The emergency conditions arouse exposed the

educator's ability to conduct online teaching and learning and their challenges to handle technical support. Quantitative and qualitative analysis has shown the positive contribution of emerging technologies during the COVID period, which forced the learner to familiarize themselves with the latest technologies that they previously avoid may be based on many reasons. Virtual/digital learning departments are now playing a key role along with the digital industries to help them develop and strengthen the learning management system. Digital communication technologies (AI, ML Big Data, VR) are evolving rapidly which could be helpful to improve the quality of interactive and virtual teaching in the coming future. Innovative teaching pedagogies are required to engage and motivate students and prepare them for independent studies. Continuous professional development courses could be helpful to enhance faculty members' skills attitudes and understanding towards the need's students. Emerging technologies have a lot to offer to achieve E-learning so that education can go to the masses without any barriers. Further research work is required to explore the role of artificial intelligence in E-learning.

## References

Abualhaija, M. (2022). Change and Resistance to Change during COVID-19. In O. Noroozi & I. Sahin (Eds.), *Proceedings of IHSES 2022-- International Conference on Humanities, Social and Education Sciences* (pp. 117-124), Los Angeles, USA. ISTES Organization.

Akturk, A.O. & Saka Ozturk, H. (2019). Teachers' TPACK Levels and Students' Self-efficacy as Predictors of Students' Academic Achievement. *International Journal of Research in Education and Science (IJRES), 5*(1), 283-294.

Albó, L., M. Beardsley, J. Martínez-Moreno, P. Santos and D. Hernández-Leo (2020). *Emergency remote teaching: Capturing teacher experiences in Spain with SELFIE*. European Conference on Technology Enhanced Learning, Springer.

Alshehri, A.H.A. (2022). Impact of Online Learning on Gifted Students. *International Journal of Education in Mathematics, Science, and Technology (IJEMST), 10*(4), 849-867. https://doi.org/10.46328/ijemst.2641

Archambault, L., Leary, H., & Rice, K. (2022). Pillars of online pedagogy: A framework for teaching in online learning environments. *Educational Psychologist, 57*(3), 178-191.

Atak, V., Yaşar, H., & Purzer, Ş. (2022). Seeing the Invisible: A Retrospective Examination of Education during COVID-19. *International Journal on Social and Education Sciences (IJonSES), 4*(2), 178-189. https://doi.org/10.46328/ijonses.345

Beardsley, M., Albó, L., Aragón, P., & Hernández-Leo, D. (2021). Emergency education effects on teacher abilities and motivation to use digital technologies. *British Journal of Educational Technology, 52*(4), 1455-1477.

Bruun, A. and D. Zachariassen (2020). *Zoom-fatigue: hvad ved vi fra samtaleanalysen?[Zoom-fatigue: what do we know from conversation analysis?],* Aarhus University, Denmark.

Cannon, H. M. (2004). *Redesigning the principalship in Catholic schools.* Australian Catholic University.

Charania, A., Bakshani, U., Paltiwale, S., Kaur, I., & Nasrin, N. (2021). Constructivist teaching and learning with technologies in the COVID-19 lockdown in Eastern India. *British Journal of Educational*

*Technology, 52*(4), 1478-1493.

Dagnino, F. M., Dimitriadis, Y. A., Pozzi, F., Asensio-Pérez, J. I., & Rubia-Avi, B. (2018). Exploring teachers' needs and the existing barriers to the adoption of Learning Design methods and tools: A literature survey. *British Journal of Educational Technology, 49*(6), 998-1013.

El-aasar, S. A., & Farghali, G. F. (2022). Predictive Study of the Factors and Challenges Affecting the Usability of E-Learning Platforms in the Light of COVID-19. *International Journal of Education in Mathematics, Science, and Technology (IJEMST), 10*(3), 568-589. https://doi.org/10.46328/ijemst.2428

Feldmann, B. (2014). Two decades of e-learning in distance teaching–from Web 1.0 to Web 2.0 at the University of Hagen. *International Workshop on Learning Technology for Education in Cloud*. Springer.

Gewerc, A., Persico, D., & Rodés-Paragarino, V. (2020). Guest Editorial: Challenges to the Educational Field: Digital Competence the Emperor Has No Clothes: The COVID-19 Emergency and the Need for Digital Competence. *IEEE Revista Iberoamericana de Tecnologias del Aprendizaje, 15*(4), 372-380.

Grimus, M. (2020). Emerging technologies: Impacting learning, pedagogy and curriculum development. *Emerging technologies and pedagogies in the curriculum,* 127-151.

Hebebci, M. T. (2021). The bibliometric analysis of studies on distance education. *International Journal of Technology in Education (IJTE), 4*(4), 796-817. https://doi.org/10.46328/ijte.199

Kibici, V. B. & Sarıkaya, M. (2021). Readiness Levels of Music Teachers for Online Learning during the COVID 19 Pandemic. *International Journal of Technology in Education (IJTE), 4(*3), 501-515. https://doi.org/10.46328/ijte.192

Kilincer, O. (2021). An Investigation of Pre-service Music Teachers' Attitudes towards Online Learning during the COVID-19 Pandemic. *International Journal of Technology in Education and Science (IJTES), 5*(4), 587-600. https://doi.org/10.46328/ijtes.304

Korkmaz, G. & Toraman, Ç. (2020). Are We Ready for the Post-COVID-19 Educational Practice? An Investigation into What Educators Think as to Online Learning. *International Journal of Technology in Education and Science (IJTES), 4*(4), 293-309.

Nnebedum, C., Obuegbe, A. S., & Nwafor, H. E. (2021). Assessment of Schools' Reopening after COVID-19 Closures. *International Journal on Studies in Education (IJonSE), 3*(2), 86-91.

Ozturk, M. U. & Ozturk, M. S. (2022). The Analysis of Fine Arts Students' Social Media Awareness Levels Related to Appearance. *International Journal of Education in Mathematics, Science, and Technology (IJEMST), 10*(3), 722-739. https://doi.org/10.46328/ijemst.2559

Pangayan, V. (2021). Pandemic COVID-19 and e-learning in higher education: Creative art student's experiences. In M. Shelley, I. Chiang, & O. T. Ozturk (Eds.), *Proceedings of ICRES 2021--International Conference on Research in Education and Science* (pp. 98-107), Antalya, TURKEY. ISTES Organization.

Popa, D., A. Repanovici, D. Lupu, M. Norel and C. Coman (2020). Using mixed methods to understand teaching and learning in Covid 19 times. *Sustainability, 12*(20), 8726.

Qi, Y. (2021). Users' social interaction on online fitness videos during the COVID-19 pandemic in China - evidence from the Bilibili website. In V. Akerson & M. Shelley (Eds.), *Proceedings of IConSES 2021--*

*International Conference on Social and Education Sciences* (pp. 184-194), Chicago, USA. ISTES Organization.

Sarikaya, M. (2021). An Investigation of the Relationship between COVID-19 Anxiety and Burnout among Music Teachers. *International Journal on Social and Education Sciences (IJonSES), 3*(4), 789-806. https://doi.org/10.46328/ijonses.274

Simamora, R. M., De Fretes, D., Purba, E. D., & Pasaribu, D. (2020). Practices, challenges, and prospects of online learning during Covid-19 pandemic in higher education: Lecturer perspectives. *Studies in Learning and Teaching, 1*(3), 185-208.

van den Akker, J. (2013). Curricular development research as specimen of educational design research. *Educational Design Research,* 53-70.

# Analysis of Environmental Literacy Levels of Social Studies Pre-Service Teachers in Terms of Various Variables

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**Abstract**: For a sustainable environment, raising future generations as environmentally literate individuals is vital, and this responsibility falls on the shoulders of teachers. Because the construction of future generations is the duty of teachers, to carry out this responsibility, teachers and pre-service teachers, from education faculties to the schools where they work, must first be environmentally literate individuals themselves. In this case, the study aims to examine the environmental literacy of social studies pre-service teachers in a versatile way. For this purpose, the descriptive survey model was used in the study, and the collected quantitative data were analyzed. In order to investigate the environmental literacy levels of pre-sercice teachers, a 4-dimensional scale developed by Kaplowitz ve Levine (2005) and adapted by Teksöz, Şahin, and Ertepınar (2010) according to Turkish and Turkish conditions was used in this study. Within the scope of the research, the relevant scale was applied to a total of 376 pre-service teachers studying in the Social Studies Teaching program of Erciyes University and Süleyman Demirel University in Turkey. According to the results, a significant difference was found between the pre-service teachers' environmental knowledge and environmental literacy and the state of their thinking that environmental education in Turkey raises environmentally literate individuals. Moreover, statistically, significant differences were found between the environmental literacy and gender of the pre-service teachers in favor of female pre-service teachers. In light of the findings, suggestions were presented to experts and other researchers.

**Keywords:** Environmental Education, Environmental Literacy, Social Studies Pre-Service Teacher.

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## Introduction

The crisis of environmental problems resulting from ecological degradation is one of the most substantial threats facing humanity today (Shafi, 2005). The reason is that 24% of global deaths are caused by modifiable

environmental factors (World Health Organization, 2018). If these changes that occur in the environment are negative and harmful, they are defined as environmental problems (Alım, 2006). In order to understand the leading causes and effects of environmental problems, first of all, it is necessary to know and understand the essential characteristics of the environment. This is a primary requirement to imagine the strength and limits of the ecosystem in which we live (Akyüz, 2020).

In this respect, environmental knowledge is vital for producing and developing ecological actions because, in this way, the individual will know what kind of behavior to take towards the environment. Therefore, environmental knowledge is an intellectual prerequisite for developing and exhibiting ecological behavior (Akman, Tütünsatar, & Yetişen, 2022; Bulut, 2022; Keskin, Akcay, & Kapici, 2020; Lai, 2018; Lasminawati et al, 2022; Lee, 2021; Otto & Kaiser, 2014). On the other hand, environmental literacy, born out of environmental knowledge and awareness (Roth, 1968), is much more than a component of environmental education (Stables & Bishop, 2001). Because environmental literacy starts with framed information, it also includes understanding the underlying principles of behavior, the knowledge and skills needed to research the issue, and how to apply this information (Cesljarev, & Akerson, 2022; Coyle, 2005; Wannapiroon et al., 2021;). Knowing how the world works and learning to ensure sustainability by protecting the environment is the basis of environmental literacy (Orr, 1990). Creating an environmentally literate society is one of the primary goals of environmental education (Genc, 2015). In light of the vital role of teacher education in transforming education and society so that a sustainable future is possible, there is an increasing interest in the relationship between academic departments and the development of teacher candidates' environmental literacy (Goldman, Yavetz & Pe'er, 2014). In this context, several key educators in the field of environmental education have sought to further clarify and refine the broad definition of environmental education so that it can be used in goal and objective planning and in the evaluation of programs that promote environmental literacy and make them attractive (Moseley, 2000). The reason is that the architects of a successful environmental education are teachers (Lloyd-Strovas, Moseley, & Arsuffi, 2018).

Education is crucial to enable individuals to understand the environmental importance and how to create a sustainable environment. Rickinson (2001) states that environmental education should include environmental knowledge, attitudes, and behaviors. This training should be adapted to improve environmental literacy. Şahin, Ünlü, and Ünlü (2016) stated that raising environmentally conscious people is only possible if individuals receive a competent environmental education about environmental problems. Because environmental education in Turkey is limited only to university life, it does not have critical importance at the university level and is limited only to specific departments. According to Kıyıcı, Yiğit, and Darçın (2014), in today's world, where it is essential to raise individuals to be environmentally literate, conscious, and sensitive, people should be raised in order to prevent environmental problems that have become serious problem for humanity.

In light of this perspective, teacher and pre-service teachers' environmental knowledge and environmental literacy levels are vital for a sustainable environment. Regarding environmental literacy, which also takes place in social studies education, it is critical to determine the environmental literacy status of pre-service teachers

who will carry out environmental education for a sustainable world and a healthy future generation. Within the framework of this general purpose, it is aimed that the data collected about the environmental literacy levels of teacher candidates can reveal more detailed results in order to ensure a sustainable future. Therefore this study aims to examine social studies pre-service teachers environmental literacy and environmental knowledge. In this context, answers to the following questions were sought in this study:

1- Is there a significant difference between social studies pre-service teachers' environmental knowledge scores and their genders?
2- Is there a significant difference between social studies pre-service teachers' environmental literacy scores and their gender?
3- Is there a significant difference between social studies pre-service teachers' environmental knowledge scores and their thinking that environmental education in Turkey raises environmentally literate individuals?
4- Is there a significant difference between social studies pre-service teachers' environmental literacy scores and their thinking that environmental education in Turkey raises environmentally literate individuals?
5- Is there a significant difference between social studies pre-service teachers' environmental knowledge scores and their status of receiving environmental education?
6- Is there a significant difference between the environmental literacy scores of social studies pre-service teachers and their status of receiving environmental education?

## Method

### Model of the Research

In this study, which aims to examine the environmental literacy levels of social studies teacher candidates, the descriptive survey model, one of the quantitative research methods, was used. Survey researches allow the sample taken from the universe on a particular subject to be seen through numerical expressions and the behavior, attitude, etc. of individuals. It allows the collection of data on variables that cannot be measured directly (Creswell, 2017). In other words, a screening study on social studies pre-service teachers aimed to determine the environmental literacy levels and examine the results.

### Participants of the Study

Social studies pre-service teachers studying at the education faculties of Erciyes University and Süleyman Demirel University in the academic year 2021-2022 in Turkey participated in the research. 256 (68.1%) of the teacher candidates are female, and 120 (31.9%) are male. In addition, 255 (67.81%) of the pre-service teachers do not think environmental education in Turkey raises environmentally literate individuals; 121 (32.18%) think environmental education in Turkey raises environmentally literate individuals. 247 (65.69%) of the pre-service teachers stated that they did not receive environmental education and 129 (34.3%) stated that they received environmental education.

**Data Collection Tools and Data Processing**

In the study, "Environmental Literacy Scale" and Environmental Knowledge Test developed by Kaplowitz and Levine (2005) and adapted into Turkish by Teksöz, Şahin, and Ertepınar (2010) were used in order to determine the environmental literacy of social studies teacher candidates. The environmental literacy scale consists of 38 items; items 3, 5, 7, 8, 14, 15, 17, and 24 are negative items for environmental literacy, while the others are positive items. The KMO value of the scale was found to be .88, and it was stated that the data were suitable for factor analysis. It consists of items collected in the first dimension with factor loadings ranging from .691 to .418 and belongs to the "Environmental Use" dimension.

In the second dimension, the items named "Concern for Environmental Issues" in the original scale were loaded with factor loads ranging from .678 to .481. In the last dimension, "Attitude Towards Environment," items were loaded with factor loadings varying between .584 and .391. In addition, the internal consistency coefficients of the scale were specified as .81 for "Environmental Use," .88 for "Concern for Environmental Issues," and .70 for "Attitude towards Environment" (Teksöz, Şahin & Ertepınar, 2010). The environmental knowledge test consists of 11 multiple-choice questions. A score of 1 was given for correct answers and 0 for incorrect answers. The factor loads of the "Environmental Knowledge" questions ranged from .684 to .316, and the internal consistency coefficient was stated to be .88.

No missing data was found in the data collected in the study. While filling the tools by the pre-service teachers, no questions were left blank. In addition, Mahalanobis distances were calculated, and 25 observations showing one-way extreme values were removed from the dataset. After the abovementioned regulations, it was decided to include 376 tools out of 401 for teachers.

As a result of the factor analysis performed for the environmental literacy scale in this study, it was observed that the correlation coefficients calculated between the factors and their items ranged from .62 to .89. According to Büyüköztürk (2002), a correlation coefficient of .60 and above can be interpreted as a high level of correlation. In addition, as a result of the confirmatory factor analysis performed in the study, the value obtained by dividing the chi-square fit index value by the degree of freedom ($\chi 2$ / df = 4.39) was found to be below 5, which is considered an acceptable or excellent value (Marsh & Hocevar, 1988). In addition, when the RMSEA (.095), SRMR (.065), GFI (.94), CFI (.75), NFI (.91), RFI (.92) values were examined, it was determined that the model showed acceptable fit or perfect fit. (Fan, Thompson & Wang, 1999; Hu & Bentler, 1999).

In the study, the reliability coefficient of KR-20 for the environmental knowledge test was calculated as .72. In addition, the mean of Item Difficulty (p) was calculated as .64, and the mean of Item Discrimination (r) was calculated as .41. The item discrimination of the test can be considered as an acceptable situation (Turgut & Baykul, 2012).

**Analysis of Data**

The study examined whether there is a statistically significant difference between the social studies pre-service teachers' environmental literacy and environmental knowledge scores (continuous independent variables) and the categorical independent variables. For this purpose, it was first examined whether the data collected were normally distributed since the statistical analyses to be applied had some assumptions. In this context, skewness-kurtosis values, Kolmogorov–Smirnov/Shapiro Wilk statistics, QQ Plot, and Histogram graphs were examined.

In this context, it was observed that the index obtained by dividing Environmental Knowledge scores (Skewness= 0.141 and Kurtosis= 0.272) and Environmental Literacy (Skewness= 1.273 and Kurtosis= 2.057) skewness-kurtosis statistics by their standard errors was not within the range of ±1.96 (Tabachnick & Fidell, 2013). In addition, Kolmogorov-Smirnov and Shapiro-Wilk statistics ($p>.05$), QQ plots, and Histogram graphs were also examined. As a result, it was determined that the data did not show normal distribution. Considering the normality of the data obtained in the research, data were analyzed with their nonparametric equivalents instead of parametric analyses. In addition, the significance level was accepted as .05 in the statistical analyses used in the research.

## Results

### Findings Regarding the First Question of the Research

When Table 1 is examined, it is seen that the mean rank of male pre-service teachers' environmental knowledge scores (198.10) is higher than that of female pre-service teachers' (184.00). The findings revealed that this difference between the environmental knowledge scores of the two groups and the gender variable was not statistically significant ($U=14207.500$; $p>0.05$). In other words, it can be said that the gender of pre-service teachers does not have a significant effect on environmental knowledge scores.

Table 1. Mann Whitney U Test Results for the First Question of the Study

| | N | MR | SR | U | p |
|---|---|---|---|---|---|
| Female | 256 | 184.00 | 47103.50 | 14207.500 | 0.235 |
| Male | 120 | 198.10 | 23772.50 | | |

### Findings Regarding the Second Question of the Study

When Table 2 is examined, it is seen that the mean rank of environmental literacy scores of female pre-service teachers' (203.23) is higher than that of male pre-service teachers' (157.07). The findings revealed that this difference between the environmental literacy scores of the two groups and the gender variable was statistically significant ($U=11588.500$; $p<0.05$). In other words, it can be said that the gender of pre-service teachers has a significant effect on environmental literacy scores. When the effect size was examined ($d=0.378$), it was determined that this difference had a small effect size (Cohen, Manion & Morrison, 2007).

Table 2. Mann Whitney U Test Results for the Second Question of the Study

| | N | MR | SR | U | p | d |
|---|---|---|---|---|---|---|
| Female | 256 | 203.23 | 52027.50 | 11588.500 | 0.000* | 0.378 |
| Male | 120 | 157.07 | 18848.50 | | | |

**p<0.05*

**Findings Regarding the Third Question of the Study**

When Table 3 is examined, it is seen that the mean rank (207.52) of the environmental knowledge scores of the pre-service teachers who do not think that the environmental education carried out in Turkey raises environmentally literate individuals is higher than the mean rank (148.42) of the pre-service teachers who think that the environmental education carried out in Turkey raises environmentally literate individuals. The findings revealed that this difference between the environmental knowledge scores of the two groups and the variable of thinking that environmental education carried out in Turkey raises environmentally literate individuals are statistically significant (U=10578.000; p<0.05). In other words, it can be said that the pre-service teachers' thinking that environmental education in Turkey raises environmentally literate individuals statistically significantly affects their environmental knowledge scores. When the effect size was also examined (d=0.605), it was determined that this difference had a moderate effect size.

Table 3. Mann Whitney U Test Results for the Third Question of the Study

| | N | MR | SR | U | p | d |
|---|---|---|---|---|---|---|
| Yes | 121 | 148.42 | 17959.00 | 10578.000 | 0.000* | 0.605 |
| No | 255 | 207.52 | 52917.00 | | | |

**p<0.05*

**Findings Regarding the Fourth Question of the Study**

When Table 4 is examined, it is seen that the mean rank of environmental literacy scores of pre-service teachers who do not think that environmental education in Turkey raises environmentally literate individuals (197.23) is higher than the mean rank of environmental literacy (170.11) of pre-service teachers who think that environmental education in Turkey raises environmentally literate individuals. The findings revealed that this difference between the environmental literacy scores of the two groups and the variable of thinking that environmental education carried out in Turkey raises environmentally literate individuals are statistically significant (U=13202.000; p<0.05). In other words, it can be said that the pre-service teachers' thinking that environmental education in Turkey raises environmentally literate individuals statistically significantly affects their environmental literacy scores. When the effect size was examined (d=0.261), it was determined that this difference had a small effect size.

Table 4. Mann Whitney U Test Results for the Fourth Question of the Research

| | N | MR | SR | U | p | d |
|---|---|---|---|---|---|---|
| Yes | 121 | 170.11 | 20583.50 | 13202.000 | 0.024* | 0.261 |
| No | 255 | 197.23 | 50292.50 | | | |

**p<0.05*

**Findings Regarding the Fifth Question of the Research**

When Table 5 is examined, it is seen that the mean rank of environmental knowledge points (191.98) of the pre-service teachers who received environmental education is higher than the mean rank of environmental knowledge (186.68) of the pre-service teachers who did not receive environmental education. The findings revealed that this difference between the environmental knowledge scores of the two groups and their environmental education status was not statistically significant (U=15483.000; p>0.05). In other words, it can be said that pre-service teachers' environmental education status does not significantly affect their environmental knowledge scores.

Table 5. Mann Whitney U Test Results for the Fifth Question of the Study

| | N | MR | SR | U | p |
|---|---|---|---|---|---|
| Yes | 129 | 191.98 | 24765.00 | 15483.000 | 0.650 |
| No | 247 | 186.68 | 46111.00 | | |

**Findings Regarding the Sixth Question of the Research**

When Table 6 is examined, it is seen that the mean rank of environmental literacy scores of pre-service teachers who do not receive environmental education (190.47) is higher than the mean rank of environmental literacy scores of pre-service teachers who receive environmental education (184.72). The findings revealed that this difference between the environmental literacy scores of the two groups and their environmental education status was not statistically significant (U=15444.000; p>0.05). In other words, it can be said that pre-service teachers' environmental education status does not significantly affect their environmental literacy scores.

Table 6. Mann Whitney U Test Results for the Sixth Question of the Study

| | N | MR | SR | U | p |
|---|---|---|---|---|---|
| Yes | 129 | 184.72 | 23829.00 | 15444.000 | 0.626 |
| No | 247 | 190.47 | 47047.00 | | |

## Discussion, Conclusion and Recommendations

According to the findings obtained in the study, no statistically significant difference was found between the

environmental knowledge scores of social studies teacher candidates and their gender. However, a statistically significant difference was found between environmental literacy scores and gender in favor of female teacher candidates at a small level. There was a statistically significant difference between the pre-service teachers' thinking that environmental education in Turkey raises environmentally literate individuals and both their environmental knowledge and environmental literacy scores in favor of those who do not think that environmental education in Turkey raises environmentally literate individuals. No statistically significant difference was found between the pre-service teachers taking environmental education courses and both their environmental knowledge scores and their environmental literacy scores. In a study conducted by Artun (2013) and Işıldar and Yıldırım (2008) with social studies teacher candidates, no statistically significant difference was found between environmental knowledge and gender. On the other hand, it was observed that a significant difference between environmental literacy and gender was also found by some researchers in the literature (Erol & Gezer, 2006; Gardos & Dodd, 1995).

Environmental education has excellent value for a country because a good critical environment and a sustainable education create an environment for transforming individuals and societies, where individuals respect their equal-based differences in their concerns and thoughts about common environmental areas (Wildemeersch, 2018). Echavarren's (2017) study conducted on a large sample based on individuals in 51 countries stated that there was a negative correlation between per capita gross domestic product and environmental concern. In other words, more prosperous countries also revealed that the environmental concerns of the population are weaker than emerging countries. He also stated that environmental concerns in these countries are also on environmental education. In their study with university students, Zsóka, Szerényi, Széchy, and Kocsis (2013) stated a strong relationship between environmental knowledge, environmentally sensitive action, and environmental commitment levels, and they stated that this was significantly related to the intensity of environmental education. On the other hand, Arbuthnott (2009) stated that environmental knowledge and attitudes are not fully reflected in daily activities regarding consistent environmental behavior in universities.

According to the findings obtained in the study, the environmental education of pre-service teachers should be investigated in more detail by other researchers, and the relevant authorities should support the content of environmental education in a way that strengthens environmental literacy. In addition, case thinking that environmental education carried out within the scope of education programs in Turkey raises environmentally literate individuals; As a result of the statistically significant difference in favor of those who do not think, studies should be carried out by other researchers or experts to determine the factors and causes of this situation in detail.

## References

Akman, Ö., Tütünsatar, H. E., & Yetişen, S. (2022). Institute of Applied Culture and Arts for Children: "Environmental Literacy with Art". In P. Dankers, M. Koc, & M.L. Ciddi (Eds.), *Proceedings of*

*ICEMST 2022-- International Conference on Education in Mathematics, Science and Technology* (pp. 33-42), Antalya, Turkey. ISTES Organization.

Akyüz, E. (2020). Çevre sorunlarında bilinmeyen 100 bilimsel gerçek. Astana Yayınları.

Alım, M. (2006). Avrupa birliği üyelik sürecinde Türkiye'de çevre ve ilköğretimde çevre eğitimi. *Kastamonu Eğitim Dergisi*, *14*(2), 599-616.

Arbuthnott, K. D. (2009). Education for sustainable development beyond attitude change. *International Journal of Sustainability in Higher Education*, *10*(2), 152-163. https://doi.org/10.1108/14676370910945954

Artun, H. (2013). Sosyal bilgiler öğretmen adaylarının çevre okur-yazarlık düzeylerine etki eden faktörlerin değerlendirilmesi. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi*, *34*(34), 1-14.

Bulut, A. (2022). Evaluation of the Place of Nature and Environment in Educational Life in Accordance with the Opinions of Teachers. In O. Noroozi & I. Sahin (Eds.), *Proceedings of IHSES 2022-- International Conference on Humanities, Social and Education Sciences* (pp. 182-187), Los Angeles, USA. ISTES Organization.

Büyüköztürk, Y. (2002). Faktör analizi: Temel kavramlar ve ölçek geliştirmede kullanımı. *Kuram ve Uygulamada Eğitim Yönetimi*. *32* (32), 470-483.

Cesljarev, C., & Akerson, V. (2022). Integrated Assessments of K-12 Students' Science and Literacy Knowledge. *International Journal of Research in Education and Science (IJRES)*, *8*(3), 471-485. https://doi.org/10.46328/ijres.2718

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education* (6th ed). Routledge/Taylor & Francis Group.

Coyle, K. (2005). Environmental literacy in America: What ten years of NEETF/Roper research and related studies say about environmental literacy in the US. *National Environmental Education & Training Foundation*.

Creswell, J. W. (2017). *Eğitim araştırmaları: Nicel ve nitel araştırmanın planlanması, yürütülmesi ve değerlendirilmesi*. Edam.

Echavarren, J. M. (2017). From objective environmental problems to subjective environmental concern: a multilevel analysis using 30 indicators of environmental quality. *Society & Natural Resources*, *30*(2), 145-159. https://doi.org/10.1080/08941920.2016.1185555

Erol, G. H., & Gezer, K. (2006). Prospective of elementary school teachers' attitudes toward environment and environmental problems. *International Journal of Environmental and Science Education*, *1*(1), 65-77.

Fan, X., Thompson, B. & Wang, L. (1999). Effects of sample size, estimation methods, and model specification on structural equation modeling fit indexes. *Structural Equation Modeling*, *6*(1), 56-83.

Gardos, V. T., & Dodd, D. K. (1995). An immediate response to environmentally disturbing news and the environmental attitudes of college students. *Psychological Reports*, *77*(3), 1121-1122. https://doi.org/10.2466/pr0.1995.77.3f.1121

Genc, M. (2015). The project-based learning approach in environmental education. *International Research in Geographical and Environmental Education*, *24*(2), 105-117.

Goldman, D., Yavetz, B., & Pe'er, S. (2014). Student teachers' attainment of environmental literacy in relation to their disciplinary major during undergraduate studies. *International Journal of Environmental and*

*Science Education*, *9*(4), 369-383. 10.12973/ijese.2014.222a

Işıldar, G. Y., & Yıldırım, F. (2010). Çevre eğitiminin çevreye duyarlı davranışlar üzerindeki etkisi. *Eğitim ve Bilim*, *33*(148), 13-27.

Kaplowitz, M. D., & Levine, R. (2005). How environmental knowledge measures up at a big ten university. *Environmental Education Research*, *11*(2), 143-160.

Keskin, C., Akcay, H., & Kapici, H. O. (2020). The Effects of Environmental Science e-Projects on Middle School Students' Behaviors and Attitudes. *International Journal of Technology in Education and Science (IJTES)*, *4*(2), 160-167.

Kıyıcı, F. B., Yiğit, E. A., & Darçın, E. S. (2014). Doğa eğitimi ile öğretmen adaylarının çevre okuryazarlık düzeylerindeki değişimin ve görüşlerinin incelenmesi. *Trakya Üniversitesi Eğitim Fakültesi Dergisi*, *4*(1), 17-27.

Lai, C. (2018). A Study of Fifth Graders' Environmental Learning Outcomes in Taipei. *International Journal of Research in Education and Science (IJRES)*, *4*(1), 252-262. DOI:10.21890/ijres.383171

Lasminawati, E., Jumadi, Wilujeng, I., & Firmanshah, M.I. (2022). Complexity Analysis of Integrated Science Test Item Global Competence on Environmental Sustainability Content. In P. Dankers, M. Koc, & M.L. Ciddi (Eds.), *Proceedings of ICEMST 2022-- International Conference on Education in Mathematics, Science and Technology* (pp. 94-103), Antalya, Turkey. ISTES Organization.

Lee, K. J. M. (2021). Identifying difficulties with cultural valuation of the environment. In S. Jackowicz & I. Sahin (Eds.), *Proceedings of IHSES 2021-- International Conference on Humanities, Social and Education Sciences* (pp. 23-40), New York, USA. ISTES Organization.

Lloyd-Strovas, J., Moseley, C., & Arsuffi, T. (2018). Environmental literacy of undergraduate college students: Development of the environmental literacy instrument (ELI). *School Science and Mathematics*, *118*(3-4), 84-92. https://doi.org/10.1111/ssm.12266

Marsh, H. W. & Hocevar, D. (1988). A new, more powerful approach to multitrait-multimethod analyses: Application of second-order confirmatory factor analysis. *Journal of Applied Psychology*, *73*(1), 107–117. https://doi.org/10.1037/0021-9010.73.1.107

Moseley, C. (2000). Teaching for environmental literacy. *The Clearing House*, *74*(1), 23-24.

Orr, D. W. (1990). Environmental education and ecological literacy. *The Education Digest*, *55*(9), 49.

Otto, S. & Kaiser, F. G. (2014). Ecological behavior across the lifespan: Why environmentalism increases as people grow older. *Journal of Environmental Psychology*, *40*, 331-338.

Rickinson, M. (2001). Learners and learning in environmental education: A critical review of the evidence. *Environmental Education Research*, *7*(3), 207-320.

Roth, C. E. (1968). Curriculum Overview for Developing Environmentally Literate Citizens. Retrieved, November 10, 2021, https://eric.ed.gov/?id=ED032982

Shafi, S. M. (2005). *Environmental pollution*. Atlantic Publishers & Dist.

Stables, A., & Bishop, K. (2001). Weak and strong conceptions of environmental literacy: Implications for environmental education. *Environmental Education Research*, *7*(1), 89-97. https://doi.org/10.1080/13504620125643

Şahin, S., Ünlü. E., & Ünlü, S. (2016). Öğretmen adaylarının çevre okuryazarlık farkındalık düzeylerinin

incelenmesi. *Education Sciences*, *11*(2), 82-95. http://dx.doi.org/10.12739/NWSA.2016.11.2.1C0655

Tabachnich, B.G., & Fidell, L.S. (2013). *Using multivariate statistics* (6th edn). Pearson Education.

Teksöz, G., Şahin, E., & Ertepınar, H. (2010). Çevre okuryazarlığı, öğretmen adayları ve sürdürülebilir bir gelecek. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *39*(39), 307-320.

Turgut, M. F. ve Baykul, Y. (2012). *Eğitimde ölçme ve değerlendirme*. Pegem Akademi.

Wannapiroon, P., Nilsook, P., Techakosit, S., & Kamkhuntod, S. (2021). STEM Literacy of Students in Vocational Education. *International Journal of Technology in Education and Science (IJTES)*, *5*(4), 527-549. https://doi.org/10.46328/ijtes.253

WHO. (2018). *Preventing disease through healthy environments: a global assessment of the burden of disease from environmental risks.* World Health Organization. https://www.who.int/publications/i/item/9789241565196

Wildemeersch, D. (2018). Silence a matter of public concern: reconsidering critical environmental and sustainability education. *Environmental education research*, *24*(9), 1371-1382. https://doi.org/10.1080/13504622.2017.1301385

Zsóka, Á., Szerényi, Z. M., Széchy, A., & Kocsis, T. (2013). Greening due to environmental education? Environmental knowledge, attitudes, consumer behavior and everyday pro-environmental activities of Hungarian high school and university students. *Journal of cleaner production*, *48*, 126-138. https://doi.org/10.1016/j.jclepro.2012.11.030

# International Experience and China's Choice of STEM Education: Enlightenment from the STEM Education Policy in the UK and the US

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**Abstract**: In the 21st-century advent of the era of intelligent technology and the digital transformation of education, many countries attach great importance to the cultivation of science and technology talents, and take STEM education as a long-term national strategy for national competence, scientific and technological development and social progress. Also, due to the variant cultural-historical traditions and socioeconomic conditions, STEM education content varies from country to country. Also, due to different social and historical stages, especially the various levels of scientific and technological development, the objectives, contents and methods of STEM education are also experiencing continuous evolution. Thus, from the international comparative education perspective, this research explores the national STEM educational policies, innovative STEM education cases, as well as representative achievements of STEM education in the United States and the United Kingdom, and China. Above all, combined with the current conditions and difficulties of STEM education in China, this research finally proposes advice for China's STEM education reform for policy makers' reference: (1) Employer involvement in STEM education; (2) Public perceptions and attitudes towards science, economics, well-being, and careers in science in the UK; (3) Focus on the cultivation of girls' STEM interests and vocational empowerment; (4) Emphasis on parents and families' influence on students' STEM career choice.

**Keywords:** STEM education, international comparative education, China, America, Britain

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## Introduction

STEM education is an acronym for Science, Technology, Engineering, and Math education, which integrates the four disciplines into a cohesive and interdisciplinary learning paradigm based on real-world applications. Basic elements of STEM education are contained in different educational stages and environments to construct the basic units of the STEM education system, which include the curriculum system, teaching materials, teacher qualifications, teaching methods, and teaching resources. Thus, this international comparative STEM education

study analyses the similarities and differences in terms of the above key elements.

The facilitation of STEM education has become an international trend for transformative technological development. Firstly, many countries attach great importance to the cultivation of science and technology reserve talents, and regard STEM education, especially from kindergarten to university level, as a key foundation for scientific and technological development and social progress. Notably, STEM education in different nations also shows diverse characteristics. Culture and economy determine a country's basic STEM education stance, while the goals, content, and methods of STEM education change with the level of scientific and technological development in different social and historical stages. Besides, with the advent of the era of intelligent technology, global STEM education has undergone digital transformation.

STEM Education implementation plans in Europe and America are taking the leading role with their fast STEM educational development. First of all, in the 21st century, the United States promulgated K-12 STEM Education Framework and Next Generation Science Standards, expressing "scientific literacy" as the performance expected of students, and designing the core content of science learning from three dimensions of science and engineering practice, common concepts and subject core ideas. Moreover, after the UNESCO *Education 2030 Action Framework*, countries have re-examined existing policies and developed a new vision for STEM education to cope with a rapidly changing world, with greater emphasis on “interdisciplinary teaching”, “systems thinking”, “lifelong learning”, “collaboration”, “multiculturalism” and “autonomy”. Besides, in 2019, the European Parliament (EP) stressed that science literacy is not limited to knowledge of science content, but also includes the ability to engage critically on science-related issues and make informed decisions. It calls for the inclusion of this new scientific literacy orientation in school curricula and emphasizes the importance of basic literacy, scientific knowledge and ability, and contextual understanding of science.

Following the world trend, the Chinese ministry of education also launched a series of policies for the development of scientific quality and put forward new requirements for STEM education. *The Outline of the National Science Literacy Action Plan (2021-2035)* starts the process of high-quality development of scientific literacy in China in the next 5 to 15 years, and sets out clear tasks for STEM education for children and adolescents. Against this background, rethinking STEM education to identify key actions to achieve mission objectives is of vital significance for China’s STEM education reform.

Furthermore, it is worth noting that the scientific literacy of Chinese students is in great need of transformative cultivation and immediate enhancement. The international assessment shows that compared with those in technologically advanced countries, Chinese students in compulsory education have an overall advantage in mastering basic science knowledge. In detail, the proportion of top-tier students and dynamic problem-solving ability is insufficient, including the lack of in-depth understanding of scientific knowledge production process and nature of science, the weakness in a true grasp of the meaning and application of the scientific method, being short of sustained interest in science, insufficient understanding of scientific career, and deficient expectations for science-related careers lag far behind those in developed countries.

Above all, there are blind spots and misunderstandings in STEM education in China. Chinese primary and middle school students lack scientific thinking activities and scientific practice opportunities. Even in developed areas of China, the proportion of scientific reasoning training in science classes is very low. Also, many middle school classrooms lack “demonstration”, “modeling”, “computational thinking” and other scientific education pedagogies. If such misperception of STEM education cannot be effectively solved and corrected in time, it is bound to produce a vicious circle to STEM education results and even the gap in science talent cultivation at the university level.

This study has both theoretical and practical significance. On one hand, theoretically, by comparing the curriculum system, teaching resources, and teaching methods of STEM education in China, the United States, and the United Kingdom, the study concludes the most efficient curriculum, innovative policies, and cutting-edge theories to get a critical comprehension of STEM educational developments, experiences and challenges in western and eastern education institutions for STEM research. Also, this study analyzes the current situation, problems, and countermeasures of STEM education in the three countries’ real context, which provides the dual research level of macro and micro level for STEM education research, and expands the depth and breadth of original STEM education research.

On the other hand, practically, rooted in the current reality of China’s social circumstances, this study follows the research logic of finding problems first, then analyzing problems, and finally aiming at solving problems. From the perspective of comparison between Chinese and Western education, this study analyzes the achievements and level of STEM education and proposes specific suggestions that can solve the problems of STEM education, such as formalization, mechanization, and fragmentation, to a certain extent, predict the future development direction of STEM education, and improve the scientific quality of the whole people. Arguably, the study could meet the research gap by providing the referable suggestions for Chinese STEM education reform in comparison to the US and UK.

## Method

### Research Question

This study explores three research questions as follows:

1. What are the differences among the development characteristics of STEM education in China, the US, and the UK?
2. What are the existing problems of STEM education in China?
3. On the basis of absorbing high-quality strategies from the UK and the US, what are the specific suggestions for STEM education that aim at enhancing the theoretical basis and practical basis for STEM education development in China?

**Data Analysis**

This study utilizes two research methods, involving the literature research method and the investigation method. First of all, by sorting out domestic and foreign papers, monographs, and policy documents, the characteristics of STEM elements in the three countries are summarized to provide a theoretical basis and support for problem analysis.

Meanwhile, with the investigation method, combined with observation and data, this paper analyzes the implementation status of STEM education, systematically analyzes the basic situation of basic elements, and analyzes the differences between STEM education in China, The United States, and The United Kingdom.

## Comparative Study of STEM education in China, US, and UK

**Policy Initiatives and Reform Process**

This section concludes the policy initiative and reform process of STEM education in China, the U.S., and the U.K.

***Development History of STEM Education: Rise and Development from the United States***

Originally, STEM education was accompanied by the idea of inquiry from its birth. STEM education was formed in the middle of the 19th century when science was introduced into classrooms. Spencer, a famous British thinker, published *What knowledge is of most worth*, which has caused extensive and far-reaching influence on all walks of modern life. The article not only clearly points out that scientific knowledge is of great value, but also suggests that scientific knowledge is equally beautiful and poetic to the subjects of arts.

Moreover, in the first half of the 20th century, the goal of STEM education had risen to the national and social level, and people realized that science could be used to address a range of social problems, and STEM education received attention accordingly. Professor John Dewey of Columbia University put forward the slogan “education is life, school is society” and advocated the teaching method of "learning by doing". Dewey, in particular, offers insights into STEM education. He argues that STEM education places too much emphasis on the accumulation of knowledge and not enough on science as a way of thinking and cognitive attitude.

Furthermore, in the second half of the 20th century, inquiry became the theme of science curriculum reform. In 1957, Sputnik launch triggered a panic in the U.S. government that led to massive education reform. In this reform, STEM education is given unprecedented importance, because there is a deep recognition that STEM education is relevant to national security and economic development.

In recent years, “practice-based” pedagogy has gradually become the focus of the STEM curriculum. The

emergence of "practice" in the STEM educational discourse system does not mean the dilution or even retreat of "inquiry", but the expansion and development of existing inquiry thoughts. On July 19, 2011, the Framework for K-12 STEM Education, jointly developed by the National Academy of Research (NRC) and several organizations in America established. The practice-based and interdisciplinary core concepts were released, outlining the blueprint of STEM education for the "new generation" with detailed guidance, and pointing out the specific path and direction for the next stage of development of the science curriculum in the United States.

***The Development of STEM Education in the UK: Reform Policies***

STEM subjects in schools and universities have been consistently supported by the UK government and the devolved administrations for decades. With government-supported teacher training and continuing professional development for science and math teachers, STEM employers have developed their own ways to support curriculum materials and programs to enrich students, and science and academic institutions and STEM charities provide a range of support for STEM education and scientists. Besides, over the past two decades or so, many policy reports have explored and expanded on this thesis. A key document is the Treasury's Ten-year Review, the Science and Innovation Investment Framework 2004-2014. The main objectives involving more powerful scientists, engineers, and technologists take this step to effect change; Improve the quality of science teachers and lecturers and ensure national teacher training targets meet the results of the number of students studying science at the GCSE level; Increase the number of people choosing SET subjects in post-16 education and higher education; Elevate the proportion of qualified students in research and development occupations and the proportion of ethnic minorities and women in higher education.

***The Development of STEM Education in China: Policy Reform***

Following the initiative and rapid development of American STEM education, China also launched multiple policy reforms to support STEM education. Initially, in 1999, the Ministry of Education launched a new round of basic education curriculum reform. Later, in 2000, Changchun Normal University set up a pilot program for training undergraduate teachers of comprehensive science. Remarkably, in 2001, the Ministry of Education officially approved the establishment of the STEM education undergraduate program at Chongqing Normal University, and the opening of the STEM education program has been popularized since then. Moreover, in the Catalogue of Undergraduate Majors of Colleges and Universities issued by the Ministry of Education in 2012 and 2020, the discipline category of STEM education is education, and the major code is 040102, which is education major. With the continuous efforts for the construction of STEM education, on June 25, 2021, The State Council issued the Outline of the National Scientific Literacy Action Plan (2021-2035), which proposed to promote the opening of STEM education undergraduate programs in normal colleges and comprehensive universities and expand the enrollment scale.

***Results of the Comparison***

From the comparison of the STEM education policy development process of the three countries, it can be found that the starting sequences of the STEM education initiatives as formal policies are the US, the UK, and China respectively. Meanwhile, each country also has a distinctive STEM education developmental focus, the features involving especially emphasizing K-12 STEM education in the US for building future talent pool to facilitate national technology development, focusing on labor markets' talent requirements and career development goals and at the same time boosting STEM teacher education in the UK, and mainly applying STEM education reforms in higher education with enhancing certain STEM field research and innovation in China.

**Implementation Status**

Following the policy support in the three nations, the second comparative section further analyzes the implementation status in the real practices of STEM education in the U.S., the U.K, and China.

***Implementation Status of STEM Education in the United States***

In America, the main and earlier STEM education implementation is motivated by solving the challenge of stimulating teenagers' interest in STEM subjects in the K-12 education stage. According to the U.S. Department of Education, only 16 percent of high school students are interested in a STEM career and have proven a proficiency in mathematics. Moreover, according to the department website, currently nearly 28 percent of high school freshmen declare an interest in a STEM-related field, but 57 percent of these students will lose interest by the time they graduate from high school. As a result, the Obama administration announced the 2009 "Educate to Innovate" campaign to motivate and inspire students to excel in STEM subjects.

***Current Situation of STEM Education Implementation in the UK***

Moreover, at the initial stage of the implementation of STEM education in the UK, there were also a series of challenges. Over the past 30 years, there has been a decline in the number of young people studying STEM subjects in the later stages of school, followed by a shortage of STEM graduates and employed people with adequate STEM backgrounds. Moreover, except for the students' decreasing enthusiasm for STEM learning, there are also tough challenges in advancing STEM teacher education in the UK. In detail, one of the main challenges facing STEM education in the UK is the quality of teachers, along with their involvement in innovative pedagogies of STEM, and teachers' personal comprehension and expertise in scientific literacy are also inadequate. Last but not the least, it is a common and ambivalent phenomenon that the prominent professionals with deep expertise in STEM subjects are drawn to follow careers in STEM itself, while the status of the teaching profession in the UK discourages "genuine scientists" from pursuing a teaching career, which implies that dilemma of the public's biased recognition of the STEM professionals' career choices in Britain.

***Implementation Status of STEM Education in China***

In China, a case study has shown the investigation of the realistic picture of STEM education in China's compulsory education stage (Tian Wei, 2021). In this research, the respondents are Grade 4 and 8 students and related science teachers, with the research methods of random sampling conducted in seven provinces in the eastern, central, western and northeastern regions, and questionnaires and structured interviews were adopted. The wide-scale survey includes 21,467 fourth-grade students, 15,739 eighth-grade students, 1,533 fourth-grade science teachers, 1,518 eighth-grade physics teachers, 1,003 eighth-grade biology teachers and 975 eighth-grade geography teachers.

Notably, the research results in Tian Wei's case study have clearly disclosed the heated problems of STEM education practices in Chinese schools, involving:

(1) Course offering: Basic guarantee but lacking in quantity and quality.

(2) Teachers: the educational level has been significantly improved but the professional quality is lacking.

(3) Inquiry experiment teaching: significant effect but low implementation degree.

(4) Experimental teaching resources: basic configuration but low utilization rate.

To sum up, in terms of the comparative analysis of typical changes in the STEM education implementation of the three nations. The research finds that the challenges in K-12 students' STEM interest cultivation are the main impediment of American STEM education. In the UK, instructing and boosting STEM teachers' professional identity and career choices have become a severe problem. Students' preference for Career choice. While China mainly has to face a lack of practical and experimental STEM instruction, as well as an interdisciplinary curriculum.

**Research Trends and Characteristics**

This section analyses the STEM education research conditions in the academia of America, Britain, and China.

***China***

In order to explore the general research trend of STEM education in China, the author retrieves the STEM-related publications in the last two decades from the China National Knowledge Infrastructure (CNKI). Just as shown in the following line chart, the number of STEM-themed papers published in China fluctuates at 140 per year, so the research trend is comparatively stable, and in 2022, the total publications of STEM education papers are expected to reach 147 (see Figure 1).

Notably, according to the relevant literature in the last two decades, the research hotspots of STEM education in China mainly focus on three aspects. The first research focus is on scientific literacy, especially on the

transformation of the connotation of scientific literacy under the framework of core literacy. Notably, the cultivation path of scientific literacy requires inquiry-based teaching and integrated science curriculum development.

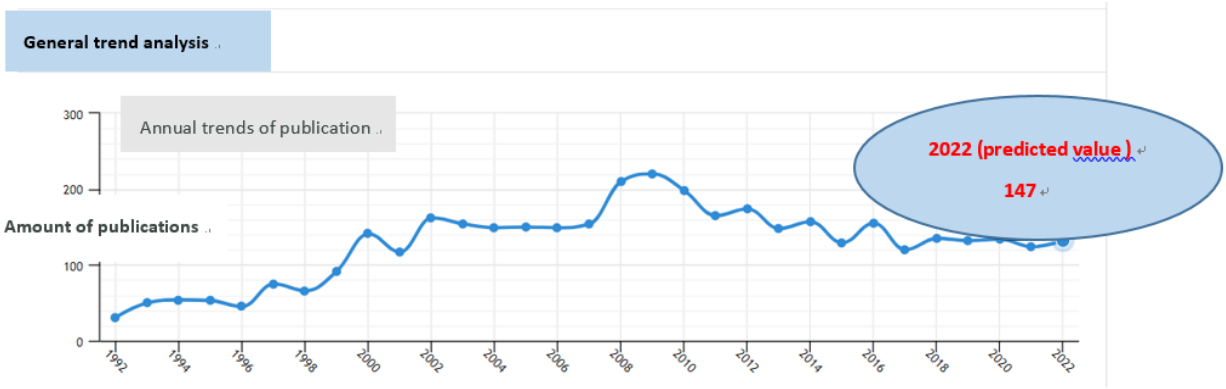


Figure 1. The Research Trend of the STEM-themed Publications in China from 1992-2022

Note:

Data source: total number of literature: 6983;

Search conditions: (subject% = 'science education' or title% = 'science education') and ((core journal = 'y') or (CSSCI journal = 'y')); check

Search scope: Journal retrieved at CNKI

The second focus is on the Chinese scholars' publications' international reference and interdisciplinary exploration of the science curriculum. For the STEM education policymakers and curriculum designers, both the absorption of global experience and localization deduction of science curriculum matter, so that the STEM curriculum reform in China could from a comprehensive and interdisciplinary perspective.

The third focus is the STEM subjects' teacher training. It is of vital significance to integrate the subject knowledge, teaching methods, and teaching reflection ability together into teacher scientific literacy training. Meanwhile, the STEM teacher training should also be supported with a policy guarantee as a standardized rule and catalyzer.

***The US***

In the US, the research focus and reform achievements of STEM education are mainly about curriculum design. Thus, this section would introduce the curriculum structure of STEM Education in the United States. Firstly, one representative STEM curriculum in America, is the SFA (Science for All Americans) with the analytical science curriculum contents (Table 1). The SFA lists scientific knowledge and concepts that need to be taught and learned, and describes the interrelation between concepts, expression, and application of concepts in social life in detail in order to make it easier for teachers to understand the meaning of scientific concepts and their importance in social life.

Table 1. SFA Science Curriculum and Content Standards

| The natural environment | Living environment | The human organism |
|---|---|---|
| The universe | Diversity of life | The characteristics of people |
| The earth | genetic | The growth of the people |
| Factors affecting the landscape | cells | The basic function |
| Material structure | The interdependence of life | learning |
| Energy conversion | Flow of matter and flow of | The body health |
| An object moves | energy | Mental health |
| The forces of nature | Evolution of life | |
| **The human society** | **The transformed world** | **The world of mathematics** |
| Cultural influence on behavior | agricultural | digital |
| Group behavior | Materials and Manufacturing | The relationship between |
| Social change | Energy and Utilization | symbols |
| The harmonious balance of | communication | The shape of |
| society | Information processing | uncertainty |
| Political and economic systems | Health care technology | reasoning |
| Social conflict | | |
| Global interdependence | | |

Besides, Content Analysis of American NGSS Science Courses is also a typical curriculum for STEM education in the US. Instead of elaborating on the representation and application of scientific knowledge and concepts in social life, NGSS focuses on a limited set of core concepts. Also, NGSS emphasizes the systematic learning of disciplines and interdisciplinary concepts. Notably, NGSS divides grades K-12 into four stages, involving grades K-2, 3-5, middle school, and high school. It sets specific requirements for each core concept at different levels of learning and establishes a clear learning progression.

***The Goal of STEM Education in the UK: STEM and the Labor Market***

In the UK, the curriculum provides a clear vision of STEM with two main objectives, including the qualified talents' entrance to the STEM labor force, and the STEM literacy of the mass. Most studies in the UK tend to support the official view of the importance of STEM training for the labor market. For example, the authoritative House of Lords in the UK (2012) reported that STEM education in the UK explicitly linked the demand for high-quality STEM graduates in the British labor market to economic growth and prosperity accumulation. Moreover, the report cites evidence from the Council for Industry and Higher Education (CIHE), which warns that the workforce of the future will increasingly need higher levels of skills as the restructuring of the economy forces firms into the value chain of talent assessment and industrial growth. These emerging jobs facing the future transformative industry will increasingly require talents with the abilities offered by STEM qualifications.

**Referable Global Innovative STEM Education Cases**

This section would reflect on five innovative cases of STEM education in Spain and the UK, involving drama

education, support from dialogue and community, assistance from vocational exchanges at diverse levels, STEM textbooks that take teachers into consideration, and a trust delivery pathway for employer involvement in STEM education.

***Drama-supported STEM Education in the UK***

Firstly, drama-supported STEM education activities could play a pivotal role in equipping the public with scientific aspirations since dramatic activities are considered as particularly useful teaching and learning strategies for integrating emotional and cognitive education into action (Littledyke 2008). Moreover, a meta-analysis (Lee et al. 2015) shows that drama-based activities have a significant impact on achieving outcomes in educational settings, in particular when the dramatic activities are led by classroom teachers or researchers rather than taught by artists, and are integrated into more than five courses like English Language Arts or Science curriculum compared to other areas. Therefore, as a collaborative art form, applied drama education is regarded as a distinctive pedagogy that aims to encourage interaction and collaboration, emphasizing the student-centered pedagogy, and can also remove the learners' stereotypes about scientific careers and stimulate their inner enthusiasm and motivations.

For instance, there is a representative real case called PERSEIA drama education combined with STEM education. PERSEIA is based on two specific theatrical forms, which are scientific stand-up comedy used in Spain and scientific busking in the UK. Scientific stand-up consists of individual stand-up shows that use jokes and humorous performances to deconstruct clichés and biases about science and explain common people's daily scientific activities and recent scientific discoveries (Villanueva, Marimon & González, 2020).

In this way, the stand-up comedy communicates with its audience about scientific recognition through humorous and emotional interaction. In addition, PERSEIA adapts stand-up or busking scripts as a key agenda for responsible research and innovation (Owen et al., 2012; Heras and Ruiz-Mallen 2017), focusing on motivation for STEM work, breaking down stereotypes in science, highlighting ethical issues, overcoming social challenges, and hindering gender differences in science.

***(2) STEM Education based on Dialogue and Community***

Secondly, another effective emerging STEM education pedagogy is to frame STEM education as a dialogue between formal and informal communities, which ought to be established in an informal science education environment in the community, a more formal study of science in universities, combined with efficient knowledge production based on the constructive partnership between multiple stakeholders in the STEM field. Besides, in this communist model of STEM education, conversational understanding takes on special significance, both in the context of community relations and in the approaches to STEM education adopted in education institutions.

***(3) Vocational Exchanges at Different Levels assist STEM Education***

Thirdly, internationally, there are explorations of STEM teaching strategies that require the vocational exchanges of STEM knowledge and abilities at different levels. For example, in the UK, the ASE website provides information and activities to communicate STEM careers, which involve multiple stakeholders' diverse facilitating activities, like providing basic information about STEM careers, improving career profiles and interviews with STEM professionals, updating STEM career posters, selecting STEM ambassadors, and collecting STEM insights from all sectors in society.

***(4) STEM Textbooks that take Teachers into Consideration***

Fourthly, teacher preparation for STEM education should also be considered a fundamental component of STEM education. For example, in UK schools, Bell (2012) found that STEM education does not have a planned impact because many teachers are not aware of existing STEM efforts and are unsure what they can contribute to students' better understanding and learning of STEM subjects even if several organizations and the Ministry of Education in the UK has developed educational materials to assist teachers in teaching from a STEM perspective. Therefore, in order to engage teachers in STEM education goals, it is of great necessity to take teachers' understanding and recognition perspectives into the STEM textbooks' compilation.

***Trust Delivery Pathway for Employer Involvement in STEM Education***

In the UK, the delivery of employer participation related to STEM education activities takes place primarily through three delivery routes, especially primarily through national intermediaries, in particular via three trusts. The first is the Engineering Development Trust (EDT). About half of EDT's income comes from employer donations and one-sixth from school fees. EDT specializes in activity days, curricular-focused in-company educational experiences, semester-long themed programs, STEM college courses for older students, and one-year paid internships.

The second representative one is the Industrial Trust, which focuses on enabling young people aged 13 to 17 to work with engineers and technical experts from the industry. The third one is the Smallpeice Trust, which is committed to enabling juveniles aged 13 to 17 to work with engineers and technical experts from the STEM industry.

**Result Analysis: Multiple Stakeholders and Suggestions for STEM Education in China**

This chapter firstly analyses several notable aspects involving multiple stakeholders including STEM employment support, public perceptions, female career empowerment, and families' influence based on the international comparative analysis in chapter III, and proposes suggestions for future STEM education enhancement accordingly subsequently.

***Employer Involvement in STEM Education***

In terms of experience in the UK, employer engagement is the main means of increasing STEM enrolment and achievement, and this model of the labor market and STEM education inclusion could be a reference to the STEM reform strategy in China. Moreover, the long-term reform progress of STEM subjects ought to take into account three key principles. The first emphasis is efficiency, which means minimizing the cost of connecting employers and employees with schools and students to build a close connection and frequent exchanges. Besides, the second focus is effectiveness, which aims to increase young people's understanding of current and future labor market opportunities through employer engagement. Finally, an important goal is equity, which should make sure that young people whose families are not conducive to science capital can equally take advantage of the favorable STEM education and career development resources by participating in activities that support STEM learning for making progress.

***Public Perceptions and Attitudes towards Science, Economics, Well-being, and Careers in Science in the UK***

The second experience that is constructive to China's STEM education is the UK's efforts in the public attitude to STEM education. Flash Eurobarometer (2008) illustrates the research results on "Young People and Science", which shows that in the UK, less than a third of respondents are interested in studying engineering (28 percent), science (25 percent), or math (24 percent), and only 4% of respondents said they would definitely study Sciences. Moreover, this survey implies that the specific connection between science and the economy seems less clear to the surveyed public. There is limited public awareness of how the linkage between science and business might work or wonder how science might create transformative jobs (Villanueva, Marimon & González, 2020).

***Focus on the Cultivation of Girls' STEM Interests and Vocational Empowerment***

The third notable measure is the empowerment of female STEM education. According to research, significant gender differences are associated with future career preferences (Littledyke 2008). Boys are more interested in engineering and math than girls, while girls often believe they are could not have a good command of learning engineering, biology or medical skills. Moreover, similar circumstances go for Spain (Sainz 2011). Despite the fact that science itself involves curiosity, creativity and imagination, young people in Europe, especially girls, still perceive the complexity of science as a barrier and that careers in science are useless and unprofitable, which may discourage them from pursuing research in scientific fields (Kahle et al. 1993).

***(4) Emphasis on Parents and Families' influence on Students' STEM Career Choice***

Fourthly, the importance of parents and families in influencing students' career choices is often overlooked. With many adults fearful of or simply unaware of STEM subjects, governments, schools, and other institutions should consider how to raise awareness and confidence in STEM careers among parents. Informal STEM

learning activities, such as clubs and visits, should be more explicitly linked to the stimulation of learners and their parents' interests. Thus, there should be more opportunities for enrichment and improvement in mathematics, design, technology, engineering, etc.

## Conclusion

In conclusion, according to the above discussion of international comparative STEM education, the author proposes suggestions on four aspects of STEM education enhancement in China:

- Firstly, STEM education should equip learners with the necessary critical thinking and analytical skills, like guiding students to think deeply and independently, along with integrating and developing basic literacy of language and Mathematics to support scientific analysis.
- Second, interdisciplinary integration is of vital significance, like the basic subjects of STEM education should be formally integrated into the curriculum of engineering education. Meanwhile, it is also necessary to cultivate teachers' and students' computing thinking with educational technologies like artificial intelligence education.
- The third pivotal aspect is STEM teacher education. On one hand, there is a need to strengthen STEM teacher education research to improve the STEM teacher education quality with a high standard. Also, schools' STEM education reform in teaching practices needs the support of localized STEM education research to adapt to the local talent needed in regional industries. On the other hand, the teacher education institutions need to expand the enrollment of STEM teacher education, and which should be supported by the national technological competence strategies and educational policies made by administrations.
- Last but not the least, the fundamental support should rely on the STEM policy transformation. STEM education reform in China needs a legislative guarantee from the National People's Congress in order to promote STEM education from elite education to mass education as a common good and mutual curriculum.

## References

Flash Eurobarometer. (2008). *Young people and science, series n 239*. The Gallup Organisation.

Heras, M., & Ruiz-Mallén, I. (2017). Responsible research and innovation indicators for science education assessment: how to measure the impact? *International Journal of Science Education*, *39*(18), 2482–2507.

Kahle, J. B., Parker, L. H., Rennie, L. J., & Riley, D. (1993). Gender differences in science education: building a model. *Educational Psychologist*, *28*, 379–404.

Lee, B. K., Patall, E. A., Cawthon, S. W., & Steingut, R. R. (2015). The effect of drama-based pedagogy on PreK-16 outcomes: a meta-analysis of research from 1985 to 2012. *Review of Educational Research*, *85*(1), 3–49.

Littledyke, M. (2008). Science education for environmental awareness: approaches to integrating cognitive and affective domains. *Environmental Education Research*, *14*(1), 1–17.

Owen, R., Macnaghten, P., & Stilgoe, J. (2012). Responsible research and innovation: from science in society to science for society, with society. *Science and Public Policy*, *39*(6), 751–776.

Spencer, H. (1884). *What knowledge is of most worth* (Vol. 3, No. 138). JB Alden.

Sainz, M. (2011). Factors which influence girls' orientations to ICT subjects in schools. Evidence from Spain. *International Journal of Gender, Science and Technology*, *3*(2), 387–406.

Villanueva Baselga, S., Marimon Garrido, O., & González Burón, H. (2020). Drama-based activities for STEM education: encouraging scientific aspirations and debunking stereotypes in secondary school students in Spain and the UK. *Research In Science Education*, 1-18.

# Sustainable Marble Mining and Environment

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**Abstract**: In history, the need for urbanization has arisen with the beginning of collective living of humanity. Mining activities gained a different dimension with this urbanization. The use of marble has been important since then. The use of marble is very common in historical buildings in many parts of the world. This shows that the knowledge of human beings about marble mining is quite deep-rooted. With the increasing world population and industrialization, environmental problems are also increasing. One of the most important reasons for this situation is mining activities. Due to the activities that cause environmental destruction all over the world and the increase in sensitivity to environmental issues, mining-related projects come to the public agenda much more frequently. Irresponsible mining activities cause irreversible damage to the environment. At the same time, the sustainable implementation of these activities is very useful and necessary in meeting the present needs of people. In this study, the current situation regarding sustainable activities for today's marble mining will be presented in detail..

**Keywords:** Environment, marble, sustainable mining, Turkey

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## Introduction

The first step of humanity to civilization in history actually starts with mining. The history of the use of natural stone and marble goes back to ancient times, when humanity began to live collectively and cities were formed. The prevalence of the use of marble and natural stone in historical buildings located in many parts of the world today draws attention as the first architectural element that stands out. This shows that humanity has very old and deep-rooted experiences in the works of obtaining marble and natural stone. However, the dimensions of this mining activity carried out in the past centuries are quite small compared to those of the current century (Bilgin, 2013).

The first step of humanity to civilization in history actually starts with mining. The history of the use of natural stone and marble goes back to ancient times, when humanity began to live collectively and cities were formed. The prevalence of the use of marble and natural stone in historical buildings located in many parts of the world today draws attention as the first architectural element that stands out. This shows that humanity has very old and deep-rooted experiences in the works of obtaining marble and natural stone. However, the dimensions of this mining activity carried out in the past centuries are quite small compared to those of the current century. The rapid increase in the world population has brought along the high demand for raw materials (Kocabağ, 2018). Accordingly, urbanization and the growth in the construction sector increase the use of marble. Although many countries around the world produce in this sector, our country has a great potential in this field and is one of the few countries in the world in terms of marble and natural stone production. There are important natural stone and marble reserves in many provinces and production is carried out in opened quarries.

## Marble industry in Turkey

According to General Directorate of Mineral Research and Exploration (MTA) reports in Turkey, Turkey has 40% of the world's marble potential with its 5 billion m³ marble reserves. With a total reserve of 13.9 billion tons (approximately 5.1 billion m³), Turkey's apparent reserve of around 1.6 billion tons is at a level that can meet world consumption for 80 years at its current pace. Marble reserves of over 80 different structures and more than 120 different colours and patterns have been identified in Turkey. Turkey has significant marble reserves within the natural stone subgroup in terms of mineral assets. In Turkey, where marbles of many types, colours, patterns and quality are extracted, most of the reserve is located in Afyonkarahisar, Balıkesir, Muğla, Eskişehir, Denizli, Elazığ, Tokat, Çanakkale, Konya, Bilecik and Kırşehir. and operates in the field of natural stone/marble processing in many medium-sized enterprises (WP, 2022).

Marble mining, like all mining operations, processes non-renewable assets and causes permanent changes in nature that cannot be reinstated. It is possible to cause irreparable damage (Taş and Çakır, 2015). For him, working with a sustainable responsible mining approach and corporate Social Responsibility approach is perhaps more important than any other sector. Marble mining causes dust, noise, water and solid waste pollution on the environment as well as disrupting the natural environment, changing the topographic structure, destroying biological habitats and damaging biological diversity (Rizzo et al., 2018).

## Sustainable Development and Mining

Sustainable development, within the scope of realizing the human development goals; it is a development approach based on the sustainability of natural resources that enable the environment, economy and society to be handled in a balance and human activities. It is necessary to properly use the existing mineral resources that we have. In countries where these resources are not used, impoverishment and the lack of resources for future generations is a normal result. The continuous increase in mining projects in a country will provide national

income, foreign capital inflow, employment, the development of new technologies, education, electricity, water, roads and the formation of new settlement areas. In short, mining activities carried out with the awareness of responsibilities will create an environment for the economic and social enrichment and development of that country.

Today, South Africa, Canada, Australia, Chile, USA, Sweden etc. Countries like these are the best examples of sustainable mining. Turkey, which is rich in underground resources with appropriate policies, carries out mining activities at the level of these countries, increasing day by day.

After the World Sustainable Development Summit held in Johannesburg in 2002, the Intergovernmental Forum on Mining, Minerals and Metals and Sustainable Development (IGF) was established by countries that consider mining to be important for their economies. IGF is a voluntary cooperation platform recognized by the UN and managed by its members. 79 countries are members (Fig. 1) (IGF, 2013). In the IGF, as a guide to the mining institutions of the member states, it has established principles on what should be done at every stage of mining, including the exploration of the mine, the closure of the facility after the end of the reserve, and the rehabilitation and reintroduction of old mining sites, and it encourages the member states for sustainable mining.

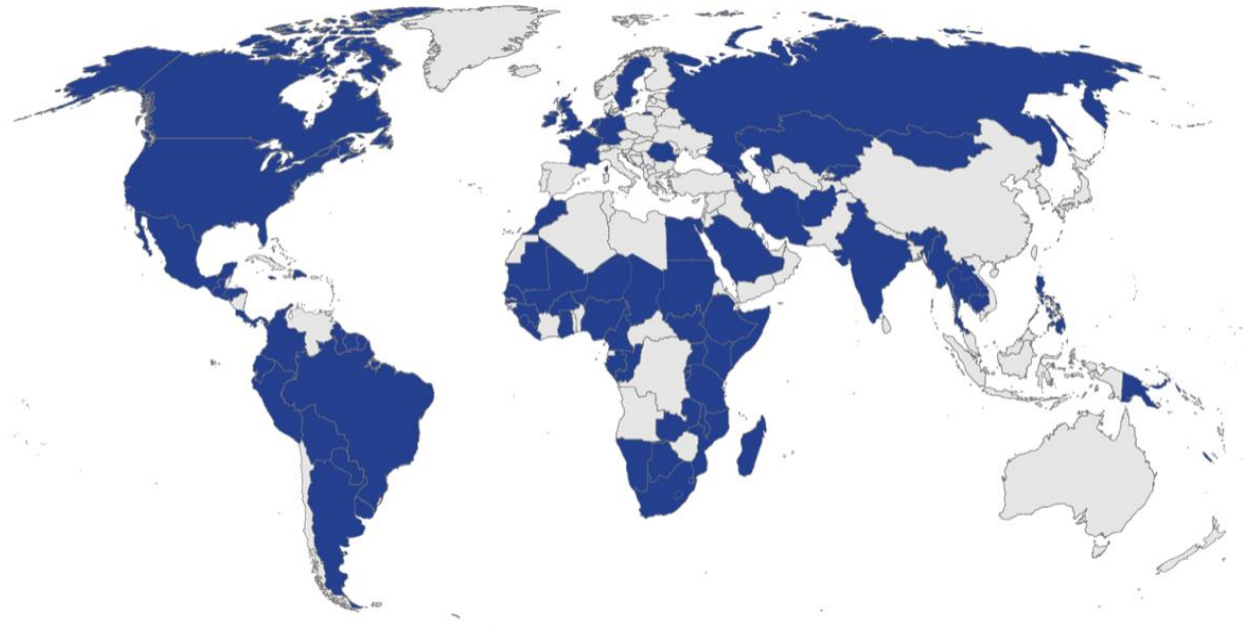

Figure 1. IGF Member Countries

Apart from these international platforms, many national mining organizations have also prepared guidelines and principles regarding sustainable mining for member companies to comply with. These include the Australian Minerals Council's Sustainable Enduring Values Guide (MCA, 2005) and the Mining Association of Canada-MAC's Towards Sustainable Mining (TSM) Principles (MAC, 2015) can be cited.

**Evaluation of Marble Waste**

Marble mining causes dust, noise, water and solid waste pollution on the environment as well as destroying the natural environment, changing the topographic structure, destroying biological habitats and damaging biological diversity. In marble mining, solid marble waste is generated at two stages of operation: during the block extraction process in the quarry and during the processing of the marble block to convert it into advanced products. The amount of waste generated during the quarry operation phase depends on the type of rock, the geology and morphology of the marble bed, the crystal structure and texture of the rock, the suitability of the selected operating method and operating tools, etc. It varies according to factors and can reach quite high rates.

Regarding the evaluation of marble waste, it is seen that the possibility of using it in many different areas has been investigated even when looking at the literature available only from the internet. According to literature data piece marble wastes:

- Retaining walls, erosion and slope slopes and bridge foot controls,
- Road foundation material,
- Flood prevention and improvement of stream beds,
- Concrete brick (briquette) production,
- Aggregate production,
- Landscape stone.

Powder marble wastes;

- Substitution for cement in concrete,
- Substitution for fine sand in concrete,
- Developing the geotechnical properties of clay soils,
- Aerated concrete production.
- Ceramic Brick production,
- As a floor covering in landfills,

It is used. In addition to these, the wastes of the marble industry include plastic, paint, paper, ceramics, etc. used in industries.

**Main Problems in Sustainable Development**

The subject of sustainable development generally covers social, economic and environmental problems. However, problems may arise in terms of project design and continuity. If we give the subjects to be studied under the main headings:

Poverty: Most mineral-rich countries are either underdeveloped or developing countries. Developing countries have to create the necessary infrastructure conditions in order to attract mining investments to

their countries.

Land Use: Mines are only in certain locations and on-site production is required. Therefore, mining companies should be able to easily reach these areas in order to find and operate the mine, and they should carry out mining activities without causing environmental destruction.

Society: The mining activity needs to distribute sustainable development to people in the surrounding area. It is a very important issue for the people of the region and indirectly for the country.

Market Situation: Strategies should be determined not to leave the costs of our current incomes to the next generations. If metals and minerals are to be a part of a sustainable future, attention should also be paid to how they will be produced, how they will be processed and used, and how they will be recycled and waste management.

Financial: Investments in mining activities are on-the-spot investments and require long-term and large financial expenditures. In this regard, it is important for the state to engage in encouraging practices.

Management: Consideration should be given to how mining activities will be conducted without harming the natural environment. Rules and boundary conditions must be observed within the legal framework.

Non-Governmental Organizations-NGO's: It should be taken as a basis that the production and research projects in the mines are not stopped, that the economy is not harmed and that irreversible damage is not done to the environment. In this context, companies engaged in mining activities should cooperate with non-governmental organizations and the state.

The state, mining companies and society have to develop, comply with and protect an economic, social and environmental management model in order to make a permanent and sustainable investment and business today. The biggest responsibility in this regard is the state, which is the rule maker and implementer, but mining companies must also have a sustainable mining policy. Many mining companies working seriously in today's mining have a sustainable mining policy. To give an example of this;

- To create the administrative structure that will use the financial resources of the mining company in the best and correct way,
- Establishing good relations with the people in the region, gaining their trust and distributing the economic gain to the social environment in the most appropriate way,
- Not harming the environment while using the mine in the best way and providing maximum gain,
- Adding new resources to existing resources, increasing the value of the company and leaving resources to future generations,
- To protect the safety and health of everyone working in the mine site,
- Implementing and developing the latest technologies. By using and developing new technologies, it can increase the recovery efficiency and make it possible to operate low-grade fields,
- To make it possible to reuse old mine wastes with economic and technological methods.

## Conclusions

Sustainable mining is now a necessity rather than a choice. Every non-renewable resource we operate inefficiently and every material we throw away in the business process means that the right to live of future generations has been stolen. For this reason, starting from the exploration stage in marble business, it should be aimed to use the appropriate engineering methods and tools and to operate the resources with minimum waste and to bring them into the economy (Kocabağ, 2018).

In addition to the effort to minimize the waste rate in the management process, although it is obligatory to dispose of the waste in a way that causes the least harm to the environment, the most important thing is to bring the wastes back into the economy. Although there are different applications where marble waste can be used, the main problem here is how to economically bring together the waste producer and the waste user, rather than whether it is possible. In this regard, when we look at the current situation of the marble sector, the scattered structure of the sector and the fact that the companies in the sector are mostly small and medium-sized companies, it is necessary to organize the sector in order to collect the wastes economically in order to evaluate the wastes efficiently.

In summary, it is a must to benefit from natural resources for sustainable development. This is an inevitable reality in the model of increasing world population and especially in a developing country like Turkey. In today's global world, all mines can be operated responsibly and sensitively to society and the environment. What the industry and the government should do is to constantly promote modern mining, explain its benefits and inform every segment of the society. In this regard, the state, in particular, should be responsible for really wanting sustainable mining, creating economic and social development in this area and ensuring its permanence. It should be followed whether non-governmental organizations, local people and mining companies act together and provide economic and environmental awareness. Mining companies should take into account the social and environmental factors and operate the existing mineral reserves with the best profitability.

## References

Bilgin, Ö. & Koç, E. (2013). Mermer Madenciliğinde Çevresel Etkiler, *Madencilik Türkiye Dergisi*, *28*, 68-79.

IGF, Mining Policy Framework-Mining and Sustainable Development, (2013), *Sustinable marble mining*, 13.10.2022, http://igfmining.org/wp-content/uploads/2017/02/MPF-English-Oct-2013.pdf

Kocabağ, D. (2018). Sürdürülebilir madencilik bağlamında mermer sanayi ve mermer atıklarının değerlendirilmesi. *Muğla Büyükşehir Belediyesi Kültür Yayınları – 6*, *1*, 51-92.

MCA, The Mineral Council of Australia, (2005). Enduring Value, *The Australian Mineral Industry Framework for Sustainable Development*, 14.10.2022, http://www.minerals.org.au/file_upload/files/resources/enduring_value/EV_Summ ary Booklet_June 2005.pdf

MAC, The Mining Association of Canada, (2015). *Towards Sustainable Mining 101: A Primer*, 14.10.2022. http://mining.ca/sites/default/files/documents/ TSM_Primer_March_2015.pdf

Rizzo, G., D'Agostino, E. F. & Ercoli, E. L. (2018). Problems of soil and groundwater pollution in the disposal of marble slurries in NW Sicily, *Environmental Geology*, *55*, 929–935.

Taş, B. & Çakır, M. (2015). İscehisar ilçesinde mermer sanayisi ve çevre sorunları, *Doğu Coğrafya Dergisi*, *20*(34), 25-34.

*WP (2022). Wikipedia, Türkiye'de mermer sektörü, 14.10.2022,* https://tr.wikipedia.org/wiki/Türkiye%27de_mermer_sektörü

# The Willingness to Pay on Indonesian Fashion Longevity Using Structural Equation Modelling Post Pandemic

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**Abstract**: The need for fashion products is never-ending. Consumers' willingness to buy fashion products depends on quality, design trends, brand, and price. This study wants to find what parameters have a significant effect on the willingness to buy a product after COVID-19. The objects studied were Muslim clothing products with the DP and HU brands. This study uses the structural equation modelling method, with 50 adult Muslim women as respondents. All respondents were regular customers at the two Muslim clothing brand counters DP and HU. The results showed that product quality did not have a significant effect on purchase intention. The design trend is proven to have a significant effect on willingness to pay. Interestingly, the brand and price do not significantly affect purchase intention, even though this study's respondents were regular customers of the two brands' case study. For buyers, the design model is the main parameter in choosing a product.

**Keywords:** design, fashion, longevity, post pandemic

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## Introduction

The need for fashion products has become one primary human need. Fashion is defined as an appearance that is recognized and categorized as low obviousness, high impulse buying, shorter life cycle, and high instability of market demand. Therefore, to be moneymaking in the industry, fashion is essential to take the 'speediness to market' tactic on fashion trends that differ from competitors (Bhardwaj and Fairhurst, 2010). Consumers choose fashion based on quality, design trends, brands, and prices (Yu, Hudders and Cauberghe, 2018; Novotova, 2016). The development of the design product needs to recognize consumer's voices (Cooper, 2018). Design

Muslim fashion in Indonesia is quite promising. Fashion business development can come from the sales data, which always increases from year to year. However, the competition for the Muslim fashion industry in Indonesia is very tight. Trend factors, innovation, and creativity need considering in the development of increasingly varied Muslim clothing products (Dewi, Syairudin and Nikmah, 2015; Zennouche, Zhang and Bo, 2014). However, for the fashion industry, parameters are needed that significantly influence consumer decisions to buy their products in order to survive in the market (Goworek *et al.*, 2018; Meraviglia, 2018; Unger and Eppinger, 2011).

This study aims to find out what parameters significantly impact the willingness to buy fashion products. This study involved two well-known Muslim clothing brands, namely DP and HU. We hide these two brands to maintain the neutrality of the research. The pattern of selling Muslim clothes, which has begun to shift from offline sales to online sales, has quite an impact on today's consumer buying styles (Acharya *et al.*, 2018; Guercini, Bernal and Prentice, 2018). Besides, the proliferation of e-commerce-based Muslim clothing sales also impacts offline sales (Guercini, Bernal and Prentice, 2018). Fashion manufacturers' decisions must be fast and precise, considering that fashion products are types of products that have a short life span or are quickly obsolete due to exhausting trends or consumer boredom (Philip, Anian and Raja, 2020; Bonnefoi, 2012). Fashion products usually identical to brands. With well-known brands, the selling price will be more expensive (Kabukcu, 2016).

Is it true that brand parameters still the standard for buying decisions? Other parameters such as quality, trend, or price on which consumers buy fashion products in Indonesia are still important? This study is only limited to the necessary parameters: brand, price, quality, and trend. Meanwhile, additional parameters for online sales, such as delivery speed, packaging quality, and product suitability with images in e-commerce (Saha, Zhuang and Li, 2020), are not discussed in this study.

## Method

This study uses purposeful sampling (Koerber and McMichael, 2008). The respondent criteria are that they have become customers of the DP and HU brands. Accustomed to making online and offline purchases for Muslim clothes, including the DP and HU brands. The number of samples used in this study is one hundred Muslim women, ranging in age from 20 to 60 years. In this study, the data collection method used was a questionnaire—collecting data by using questionnaires through forms containing questions and submitted in writing to respondents. The list of questions in this study used closed questions.

The variables analyzed are the dependent variable or dependent variable (Y), which includes Willingness to Pay Premium, and the independent variable or independent variable (X) includes product quality, trend, brand, and price. The research data analysis method in this fashion business case used the Structural Equation Modeling (SEM). The SEM analysis step of the measurement model or outer model describes any relationship between

latent variables and their manifest variables. The software used is WarpPLS version 5.0. The measurement model for consumer respondents HU and DP are in Figure 1.

The questionnaire is closed using five alternative answers containing quality, trend, brand, and price statements. The questionnaires were distributed to one hundred respondents for purpose sampling through the google form application via the WhatsApp link. Respondents selected were adult Muslim women, online and offline customers for DP and HU brands. This selection is essential to get a valid opinion about women's Muslim clothing products in Indonesia.

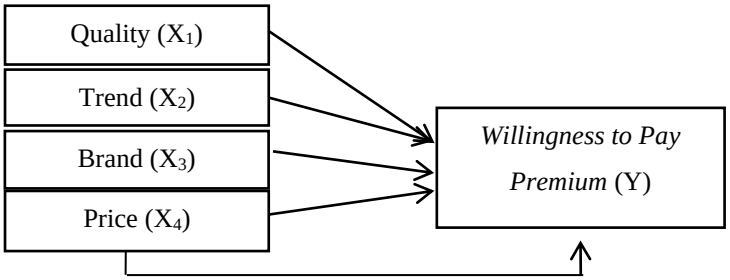


Figure 1. Design of the Research Model

SEM steps are as follows the evaluation of the measurement model (outer model) and structural model (inner model). The outer model consists of:

1. Indicator reliability, shows how many variants of indicators can be explained by latent variables by taking into account the loading factor value> 0.6. The higher the outer loading value of a construct indicates that the indicators in the construct have a lot in common. This characteristic is called an indicator of reliability.
2. Convergent validity, generally checked with average variance extracted (AVE).

The inner model consists of:

1. Determine the value of the path coefficient, which is standardized with a value range of -1 to +1. The path coefficient value that is close to the value of +1 indicates a strong positive relationship, whereas if the value is close to -1 it indicates a strong negative relationship.
2. Inner model analysis can be evaluated by using R-square for the dependent construct. In addition to seeing the R-square value, the PLS (Partial Least Square) model is also evaluated by looking at the predictive relevance Q-square value for the constructive model.

## Results

Factor loading is the initial stage in testing the validity of a model, the condition for the loading factor is that it must be> 0.6 which is less than 0.6 which is not used (Arifin and Yusoff, 2016). To find out the analysis of the outer model of this research, it can be seen in Table 1.

Table 1 shows that the loading factor of more than 0.6 for the quality variable (X1) is X1.2 and X1.4. The trend variable (X2) which fulfills the conditions is X2.1. The brand variables (X3) are X3.1 and X3.4. and the price variables that meet the requirements are X4.3 and X4.4. Convergent validity is used to obtain a value based on the correlation between the component / indicator value and the construct value. In this study, the expected average variances extracted value is> 0.5 but if the AVE value is below 0.5 but the CR value is above 0.6 then the data is still acceptable (Lam, 2012). The results of the average variances extracted (AVE) and Composite Reliability (CR) values can be seen in Table 2.

Table.1 Outer Model Algorithm Results

| | X1 | X2 | X3 | X4 | Y | SE | P value |
|---|---|---|---|---|---|---|---|
| **X1.1** | (-0.150) | 0.171 | 0.257 | -0.091 | -0.118 | 0.096 | 0.060 |
| **X1.2** | (0.730) | -0.166 | 0.038 | -0.135 | 0.162 | 0.082 | <0.001 |
| **X1.3** | (0.098) | 0.136 | -0.028 | 0.437 | 0.026 | 0.097 | 0.158 |
| **X1.4** | (0.802) | 0.167 | 0.017 | 0.053 | -0.173 | 0.080 | <0.001 |
| **X2.1** | -0.012 | (0.619) | -0.042 | 0.288 | 0.146 | 0.085 | <0.001 |
| **X2.2** | 0.327 | (0.560) | -0.100 | -0.197 | -0.030 | 0.086 | <0.001 |
| **X2.3** | 0.275 | (-0.640) | -0.128 | 0.106 | 0.115 | 0.084 | <0.001 |
| **X3.1** | -0.081 | -0.041 | (0.764) | 0.099 | 0.066 | 0.081 | <0.001 |
| **X3.2** | 0.030 | 0.035 | (0.011) | 0.457 | -0.465 | 0.100 | 0.455 |
| **X3.3** | 0.112 | 0.318 | (0.538) | 0.078 | -0.103 | 0.086 | <0.001 |
| **X3.4** | 0.002 | -0.177 | (0.792) | -0.155 | 0.013 | 0.081 | <0.001 |
| **X4.1** | 0.011 | -0.125 | -0.037 | (0.568) | -0.145 | 0.086 | <0.001 |
| **X4.2** | 0.015 | -0.156 | 0.219 | (0.268) | -0.000 | 0.093 | 0.002 |
| **X4.3** | 0.050 | 0.015 | -0.026 | (0.832) | 0.181 | 0.080 | <0.001 |
| **X4.4** | -0.078 | 0.150 | -0.023 | (0.672) | -0.101 | 0.083 | <0.001 |
| **Y1.1** | 0.262 | -0.028 | 0.016 | 0.071 | (-0.702) | 0.083 | <0.001 |
| **Y1.2** | -0.113 | -0.193 | -0.025 | 0.553 | (-0.281) | 0.093 | 0.002 |
| **Y1.3** | -0.098 | -0.177 | -0.087 | 0.188 | (0.603) | 0.085 | <0.001 |
| **Y1.4** | 0.367 | 0.057 | 0.100 | 0.159 | (0.575) | 0.086 | <0.001 |

Table 2 shows the results of the calculation of Average Variances Extracted (AVE) and Composite Reliability (CR). In this study, the expected average variances extracted was> 0.5. From the calculation of the highest AVE is the variable price with an AVE value of 0.385 and the willingness to pay is 0.317 so that no one reaches the expected AVE point. In the price variable, it appears that the CR value is 0.690 with willingness to pay is 0.014. From the calculation of CR that meets the requirements of more than 0.6 is the variable price, namely 0.69. AVE is under 0.5, however composite reliability is higher than 0.6, the convergent validity of the construct is still acceptable (Lam, 2012).

Table 2. Results of Average Variances Extracted (AVE), Composite Reliability (CR)

| **Variable** | **AVE** | **CR** |
|---|---|---|
| **X1 (Quality)** | 0.302 | 0.439 |
| **X2 (Trend)** | 0.369 | 0.133 |
| **X3 (Brand)** | 0.375 | 0.639 |
| **X4 (Price)** | 0.385 | 0.690 |
| **Y (*Willingness To Pay*)** | 0.317 | 0.014 |

The structural model or inner model describes the relationship model between latent variables which is formed based on the substance of the R-Square theory. R-Square is used to measure the success rate of the regression model we use in predicting the value of the dependent variable. The determination of R squared which shows several percentages of the variance of endogenous constructs can be explained by the construct which is hypothesized to influence it (exogenously) the higher the R squared, the better. Requirements that must be on the q square test are 0.02 (small), 0.15 (moderate) and 0.35 (large). The value of Q squared must be greater than 0 (zero), the calculation for Q squared 0.129. This means that the predictive validity model estimate is small, which is more than 0.02. It can be concluded that the variables used have a fairly good effect.

Table 3. Results of the R-Square Inner Model and Q-square

| | R-Square | | | | *Q-squared* |
|---|---|---|---|---|---|
| | X1 | X2 | X3 | X4 | |
| Y | 0.001 | 0.038 | 0.025 | 0.011 | 0.129 |

To make a decision, which variable has an effect on willingness to pay, is shown in Table 4. The basis for the decision is that p-value> 0.05, then H0 is accepted, while H1 is rejected, and p-value <0.05, then H0 is rejected and H1 is accepted.

Table 4. Direct Effect Estimation Result Output

| Hypothesis | Path Coefficients | P-Value | Information |
|---|---|---|---|
| Product quality to willingness to pay | 0.020 | 0.421 | Not significant |
| Trend to willingness to pay | 0.187 | 0.026 | Significant |
| Brand to willingness to pay | -0.149 | 0.062 | Not significant |
| Price to willingness to pay | 0.082 | 0.202 | Not significant |

The estimation results of the path coefficients to test the strength of the direct influence between the predictor variables on the criteria without the role of the mediating variable. The basis for the decision is that the p-value is> 0.05, then H0 is accepted, while H1 is rejected, and the p-value is <0.05, then H0 is rejected and H1 is accepted. The p-value of the product quality variable against willingness to pay is 0.421 (above the value of

0.05), so H0 is accepted and H1 is rejected with a path coefficient value of -0.020. It means that the price quality variable has no effect on willingness to pay. The p-value of the brand variable for willingness to pay is 0.026 (above the value of 0.05), so H0 is rejected and H1 is accepted with a path coefficient value of 0.187. It means that the trend variable has an influence on willingness to pay.

The p-value of the trend variable for willingness to pay is 0.062 (above the value of 0.05), so H0 is accepted and H1 is rejected with a path coefficient value of -0.149. It means that the brand variable has no influence on willingness to pay. The p-value of the price variable for willingness to pay is 0.202 (above the value of 0.05), so H0 is accepted and H1 is rejected with a path coefficient value of 0.082. It means that the price variable has no influence on willingness to pay. Of the four variables, it turns out that the trend variable has a significant effect on willingness to buy.

## Discussion

This study's results indicate that the variable that most influences willingness to buy is the trend. This result supported previous study trends that affected in young customers (Gazzola *et al.*, 2020). Even though the respondents are regular customers of both brands, it turns out that if the two brands are not provided with products that are in line with the trend, they will not hesitate to choose another brand. This study's findings are different from the previous one. Namely, the indicator that affects customer satisfaction is performance (Ningsi, 2018).

In this study, the brand variable did not have a significant impact on the willingness to buy. This is different from previous studies of fashion, which states that brands affect purchase intention as an unfunctional factor (Akturan and Bozbay, 2018; Joy *et al.*, 2012; Acharya *et al.*, 2018). However, in the previous research, the brands used as the basis of the research were global brands, whereas, in this study, the brands used were original Indonesian local brands. Even though the two brands were well-known in Indonesia, they did not significantly impact consumer buying intentions.

The study conducted tried to explore a different side from previous research, although the trend variable only distinguished it. This study gives a surprise that even though you have become a customer of a well-known brand, it turns out that the variable that has a significant influence and becomes the basis for the decision to buy Muslim clothes is a trend factor—brand as the decision to buy Muslim clothes to global brands (Akturan and Bozbay, 2018; Netemeyer *et al.*, 2004). Interestingly, in this study, it turns out that Indonesian consumers, for local Muslim clothing brands in Indonesia, are not an essential factor. Trends can be created by Muslim clothing manufacturers, especially Indonesia Muslim fashion, which has an Islamic spiritual business (Kurt *et al.*, 2020). While brands management did not build only on prestige, but building a brand is the same as developing trust, culture, and business systems (Beltrami, Kim and Rolkens, 2020; Wang, 2016). Trust is currently also dominated by mobile technology and consumer reviews. Even potential consumers trust reviews more than

advertisements (Park, Lee and Han, 2007; Filieri, 2015; Mehta and Pandya, 2020).

## Conclusion

This study proves that the trend variable has more impact on willingness to pay than the variable brand, price, and quality. This similar result in hijab studies was also has been conducted in 2015 (Dewi, Syairudin and Nikmah, 2015). This study shows that although the Muslim clothing products purchased are branded products, the brand is not an important variable in making a buying decision. For consumers, design trends are more important than the other three variables. This study shows that Indonesian consumers are based on trends or fast fashion consumption ( Cavender, 2018). The price variable turns out to be not the main factor. Even the brand has become one variable for customers will pay more expensive (Netemeyer *et al.*, 2004). Buyers are willing to pay more if the wanted product is following the current trend. Meanwhile, the quality factor is also not a significant factor.

This study has limitations. It only examines trends, price, quality, and brand variables. Many gaps can be explored, such as variable delivery, service, the interaction between sellers and buyers, which can be used as development studies. This study of willingness to pay only examines two local brands, Muslim clothing in Indonesia. Future research can be developed with brand equity, compared to other Muslim clothes, with global brands.

## References

Acharya, A. *et al.* (2018). Big data, knowledge co-creation and decision making in fashion industry. *International Journal of Information Management*, 42(July), pp. 90–101. doi: 10.1016/j.ijinfomgt.2018.06.008.

Akturan, U. and Bozbay, Z. (2018). Attractiveness, Purchase Intention, and Willingness to Pay More for Global Brands: Evidence from Turkish Market. *Journal of Promotion Management*, 24(6), pp. 737–754. doi: 10.1080/10496491.2017.1408522.

Arifin, W. N. and Yusoff, M. S. B. (2016). Confirmatory Factor Analysis of the Universiti Sains Malaysia Emotional Quotient Inventory Among Medical Students in Malaysia. *SAGE Open*, 6(2). doi: 10.1177/2158244016650240.

Beltrami, M., Kim, D. and Rolkens, F. (2020). *The State of Fashion 2020*, *McKinsey&Company*. McKinsey & Company.

Bhardwaj, V. and Fairhurst, A. (2010). Fast fashion: Response to changes in the fashion industry. *International Review of Retail, Distribution and Consumer Research*, 20(1), pp. 165–173. doi: 10.1080/09593960903498300.

Bonnefoi, T. (2012). Demand Forecast for Short Life Cycle Products: Zara Case Study. pp. 1–15.

Carol Cavender, R. (2018). Exploring the Influence of Sustainability Knowledge and Orientation to Slow

Consumption on Fashion Leaders' Drivers of Fast Fashion Avoidance. *American Journal of Theoretical and Applied Business*, 4(3), p. 90. doi: 10.11648/j.ajtab.20180403.12.

Cooper, R. G. (2018). The drivers of success in new-product development. *Industrial Marketing Management*, (January), pp. 1–12. doi: 10.1016/j.indmarman.2018.07.005.

Dewi, D. S., Syairudin, B. and Nikmah, E. N. (2015). Risk Management in New Product Development Process for Fashion Industry: Case Study in Hijab Industry. *Procedia Manufacturing*, 4(Iess), pp. 383–391. doi: 10.1016/j.promfg.2015.11.054.

Filieri, R. (2015). What makes online reviews helpful? A diagnosticity-adoption framework to explain informational and normative influences in e-WOM. *Journal of Business Research*, 68(6), pp. 1261–1270. doi: 10.1016/j.jbusres.2014.11.006.

Gazzola, P. *et al.* (2020). Trends in the fashion industry. The perception of sustainability and circular economy: A gender/generation quantitative approach. *Sustainability (Switzerland)*, 12(7), pp. 1–19. doi: 10.3390/su12072809.

Goworek, H. *et al.* (2018). Managing sustainability in the fashion business: Challenges in product development for clothing longevity in the UK. *Journal of Business Research*, (July), pp. 0–1. doi: 10.1016/j.jbusres.2018.07.021.

Guercini, S., Bernal, P. M. and Prentice, C. (2018). New marketing in fashion e-commerce. *Journal of Global Fashion Marketing*, 9(1), pp. 1–8. doi: 10.1080/20932685.2018.1407018.

Joy, A. *et al.* (2012). Fast fashion, sustainability, and the ethical appeal of luxury brands. *Fashion Theory - Journal of Dress Body and Culture*, 16(3), pp. 273–295. doi: 10.2752/175174112X13340749707123.

Kabukcu, E. (2016). A Research on QFD- " House of Brand " in Fashion Industry, (August). doi: 10.17265/1537-1506/2016.04.006.

Koerber, A. and McMichael, L. (2008). Qualitative sampling methods: A primer for technical communicators. *Journal of Business and Technical Communication*, 22(4), pp. 454–473. doi: 10.1177/1050651908320362.

Kurt, Y. *et al.* (2020). The role of spirituality in Islamic business networks: The case of internationalizing Turkish SMEs. *Journal of World Business*, 55(1), p. 101034. doi: 10.1016/j.jwb.2019.101034.

Lam, L. W. (2012). Impact of competitiveness on salespeoples commitment and performance. *Journal of Business Research*, 65(9), pp. 1328–1334.

Mehta, P. and Pandya, S. (2020). A review on sentiment analysis methodologies, practices and applications. *International Journal of Scientific and Technology Research*, 9(2), pp. 601–609.

Meraviglia, L. (2018). Technology and counterfeiting in the fashion industry: Friends or foes? *Business Horizons*, 61(3), pp. 467–475. doi: 10.1016/j.bushor.2018.01.013.

Netemeyer, R. G. *et al.* (2004). Developing and validating measures of facets of customer-based brand equity. *Journal of Business Research*, 2963(February), pp. 209–224. doi: 10.1016/S0148-2963(01)00303-4.

Ningsi, B. A. (2018). Analisis Kepuasan Pelanggan Atas Kualitas Produk dan Pelayanan Dengan Metode SEM-PLS. *Jurnal Statistika dan Aplikasinya*, 2(2), pp. 8–16. doi: 10.21009/jsa.02202.

Novotova, J. (2016). Determining the categories of fashion by price and quality from a consumer point of view. *AD ALTA-Journal of Interdisciplinary Research*, 6(2), pp. 70–77.

Park, D. H., Lee, J. and Han, I. (2007). The effect of on-line consumer reviews on consumer purchasing intention: The moderating role of involvement. *International Journal of Electronic Commerce*, 11(4), pp. 125–148. doi: 10.2753/JEC1086-4415110405.

Philip, R. S., Anian, A. M. and Raja, A. S. M. (2020). Planned fashion obsolescence in the light of supply chain uncertainty. *Academy of Strategic Management Journal*, 19(1), pp. 1–17.

Saha, S. K., Zhuang, G. and Li, S. (2020). Will consumers pay more for efficient delivery? An empirical study of what affects E-customers satisfaction and willingness to pay on online shopping in Bangladesh. *Sustainability (Switzerland)*, 12(3). doi: 10.3390/su12031121.

Unger, D., & Eppinger, S. (2011). Improving product development process design: a method for managing information flows, risks, and iterations. J*ournal of Engineering Design, 22*(10), 689-699.

Wang, L. (2016). The New Trend and Application of Customer Relationship Management under Big Data Background. *Modern Economy*, 7(July), pp. 841–848. doi: 10.4236/me.2016.78087.

Yu, S., Hudders, L., & Cauberghe, V. (2018). Are fashion consumers like schooling fish? The effectiveness of popularity cues in fashion e-commerce. *Journal of Business Research*, *85*, 105-116.

Zennouche, M., Zhang, J. and Bo, W. W. (2014). Factors influencing innovation at individual, group and organisational levels: A content analysis. *International Journal of Information Systems and Change Management*, 7(1), pp. 23–42. doi: 10.1504/IJISCM.2014.065052.

# Effects of Cutting Speed on Chip Formation during Turning of AISI 304L Stainless Steel

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**Abstract**: Austenitic stainless steels have high corrosion resistance and good mechanical properties. They have been widely used in various industrial sectors. Considering the importance of subtractive processing of these metals, it is important to investigate parameters of the manufacturing process that affect the different aspects of the surface integrity of the product. The objective of this work is to evaluate the effects caused by the cutting speed on the chip formation of AISI 304L stainless steel. Eight cutting speeds were selected between the range of 155 to 289 m/min and the other parameters were kept constant. Turning was performed on a CNC (Computer Numeric Control) lathe using a PVD ((Ti,Al)N + TiN) coated carbide tool and no cutting fluid was used in the cutting operation. The cutting temperature was obtained using a thermal imaging camera. The generated chips were cataloged and selected according to ISO (International Organization for Standardization) 3685/2017 for each cutting condition and evaluated according to thermal and mechanical loads.

**Keywords:** AISI 304L, Turning, Chip Shape, Cutting Speed.

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## Introduction

Currently, how to seek more and more efficient production processes with lower operating costs Implementing process improvements leads to a response in company gains, as well as product quality. According to (MARIOTTO SFF, 2009 the main point of this metal is that the treatment gives it resistance to corrosion, especially at high temperatures. improvement is due to the presence of chromium in its composition in contact with oxygen in which a thin film of chromium oxide forms on its entire surface, adding the quality of impermeability and insolubility in corrosive situations. Due to their high tensile strength and excellent mechanical properties, the use of austenitic stainless steels in large manufactured manufacturers is gradually increasing.

The behavior in the machining process of the materials can suffer variations that depend on the interaction between the development in the manufacture and the characteristics of the material of the part. Thus, one of the main objectives of this research is the formation of the chips generated during the turning process, as well as the analysis of the tool material and its geometry, in temperatures and in the chip itself. In order to be able to carry out a machining process, advanced studies on various parameters are essential, such as the temperature generated, so that the temperature variation will influence the cutting of the part, cutting fluid, cutting power, among others.

Thus, the study of chip formation is essential, since this knowledge has provided great advances in machining processes. One of the main analyzes carried out concerns their sizes, since determining and controlling the thickness of the chip allows you to maximize the productivity and efficiency of metal cutting, reducing the flow difficulty and consequently the torque. Regarding the cutting parameters, Smith states that the feed is the parameter with the greatest influence on the shape of the chips.

In addition, according to Degenhardt et al., even if the chips have a small thickness, it is not recommended that they be too long, as they cause severe obstruction inside the helical flutes and chipping on the edges, intertwine in the system and lead to wear, low useful life , poor tool quality. Thus, it is notable that, in order to obtain a more qualified process, it is essential that the thickness and length of the chip are as small as possible. As a result, chip classification is based on ISO 3685/2017.

In machining processes, temperature has a large interference factor, this is mainly due to the formation of the

part, since all work in removing the material through the penetration of the cutting tool is converted into heat, so that there will be a large increase in temperature, due to factors such as friction, plastic deformation of the machined part and the shear that occurred. In general, this work aimed to evaluate the power consumed by the machine tool that will impact the energy matrix, directly affecting operating costs, for external turning of stainless steel 304l for different cutting speeds.

## Materials and Methods

The turning process was selected and eight (8) specimens were prepared, both 100 mm long and 51.4 mm in diameter. Thus, the experimental test was divided into the following stages:

- The specimens were fixed on a CNC lathe model LOGIC 195 III, present at the Laboratory of Machine Tools of the Federal Institute of Paraíba (IFPB), Campus Cajazeiras.
- Part, tool and machine referencing.
- G-code implementation in a FANUC MC-0i controller.
- Installation of the Fluke 430-II energy analyzer: Device used to measure the power consumed by the CNC lathe used.

During the machining of the test specimens, 8 (eight) cutting speeds (vc) were selected, while the feed (f) and the cutting depth (ap) were kept constant, with f equal to 0.05 mm/rev and ap equal to 1 mm. Table 1 presents the cutting speeds selected for the experiment.

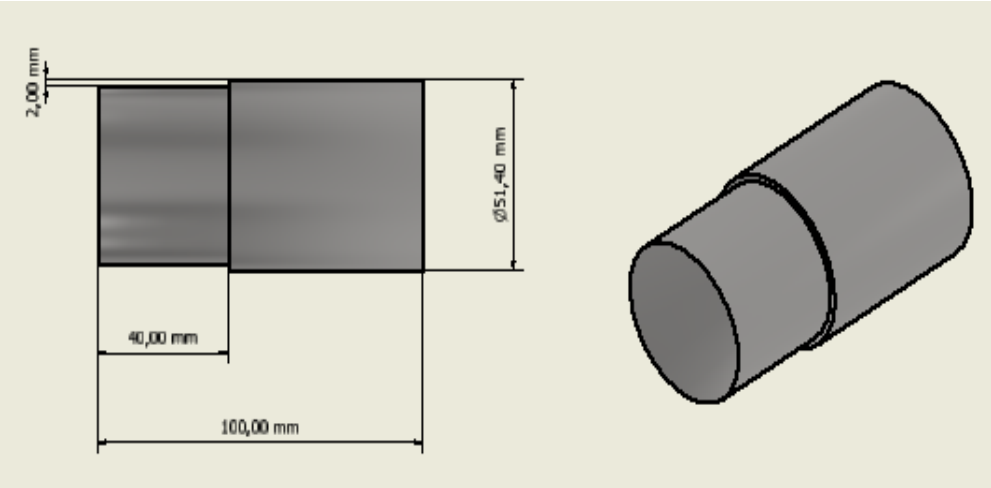


Figure 1. Technical Drawing of the Specimens Used

To perform the turning of these specimens, an insert model TNMG160408-MF1 CP500 (Fig. 2a) was used, with a 0.8 mm nose radius, 60º nose angle and 0º clearance angle, coupled to a support PTGNL 2020K16 with a draft angle equal to -5º (Fig. 2b), both manufactured by SECO Tools.

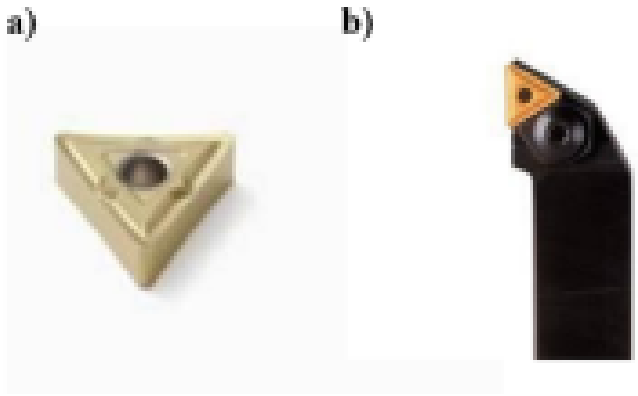


Figure 2. a) TNMG160408-MF1 CP500 Insert, and b) PTGNL2020K16 Tool Holder. [9-10]

As for the machining parameters, the depth of cut (ap = 1 mm) and feed (f = 0.05 mm/rev) were kept constant. Thus, it was decided to vary only the cutting speed. The cutting parameters used to perform the tests are indicated in Figure 3.

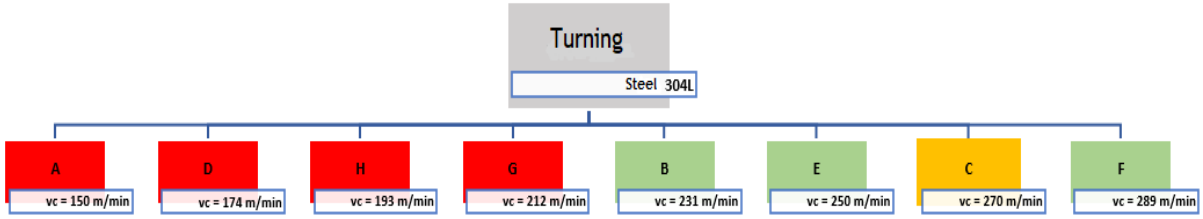


Figure 3. Parameters of Cutting Speeds used in the Tests

Temperature measurements were performed using a thermographic camera with a resolution of 100 x 140 pixels, Flir, model i7 (Figure 3), capturing temperatures in the range of -25 ºC to 300 ºC. Thus, during the turning of each part, three images were captured at a distance of approximately 30 cm from the focus.

Figure 4. Flir i7 Thermographic Camera

After carrying out each test, chip samples were collected and separated (Figure 4). Each sample was duly identified with information on the cutting parameters that were used to obtain it.

Figure 5. Sample of Chips collected after Machining Parts

## Results and Discussion

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It is possible to observe in Figure 6 the measured cutting temperatures. The cut temperature expressed in the table is calculated from the average of the temperatures obtained plus 30% of the value of the average itself, since, according to Soller, when the temperature shift measured with the thermal camera is ignored, the values end up being undervalued by about 30%.

| AISI 304L stainless steel | | | | |
|---|---|---|---|---|
| Sample | ap (mm) | f (mm/rot) | Vc (m/min) | Cutting temperature °C |
| A | 1 | 0,05 | 155 | 76,3 |
| D | | | 174 | 85,1 |
| H | | | 193 | 93,8 |
| G | | | 212 | 99,6 |
| B | | | 231 | 106,2 |
| E | | | 250 | 117,6 |
| C | | | 270 | 124,5 |
| F | | | 289 | 136,6 |

Figure 6.Temperatures and Cutting Conditions of AISI 1045 Steel

From the data in Figure 6, Figure 7 can be constructed in a way that compares the cutting speeds (150~298 m/min), it is observed that for a higher cutting speed ratio, the temperature increases proportionally. Note that the temperature has the highest value when using a lower aspect ratio.

Figure 8 shows the results obtained from the visual analysis of the formation of chips collected after

longitudinal turning of AISI 304L steel. Therefore, it can be noted that the main forms of the steels in question are helical short washer chips, according to Diniz, characterized by chips that do not pose risks to the process when the Material Removal Rate (MRR) is high. Helical chips have a tendency to jump out of the usable axis. It is noteworthy that this form was predominant when a feed rate equal to 0.05 mm/rev.

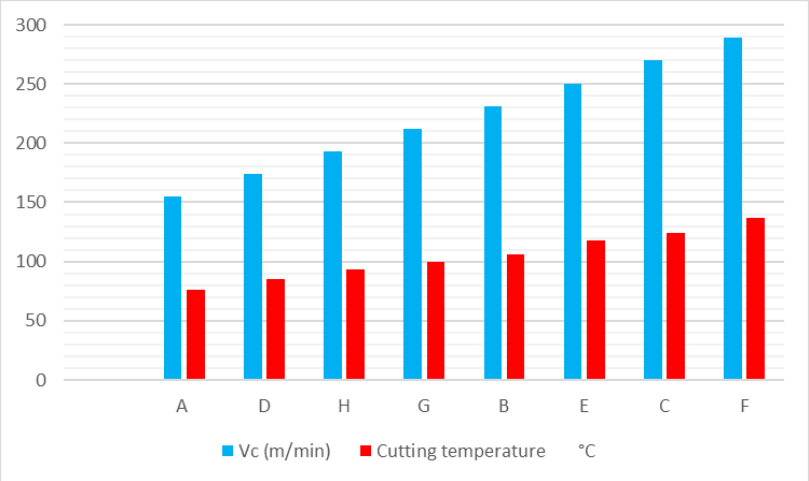


Figure 7. Cutting Temperature X Cutting Speed(Vc)

| AISI 304L stainless steel | | | | |
|---|---|---|---|---|
| Sample | ap (mm) | f (mm/rot) | Vc (m/min) | Form |
| A | 1 | 0,05 | 155 | Short tubular chips |
| D | | | 174 | Short tubular chips |
| H | | | 193 | Snarled tubular chips |
| G | | | 212 | Short tubular chips |
| B | | | 231 | Long tubular chips |
| E | | | 250 | Snarled cork screw chips |
| C | | | 270 | Long cork screw chips |
| F | | | 289 | Snarled cork screw chips |

Figure 8.Chip Shapes and Cutting Conditions of AISI 304L Steel

## Conclusion

Conclusions obtained

- With the increase in cutting speed and turning of AISI 304 L steel, the cutting temperature increased proportionally.
- The formation of chips, it was noted that the short tubular shape was predominant in this process However, some unwanted chip shapes were obtained Thus, the most desirable and least harmful chip shape was obtained with the initial speeds of the process.
- Therefore, the higher the cutting speed, the lower the desired chip quality when getting tangled chips,

the tool workpiece interface temperature will tend to increase.

## Recommendations

For further work, it is advisable that the measurement system be more accurate, as measurements with a thermal camera are exposed and errors can be inserted, the area of piece-tool contact is not possible for an accurate visualization.

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## References

Diniz, A. E., Marcondes, F. C., & Coppini, N. L. (2003). Tecnologia da usinagem dos metais. Editora Artliber, 4ª ed., São Paulo, Brasil.

Batzer, S.A., Haan, D.M., Rao, P.D., Olson, W.W. and Sutherland, J.W. (1998). Chip morphology and hole surface texture in the drilling of cast aluminum alloys. *Journal of Materials Processing Technology, 79*, 72–78.

Smith, G. T. (1989). *Advanced Machining – The Handbook of Cutting Technology*. IFS Publications. ISBN 1-85423-022-6.

Degenhardt, J.A., DeVor, R.E. and Kapoor, S.G. (2005). Generalized groove-type chip breaker effects on drilling for different drill diameters and flute shapes. *International Journal of Machine Tools & Manufacture, 45*, 1588-1597.

ABNT (2017). NBR ISO 3685: Ensaio de vida da ferramenta de ponta única para torneamento.

Souza, AC de et al. (2001). Condições econômicas no processo de usinagem: uma abordagem para consideração dos custos. In: *VII Congresso Internacional de Custos.* Léon, Espanha.

Machado, A., Abrão, A.M., Coelho, R.T., Silva, M.B. (2009). *Teoria da Usinagem dos materiais*. São Paulo: Blucher.

Trent, E.M.; Wright, P. K. (2000). *Metal Cutting, 2a ed.* Butterworth-Heinemann, Woburn, USA.

SECO Tools, Inserto TNMG160408-MF1 CP500.Disponível em:<https://www.secotools.com/article/p_00091359>. Acessado em: 14 de março de 2021.

SECO Tools, Suporte PTGNL2020K16. Disponível em: <https://www.secotools.com/article/p_00092224>. Acessado em: 14 de março de 2021.

Soluções Industriais, Termovisor para identificar problemas. Disponível

em:<https://www.solucoesindustriais.com.br/empresa/automatizacao-e-robotica/rti-automacao-comercio-e-instalacoes-ltda-/produtos/instrumentacao/termovisor-para-identificar-problemas>. Acesso em: 08 de dezembro de 2021.

Soler, D., Childs, T. H., & Arrazola, P. J. (2015). A note on interpreting tool temperature measurements from thermography. *Machining Science and Technology*, *19*(1), 174-181.

# Mining and Climate Change

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**Abstract**: Since the industrial revolution, the effects of global climate change, which is caused by excessively high amounts of greenhouse gas emissions in the atmosphere, are already being monitored and it is estimated that these effects will become even more cleared in the future. Climate change is one of the most important problems of today, which negatively affects all areas of life such as the natural environment, urban life, development and economy, technology, human rights, agriculture and food, clean water and health. The relationship between mining and climate change is mainly focused on the negativity of the gases that are finally released by the combustion of fossil fuels, mining activities there are greenhouse gases that occur as a result, there are adverse effects of climate change on these gases. The mining sector is also affected by the negative consequences of climate change. Mining activities in the Marmara and Aegean Regions of Turkey should take the global climate change into its main agenda, adapt and create greenhouse gas reduction policies.

**Keywords:** Climate change, Greenhouse, Mining, Turkey.

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## Introduction

Awareness in the extractives industries of the potential negative impacts of climate change on the mining sector has grown in the past years. The impacts of extreme weather events such as recurring droughts, floods and cyclones experienced in some of the world's leading mining regions, such as Australia, Chile and Mongolia have led some sections of the industry to start thinking about their own vulnerabilities and the risks climate change could pose. However, there has been little research and debate that takes a more comprehensive look at the links between climate change and mining (URL-1).

With population growth and developing technology, there is excessive pressure on the environment. The free

economic growth process, which does not take into account environmental values, causes serious damage to the depletion of non-renewable natural resources, irreversible pollution of receiving environments and the continuation of living life (Rüttinger, L. and Sharma, V., 2016).

While environmental problems were local or regional problems before, they have reached global dimensions today; mainly climate change, air and water pollution, loss of biodiversity, deforestation, loss of agricultural lands etc. The problems have become the problems of all humanity.Pollution or deterioration of the environment is the event that the elements that make up the environment gradually change in quality and lose their value due to various external factors. Environmental problems do not appear out of nowhere, they accumulate over a long period of time. In particular, the disruptive effect of industrialization activities, which increased rapidly after the industrial revolution, on the natural balance of the world, started to exceed the carrying capacity of nature and caused negative results at the local and global level. The most important of these results is global warming, or more accurately, climate change. Climate change is one of the most important problems of today, which negatively affects all areas of life such as the natural environment, urban life, development and economy, technology, human rights, agriculture and food, clean water and health (CANE, 2022).

The increase in the use of fossil fuels, the destruction of forests, changes in land use, industrial processes, rapid population growth and human activities have accelerated global warming by causing greenhouse gases to accumulate in the atmosphere and have made climate change one of the most important problems threatening human life. It has been scientifically proven today that climate change, which is an issue beyond an environmental problem on a global scale, will continue to affect the world in the long run, and that the planet will face changes in temperature increase and precipitation patterns in the next few decades.

Greenhouse gases (GHG) causing global warming; Gases emitted to the air mainly originating from fossil fuels, various industrial activities, especially cement, energy, transportation, mining and industrial agriculture. Although the relationship between mining and climate change mostly focuses on the negativities caused by the gases released as a result of the combustion of fossil fuels, there are greenhouse gases formed as a result of mining activities and the mining sector is also affected by the negative consequences of climate change.

## Climate Change

Climate change is the world's most important environmental problem globally. It is increasing exponentially with the industrial revolution and continues to be a bigger problem for the world. The concept of climate change is the change caused by human activities in addition to the natural variability of the climate experienced during the long geological history of the earth. It refers to the increase in the average surface temperatures of the Earth and the changes in the climate as a result of the rapid increase in the greenhouse gas accumulations released into the atmosphere by human activities such as the burning of fossil fuels, land use changes, deforestation and industrial processes. In the United Nations Framework Convention on Climate Change, climate change is

defined as "a change in climate as a result of human activities that directly or indirectly degrade the composition of the global atmosphere, in addition to natural climate change observed over a comparable period of time". The increase in greenhouse gas emissions has been clearly observed since the 1850‘s, that is, since the industrial revolution.

The burning of fossil and biomass fuels is the largest source of anthropogenic greenhouse gas emissions. Burning fossil fuels for transportation, electricity generation, industrial consumption and domestic use; changes in land use; waste disposal and the use of industrial fluorinated gas can be counted as the main sources of greenhouse gases. Factors such as global dimming due to the increase in the amount of dust in the atmosphere, and the formation of urban heat islands in metropolitan cities due to urbanization errors contribute to climate change (Duygu, 2010).

The mining sector is extremely energy-intensive and therefore, one of the major emitters of greenhouse gases (Norgate and Haque 2010). In Australia, for example, mining is the fourth largest consumer of energy and recorded the largest energy consumption growth rate over a 3-decade period between 1980-81 and 2012-13 (Stanwix et al. 2015). Additionally, the industry produces fossil energy resources that further contribute to global CO2 emissions. Coal provides for approximately 20% of the world’s primary energy demand, contributing to global warming through direct emissions when burned, but also through fugitive emissions that are released during the process of mining coal from under the earth’s surface (MCA 2015). Although large mining companies continue to undertake efforts to trap and conserve fugitive emissions, industry-wide efficiency on this front remains ad hoc and inconsistent, particularly in weaker regulatory environments (CIE 2011, Cooke and Hearps 2011).

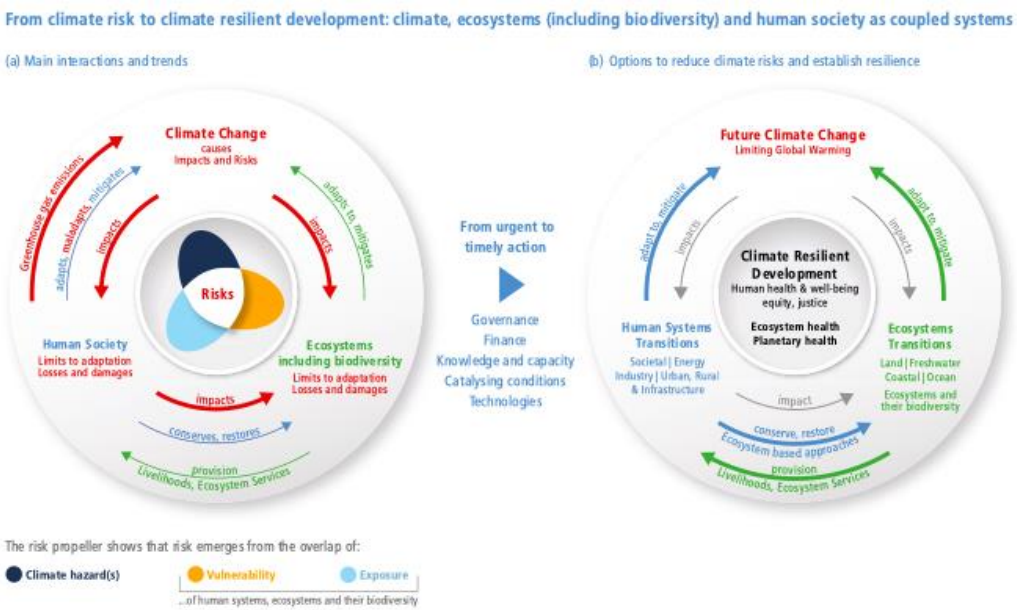


Figure 1. Coupled Systems Climate, Ecosystems (including their Biodiversity) and Human Society (IPCC, 2022)

As Figure 1 shows, a strong focus is needed on the interactions between climate, ecosystems and human society. These interactions form the basis of risks arising from ecosystem degradation and biodiversity loss, especially climate change. As seen in the first figure (a), humans are causing climate change. Climate change, on the other hand, produces impacts and risks that, through hazards, exposure and vulnerability, can exceed the limits of adaptation and lead to loss and damage. Humans can adapt and mitigate climate change, while ecosystems can adapt and reduce it within limits. Ecosystems and biodiversity provide livelihoods and ecosystem services. Humans affect ecosystems and can also restore and protect them.

As the second Figure (b) shows, achieving climate-based development goals and supporting human, ecosystem and planetary health as well as human well-being requires society and ecosystems to become more resilient. Recognition of climate risks can strengthen adaptation and mitigation actions and transitions that reduce risks. Action is driven by governance, finance, knowledge and capacity building, technology and catalyst conditions. Transformation requires system transitions that strengthen the resilience of ecosystems and society.

In Figure a, the blue arrows represent key human society interactions, the green arrows for ecosystem interactions, the effects of climate change, and the ongoing climate change the red arrows represent the effects of human activities, including losses and damages.

In Figure b, blue arrows represent human system interactions, green arrows represent ecosystem (including biodiversity) interactions, and grey arrows represent reduced impacts from climate change and human activities.

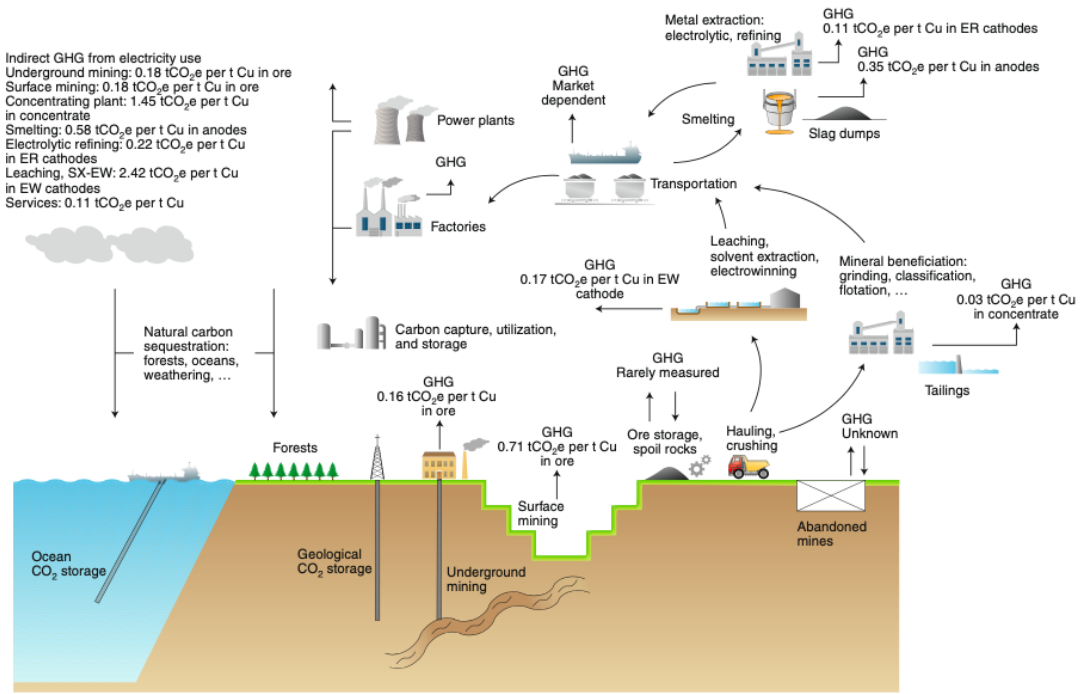


Figure 2. Potential Sources and Sinks of GHG Emissions associated with the Primary Copper Supply Chain (Azadi et al., 2020)

The main stages of production in the primary copper supply chain are shown in Figure 2. Fuel and electricity consumption associated with open pit and underground mining processes are a major source of greenhouse gas (GHG) emissions. However, the magnitude of greenhouse gas emissions associated with individual mining and mineral processing operations is highly variable due to site-specific differences. In addition, ore comminution processes (eg. crushing, grinding) consume significant amounts of energy, resulting in significant indirect GHG emissions. The embodied energy and GHG emissions of the grinding media (for example, low alloy or high chromium steel balls) – although not presented here due to the lack of current reporting on such sources by the industry – can make significant contributions.

## Mining and Climate Change

The place of mines in social life and their contribution to the economy cannot be denied. However, it is imperative to produce mines with environmentally friendly methods in which engineering science and technique are applied. Mining involves the extraction and processing of minerals, and the disposal of waste rock and by-products. In the case of a mining operation, the mine and its processes, infrastructure and employees are all exposed to the local climate of the area. The potential and actual interactions of climate change upon, and intensified by, mining is only now beginning to be evaluated and understood, e.g., Pearce et al. (2011); Prowse et al. (2009); Nelson and Schuchard (2014); Lin (2012); ICMM (2013). This is partly due to the fact that climate change may very well further exacerbate or cause new impacts upon the local environment and communities where mining operations are located. This is in relation to the extraction and processing of mineral resources, the health and safety of employees, and the potential and actual impacts upon the local community and wider area or region because of variations in climatic conditions. The advent of climate change science has brought to the forefront significant concerns. Specifically, over the potential and actual consequences of extreme variations to established weather patterns at all spatial-temporal scales.

Mining is a sector that is particularly vulnerable to climate change (Arent et al. 2014). It is inherently dependent on the natural environment and the industry's long-term viability – and therefore, strategic decision-making with regard to mining operations – is directly tied to the location of the resource to be mined from under the earth's surface. As a result, the industry is not relocatable should natural environ- mental conditions become unsupportive for varying reasons. The mining sector requires a number of suitable natural conditions including, but not limited to, a habitable climate, access to water resources and supporting infrastructure to extract resources and process them for future domestic and/or inter- national use (Pearce et al. 2009).

Relatively little knowledge exists on how climate change may impact mining operations and the extrac- tives sector. Although there are some efforts underway to recognise and address the mining industry's sensitivity to climatic changes, evidence-based robust knowledge that explores the full range of causal relationships and links between the two remains little and far between. There has been some work emerging from Canada and Australia – OECD's two most resource-dependent regions – in the recent past that has investigated the influence of

climatic changes on the future of the mining industry in these economies (Ford et al. 2011, Pearce et al. 2011, Loechel et al. 2013, Sharma et al. 2013).

Changing climatic conditions will have both direct (operational and performance-based) and indirect (securing of supplies and rising energy costs) impacts on the mining sector (Sharma et al. 2013). These include, but are not limited to: water-related impacts (droughts, floods, cyclones and storms); heat-related impacts (bush fires and heat strokes); and sea level rise. A combination of these effects may jeopardise the sector's viability by denying the industry – and its personnel – a safe operating landscape, both spatially (impacts felt across the immediate vicinity of the mining site and areas further downstream) as well as temporally (including, sporadic short-term and more permanent long-term changes).

Underlining these risks is the fact that some of the world's largest mining operations currently operate in remote, climate-sensitive regions (e.g., Mongolia's Gobi Desert, the Atacama in Chile, Pilbara in Western Australia and the Canadian North and Arctic) (Fig. 3).

**(a)** **(b)**

Figure 3. (a) The Chuquicamata open pit copper mine is the biggest of its kind and located in one of the driest places in the world – the Atacama Desert in Chile, (b) Under the Greenlandic Kvanefjeld Pleateau lies one of the worldwide largest deposits of rare earth elements.

Energy consumption, effects on air, effects on water resources, land use, health and safety are counted as environmental problems caused by mining activities. Although mining activities were considered as activities that cause only local environmental problems until recently, today it has started to be counted among activities that cause climate change, which is one of the global environmental problems (UNFCCC). The relationship between mining activities and climate change can be examined under two headings; emissions from mining activities and effects of climate change on the mining industry.

**Emissions from Mining Activities**

Although the mining industry perceives climate change primarily as a political or regulatory risk, mining has

elements that cause climate change. Mining is included as a title in climate change inventory studies (UNFCCC). The mining sector is an energy-intensive sector and the majority of greenhouse gas emissions are caused by the energy sources used in the sector. Effects of mining activities on climate change; emissions from energy used for production (including emissions from fuels used in vehicles), emissions generated during the production of materials used by the industry, gases released in case of blasting, and gases such as methane (CH4), carbon dioxide (CO2), which are considered underground greenhouse gases, during or after production can be counted as a revelation.

Although $CO_2$ emissions vary greatly depending on the characteristics of the mine extracted from the underground, according to a study conducted in 2009, according to the assumption that 400 tons of explosives are used for the production of 1 million tons of coal, 74400 tons of $CO_2$, and according to the assumption that 200 tons of explosives are used in the production of 1 million tons of metal ore, 32000 tons of $CO_2$ it has been reported that it will be released into the atmosphere (Orica, 2009).

In the technical documents of the IPCC-6 (2022), average standard values for methane and carbon dioxide discharge are given according to the production technology of the mine (underground mining, open pit operation) and for abandoned mine sites. Emission inventory calculations are determined by calculating these values (UNFCCC).

**Effects of Climate Change on Mining Industry**

Mining is a mandatory activity in the mine location. Mining areas, on the other hand, often have extremely challenging geographies and sensitive environmental conditions. The basic conditions that determine the operating conditions in mining are the geological structure and bedding structure of the place where the mine is located, the weather conditions of the place where the operation will be carried out, the water requirement of the enterprise and the presence of unwanted water in the enterprise are the factors that determine the operating parameters.

Due to the wide geographical distribution of mining activities, changes in temperature and precipitation due to climate change, more frequent and severe extreme weather events will have complex effects on the sector. Climatic conditions will directly affect the stability of the infrastructure and the efficiency of the machinery and equipment used in mining operations (Pearce et al., 2009). Climate change will also affect the cost of water and energy resources.

High temperatures, changes in precipitation patterns, higher sea levels or vice versa, changes in lakes or river levels will affect the mining industry in various ways (ICMM, 2013). The impact of floods or storms in transportation to the mines or on the roads within the mine site or the transportation networks where ore is transported are also areas where mining due to climate change will be affected.

The possible effects of climate change on the mining sector can be listed as follows;

- May damage the infrastructure of mining operations: natural disasters, changes in precipitation patterns and rising sea levels; It may affect the working efficiency of equipment used in transportation, energy infrastructure and mines, and equipment may become unusable. Extreme temperatures will increase the risk of fire depending on the characteristics of the area.
- Supply and transportation problems may occur: Increasing temperatures, more precipitation, changing precipitation and rising sea levels will hinder access to the goods and services that the mining operation needs. Personnel access to the facility may make it difficult for the produced mine to reach ore processing facilities or ports. Disruptions may occur in the transportation of consumables such as diesel oil, oil, timber, explosives used by the mining enterprise to the mine site.
- Difficulties may arise in occupational health and safety conditions: While natural disasters bring emergency health and safety risks, warmer weather conditions may threaten the health of workers in mining operations and increase accidents. Diseases that may occur in employees may increase and loss of workforce may occur.
- Increasing temperatures can increase the prices of the resources used: Mining activities are energy-intensive operations. Increasing energy prices and water prices with temperature changes will directly affect the economy of the enterprise.
- Increasing temperatures and precipitation may directly affect the operating conditions: Natural disasters such as floods and landslides that may occur in the mining area will make it necessary to take the necessary precautions while planning the mining operation. An increase in rainwater interceptions, measures to be taken in tailings dams and leaching areas, and increasing the safety coefficients on step slopes can be given as examples of these measures.
- It may increase the concerns of the local people where the mines are located: Mining activities are activities that are met with concern in the society and environmental sensitivities are very high. The increase in problems such as drought, flood, rising temperatures and natural disasters that will increase with climate change, the increase in problems such as famine and diseases, worsening of social conditions will increase environmental sensitivities in mining areas. Businesses will need to work more carefully and more safely in terms of environmental compliance.

## Conclusions

The relationship between mining activities and climate change mostly focuses on the negative effects of the gases released as a result of the combustion of fossil fuels. However, methane and carbon dioxide greenhouse gases are produced due to coal production, originating from abandoned mines and underground-open pits, and these gases have a negative contribution to climate change.

While the mining industry perceives climate change only as a political or regulatory risk, the mining industry is also affected by the negative consequences of climate change and will be increasingly affected. The mining

industry should take a proactive approach to adapting to climate change.

- Long-term planning should be done in the supply of critical inputs to mining processes. For example, major bottlenecks may be encountered in the supply of water and energy.
- Necessary precautions should be taken for the health and safety of the employees, the risks of communicable diseases, diseases related to extreme temperatures and the possibility of accidents related to rising temperatures.
- The increase in physical risks will make project financing riskier. Care should be taken in the selection of economic instruments.

Turkey, which is one of the countries that will suffer the most from global warming and related climate change, should both be a part of the international cooperation for the solution of global warming and develop policies and strategies at the national level in line with these decisions.

## References

Arent, D., Pless. J., Mai, T., Wiser, R., Hand, M., Baldwin, S., Heath, G., Macknick, J., Bazilian, M., Schlosser, A. and Denholm, P. (2014). Implications of high renewable electricity penetration in the U.S. for water use, greenhouse gas emission, land-use, and materials supply. *Applied Energy, 123*, 368-377.

CIE, (Centre for international economics), (2011). Coverage of coal mining fugitive emissions in climate policies of major coal exporting countries. Briefing note. Canberra: Centre for International Economics.

Climate Action Network Europe (CANE), (2022). *Kömürün İklim Değişikliğine Etkisi.* 14.10.2022. https://komurungercekbedeli.org/iklim-degisikligine-etkisi.html

Cooke, D. and Hearps, P. (2011). Fugitive emissions: what is the real footprint of coal seam gas? in: the Conversation, 18.10.2022. http://theconversation.com/fugitive-emissions-what-is-the-real-footprint-of-coal-seam-gas-2940.

Ford, J., Pearce, T., Prno, J., Duerden, F., Berrang Ford, L., Smith, T. and Beaumier, M. (2011). Canary in a coal mine: perceptions of climate change risks and response options among Canadian mine operations. *Climatic Change 109*(3-4), 399-415.

International Council on Mining and Metals (ICMM), (2013). *Adapting to a changing climate: implications for the mining and metals industry accessed*, 13.09.2022. http:// www.icmm.com/page/92086/adapting-to-a-changing-climate-implications- for-the-mining-and-metals-industry.

IPCC, (2022). Climate Change 2022: *Impacts, Adaptation and Vulnerability*. 13.10.2022. https://report.ipcc.ch/ar6/wg2/IPCC_AR6_WGII_FullReport.pdf

IPCC-6, (2022). *Değerlendirme Raporu İklim Değişikliği 2022: Etkiler, Uyum ve Kırılganlık.* 12.10.2022. https://www.birbucukderece.com/bilimsel-kaynaklar/ipcc-6-degerlendirme-raporu-iklim-degisikligi-2022-etkiler-uyum-ve-kirilganlik

Lin, C. (2012). Climate change adaptation in acid sulfate landscapes. *American Journal of Environmental Sciences, 8*(4), 433-442.

Loechel, B., Hodgkinson, J.H. and Moffat, K. (2011). *Pilbara regional mining climate change adaptation workshop. Report on workshop outcomes. CSIRO Report*. 11.10.2022. https://publications.csiro.au/rpr/download?pid=csiro:EP118134&dsid=DS1.

MCA, (Mineral Council of Australia), (2015). *Emissions from coal mining*. 10.11.2022. http://www.minerals.org.au/resources/coal21/low_emissions_coal_technologies/emissions_from_coal_mining.

Nelson, J. and Schuchard, R. (2014). Adapting to climate change: a guide for the mining industry accessed, 20.10.2022, http://www.bsr.org/en/our-insights/climate-change- adaptation.

Norgate, T. and Haque, N. (2010). Energy and greenhouse gas impacts of mining and mineral processing operations. *Journal of Cleaner Production*, *18*(3), 266-274.

Orica, 2009, Unearthing the Carbon Footprint, 13.10.2022. http://www.oricaminingservices.com/

Pearce, T. D., Ford, J. D., Prno, J., Duerden, F., Pittman, J., Beaumier, M. (2011). Climate change and mining in Canada. *Mitigation and Adaptation Strategies for Global Change*, *16*(3), 347-368.

Pearce, T.D., Ford, J.D., Prno, J., Duerden, F., Berrang-Ford, L., Smith, T., Pitman, J., Reid, A., Beaumier, M. and Marshall, D. (2009). *Climate change and Canadian mining: opportunities for adaptation*. *David Suzuki Foundation.* 11.10.2022. http://www.davidsuzuki.org/publications/downloads/2009/Climate_Change_And_Canadian_Mining.pdf.

Pearce, T., J. D. Ford, J. Prno, F. Duerden, J. Pittman, M. Beaumier, L. Berrang-Ford and Smit, B. (2011). Climate change and mining in Canada, *Mitigation and Adaptation Strategies for Global Change*, *16*(3), 347–368.

Phillips, J. (2016). Climate change and surface mining: a review of environment-human interactions & their spatial dynamics. *Applied Geography*, *74*, 95-108.

Prowse, T. D., Furgal, C., Chouinard, R., Melling, H., Milburn, D. and Smith, S. L. (2009). Implications of climate change for economic development in northern Canada: energy, resource, and transportation sectors. *Ambio*, *38*(5), 272-281.

Rüttinger, L. and Sharma, V. (2016). Climate change and mining a foreign policy perspective. *University of Queensland*. 13.10.2022. https://climate-diplomacy.org/sites/default/files/2020-10/Report-Climate-Diplomacy-Climate-Change-and-Mining.pdf

Sharma, V., Van De Graaff, S., Loechel, B. and Franks, D.M. (2013). Extractive resource development in a changing climate: learning the lessons from extreme weather events in Queensland, Australia, *National Climate Change Adaptation Research Facility*, 110.

Stanwix, G., Pham, P. and Ball, A. (2015). End-use energy intensity in Australia. Canberra: Australian Government, Department of Industry and Science.

UNFCCC, *United Nations Climate Change*. 11.10.2022. http://unfccc.int/ghg_data/items/4133.php

# Investigating Teachers of STEM Fields Practices at the Lebanese Elementary Public Schools

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**Abstract**: My action research is guided by the following research questions: (1) What kind of instruction STEM fields' teachers apply in their classrooms? How are students' engagement and learning during a STEM lesson? The sample is formed of 33 public schools, 27 teachers (chemistry, Biology, and math) who were all females, and 810 students, grades 2 to 6, during the school year 2021-2022 in Beirut, Lebanon. Subject teachers (math and sciences) were trained on the use of Microsoft teams, Google drive and other technological tools, by the Center of Educational Resources (CERD) to reach their students during the pandemic. Questionnaires were distributed to 27 STEM fields teachers but only 13 responded, and observations were conducted while they were implementing STEM activities concerning different topics such as heart anatomy and acids and base lessons. First results show that teachers of STEM fields at the elementary level rely heavily on rote learning and students' engagement is minimal.

**Keywords:** STEM fields, CERD, teachers' strategies, students' engagement, rote learning

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## Introduction

Math and sciences teaching and learning at all levels act as the basis for students to select Sciences, Technology, Engineering, and Math (STEM) education and later on to enter STEM field work (National Science Board, 2021). Elementary and secondary STEM education is vital to provide future labor force in STEM fields (National Science Board, 2021). It prepares young generation with the needed skills and dispositions to work in complex and challenging surroundings (Chai, Rahmawati & Jong, 2020).

Nowadays more than ever, students need information and expertise in STEM education to succeed in a 21st century global economy (Sahin, et al., 2019; Yıldırım, & Şahin Topalcengiz, 2019). Accordingly, it is important for STEM fields' teachers to be equipped with the needed skills, knowledge, efficacy and competencies such as collaboration and critical thinking (Kelley and Knowles, 2016; Nadelson, et al., 2013; Prentiss Bennett, 2016; Thinzarkyaw, 2019; Wu & Albion, 2019, Yıldırım et al., 2019) to cater for their students' needs.

Education is a main pillar in the social and economic life in Lebanon. Educators claim that the Lebanese educational system relies mostly on rote learning and memorization (Du et al., 2020; Mukhamedov, 2018). Thus, to improve the educational system in Lebanon, students need to use mainly inquiry, mathematical thinking, and engineering design while experimenting and drawing conclusions (Darling-Hammond, 2006).

Moreover, the results of the Program for International Student Assessment (PISA, 2018) showed that over 60 percent of Lebanese students lack basic proficiency in math, sciences, and reading. Consequently, the system is leaving the young generation incapable of competing in the work field (World Bank, "*Expectations and Aspirations: A New Framework for Education in the Middle East and North Africa.*", 2018).

In the same context, teachers play a major role in implementing STEM education, they need to understand STEM framework thoroughly (Mukhamedov, 2018). To reach this end, teachers need to be given special support to develop their expertise in the implementation of teaching and learning activities in an integrated manner (Syukri, Yulisman & Nurina, 2020). In addition, researchers investigated the strategies that teachers use while starting to implement a STEM unit, Capobianco and Rupp (2014) concluded that teachers spent most of the time on planning and identifying the problem and little time was spent on testing and redesigning.

Given the variety of teachers' instructions while implementing STEM education and students' engagement, and the fact that little to no research has examined the strategies that teachers follow in the classrooms in Lebanon, the research's purpose is to examine these approaches and students' engagement while implementing a lesson in the STEM fields' classroom in Lebanon. My action research is guided by the following research questions:

1. What kind of instruction STEM fields' teachers apply in their classrooms?
2. How are students' engagement and learning during a STEM lesson?

## Integrated STEM Education

Educators have given a lot of definitions for STEM education (Brown et al., 2011; Honey et al., 2014; Kelley & Knowles, 2016; Wells, 2016). A unified definition of integrated STEM education is far from being true and no clear agreement within literature is found. Sanders (2009) voiced that STEM education is "approaches that explores teaching and learning between/ among any two or more of the STEM subject areas, and /or more other school subjects" (p.21). Other educators defined STEM education as "standards-based, meta-discipline reading at the school level where all teachers, especially science, technology, engineering, and mathematics (STEM) teachers, teach an integrated approach to teaching and learning, where discipline-specific content is not divided, but address and treated as one dynamic, fluid study" (p. 6).

Also, Honey et al., (2014) defined STEM education as "working in the context of complex phenomena or situations on tasks that require students to use knowledge and skills from multiple disciplines" (p. 52). On the other hand, educators provided another definition for STEM education, they claimed that it is "an effort to

combine some or all of the four disciplines of science, technology, engineering, and mathematics into one class, unit, or lesson that is based on connections between the subjects and real-world problems" (Moore et al., 2014, p. 38). Kelley and Knowles (2016). Defined STEM education as "the approach to teaching the STEM content of two or more STEM domains, bound by STEM practices within an authentic context for the purpose of connecting these subjects to enhance student learning" (p. 3).

Wells (2016) emphasized the importance of engineering design approach while working on projects and designing solutions to problems. Brown et al. (2011), Moore et al. (2014), and Sanders (2009) defined STEM education as the integration of one subject or more. Other educators, (Honey et al., 2014; Moore et al, 2014; Kelley & Knowles, 2016) voiced that the context plays a major role in STEM education. Honey et al. (2014), Moore et al. (2014) voiced the necessity of teaching a subject in the context of another subject.

On the other hand, Kelley and Knowles emphasized the importance of the authenticity of the context and considered STEM as an approach. Hence, there are no subjects in STEM education, rather there are exchangeable abilities that can be interrelated between STEM subjects. In this study, integrated STEM education is presented as an approach that combines two or more STEM fields following STEM practices implanted in genuine context or real-life problems where students apply engineering design to investigate solutions.

## Approaches for STEM Integration

Researchers (Hurley, 2001; Bybee,2013) studied the approaches of STEM integration. Hurley (2001) suggested that Math and Science integration may happen by means of 5 approaches: sequences (math and science are taught one after the other), parallel (math and science are taught at the same time) partial (math and science are taught partially together), enhanced (one is the major subject while the other supports it), and total (both are taught together and are of equal importance.

While Hurley (2001) focused on math and science integration, Bybee (2013) added technology and engineering design. He voiced that the approaches for STEM integration are: science is the major subject and math, technology, and engineering support its teaching. (b) math and science are taught separately but are integrated through technology or engineering; (c) two or more subjects are integrated together to make a new course where these subjects have equal importance; (d) math and science are taught one after the other and technology and engineering are integrated in the math and science lessons; (e) all subjects are used to solve a current issue and they are taught in a trans-disciplinary approach.

## Conceptual Framework for Integrated STEM Education

Kelley and Knowles (2016) suggested a framework for STEM education. It is composed of 6 constituents;

engineering design, mathematical thinking, scientific inquiry, technological literacy, situated STEM learning, and community of practice. They defined STEM curriculum as formed of 4 pulleys: the engineering design, the mathematical thinking, the technological literacy and the Science inquiry. These pulleys are related by the rope of the community of practice to lift the situated STEM learning load. Each component will be discussed below.

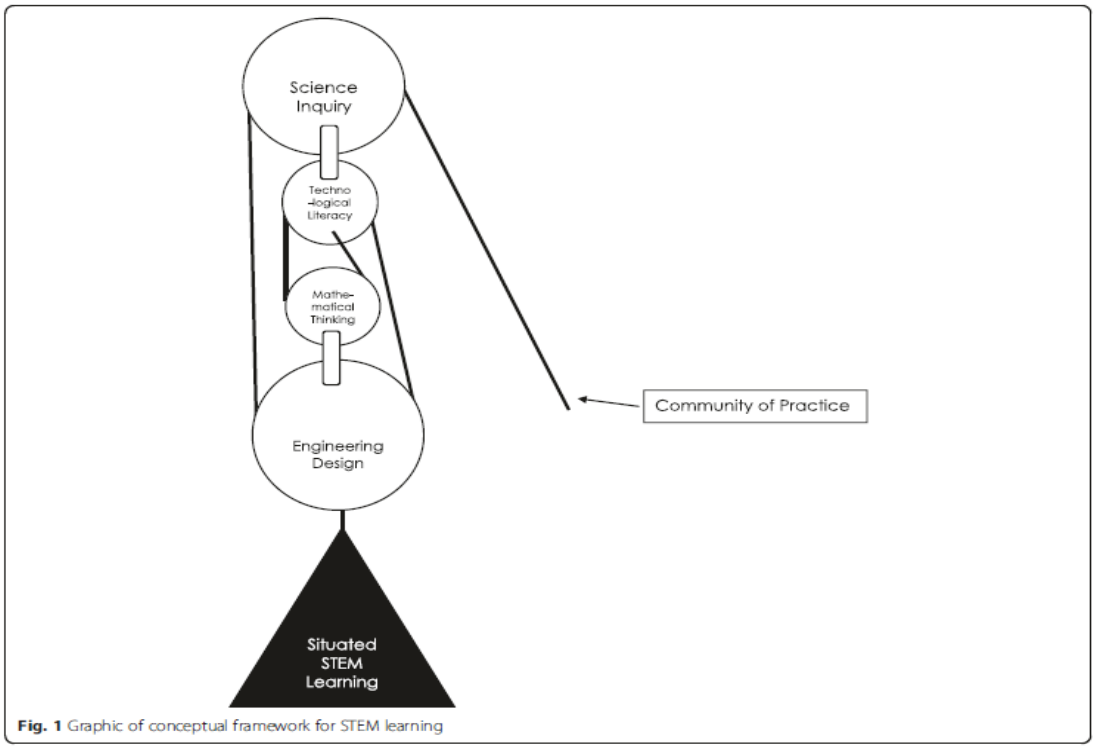


**Fig. 1** Graphic of conceptual framework for STEM learning

**Situated STEM Learning**

Situated STEM learning is grounded on the situated *cognition theory*, which stresses the necessity of physical and social contexts for any learning activity. Students need to know when they are going to use the new knowledge. Hence, teachers need to embed their teaching in authentic contexts.

**Engineering Design**

The engineering design can work as a catalyst for all STEM integrated situations. Example, in sciences, it provides instances for applying sciences inquiry and to teach math in real life situation. The engineering design allows student to use math and science inquiry to do an experiment and to predict the act of a design before building the final model. The key term for engineering design is learning by doing. To be precise, engineering design comprises eight components: problem identification, ideation, research, potential solutions, optimization, solution evaluation, alterations and learned outcomes. Each component is related to students' need to know (Wells, 2016).

**Scientific Inquiry**

Scientific inquiry allows students to act like real scientists. They doubt, conjecture, put to test ideas and search for alternatives for problem solving. Students observe a certain issue, define the problem, articulate a hypothesis, research, communicate the expectations, investigate, interpret the results of the investigation, reflect on the results and communicate the results (Kelley & Knowles, 2016; Wells, 2016). Also, teachers need to fuel students' prior knowledge to allow them ask questions. Hence, they need to build on their prior knowledge, synthesize their prior knowledge, and think out of the box to be able to understand new concepts (Kelley & Knowles, 2016).

**Technological Literacy**

The letter T in STEM escapes many people to understand. Herschbach (2009) claims that there are two facets for technology: the instrumental and the humanitarian. From an engineering perspective, the instrumental means that technology is about using and making things, whereas the humanitarian perspective sees technology as an answer to human needs and efforts. Thus, it is crucial for STEM educators to teach STEM through technology.

**Mathematical Reasoning**

Students need conceptual understanding rather than procedural understanding. For students to think mathematically they need to understand the concept behind the procedures. Kelley & Knowles (2016) voiced that STEM education helps students to learn math, apply its concepts and connects it to real life situations.

**STEM Community of Practice**

The community of practice enables teachers of different subjects to work together, share their knowledge, find solutions to issues, implement them and assess them together. Teachers of these communities work together, learn from each other, support their knowledge in different STEM fields, devise new strategies for teaching STEM and evaluate their usefulness and compare the findings to each other.

## Strategies for STEM Education

Educators (Corlu, Capraro, & Capraro, 2014, Lamberg & Trzynadlowski, 2015) studied the strategies that teachers follow to improve their implementation of STEM lessons. These strategies are as follows:

**Student-centered Approaches**

Parker et al., (2015) voiced the importance of student-centered teaching to implement STEM education. They

argued that students were involved in active learning and instructors stimulated deep thinking and student independence. Gao and Schwartz (2015) argued that while students are involved in discussions they work in groups, use their inquiry skills, problems solving skills, communication skills, and teach their friends. Hands-on activities help students behave like scientists. They tinker and experiment with objects around them. Lamberg and Trzynadlowski (2015) stressed that students have to explore, research, calculate, engineer and engage in hands-on science and math lessons. Also, engineering design, problem-based learning (PBL), project-based learning (PjBL) are strategies that engage students in hands-on activities and genuine learning. these strategies allow students to work on ill-structured situations where they have to use their higher order thinking skills and mathematical reasoning to find solutions. Thus challenging students to find new solutions.

**Engineering Design**

Engineering design is the context through which STEM education is implemented. Wells (2016) identified the 6 phases of the engineering design as follows; problem identification, ideations, research, potential solutions, optimization, solution evaluation, alterations and learned outcomes. Guzey et al., (2016) expressed that students should be involved in engineering design challenges where they research and develop suitable solutions to solve problems.

Capobianco and Rupp (2014) investigated the implementation of engineering-design based lessons and voiced that teachers spent most of the time on planning and using best practices. On the other hand, while teachers were working with their students, they spent most of the time on the first part of the design process, namely, detecting the problem and planning, and less time on testing, communicating their findings and re-designing. Dare et al., (2018) studied science teachers' implementation of STEM curricular units in physical science classes. They voiced that teachers and students were involved in engineering practices but there was little connection to math and science.

**Problem-based Learning**

Smith et al., (2009) stated 4 phases for PBL, namely, identification of the problem, individual and group work, application and solution. While using this strategy, students need to use their knowledge and skills from various fields to solve authentic problems. Khoiriyah and Husamah, (2018) voiced that problem based learning improves creative thinking skills, problem solving skills, and learning outcomes.

PBL improves the students' skills in putting the mind map of the level well enough in all aspects to good level (Karyatin, 2016). and improving thinking ability (Susanti et al., 2015), improving cognitive, affective, and psychomotor (Fauzan et al., 2017). PBL also improves the ability of mathematical problem solving (Amalia, et al., 2017;); it improves the ability of mathematical communication and social skills (Aufa, et al., 2016), and students' mathematical literacy (Indah, 2016).

**Project–based Learning**

Lesseig et al. (2016) voiced that PjBL involves the use of critical thinking, collaboration, group work, interactive discussions and practical activities. While using this strategy, students need to use concepts and apply engineering design practices from various STEM fields to reach the end product (Lesseig et al., 2016). PjBL improves student learning of sciences and math through acquiring robust content knowledge and skills in both fields (Viro & Joutsenlahti, 2020). Also, research (Kingston, 2018) reported increase in students' attendance, self-reliance, and attitudes towards learning. Moreover, Viro et al. (2020) voiced that PjBL helps in the development of 21st century skills as well as math and science understanding. Also, it promotes teamwork skills and connects between theory and practice.

**Technology Integration**

Lamberg and Trzynadlowski (2015) voiced that technology such as computers, iPads and smart boards can be used for the implementation of STEM education. Students use their laptops to search about the topic and to reach for conclusions. Brown et al. (2011) argued that the use of power point presentation does not necessarily promote students' learning. They voiced that technology must be used to relate relevant real life situations to the students' learning.

**Students' Engagement in STEM Fields Classes**

***Active Learning***

Active learning instructional strategies have been developed as a result of decades of research in the fields of math and science education, and they have shown through empirical evidence to increase content understanding, attitudes, and retention among all students (Freeman et al., 2014). Also, active learning refers to instructional techniques in the classroom that depart form the transmission approach in favor of a strategy that involves students' generation of knowledge and active problem solving (Freeman et al., 2014). Apkarian et al. (2021) stated that active learning comprises the use of strategies that promote students' engagement in problem solving and knowledge acquisition. A meta-analysis of 225 studies shows that active learning strategies always improve students' learning and reduce students' failure rates (Stains, et al., 2018)

***Student Engagement***

Research were interested in students' engagement and conceptualization for decades now (Astin, 1999; Fredricks et al., 2004; Kahu and Nelson, 2018). It has been related to better accomplishment, perseverance and retention (Finn, 2006; Kuh, et al., 2008). Eccles (2016) argued that student engagement is a multi-dimensional construct and it is best understood to include three key components: affective/emotional, cognitive and behavioral. On the other hand, Fredricks et al., (2016) added a fourth component which is social engagement.

Motivation and engagement were used interchangeably by researchers. Lately, there was a common consensus among researchers concerning these tow concepts. They agreed that motivation is an antecedent to engagement; it is the non-felt force that uplifts performance (Lim, 2004; Reeve, 2012; Reschly & Christenson, 2012). On the other hand, student engagement is work in action; an observable display (Eccles & Wang, 2012; Kuh, 2009; Skinner & Pitzer, 2012), demonstrated through a series of indicators. It is agreed upon that no one definition will satisfy all stakeholders (Solomonides, 2013), it is important for each research project to begin with a clear definition of their own understanding (Boekaerts, 2016). Therefore, in this project, student engagement is defined as follows:

Student engagement is the effort (trial and error, making mistakes, responding to teachers, etc…) that students exert in their schools, noticeable through a number of behavioral, cognitive or affective indicators. It is shaped by many influences such as relationships, learning activities and learning environment.

*Behavioral Engagement*

It is the active involvement of students in learning (Sinatra, Heddy, and Lombardi, 2015). This active involvement is noticeable and comprises students' participation in actions and obedience to rules (Fredricks et al., 2004).

*Emotional Engagement*

It is students' affective responses to an educational topic (Fredricks et al., 2004). This emotional involvement is noticeable through students' happiness, boredom, sadness or interest (Fredricks et al., 2004). These emotions were observed to play a crucial role in choices surrounding emotional engagement.

*Cognitive Engagement*

It is students' psychological asset and incentive (Sinatra et al., 2015). It is difficult to observe and measure cognitive engagement. Nevertheless, it has been proved that it has affirmative impact on student performance, persistence, and goal orientation (Appleton et al., 2006; Meece, Blumenfeld, & Hoyle, 1988).

**Instructional Practices**

Research (Nicol & Macfarlane-Dick, 2006; Prince, 2004; Wang, Yang, Wen, Koedinger, & Rosé, 2015) argued that instructional practices influence students' engagement. These practices include lectures, students' interactions and structure of the lesson and exams. Problem based learning as well as project based learning are believed to have major influence on students 'engagement (Dard, Lison, Dalle, & Boutin, 2010; Prince, 2004; Smith, Sheppard, Johnson, & Johnson, 2005). Nevertheless, it is crucial to consider teachers' practices in STEM fields classes, even those that do not fit within the bounds of a certain strategy (Barlow& Brown, 2020).

**Conclusion**

Barlow and Brown (2020) voiced the positive correlation between content delivery and active notetaking which is teachers' leading students through content and students' response by taking notes. Research (Barlow & Brown, 2020) argued that students are most alert to their teachers' practices including assessment, content delivery, and peer work in class. Moreover, there is an important interconnection between student cognitive engagement and teachers' instructional practices.

## Methods

In this section, a detailed description of the methods used in the action research is presented. The aim of this section is to provide the study's research design, sampling method, procedure and instruments for data collection and analysis. Also, reliability, validity and researcher's bias and piloting the instruments are listed in details. The method's part is divided into eight parts; Type of method, participants, procedures, data analysis method, validity and reliability, researcher's bias and assumptions, ethical considerations and table connecting procedures to research questions.

**Research**

This research is an action research study. Hence, it will provide a descriptive analysis and interpretation of the elementary teachers' practices mainly with reference to STEM framework. To meet this end, this research used mixed methods of research as qualitative and quantitative methods were used to answer the study's research questions. I used many instruments to study in depth the elementary public school teachers' practices with reference to STEM framework.

**Participants**

This research was conducted at public schools in Beirut. Purposive convenience sampling is adopted to select these schools. The participating schools were chosen based on its basic familiarity with STEM education. In many interviews, school principals, teachers and coordinators voiced that even though they do not follow STEM education in a formal way, but teachers use many STEMy approaches, namely inquiry-based learning. The sample is formed of 33 public schools, 13 teachers (chemistry, Biology, and math) who were mostly females, and 810 students, grades 2 to 6, during the school year 2021-2022 in Beirut, Lebanon.

Teachers were trained on the use of Microsoft teams by the Center of Educational Resources(CERD) to reach their students during the pandemic and they were subject teachers, i.e., math and sciences. Questionnaires were distributed to 27 STEM fields teachers, and observations were conducted while they were implementing STEM activities concerning different topics such as heart anatomy and acids and base lessons. Only 13 teachers

returned the questionnaires and since I am the observer I conducted 33 observations in grades 2 to 8 and in math and science subjects.

In summary, the participants selected for the study are all elementary public school teachers. Technology is supposed to be integrated in the taught lessons. The main focus will be on math and science lessons taught by those teachers.

**Procedures**

The procedures that were carried out to collect data for the study include class observation, interviewing and surveying. The purpose is a deep understanding of the teachers' practices at public schools. Observation helped me detect minute details concerning teachers and students' behavior, engagement and dynamics in the classroom. Interviews allowed me to comprehend the respondents' attitudes, beliefs and knowledge about the subject.

**Data Collection**

***Observations***

Observations were conducted to detect the practices that math and science teachers use while teaching a lesson. Hence, the observations gave important information linked to the first question.

I conducted observations at public elementary schools in Beirut in grades 2 to 8. They were math and science classes and teachers were using technology in their classrooms for different purposes such as preparing the lesson or conducting virtual experiments.

*Observation Instrument*

The instrument that I used to observe the public school classes is the *STEM Classroom Observation Protocol*. This protocol has been used to observe the instructional and teaching practices of teachers in the United States and includes a variety of indicators related to STEM practices (Edmunds et al., 2017). This instrument provides the researcher with a set of statements that s/he scores on a 4-point Likert scale. The range goes from "not observed" (=0) to "very descriptive" (=3). Also, it allows the researcher to write notes and specific examples that reflect the noted practices.

The protocol contains two parts. The firs one is about general information, such as class, lesson topic, lesson goals, etc. the second part deals with information related to eight dimensions, which are:

1. Math and Science Content
2. Student Cognitive Engagement in Meaningful Instruction

3. Inquiry Learning, Project-based learning and Problem-based learning
4. Teacher Instruction/ Formative Assessment
5. Common Instructional Framework
6. Student Engagement
7. Use of Technology
8. Classroom Culture

Each dimension includes certain number of indicators/ statements that are pertinent to the teaching and learning practices in the classroom. The observer will rate the instructional practice according to the rating scale that ranges from 0 to 3 as mentioned below (Edumunds et al., 2017)

1. 0 means that the instructional practice was *not observed*
2. 1 means that the instructional practice is *minimal*
3. 2 means that the instructional practice was observed to *some extent*
4. 3 means that the instructional practice is *very descriptive of the observation*

Within each dimension, there are several indicators, and the summary rating of the dimension is the average of each indicator in the same dimension (Edmunds et al., 2017).

The *STEM Classroom Observation Protocol* is a reliable instrument. The researchers (Edmunds et al., 2017) conducted three training sessions where observers examined videos of math and science classes using the STEM protocol. After the training sessions, observers went to classroom where two of them examined the same classroom. Directly after the classes, the two observers met and discussed the ratings and the common scores for all the protocol's indicators. There was a high agreement among observers while using the instrument, it ranged from 83.3% to 100 %. Thus, this instrument is reliable (Edmunds et al., 2017).

*Pilot Observation*

The *STEM observation protocol* was piloted in two classrooms that are not part of the study to make sure that all the statements apply to the research context. On the day of piloting, I explained briefly to the teachers about the research and the aim of the pilot observation. The indicators related to "Teacher Ethnicity", 'Classroom Race/ Ethnicity" and the "School Name" will be removed, because they are not applicable and for confidentiality reasons respectively. These statements were eliminated from the first page, as for other pages, the wording of all statements are clear and precise.

In the section about *Teacher Instruction/Formative Assessment*, the last column is cancelled since (4) was not given a rating. Also, the statement in *Common Instructional Framework* that deals with *students participated in guided reading discussions*, in section 5 was eliminated as the research does not deal with guided reading.

***Interviews***

13 elementary public school teachers were interviewed. Teachers mentioned their beliefs about STEM education and their teaching strategies in the classroom and barriers to the implementation of STEM education. Principals of 3 schools and 3 coordinators were also interviewed to investigate the way they support teachers.

*Interviewing Instrument*

The interviews were made up or four sections: background information, teaching strategies, technological pedagogical content knowledge and barriers to the implementation of STEM education.

***Surveys***

A questionnaire was used to conduct the online survey. The first page included an overview of the research and ethical considerations, including voluntary participation, confidentiality and anonymity of the information. The four categories of the questionnaire were: biographical background, adopted teaching practices, support that teachers get to and the fourth and last category was about the barriers for implementing STEM education. The questionnaires were typed and distributed in English.

**Data Analysis**

The data was collected through the three instruments: STEM Classroom Observation Protocol, interviews and questionnaires. the data from the interviews were analyzed qualitatively while the data from the observation protocol and questionnaires were analyzed both quantitatively and qualitatively. The questions of the STEM Observation Protocol were analyzed quantitatively. The mean of each indicator and each subscale was studied.

**Validity and Reliability**

STEM observation protocol is a valid and reliable instrument and was piloted to do necessary modifications. Triangulations is met through the use of three different instruments. Data collected through these instruments: observations, interviews and surveys were cross verified which ensured the validity of the results. Also, the participants were from different schools, classes and subject fields which added to the validity of the data.

**Research Bias and Assumptions**

Since I was the main observer, I did not interact with the students and kept my interaction with the teachers at its minimal level. As for the interviewees I believe that the participants answered the questions to their best knowledge.

**Ethical Considerations**

The study was approved by the institution that I am member of. In addition, all needed approvals to go to public schools were obtained from the Ministry of Education and Higher Education and from the Educational Bureau of the elementary schools. Moreover, approvals from the authors of the STEM Classroom Observation Protocol were also given through e-mail and the interviewees were granted anonymity and confidentiality of their identities and their schools.

Table 1. Connecting Procedures to research Questions

| | Observations | Interviews | Questionnaires |
|---|---|---|---|
| What kind of instruction STEM fields' teachers apply in their classrooms? | x | x | x |
| How are students' engagement and learning during a STEM lesson? | x | | |

## Results

This section tries to answer the research question through cross-verifying and synthesizing the results gained form each instrument

**Research question 1: What kind of instruction STEM fields' teachers apply in their classrooms?**

*Analysis of CIF: Classroom Observations*

*Global Descriptive Analysis*

Table 2. CIF Classroom Observation Mean Scores across the Grade Level and STEM Fields

| | Common instructional framework | 0 | 1 | 2 | 3 | average |
|---|---|---|---|---|---|---|
| CIF1 | Students worked collaboratively in teams or groups | 31 | 0 | 0 | 2 | 0.182 |
| CIF2 | Students used writing to communicate what they had learned | 18 | 10 | 4 | 1 | 0.636 |
| CIF3 | Teachers asked open ended questions that require higher level thinking | 17 | 6 | 5 | 5 | 0.939 |
| CIF4 | Teachers provided assistance/scaffolding when students struggled | 1 | 13 | 9 | 10 | 1.848 |
| CIF5 | Students engaged in discussion with each other | 22 | 8 | 3 | 0 | 0.424 |
| | summary of CIF | 14.6 | 8.8 | 5 | 4.6 | 0.988 |

Table 2 shows the CIF of classroom observation mean across the grade level. CIF 1, *Students worked collaboratively in teams or groups* (0.18) scored the least.

*Interpretive Analysis*

During my observations, students rarely worked in groups due to the large number of students and the small size of the classroom. On average, a typical elementary class would include up to 30 students or more. Nevertheless, teachers divided students into groups while working on the lesson about "angles "and the lesson related to "mammals". Teachers asked their students to look at pictures and to derive the characteristics of mammals. As for the math lesson, they were asked to discuss in pairs about the different types of angles that can be found in the classroom. Accordingly, students were not discussing concepts neither did they work on problems that need higher order thinking skills.

*Student-centered Approaches*

*Results from the Interviews about Approaches*

Results from the interviews showed that teachers mainly connect information to real world contexts and they would discuss with their students about information. While open ended questions and students' presentations were used scarcely.

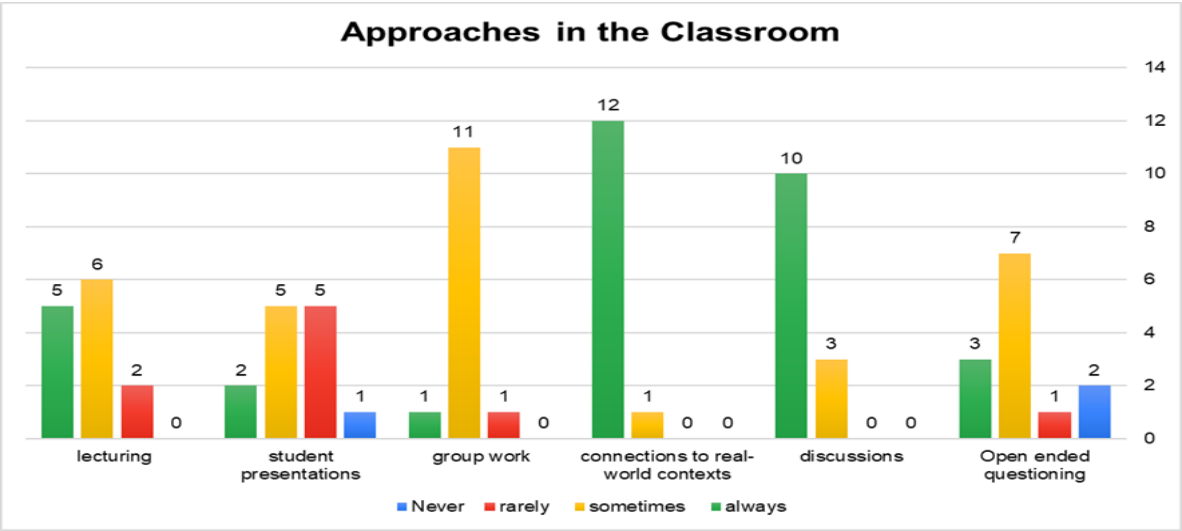


Figure 1. Approaches in the Classroom

*Inquiry-based learning*- Analysis of IBL: Classroom Observations

*Global Descriptive Analysis*

Table 3 shows the IBL classroom observation global means scores across the grade levels. All of the indicators had low scores. The overall average (0.08) shows that scientific inquiry was implemented poorly in the

classrooms and across all levels. The following indicators: *There was an explicit evidence of students using engineering (or reverse engineering) design process (0)* emphasizes that teachers did not use the engineering design nor the reverse engineering design.

Table 3.IBL Classroom Observation Mean Scores across the Grade Level and STEM Fields

| Inquiry learning | 0 | 1 | 2 | 3 | not applicable | average |
|---|---|---|---|---|---|---|
| Students had to present or explain results of project | 17 | 2 | 2 | 0 | 12 | 0.18 |
| Students worked on a project requiring creativity | 20 | 1 | 0 | 0 | 12 | 0.03 |
| There was an explicit evidence of teacher modeling engineering (or reverse engineering) design process | 19 | 1 | 1 | 0 | 12 | 0.09 |
| There was an explicit evidence of students using engineering (or reverse engineering ) design process | 21 | 0 | 0 | 0 | 12 | 0.00 |
| Summary of IBL | 19.25 | 1.00 | 0.75 | 0.00 | 12.00 | 0.08 |

*IBL Interpretive Analysis*

Mainly students at the elementary level did not engage in open ended questions either in Math or Sciences classes. They used to follow teachers' instructions to observe a certain photo while describing the reproduction of mammals or look at their skins to describe a certain phenomenon like perspiration or the senses but the layers of the skin were described by the teacher. Also, while learning about birds, students opened their books on a specific page and looked at the pictures, then they described the characteristics of birds. When teachers were asked about the absence of manipulatives, many of them voiced that due to the economic crisis they are no longer able to buy and bring to the classes the needed manipulatives.

*Results from the Interviews*

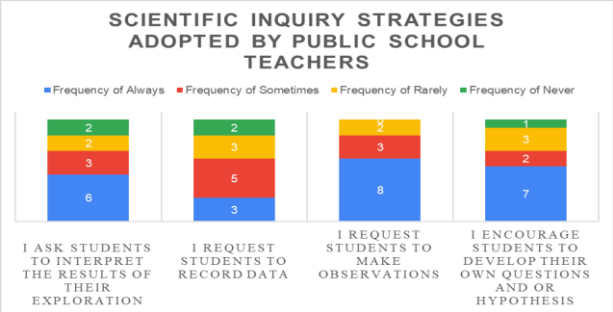


Figure 2. Scientific Inquiry Strategies Adopted by Public School Teachers

Results from the interviews showed that teachers asked their students to observe and develop their own questions. Still, students did not know how to record data of their observations or how to interpret the results of their explorations.

*Problem-based Learning*

*Findings from the Observations*

Table 4. Problem Based Learning mean Scores across the Grade Level and STEM Fields

| Problem Based Learning | 0 | 1 | 2 | 3 | not applicable | average |
|---|---|---|---|---|---|---|
| Students were engaged in open ended tasks or questions | 16 | 6 | 5 | 5 | 1 | 0.94 |
| Students engaged in hands on or real life problem solving activities or a lab experiment | 8 | 11 | 4 | 9 | 1 | 1.39 |
| Students developed their own questions and or hypotheses to explore or test | 23 | 2 | 5 | 1 | 2 | 0.45 |
| Students engaged in scientific inquiry process (tested hypotheses and made inferences) | 2 | 11 | 0 | 8 | 12 | 1.06 |
| Students determined which problem solving strategies to use | 26 | 2 | 1 | 0 | 4 | 0.12 |
| Summary of PBL | 15.00 | 6.40 | 3.00 | 4.60 | 4.00 | 0.79 |

*Results from Interviews*

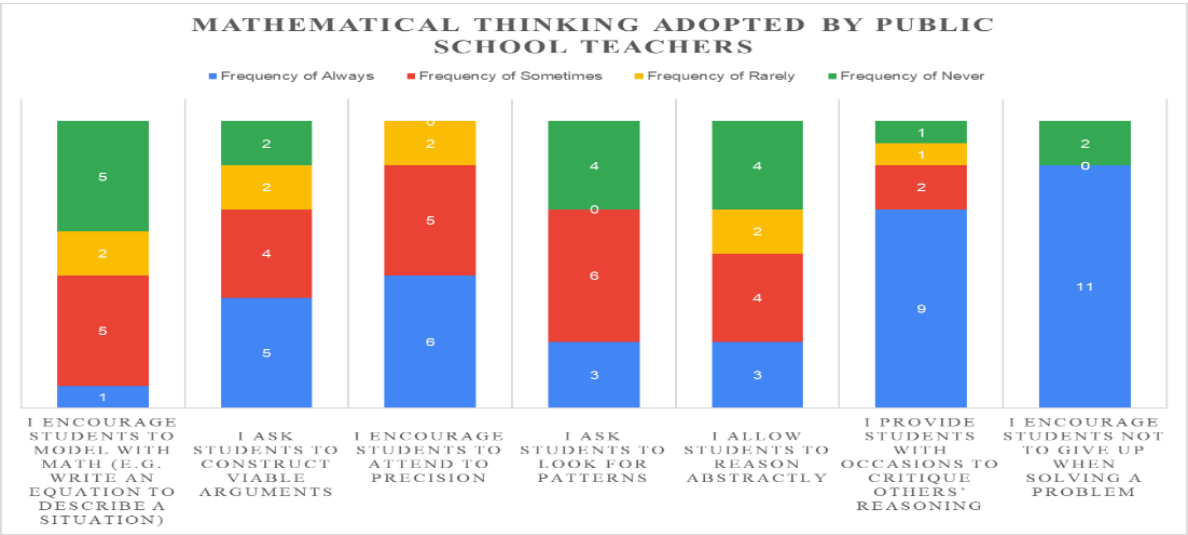


Figure 3. Mathematical Thinking Adopted By Public School Teachers

Results from the interviews showed that teachers encouraged their students to persevere while solving problems while using their critical thinking. On the other hand, results from observations showed that problem based learning was somewhat used by teachers. Students engaged in real life problems and presented explanations of

projects whenever they were applied. Teachers did not use open-ended questions and were not keen to the diversion of students' thinking.

*Project-based Learning and Constructing Models- Findings from Observations*

Table 5. Project Based Learning mean Scores Across the Grade Level and STEM Fields

| Project Based Learning | 0 | 1 | 2 | 3 | not applicable | average |
|---|---|---|---|---|---|---|
| Students had to present or explain results of project | 17 | 2 | 2 | 0 | 12 | 0.18 |
| Students worked on a project requiring creativity | 20 | 1 | 0 | 0 | 12 | 0.03 |
| There was an explicit evidence of teacher modeling engineering (or reverse engineering) design process | 19 | 1 | 1 | 0 | 12 | 0.09 |
| There was an explicit evidence of students using engineering (or reverse engineering design process | 21 | 0 | 0 | 0 | 12 | 0.00 |
| Summary of PJbL | 19.25 | 1.00 | 0.75 | 0 | 12 | 0.08 |

Results from the interviews and the observations showed that project-based learning was among the least strategies used by the teachers. During the interviews, teachers voiced that students used to do projects and build models before the economic crisis. They built workable digestive model using clay and a working model about an airport with planes and runways, etc…

Results from the surveys confirmed these findings. Teachers voiced that their approaches in their classrooms did not frequently include building models. Also, surveys set the results that project-based learning was used poorly at the Lebanese public schools.

*Technology Integration*
*Analysis of UOT: Classroom Observations*
*Descriptive Analysis*

Table 6 shows the UOT classroom observation mean scores across the grade levels. Most indicators had low scores, especially those related to students' skills practice or to their use of technology as means to represent an idea.

Table 6. UOT Classroom Observation Mean Scores across the Grade Level and STEM Fields

| | Use of technology | 0 | 1 | 2 | 3 | average |
|---|---|---|---|---|---|---|
| UOT1 | Technology was used to a high extent (as a proportion of time of the lesson and intensity of use) | 25 | 2 | 3 | 3 | 0.53 |
| UOT2 | Students used technology to explore or confirm relationships, ideas, hypotheses, or develop conceptual understanding | 26 | 1 | 1 | 5 | 0.56 |
| UOT3 | Students used technology to generate or manipulate one or more representations of a given concept or idea | 27 | 0 | 1 | 5 | 0.53 |
| UOT4 | Students used technology as a tool to meet a discreet instructional outcome (like and assignment or specific objective) | 24 | 3 | 1 | 5 | 0.63 |
| UOT5 | Students used technology to practice skills or reinforce knowledge | 25 | 2 | 1 | 5 | 0.59 |
| UOT6 | Technology was used but did not appear to provide any added benefit | 22 | 1 | 2 | 8 | 0.91 |
| UOT7 | Teacher used technology to achieve instructional goals(emphasis on the teacher here) | 16 | 2 | 4 | 11 | 1.34 |
| | Summary of UOT | 22.86 | 1.57 | 1.86 | 6.71 | 0.79 |

*Interpretive Analysis*

The score of the summary of UOT seems to be alarming. During all the observed sessions, students did not use technology as means to practice skills or for conceptual understanding. On the other hand, teachers used technology to explain. Mainly, they used technology for lesson planning and for presentation in the classroom. Also, they used it to provide students with their homework as they did not have their books until late in the school year. They sent the explanation and the students' homework on the What's App groups that they used during COVID-19.

Moreover, the books were not available due to the economic crisis and the lack of electricity at the printing companies. Thus, teachers were left with the only available option which was to send the students' homework via What's App.

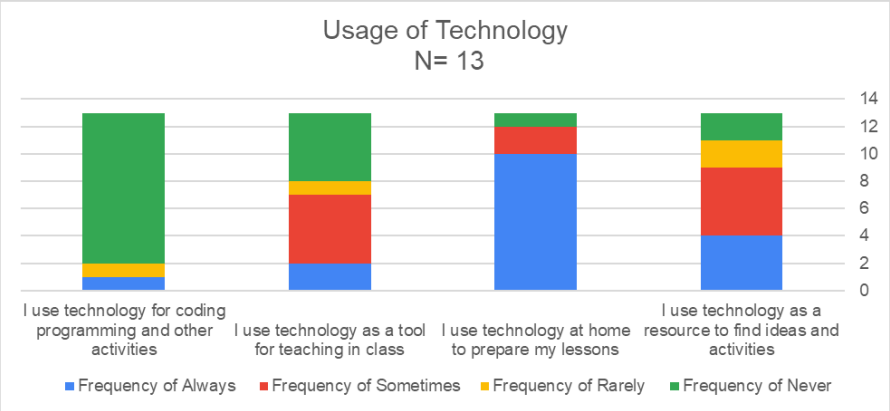


Figure 4. Usage of Technology by Public School Teachers.

*Results from Interviews*

Results from the interviews showed that technology was mainly used as a resource for lesson planning. The types of used technology were You tubes, power point presentations, and what's app. Recently, MEHE established classrooms for teacher using Microsoft teams and trained teachers to use them but due to the poverty of the parents at public schools, they were not able to use it frequently. Also, findings from observations assured the results obtained from the interviews. Technology was used mainly by teachers to prepare their lesson plans and to find interesting activities. On the other hand, students did not use it to comprehend or to manipulate the lessons' concepts.

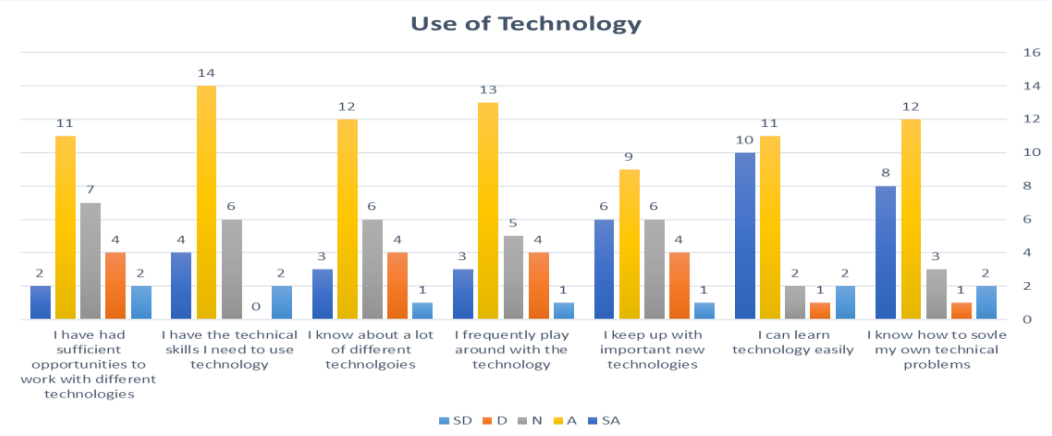


Figure 5. Usage of Technology by Public School Teachers.

*Results from Surveys*

In addition, results from the surveys showed that technology integration was mildly applied in the classrooms. Technology is used mainly as a resource to find new activities or to prepare the lessons at home. Its use in the classrooms is only to present the lesson on the screen and not as an interactive mode of teaching, i.e. the power

point presentation slides were a summary of the lesson and students were not actively participating in the construction of the understanding of the concept.

*Integration of Mathematics*

*Analysis of MSC: Classroom Observations*

Table 7. MSC Classroom Observation Mean Scores across the Grade Level and STEM Fields

| | Math and Sciences content knowledge | 1 | 2 | 3 | 0 | Mean |
|---|---|---|---|---|---|---|
| MSC1 | Math and science content information was accurate | 2 | 6 | 24 | 1 | 2.61 |
| MSC2 | teachers presentation or clarification of mathematics or science content knowledge was clear | 3 | 7 | 22 | 1 | 2.52 |
| MSC3 | teacher used accurate and appropriate mathematics or science vocabulary | 2 | 8 | 22 | 1 | 2.55 |
| MSC4 | Teacher/students emphasized meaningful relationships among different facts, skills, and concepts | 13 | 14 | 4 | 2 | 1.61 |
| MSC5 | Students mistakes or misconceptions were clearly addressed (emphasis on correct content here) | 11 | 9 | 11 | 2 | 1.88 |
| MSC6 | Teacher and students discussed key mathematical or science ideas and concepts in depth | 14 | 12 | 5 | 2 | 1.61 |
| MSC7 | Teacher connected information to previous knowledge | 14 | 10 | 4 | 5 | 1.39 |
| MSC8 | appropriate connection were made to other areas of mathematics/science or to other disciplines | 14 | 8 | 2 | 9 | 1.09 |
| MSC9 | Appropriate connections were made to real-world contexts | 7 | 5 | 13 | 8 | 1.70 |
| | Summary: quality of math and science content | | | | | 1.88 |

.

Table 6 shows the classroom observation global mean scores across the grade levels and the subjects taught. Most of the indicators show low mean scores, *Math and science content information* having the highest mean 2.69 and *appropriate connections were made to other areas of mathematics/science or to other disciplines* being the lowest with 1.09 respectively.

*Interpretive Analysis of MSC*

Math and sciences teachers across levels are university graduates with teaching diplomas. Many of those teachers had their masters too. Hence, it is normal that their content knowledge is in accordance with their teaching in the classrooms. On the other hand, teachers did not relate subjects to each other a lot because they are obliged to finish their scheduled chapters on time.

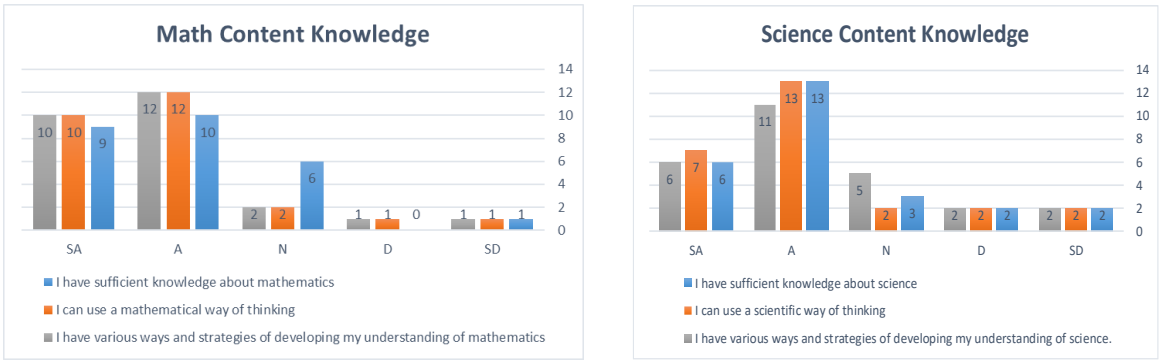


Figure 6. Math and Science Content Knowledge.

*Results from Surveys*

Surveys showed that teachers had sufficient math and science content knowledge. Thus, results of the observations and the surveys are in harmony in this area. Results from the interviews showed that mathematical thinking was used for problem solving. Its integration in sciences subjects was only in the lessons about acids and base to measure the Ph of the solution to determine whether it was and acid or a base solution. Also, results from observations showed that mathematical thinking was used poorly since students did not compare/contrast ideas. They were not given opportunities to summarize, synthesize or generalize.

**Research question 2: How are students' engagement and learning during a STEM lesson?**

*Analysis of CEM: Classroom Observations*

*Global Descriptive Analysis*

Table 8. CEM Classroom Observation Mean Scores across the Grade Level and STEM Fields

| Students Cognitive Engagement in Meaningful Instruction | 0 | 1 | 2 | 3 | Mean |
|---|---|---|---|---|---|
| Students experienced high cognitive demand of activities because teacher did not reduce cognitive demand of activities by providing directive hints, explaining strategies or providing solutions to problems before students have a chance to explore them etc. | 8 | 11 | 9 | 5 | 1.33 |
| Students were asked to explain or justify their thinking | 6 | 11 | 10 | 6 | 1.48 |
| Students were given opportunities to summarize, synthesize , and generalize | 14 | 14 | 3 | 2 | 0.79 |
| Students used a variety of means, models, drawings, graphs, concrete materials, manipulatives, etc... to represent phenomena | 15 | 14 | 3 | 1 | 0.70 |
| Students were asked to apply knowledge to a novel situation | 15 | 10 | 5 | 3 | 0.88 |
| Students were asked to compare/contrast different answers, different solutions, or different explanations/interpretations to a problem or phenomena | 20 | 6 | 2 | 5 | 0.76 |
| Summary of students' cognitive engagement in meaningful instruction | 13 | 11 | 5.33 | 3.67 | 0.99 |

Table 8 shows the level of students' engagement while at STEM fields unit. The two indicators; *Students*

*experienced high cognitive demand of activities because teacher did not reduce cognitive demand of activities by providing directive hints, explaining strategies or providing solutions to problems before students have a chance to explore them etc.* and *Students were asked to explain or justify their thinking* were the only indicators that scored moderately while the overall score was alarming.

*Interpretive Analysis of CEM*

The cognitive engagement of students while I was observing the classrooms was moderate. Mainly, students would not compare different solutions as teachers were mainly teaching to the test. Also, while teaching about chemical reactions, the science teacher would tell students to look at the rusty iron of the classroom window. She related the lesson to a real life example but did not bring to the classroom any manipulative. On the other hand, when G4 students were explaining about rhombus, they had to show the special properties of its sides and angles.

Data from the observations, interviews and surveys were used to answer the second question. The kind of students' engagement during classes will be revealed here.

Results from the interviews showed that active learning was used and students worked in groups mainly. Also, findings revealed that teachers played the role of mediators while students were the center of their teaching.

On the other hand, observations revealed that students' cognitive engagement was minimal. They did not summarize or generalize. Also, they did not explain problems or phenomena. Students were not given a variety of means to represent phenomena. They were given a problem from the book and students would solve this problem. In addition, they were not engaged in open-ended questions neither did they determine the strategies to solve problems. Globally, students did not reflect on their learning and they were not engaged in discussions pertinent to learned concepts. Consequently, even though they appeared to be engaged but their quality of engagement was on the level of applying what the teachers asked them to do.

*Results from the Surveys*

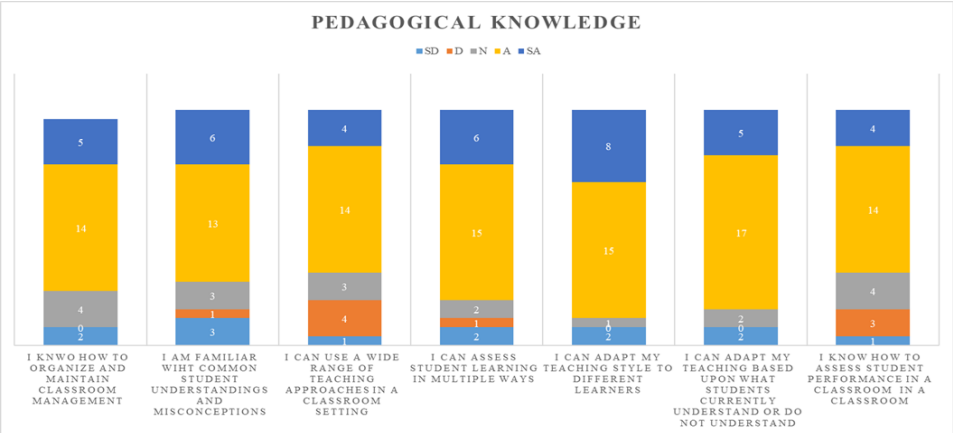


Figure 8. Pedagogical Knowledge

Results from surveys showed that students did not work in groups which contradicts the findings from the interviews. Also, the results of the surveys showed that students would reason abstractly and they would build arguments and models. These findings contradict those obtained from the observations. As a conclusion, while I was observing STEM field classes, I noticed that students were not engaged in meaningful instructions and did not reflect cognitively on their learning.

## Limitations of the Study

Some of the limitations of the research are presented here. First, the sample size of teachers interviewed. Second, I was the main observer of the sessions. Third, the research was conducted at the elementary Lebanese public schools, thus the findings of the research can not be generalized to middle or secondary private schools in Lebanon as they follow different types of curriculum and their economic status play a major role in the teaching and learning process.

## Implications and Recommendations for Further Practice

The results of this research paper can be used in several venues. An understanding of the instructions of elementary STEM field teachers in public schools in Lebanon will be helpful for developing a common understanding of the type of strategies teachers use while in their classrooms. This action research will help decision Lebanese curriculum maker on the best practices that will help teachers in introducing STEM education. Also, an understanding of the students' engagement will be useful for teachers, directors and DOPS to cater for their needs. Prensky (2005) voiced that "….. its only by listening to and valuing the ideas of our 21st century students that we will find solutions to many of our thorniest education problems." Thus, to satisfy our students we need to teach them with the same language that they understand.

## Suggestions for Future Research

This action research study can be piloted in private schools in Lebanon or at the secondary public schools. The interviews, questionnaires and observations might lead to different findings if carried in different contexts. Thus, the results will inform the directors and DOPS members about the real practices of teachers in their classrooms.

## References

Chai, C. S., Rahmawati, Y., & Jong, M. S. Y. (2020). Indonesian science, mathematics, and engineering preservice teachers' experiences in stem-tpack design-based learning. *Sustainability (Switzerland)*, *12*(21), 1–14. https://doi.org/10.3390/su12219050

Capobianco, B. M., & Rupp, M. (2014). STEM teachers' planned and enacted attempts at implementing

engineering design-Based instruction. *School Science and Mathematics, 114*(6), 258-270. doi:10.1111/ssm.12078

Darling-Hammond, L. (2016). Research on teaching and teacher education and its influences on policy and practice. *Educational Researcher, 45*(2), 83-91. https://doi.org/10.3102/0013189X16639597

Du, X., Chaaban, Y., Sabah, S., Al-Thani, A. M., & Wang, L. (2020). Active learning engagement in teacher preparation programmes - A comparative study from qatar, lebanon and china. *Asia Pacific Journal of Education, 40*(3), 283-298. https://doi.org/10.1080/02188791.2020.1717436

Iswadi, Syukri, M., Soewarno, Yulisman, H., & Nurina, C. (2020). A systematic literature review of science teachers' TPACK related to STEM in developing a TPACK-STEM scale. *Journal of Physics. Conference Series, 1460*(1), 12105. https://doi.org/10.1088/1742-6596/1460/1/012105

Edmunds, J. A., Arshavsky, N., Lewis, K., Hutchins, B.C. & Coyle, V. (2017). STEM Early College Expansion Partnership (SECEP): External Evaluation Report: Site Visits. Greensboro, NC: The SERVE Center, University of North Carolina at Greensboro.

Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education, 3*(1), 1-11.10.1186/s40594-016-0046-z.

Kelley, T. R., Knowles, J. G., Holland, J. D., & Han, J. (2020). Increasing high school teachers self-efficacy for integrated STEM instruction through a collaborative community of practice. *International Journal of STEM Education, 7*, 1–13. https://doi.org/10.1186/s40594-020-00211-w

Nadelson, L. S. (2016). The Influence and Outcomes of a STEM Education Research Faculty Community of Practice. *Journal of STEM Education: Innovations & Research*, *17*(1), 44–51.

Nadelson, L. S., Callahan, J., Pyke, P., Hay, A., Dance, M., & Pfiester, J. (2013). Teacher STEM perception and preparation: Inquiry-based STEM professional development for elementary teachers. *The Journal of Educational Research, 106*(2), 157-168.

National Science Board. (2010). *Science and engineering indicators 2010* (NSB 14-01). Arlington VA: National Science Foundation.

Sahin, A., Waxman, H. C., Demirci, E., & Rangel, V. S. (2019;2020). An investigation of harmony public school students' college enrollment and STEM major selection rates and perceptions of factors in STEM major selection. *International Journal of Science and Mathematics Education*, *18*(7), 1249-1269. doi:10.1007/s10763-019-10017-0

Thinzarkyaw, W. (2019). The practice of technological pedagogical content knowledge of teacher educators in education colleges in Myanmar. *Contemporary Educational Technology, 11*(2) doi:10.30935/cet.660829

World Bank. 2018. *Expectations and Aspirations: A New Framework for Education in the Middle East and North Africa: Overview (English)*. Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/527931542039352771/Overview

# Analysis of the Cutting Temperature and Chip Shape Induced by the Turning AISI 1045 Steel

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**Abstract**: Many factors influence products obtained from metal cutting; among them, the cutting temperature and chip formation during the turning process need particular attention as they can affect the surface integrity of the machined parts. Thus, these machining outcomes will be analyzed, and it will be expected to delineate ranges of feed rate and L/D ratio in which both cutting temperature and chip shape are desirable for an efficient process. AISI 1045 steel was used to manufacture the specimens, and the cutting temperature was obtained using thermal images. Chip analysis was performed through visual inspection. It can be noted that the results of the cutting temperature and the chip shapes presented distinct variabilities; however, when the analysis was finished, it was possible to relate both results.

**Keywords:** Cutting temperature, Feed rate, Chip shape, L/D Ratio, AISI 1045 Steel

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## Introduction

The material machinability can behave differently depending on the machining conditions. In order to be able to carry out a machining process, an advanced study of several types of parameters and conditions must be realized, mainly when there are specific machining outcomes to be investigated such as degradation of the tool and its cutting edge, cutting power, generated temperatures, application of cutting fluid, among others. It is also necessary to pay attention to chip shape since this factor is fundamental for all machining. [1].

As far as chips are concerned, one of the main analyzes performed is regarding their sizes and shapes, because as the chip thickness grows, they flow more difficulty on the rake surface, thus increasing the torque and being able to generate fractures in the cutting tool [2]. Regarding the cutting parameters, Smith [3] claims that the feed is the parameter that most influences the shape of the chips.

Furthermore, according to Degenhardt et al. [4], even if the chips have a small thickness, it is recommended that they are not too long, as they tend to be intertwined in the machine-part-tool system, leading to poor quality of the part finish, generating a high production cost. Thus, the smaller the chip thickness and length, the better the process. It is noteworthy that the chips can be better classified as to their shape based on the ISO 3685/2017 [5].

Concerning the temperature in the machining process, it has a large interference factor on the parts since it directly affects the dimensions of the material and induces residual stresses due to thermal loading. These temperatures come from the deformation energy which is transformed into thermal energy as well as the tribological conditions of the cutting system, mainly, on the chip-rake face interface. [6-7].

In the case of metal cutting, there are three heat zones. They are generated from deformation zones: Primary Shear Zone (PSZ), Secondary Shear Zone (SSZ), and Tertiary Shear Zone (TSZ) [6]. In the machining process, the maximum temperature (cutting temperature) is located close to the cutting edge (SSZ), as it is in this area where the normal and shear stresses act and are high [8].

Therefore, this work aims to evaluate the formation of chips generated and estimate the cutting temperatures induced by the longitudinal turning of AISI 1045 carbon steel.

## Method

The AISI 1045 steel was chosen considering its low cost and good mechanical properties, such as good ductility and tensile strength. Moreover it is widely used in the manufacture of axles, connecting rods, screws, etc. Eight (8) specimens were manufactured in total; Figure 1 shows the initial dimensions of the specimens.

Workpieces were clamped in a CNC Diplomat lathe, model LOGIC 195-III. To perform the turning tests of these specimens, a PVD ((Ti,Al)N + TiN) coated carbide insert was used, type TNMG160408-MF1 CP500 (Fig. 2a), with nose radius of 0.8 mm, nose angle of 60º and clearance angle of 0º. The insert was coupled to a PTGNL2020K16 holder with a rake angle equal to -5º (Fig. 2b), both manufactured by Seco Tools.

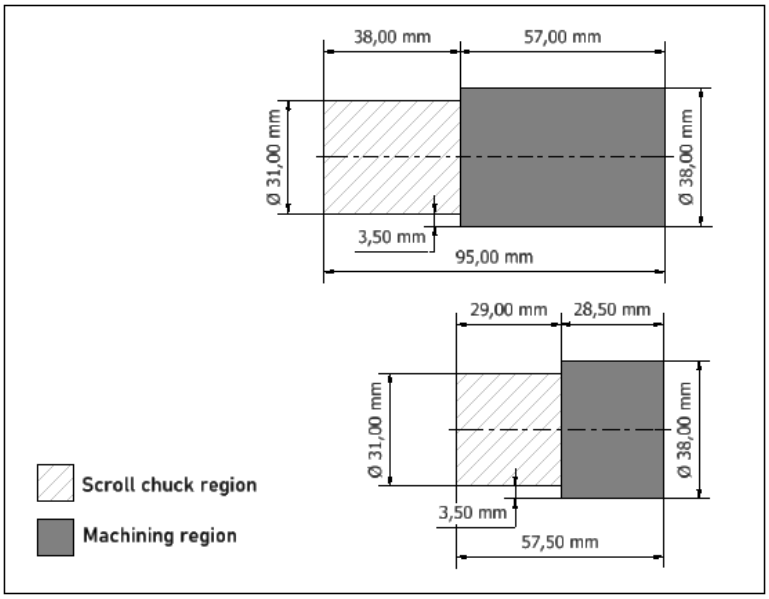


Figure 1. Technical drawing of the 1045 Steel Specimens

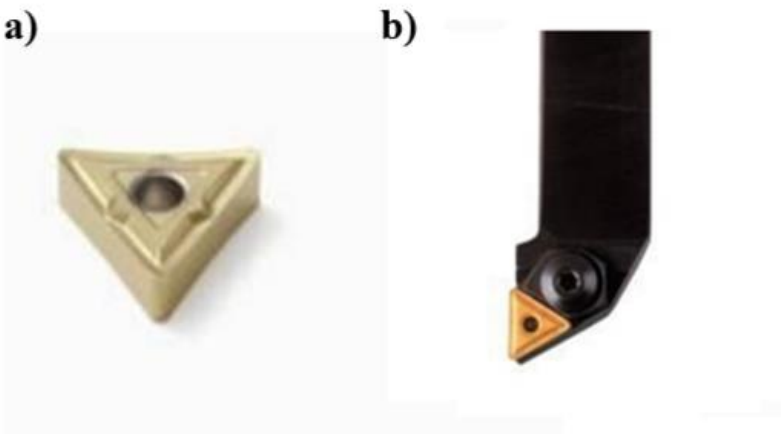


Figure 2. Cutting tool: a) Insert: TNMG160408-MF1 CP500, and b) Tool holder: PTGNL2020K16.

[9-10]

Regarding the cutting parameters, the cutting speed (Vc =190 m/min) and the depth of cut (ap = 0.50 mm) were kept constant. Thus, it was decided to vary only the advance (f), and also the (L/D) ratio, using a $2^2$ experimental design with one replica. The cutting parameters are arranged in the Tab. 1.

Temperature measurements were performed using a thermal imaging camera with a resolution of 100 x 140 pixels, Flir, model i7 (Fig. 3). Thus, during the turning of each specimen, three images were captured at a distance of approximately 30 cm from the interested area.

| Cutting parameters | Levels | |
|---|---|---|
| | -1 | 1 |
| f (mm/rev) | 0,05 | 0,1 |
| L/D (mm/mm) | 0,75 | 1,5 |
| Vc (m/min) | 190 | |
| ap (mm) | 1,5 | |

Figure 3. Cutting Parameters used in the Experimental Tests


Figure 4. Thermal Imaging Camera Model Flir i7. [11]

After turning each workpiece, samples of chips were collected and separated (Fig. 4). Each sample was properly identified with cutting parameters and cutting conditions.

Figure 5. Collected Chips after Machining Parts

## Results and Discussion

Figure 6 presents the measured cutting temperatures; the cutting temperature was calculated from the average of the temperatures obtained plus 30% of the value of the average itself, because, according to Soller [12], when disregarding the displacement of the temperature measured with the thermal camera in the middle plane, these values are underestimated by approximately 30%.

| Replica | Specimens | AISI 1045 Steel | | |
|---|---|---|---|---|
| | | L/D (mm/mm) | f (mm/rev) | Cutting temperature (°C) |
| 1 | J | 0,75 | 0,05 | 264,55 |
| | B | 1,5 | 0,05 | 226,2 |
| | I | 0,75 | 0,1 | 217,1 |
| | A | 1,5 | 0,1 | 189,8 |
| 2 | N | 0,75 | 0,05 | 277,55 |
| | E | 1,5 | 0,05 | 237,25 |
| | P | 0,75 | 0,1 | 217,1 |
| | D | 1,5 | 0,1 | 208,65 |

Figure 6. Cutting Temperature Results

Moreover, it was possible to plot the averages of the cutting temperatures of the workpiece for a L/D ratio equal

to 0.75 and 1.5, as seen in Fig; 4. Thus, it was observed that, for the L/D ratio equal to 0.75, the cutting temperature was reduced by approximately 20% when the feed rate was increased. As for the L/D ratio equal to 1.5, the temperature presents a behavior similar to the previous one, thus, from the increase in the advance, the temperature presented a reduction of approximately 14%. It is also possible to notice that the temperature has the highest values when the lowest L/D ratio is used.

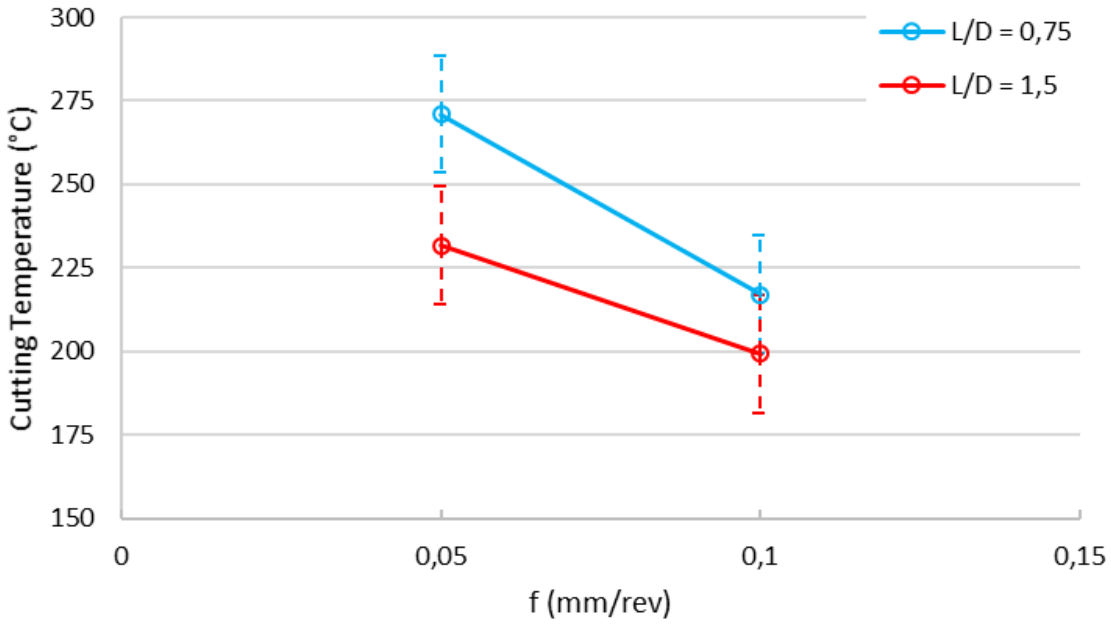


Figure 7. Effects of the Feed Rate and the L/D Ration on the Cutting Temperature

Figure 7 presents the results obtained from a visual analysis of the formation of the chips collected after the longitudinal turning of the AISI 1045 steel. It is possible to notice that the predominant shape was the short washer-type helical. According to Diniz [1], this shape is characterized as a chip that does not offer risks to the process when the Material Removal Rate (MRR) is high. The short washer-type helical chip tends to jump out of the machinable axis. It is worth noting that this form was predominant when a feed rate equal to 0.1 mm/rev.

It was possible to notice that the chip shape varied for the L/D ratio when the smallest value of the feed rate is used; thus, for the feed equal to 0.05 mm/rev and the L/D ratio equal to 0.75, the presence of long tubular and short tubular chips was verified. It can also be seen that, in this case, the snarled washer-type helical chip was the predominant form. This formation becomes quite harmful to the process, as it can cause accidents during handling and damage both the tool and the finished surface of the workpiece, causing an increase in the cutting force and, consequently, an increase in temperature in the deformation zones.

Using the feed rate equal to 0.05 mm/rev and the L/D ratio equal to 1.5, the chips with a long and snarled tubular formation were observed

| Replica | Specimens | AISI 1045 Steel | | |
|---|---|---|---|---|
| | | L/D (mm/mm) | f (mm/rev) | Shape |
| 1 | J | 0,75 | 0,05 | Tubular long and snarled washer-type helical |
| | B | 1,5 | 0,05 | Long tubular |
| | I | 0,75 | 0,1 | Short washer-type helical |
| | A | 1,5 | 0,1 | Short washer-type helical |
| 2 | N | 0,75 | 0,05 | Short tubular and snarled washer-type helical |
| | E | 1,5 | 0,05 | Snarled Tubular |
| | P | 0,75 | 0,1 | Short washer-type helical |
| | D | 1,5 | 0,1 | Short washer-type helical |

Figure 8. Chip Shapes induced by Turning AISI 1045 Steel

## Conclusion

The work permits to conclude that:

- It was observed that when increasing the feed rate in the cylindrical turning of the steel AISI 1045, the cutting temperature decreased considerably.
- As for chip formation, it was noted that the short washer-type helical shape was predominant in this process. However, some unwanted chip shapes were obtained when using the lowest feed rate. Thus, the most desirable chip shape and least harmful to the process were obtained using the highest feed rate.
- It is observed that the lower the feed rate, the higher the cutting temperature, and the more unwanted the chip quality. Thus, when getting snarled or very long chips, the cutting temperature, that is, the temperature of the tool-workpiece interface, will tend to rise.

## Recommendations

It is suggested that future works improve the temperature measurement system, considering that the adopted method does not allow a more exact visualization of the tool-chip interface. Besides, it does not allow the use of cutting fluids. It is also suggested that a chip thickness measurement be carried out, thus making it possible to determine an essential post-process metric, the Chip Compression Ratio.

## Acknowledgements

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## References

Diniz, A. E., Marcondes, F. C. e Coppini, N. L. (2000). *Tecnologia da Usinagem dos metais.* Editora Art Liber, São Paulo.

Batzer, S.A., Haan, D.M., Rao, P.D., Olson, W.W. and Sutherland, J.W. (1998). Chip morphology and hole surface texture in the drilling of cast aluminum alloys. *Journal of Materials Processing Technology, 79*, pp. 72–78.

Smith, G. T. (1989). *Advanced Machining – The Handbook of Cutting Technology.* IFS Publications. ISBN 1-85423-022-6.

Degenhardt, J.A., DeVor, R.E. and Kapoor, S.G. (2005). Generalized groove-type chip breaker effects on drilling for different drill diameters and flute shapes. *International Journal of Machine Tools & Manufacture, 45*, pp. 1588-1597.

ABNT (2017). NBR ISO 3685: Ensaio de vida da ferramenta de ponta única para torneamento.

Santos, S.C.; Sales, W.F. (2007). *Aspectos tribológicos da usinagem dos materiais.* São Paulo: Artliber.

Trent, E.M.; Wright, P. K. (2000). *Metal Cutting", 2a ed.*. Butterworth-Heinemann, Woburn, USA,

SECO TOOLS, Inserto TNMG160408-MF1 CP500.Disponível em:<https://www.secotools.com/article/p_00091359>. Acessado em: 14 de março de 2021.

SECO TOOLS, Suporte PTGNL2020K16. Disponível em: <https://www.secotools.com/article/p_00092224>. Acessado em: 14 de março de 2021.

Soluções Industriais, Termovisor para identificar problemas. Disponível em:<https://www.solucoesindustriais.com.br/empresa/automatizacao-e-robotica/rti-automacao-comercio-e-instalacoes-ltda-/produtos/instrumentacao/termovisor-para-identificar-problemas>. Acesso em: 08 de dezembro de 2021.

Soler, D., Childs, T. H., & Arrazola, P. J. (2015). A note on interpreting tool temperature measurements from thermography. *Machining Science and Technology*, *19*(1), 174-181.

# Microporous Alumina–Silica Composite Membrane with Very Low $N_2$ Permeability but High $CO_2$ Selectivity Considered for Direct Air Capture

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**Abstract**: This research involves technical approaches to capture carbon dioxide ($CO_2$) from ambient air involving a filter with a transport mechanism described based on experimental results. A silica inorganic composite membrane was prepared by using a silicone elastomer precursor using the sol-gel method on the 15 nm pore of a $TiO_2$/gamma alumina support commercially available. All experiments were single gas transport. $CO_2$, nitrogen ($N_2$) and methane ($CH_4$) flowrates were measured through the support, 1st dip coated and 2nd dip coated membranes respectively at room temperature and transmembrane pressure drops ranging from 0.01 to 0.1 bar. $N_2$ was completely blocked from going through the $CO_2$ membrane following the 2nd dip coating. The permeance of $CO_2$ in this membrane is much lower than that in only pure silica, and it is thought to possess two types of micropores, ultra-micropores through which only very small molecules such as helium (He) and hydrogen ($H_2$) can permeate through and a rather small number of micropores in which molecules such as $CO_2$ and $N_2$ were able to flow through but not simultaneously as they are unable to pass one another within the pores due to selective adsorption of $CO_2$. At low transmembrane pressure drop the membranes showed complete blockage of $N_2$ and only $CO_2$ was able to permeate over the transmembrane pressure drop of 0.01-0.04 bars. This significant because in DAC renewable energy can be used to power fans/blowers that force the air through the membranes thus making the specific energy requirement lower than that of the adsorption and absorption processes, together with higher productivity levels.

**Keywords:** Carbon dioxide, Direct Air Capture, Ambient Air, Membrane, Silica, Ceramic

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## Introduction

One of the key takeaways from COP26 in Glasgow, UK between 31 October to 12 November was the urgent decarbonization required to meet the Paris Agreement target of 1.5°C warming. In the COP27 held in the resort town of Sharm el-Sheikh, Egypt, from 7-18 November 2022 leaders were under pressure to start delivering on the promises made in the 2021 Glasgow Climate Pact. Russia's war against Ukraine has resurrected deep fault lines in international relations not seen since after the Cold War, while sanctions on Russian oil and gas have created a rush to exploit more fossil fuels and demand spikes making energy security a priority and putting climate change policy in the background.

Nevertheless, recent climatic events ranging from record floods in Nigeria and Pakistan to record droughts in China and parts of Europe exacerbated by heat waves continue to remind the world that climate change is real, and the problem is worsening. The global average atmospheric carbon dioxide ($CO_2$) concentration set another record high when it peaked in May 2022 at 421 parts per million. Prior to the Industrial Revolution, $CO_2$ levels were consistently around 280 ppm for almost 6,000 years of human civilization (Watson, S. K., June 7, 2022). Reducing $CO_2$ emissions alone will not suppress global warming, and it is necessary to capture the $CO_2$ from hard to abate sectors such as aviation and shipping and that which has been cumulatively emitted into the atmosphere over the years as well.

For this reason, negative $CO_2$ emission technology, a technology capable of removing $CO_2$ from the atmosphere, is considered essential. More especially, direct capture of $CO_2$ from the air, so-called direct air capture (DAC) (Figure 1) has attracted much attention in recent years as one of promising negative technologies, because of the high potential capacity of $CO_2$ capture. One area where the impact of negative emissions can make a significant impact is in aviation which has been under increasing pressure from both consumers and scientists to try to find proper ways to decarbonise air travel for several years, albeit with limited success.

More recently, however, at the International Civil Aviation Organisation (ICAO), triennial assembly in Montreal, Canada, on the 7$^{th}$ of September2022 member states finally agreed to support a net zero target for 2050. This development will significantly increase demand for DAC technologies in the next three decades to 2050. In general, absorption, adsorption, and membrane separation are known as representative $CO_2$ capture technologies, and DAC is essentially based on these technologies.

DAC systems using absorption and adsorption methods have already reached the level of plant scale, with several plants in operation and many more planned but the desorption process of the captured $CO_2$ from the absorbent or adsorbent requires heating to recover the captured $CO_2$ which consumes a large amount of energy and water.

On the other hand, membrane separation is generally considered as a most cost- and energy-efficient process among these capture technologies, but DAC by membrane separation has not been considered at all due to the immaturity of the membrane performance for low $CO_2$ concentration capture, especially $CO_2$ permeance. However, recent developments in the learning of membrane technology and significant cost-reduction in renewable energy production has brought the possibility that membrane processes can be considered as a new approach to DAC (Figure 1).

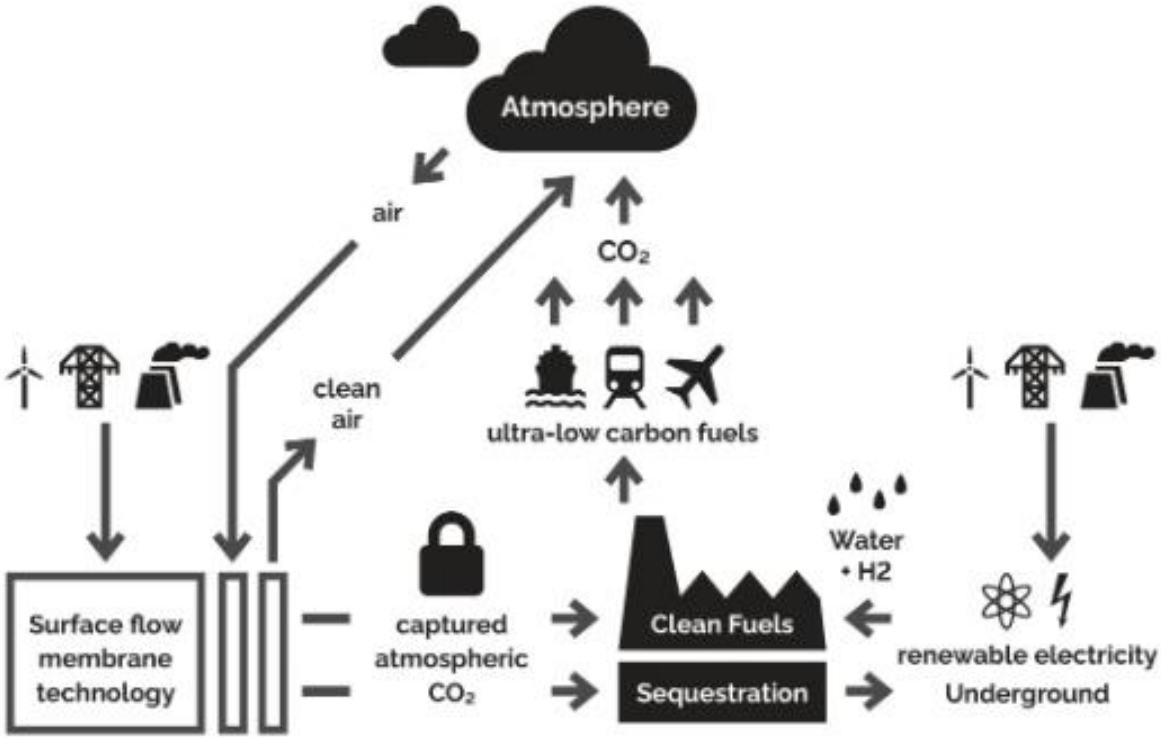



Figure 1. Renewable Energy-driven Membrane Direct Air Capture Technology (Gobina, et al., 2022)

## Inorganic Membrane Systems

Inorganic membranes are usually made from metallic oxides, metals, or elementary carbon. They can operate under harsher conditions than their polymeric counterparts and are highly selective and permeable for specific molecules. Inorganic membranes are made as standalone tubes and tubes if they are sufficiently permeable. However, that is not the case, they are made as thin films on multi-layered supporting structures. In porous inorganic membranes, a porous thin top layer is cast onto a porous metal or ceramic support.

Figure 2 show photographs of porous ceramic support (a) and porous metallic support (b). The support provides mechanical strength, and thus offers minimum mass-transfer resistance. Carbon, silicon carbide glass, titania, zeolite membranes, and so on are mainly adopted as porous inorganic membranes supported on different metallic and ceramic substrates, such as α-alumina, γ-alumina, zirconia, porous stainless steel, or zeolite.

Figure 2. Photographs of Tubular Porous Ceramic Membranes (Left) and Tubular Porous Stainless-Steel Membranes (Right)

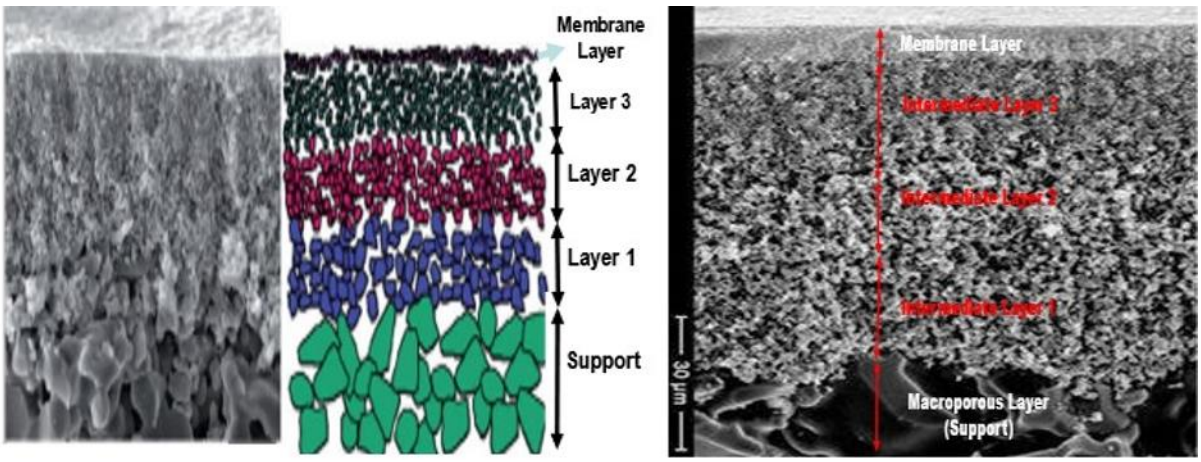



Figure 3. Typical Multi-Layered Asymmetric Ceramic Membrane Structure

## Ceramic Porous Support Composition and Manufacture

Ceramic membranes are made up of several different kinds of metal oxides including alumina ($Al_2O_3$), zirconia ($ZrO_2$), silica ($SiO_2$) and titania ($TiO_2$) (LENNTECH, https://www.lenntech.com/ceramic-membranes-features.htm). The first ceramic membranes globally were produced in France in the 1980s for the purpose of

enriching uranium for the nuclear industry. After several of the nuclear power plants were functioning in France other industrial application areas for these ceramic membranes were found out. Simultaneously, academic research into ceramic membrane systems was being conducted on several fronts such as water treatment, natural gas processing, air separation, hydrogen purification and possible use in reactor systems. A typical commonly reliable process for producing ceramic tubular membrane support is shown in Figure 4.

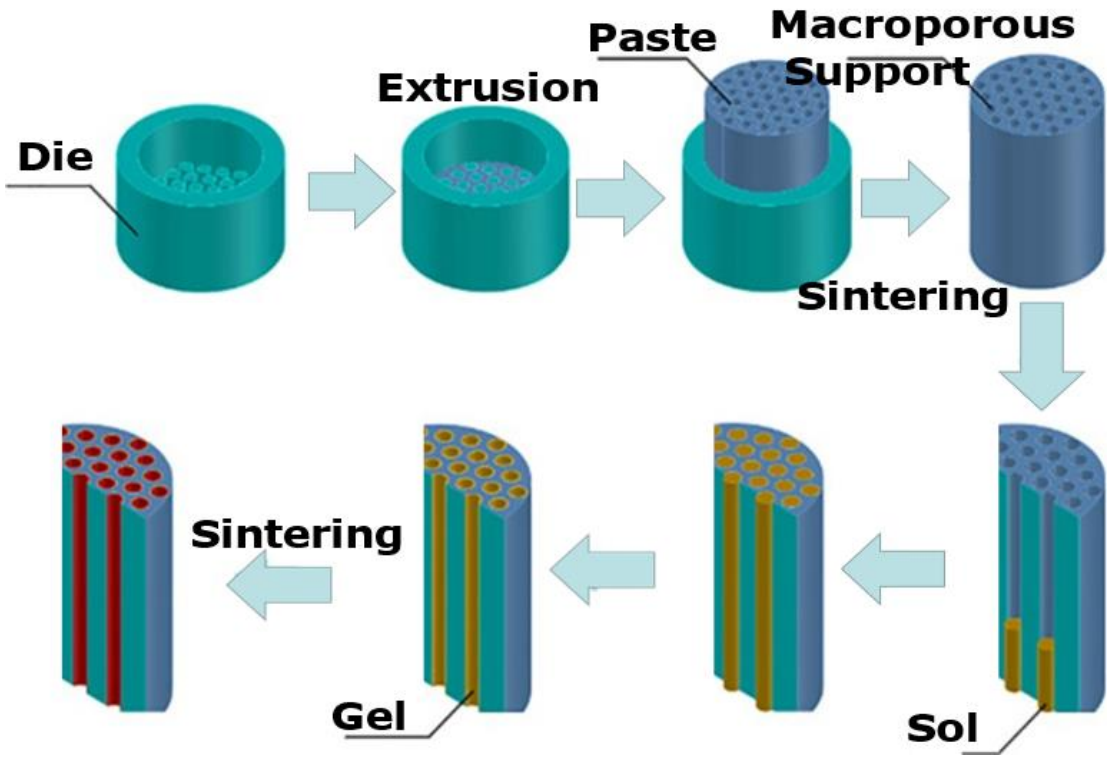



Figure 4. A Schematic Diagram of Production Process for Ceramic Tubular Membrane Supports

The macroporous support is subsequently obtained by extruding a specific paste with a die applied to effect control of the paste shape (such as number of channels, inner and outer diameters). The extrudate is subsequently dried and sintered vertically in a furnace under different controlled heating and cooling regimes.

## Metallic Porous Support Composition Manufacture

The other type of support is the porous metal filter. Although several techniques can be potentially used for the fabrication of porous metal membranes, one of the main approaches that has been used for fabrication of unsupported porous metal membranes is particle sintering. Sintering of metallic particles is derived from traditional powder metallurgy technology, whereby hot-compression of micrometre-sized metal particles or fibres at the softening temperature of the metal produces a semi-porous network.

A range of conditions (e.g., particle size, sintering atmosphere) impacts significantly on the quality of the

products from the sintering process and larger particles not only limit neck formation (due to the slow rate of mass transport), but also lead to a mechanically unstable membrane due to the more favourable finger-like macro-voids appearance.

Also, the properties of the metal powders (e.g., size, compressibility, and reactivity) used for sintering must be well characterized to determine the most appropriate heating technique and avoid densification which can occur due to over-heating. The pore size generated using sintering is controlled by the average particle deformation that is induced by the process and the surplus distance between the particles after sintering. Altering the sintering atmosphere during the sintering process can also change the morphology such that sintering most often leads to large pores (e.g., >1 μm).

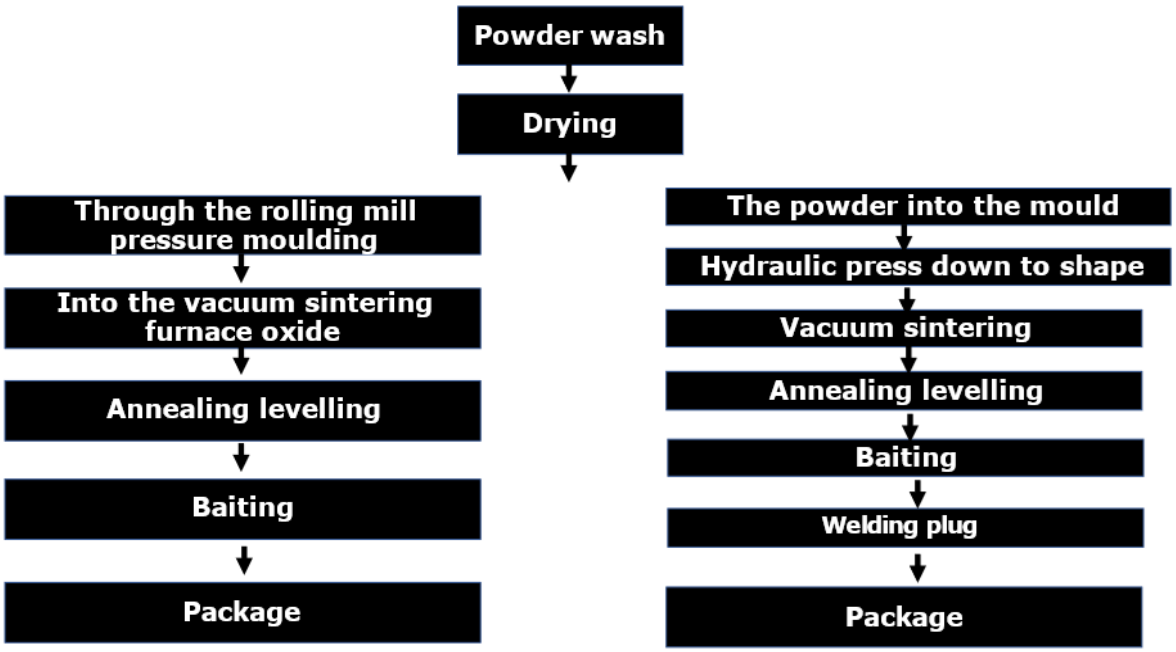
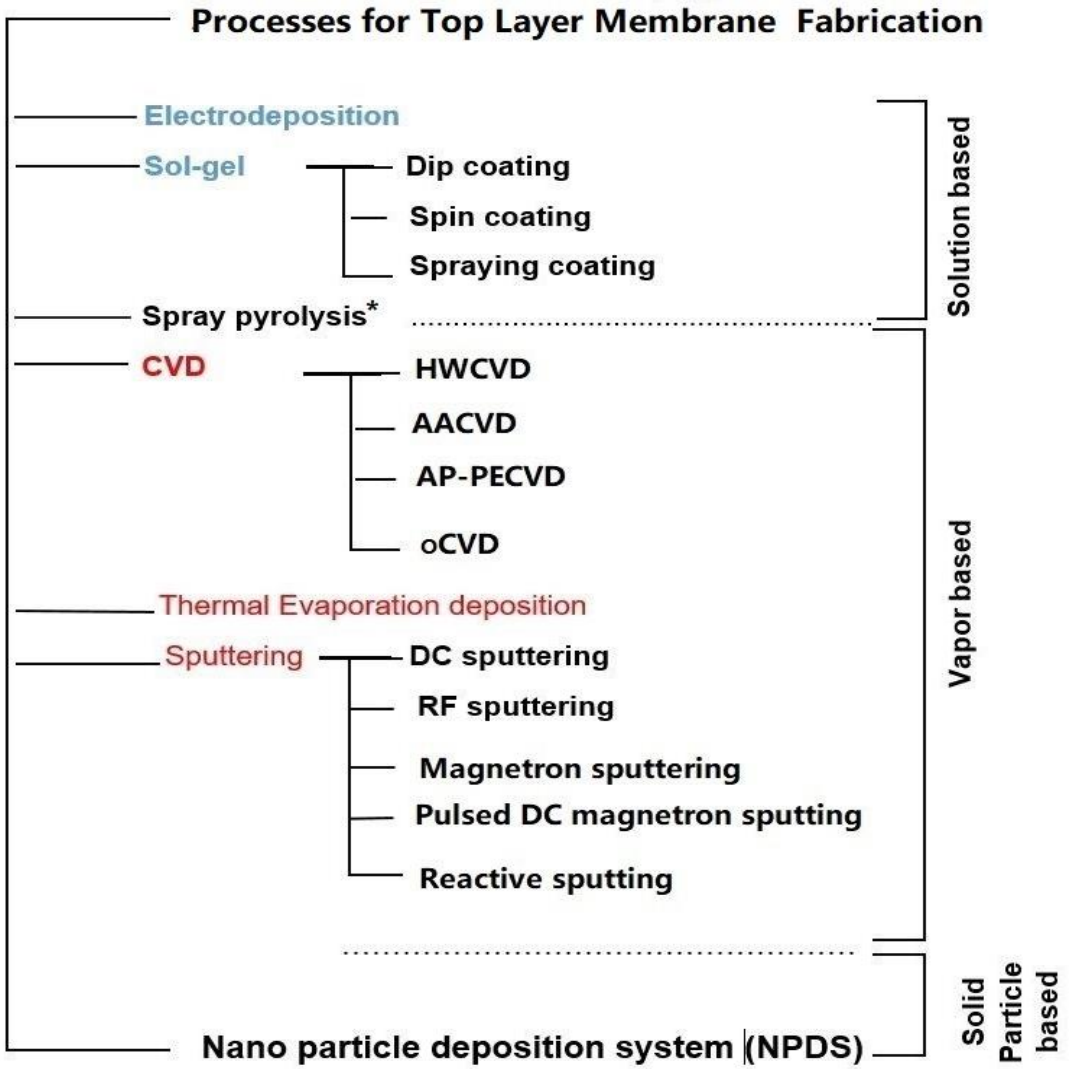



Figure 5. A Schematic Diagram of Production Process for Porous Metallic Tubular Membrane Supports

## Preparation of the Thin Separation Layer (Coated Membranes (CMs))

Various methods can be used to fabricate the top membrane layer (thin separation layer) as shown in Figure 6. These include methods such as chemical vapor deposition (CVD), sputtering, and sol-gel processes (Figure 6). Several factors impact the cost of system fabrication; most often, the deposition cost of thin layer membrane materials is dominant. If the deposition process requires high temperatures, it also leads to high process costs. In addition, various limitations caused by the necessity for high temperature and vacuum still exist in depositing top layers. The various deposition processes used for fabrication of top layers are continuously being developed using new methodologies. The various processes can be categorized into three main classes, based on the materials status followed by a detailed classification (see Figure 6).




**Spray pyrolysis is in between solution and vapor base*

Figure 6. Fabrication Methods for Membrane Top Layer

Generally, the environment will depend on the deposition technology or relevant status of the precursor. If the processes are based on using solutions, then the main parameter will be the temperature rather than vacuum. However, the vacuum dominates in the vapor-based processes. In electrodeposition and sol-gel processes, which include spin coating, dip coating, and spraying, solution-based processes are well-known. CVD, sputtering, thermal evaporation are processes based on vapours. These vapor-based processes can be classified in a number of ways, such as aerosol-assisted CVD (AACVD), hot-wire CVD (HWCVD), oxidative CVD (o-CVD), magnetron sputtering, pulsed DC magnetron sputtering, atmospheric pressure-plasma enhanced CVD (AP-PECVD), direct current (DC) sputtering, radiofrequency (RF) sputtering and reactive sputtering, depending to their materials and process parameters. Spray pyrolysis can be classified between vapor and solution processes because a solution is normally sprayed but it is deposited as a vapor. Recently, direct material deposition has been tried at room temperature.

## Literature Review

Several efforts have been recently devoted to the development of polymeric membrane materials with high $CO_2$ permeance. In literature, Kolodji, B (2019) has reported the use membranes are to perform direct air capture (DAC) by extracting and mildly concentrating the $CO_2$ in air from 400 ppm to over 1200 ppm (a factor of 3 or more increase), and sending this concentrate into low pressure ducting destined for a greenhouse. When atmosphere inside the greenhouse is increased to between 600 and 1200 ppm $CO_2$, a practice known as crop carbon enrichment, the biomass and yield of the crop correspondingly increases.

Yoo et al. For example, reported defect-free Teflon-based membranes having a $CO_2$ permeance of ~31,500 GPU (GPU: gas permeance unit (1 GPU = $7.5 \times 10^{-12}$ $m^3$(STP) $m^{-2}$ $s^{-1}$ $Pa^{-1}$, STP: standard temperature and pressure) with a $CO_2/N_2$ selectivity of 3.3 (Yoo MJ, Kim KH, Lee JH, Kim TW, Chung CW, Cho YH, et al., 2018). Free-standing siloxane nanomembranes with high $CO_2$ permeances exceeding 40,000 GPU have also been reported (Fujikawa S, Ariyoshi M, Selyanchyn R, Kunitake T., 2019). Such membranes with ultrahigh gas permeance would have the potential to capture $CO_2$ efficiently, even from the air, since the gas permeance resistance through the membranes is quite small, but the $CO_2$ selectivities are very low and polykers generally degrade even under atmospheric DAC conditions.

With regards to the support Shi, W., Yang, C., Qiu, M., Chen, X., and Fan, Y., (2022) reported on a new method that a γ-$Al_2O_3$ multilayer ultrafiltration (UF) membrane on an α-alumina (α-$Al_2O_3$) substrate was successfully fabricated *via* the sol–gel processing method. Zhou S., Xue A., Zhang Y. *et al.*, (2015), designed one-step preparation of high-performance bi-layer α-alumina ultrafiltration membranes supported on coarse tubular substrates by co-sintering process. In their approach, boehmite sol and alumina nanoparticles were mixed in different ratios for the fabrication of microfiltration layer and the ultrafiltration layer. The thickness of the microfiltration layer and the ultrafiltration layer was controlled to be 40–50 μm and about 1 μm, respectively. In their contribution. Yin, X., Guan, K., Gao, P., Peng, C., and Wu, J. (2018) proposed a new method called "precursor film firing method" for improving the permeance of ceramic microfiltration membranes by avoiding intermediate layers and dip-coating process, and efficiently control the thickness of the separation layer. Moreover, Qin, W., Peng, C., Wu, J. (2017) reported on a sacrificial interlayer-based technique used to produce membranes without any intermediate layers in a single-step coating preparation of highly permeable alumina microfiltration membrane on as-prepared alumina supports.

Based on our recent achievements in the membrane field, it is meaningful to evaluate the potential of inorganic membrane for the first time as an alternative DAC process. Two types of inorganic membranes are being developed. A more dense system based on silica and a porous support with an affinity material deposited in the porous network that acts to create an adsoptive selective surface for the flow of $CO_2$. This article presents experimental results for the silica-based inorganic membrane system for assessing the performance and applicability for DAC from a practical perspective

## Materials and Methods

### Materials

The supports consisted of aluminium oxide $Al_2O_3$, 23% titanium oxide $TiO_2$ and 1% impurity and was supplied by Ceramique Techniques Industriels (CTI), France. The tubes came with non-permeable glazed ends (0.025 m on either ends). The support tube has seven open parallel channels running the full length of the tube (Figure 7) and had a pore size of 15 nm. It was selected because of its added advantages: chemical inertness, high heat resistance and high mechanical strength (Baker 2004). Other physical characteristics of the support are presented in Table 1. Raw materials and chemical reagents used for the deposition of the thin top layer, including isopentane, silicone elastomer and curing agent (Table 2) were all purchased from Sigma Aldrich, UK. During the whole working process, water (>18.2 MΩ) treated by an ultrapure water system (RFU 424TA, Advantec Aquarius, Toyo, Japan) was employed for washing and cleaning.

Figure 7. Ceramic Support: Total Length (left) and Internal Channels (right)

Table 1. Characteristics of the Support

| **Support Parameter** | **Symbol** | **Value** |
|---|---|---|
| Total length | $L_t$ | 0.366m |
| Effective length | $L_e$ | 0.316m |
| Outer diameter | $D_o$ | 0.0256m |
| Inner diameter | $D_i$ | 0.0206m |
| Weight of support | $W_o$ | 281.3g |
| Effective permeable area | $A_{eff} = \pi D_o \times L_e$ | 0.0254m$^2$ |
| Diameter of each channel | $D_{ch}$ | 0.0047m |
| Number of channels | $N_{ch}$ | 7 |
| Pore size of the support | $r_p$ | 15nm |

Table 2. Chemicals used for Thin Top Layer Membrane Preparation

| **Component** | **Amount** |
|---|---|
| Isopentane | 900 mL |
| silicone elastomer | 100 mL |
| curing agent | 10 mL (or 10%) |

## Methods

The preparation of the thin film top layer ceramic membrane was carried out using the dip coating method (see Figure 8). Using a precision weighing balance, the initial weight of the unmodified (or uncoated) membrane was measured. Preparation of the modifying solution: 900 ml of isopentane and 100 ml of silicone elastomer base (Sylgard 184) was poured into a beaker. The solution was stirred to attain homogeneity. Thereafter, 10% (or 10 ml) of curing agent (Sylgard 184) was added; and then closed with cellophane to prevent evaporation of isopentane and left for about 20 minutes for occurrence of crosslinking effect (gelation). The solution was then transferred into a measuring cylinder and placed on a magnetic stirrer device. This was done to prevent settling of the elastomer.

(**a**) (**b**)

(**c**) (**d**)

Figure 8. Membrane Modification Process: (a) Support dipped into Solution for Coating, (b) Dried by a Rotating Mechanical Drier under Atmospheric Conditions, (c) Dried in Oven at 65 C and (d) Weighing after Coating.

It is always a good practice to close the cylinder with cellophane to prevent evaporation of isopentane. The support was then submerged or dipped into the solution for 30 minutes. Thereafter, the support was attached to a drying device for 30 minutes to ensure that a uniform distribution of elastomer along the support was achieved. The membrane is then placed and left in an oven for about 2 hours at $65^0$ C to evaporate isopentane. These steps

are repeated to achieve the desired gas transport result.

## Characterisation

The support and silica-coated membrane were characterised using several methods including liqiud nitrogen adsorption/desorption at 77K. This was carried out using an automated gas sorption analyser (Quantachrome instrument version 3.0) to determine the total surface area and pore size distribution. The isotherms have been described using the Brunauer Emmett and Teller (BET) and the Barrett-Joyner-Halenda (BJH) methods respectively. The surface morphology of the support and membrane was examined using a Zeiss EVO LS10 scanning electron microscopy coupled with the energy dispersive analysis x-ray (SEM/EDAX) to examine the thin top silica layer of the membrane.

Fourier transform infrared coupled with an attenuated total reflection (Nicolet iS10 FTIR-ATR) was used for the structural examination of both the support and silica membranes. The contact angle was measured by the Theta Flex Optical Tensiometer (also known as a goniometer, contact angle meter & drop shape analyser) sessile drop method using a syringe pump to produce the droplet of liquid, and a camera to observe the droplet on a substrate. Software connected to the camera is used to identify and calculate the contact angle of the droplet on the substrate. Theta Flow is a premium instrument for measuring contact angle, surface tension, surface free energy, dynamic contact angle and Static contact angle. Permeation measurement were also applied to determine the gas flow rate through the membranes contained in a shell and tube arrangement in cross-flow mode.

## Membrane Gas Transport Mechanisms

$CO_2$ removal from the atmosphere can be achieved in several ways including water-scrubbing, pressure swing adsorption, cryogenic separation, and membrane separation. Among these, membrane technology stands out as an excellent opportunity regarding simplicity and flexibility, whereas it comprises low energy expenditure for the process associated with low costs. The key issue with membrane-based gas separation processes in general and particularly DAC is that the driving force for the separation (which is the difference in partial pressure of the gas species across a membrane barrier) must be high. In DAC the concentration of $CO_2$ in the atmosphere is only 421 parts per million means that its partial pressure is only 0.000421 bar. This low pressure means individual gas constituents such as $CO_2$, $O_2$, $N_2$ in air can be separated attending to their different permeability rates through a porous membrane material, or to different solubilities and diffusivities through a nonporous, dense membrane material depending on their properties (see Table 8).

Effective separation takes place when some gas constituents pass through the membrane barrier quicker than others. This process can be described by three general transport mechanisms: Knudsen diffusion, solution-diffusion, or molecular sieving. However, there are generally seven gas transport mechanisms that can occur in

porous and dense membrane systems (Figure 9). The different mechanisms apply when the membrane satisfies specific structural conditions, as shown in Figure 9.

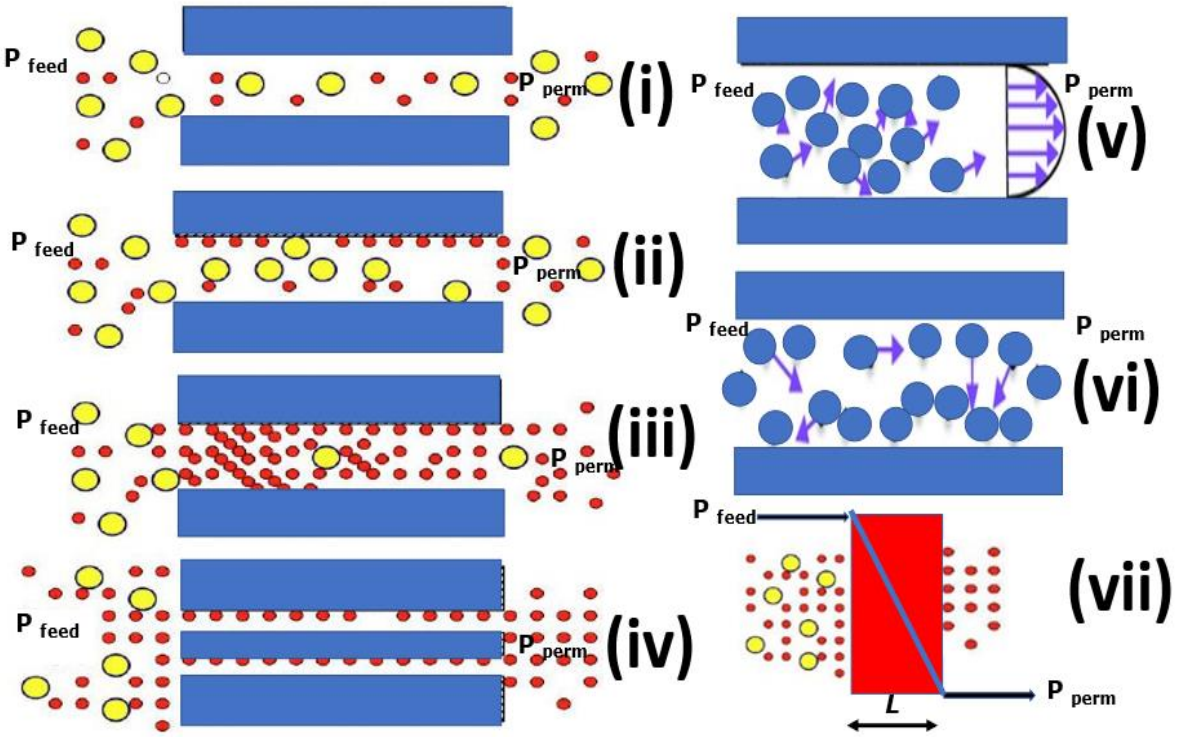



Figure 9. Porous and Dense Membranes Systems and their Gas Permeation Mechanisms. (Microporous and Mesoporous Membrane Gas Transport Mechanisms ((i) Knudsen Diffusion, (ii) Surface Diffusion, (iii) Capillary Condensation, (iv) Molecular Sieving), Macroporous Membrane Gas Transport Mechanisms ((v) Viscous Flow, (vi) Molecular Diffusion) and (vii) Solution Diffusion.

**Microporous Membrane**

In the case of gas transport through microporous membranes (e.g. silica membranes), there is an Arhenius-type temperature dependence behavior which affects the performance at elevated emperatures. It is well understood that this happens when kinetic diameter of the molecule approaches that of the pore diameter and results in very high perm-selectivity (separation factor)s. This mechanism is known as activated gas transport. It has been found that the phenomenological flux $J$ (mol.m$^{-2}$. s$^{-1}$) through microporous materials increases as function of temperature according to Equation 1:

$$J \propto J_0 \exp\left(\frac{-E_{act.}}{RT}\right) \quad (1)$$

Where $E_{act.}$ (KJ.mol$^{-1}$) is an apparent activation energy. Depending on micropore size and gas molecule size, activation energies ranging from around 2 to 40 KJ.mol$^{-1}$ have been reported (Liguori, S. and Wilcox, J., 2017).

**Mesoporous Membranes**

In mesoporous materials, as for example γ-alumina membrane, the gas transport mechanisms are: (i) Knudsen diffusion, (ii) laminar (or Poiseuille) flow and (iii) surface diffusion. However, according to these mechanisms, transport rates decrease as function of temperature as shown by Equations 2-4.

*Knudsen Diffusion*

$$F_{kn,0} = \frac{2.\epsilon_p.\mu_{Kn}.\bar{\upsilon}.\check{r}}{3RTL} \; with \; \bar{\upsilon} = \sqrt{\frac{8RT}{\pi M}} \qquad (2)$$

Where $F_{Kn,0}$ is the Knudsen permeation (mol.m$^{-2}$. s$^{-1}$Pa$^{-1}$), $\epsilon_p$ is the porosity (–), $\mu_{Kn}$ is a shape factor (–) equal to 1/τ, where τ is the tortuosity, $R$ is the gas constant (J.mol$^{-1}$. K$^{-1}$), $T$ is the absolute temperature (K), ř is the modal pore radius (m), $\bar{\upsilon}$ is the average molecular velocity (m.s$^{-1}$), $L$ is the layer thickness (m) and $M$ is the molecular mass (kg.mol$^{-1}$) of a gas molecule.

*Surface diffusion*

$$J_{S.0} = -\rho_{app}.D_S.\mu_s\frac{dq}{dl} \qquad (3)$$

Where $J_{s.0}$ is the surface diffusion flux component (mol.m$^{-2}$. s$^{-1}$), $P_{app}$ is the apparent density (kg.m$^{-3}$), defined as (1- $\epsilon_p$) $\rho_{cryst}$, $D_s$ is the surface diffusion coefficient (m$^2$. s$^{-1}$), $\mu_s$ is the reciprocal tortuosity (–) and dq/dl the surface concentration gradient (mol.kg$^{-1}$. m$^{-1}$). The activation energy for diffusion is strongly correlated with the heat of adsorption. Since it is assumed that diffusion takes place by molecules which jump from one site to another, the activation energy is a fraction of the heat of adsorption [36]. This implies that: a) strongly adsorbed molecules are less mobile than weakly adsorbed molecules, and b) that the total flux will decrease as the temperature is increased since the increased diffusivity is overruled by the decrease in surface concentration.

*Capillary Condensation*

$$\frac{\rho RT}{M} \ln\frac{P_t}{P_0} = -\frac{2\sigma\cos\theta}{r} \qquad (4)$$

Where $\rho$ is the density of the condensate (kg/m$^3$), $P_0$ the temperature dependent saturation vapour pressure for a planar interface (Pa), σ the interfacial tension(N/m), $\theta$ the contact angle and r the radius cylindrical capillary. Multilayer adsorption takes place when a species is adsorbed in several layers and is an extension of monolayer adsorption. Surface diffusion models are usually valid for up to monolayer coverage and can be extended to also include multilayer diffusion. Due to monolayer and subsequent multilayer diffusion, the permeability will

increase until an optimum is reached as capillary condensation begins and a liquid meniscus appears. After this point the permeability usually decreases because of the liquid transport contribution.

**Macroporous Membranes**

*Laminar Flow*

$$F_{p,0} = \frac{\varepsilon_p \mu_p}{8RT} \frac{r^2}{\eta L} P_m \quad (5)$$

Where $F_{kn,0}$ is Poiseuille permeation (mol.m$^{-2}$. s$^{-1}$. Pa$^{-1}$), $\mu_p$ is the reciprocal tortuosity (–), $\eta$ is the gas viscosity (N.s.m$^{-2}$), $L$ is the thickness of the porous layer (m) and $P_m$ is the mean pressure (Pa**). L**aminar flow is also sometimes referred to as viscous or streamline flow**.** Typically, this type of flow occurs at lower velocities, and the fluid flow is characterised by the by the absence of lateral mixing. At low Reynolds number when the viscous forces dominate, they are sufficient to maintain all the fluid particles in line, and then the flow is laminar.

*Molecular Diffusion*

In the general case, at a constant temperature and pressure, the molar diffusion flux $\dot{n}$ (mol.m$^{-2}$. s$^{-1}$) of substance A is directly proportional to $dC_A$/dyknown as the molar concentration gradient (mol/m³m) and a one – dimensional formulation is described by Fick's law. (Equation (6)).

$$\dot{n}_A = -D_A \frac{dC_A}{dy} \quad (6)$$

Where $D_A$ is the diffusion coefficient (m/s) in a binary system. The flow of one component must be balance by by the counterflow of the other component and therefore

$$\dot{n}_B = -D_B \frac{dC_B}{dy} \quad (7)$$

but since $C_A + C_B$= *const*ant, then

$$\left|\frac{dC_A}{dy}\right| = \left|\frac{dC_A}{dy}\right| \text{ and } D_A = D_B = D_{AB} \quad (8)$$

$D_{AB}$ is known as the interdiffusion coefficient. In order to describe a unidirectional diffusion of molecules A in a multicomponent mixture of ideal gases, the Stefan-Maxwell equation (9) is used

$$\frac{dY_A}{dy} = \sum_{j-A}^{n} \frac{d_A C_j}{C_T^2 D_{A_j}} (u_j - u_A) \quad (9)$$

Equation (9) is based on the kinetic theory of gases, in which $Y_A$ is the mole fraction of component A; $C_T$ is the total concentration (density) of mixture (= p/RT); $C_A$ = $pY_A$/RT; $c_j$ = $pY_j$/RT; $D_{Aj}$ is the interdiffusion coefficient for a pair A, j; and $u_j$ and $u_A$ are the rates of diffusion for the components of the pair respectively.

**Solution Diffusion Membrane**

Gas transport in organic and inorganic membranes can also be governed by the solution-diffusion mechanism. In polymeric membranes permeability is the product of solubility and diffusivity of the permeate specieswithin the polymer matrix while in inorganic metallic membranes the solution-diffusion mechanism occurs especially with hydrogen molecules for example, first dissolving in the metal frame-work at the high-pressure feed side, dissociating into two atoms, atomic hydrogen transporting through the metal membrane thickness and recombining back to the molecular hydrogen at the low-pressure permeate side. The hydrogen flux, *F* (mol.$m^{-2}$. $s^{-1}$) across the metal membrane with a thickness *L* (m) can be described by equation (10).

$$F = \frac{P\left(p_{Feed}^{n} - p_{perm}^{n}\right)}{L} \quad \textbf{(10)}$$

Where *P* is the hydrogen permeability (mol. m. $m^{-2}$. $s^{-1}$. $Pa^{-n}$), and $p_{feed}$ and $p_{perm}$ are the hydrogen partial pressures at the high-pressure side (feed) and low-pressure side (permeate), respectively ($Pa^n$). If the exponent *n* in Equation (10) is equal to 0.5, then Equation (10) represents the well-known Sieverts' law transport mechanism (Sieverts, A. 1929). A deviation Sieverts' law can occur if *n* is different from 0.5 and is an indication of the presence of mass transfer limitations rather than the diffusion in the bulk metal itself.

## Results

The results are divided into 3 sections vis; morphology (FTIR-ATR, SEM/EDAX, BET/BJH, contact angle), gas permeation and gas transport characteristics respectively.

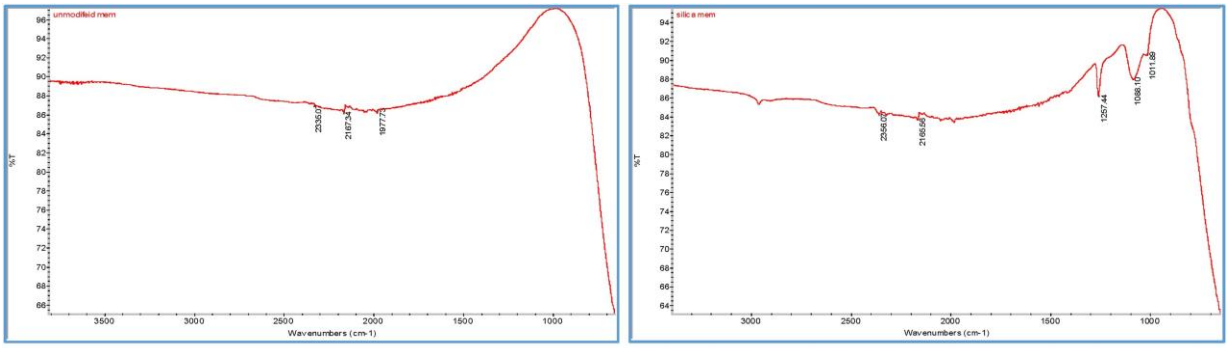
**Morphology**

Results for the morphological characterisation of the support and top thin layer are presented in Figure xxx

through xxx.

*Fourier transform infrared spectroscopy (FTIR) with Attenuated total reflectance (FTIR-ATR)*

Figure 10 shows FTIR of the support (10a) and that of dip coated silica membrane (10b). From Figure 10a and b, and comparing the FTIR of the support and that of the silica membrane, we can see that the support possed 3 bands on the spectra while the silica coated membrane possed up to 5 bands on the spectra. From Figure 10a, it was discovered that the band at 2335.00 indicated the C – H functional group while the band located at 2167.34 and 1977.73 showed the presence of C – O and functional group. It was proposed that the C – O functional groups could be as a result of the alumina in the original support.




(a) (b)

Figure 10. FTIR-ATR for Support (left) and FTIR forSilica Coated Membrane (right)

From Figurec 10b, it was discovered that the band at 2356.07 designaes the C – H functional group and the bands at 2165.58 and 1257.44 are attributed to the stretching vibrations of C – O and C – O functional groups respectively. In addition the bands at 1088.10 and 1011.89 portray C – O functional group. It was proposed that the C – O and C – O functional groups on the silica membrane spectra might have originated from the silica solution mix that was used for the membrane deposition process.

*Scanning Electron Microscopy and Energy Dispersive X-ray analysis (SEM/EDAX)*

The SEM/EDAX were carried out to study the surface morphology of the support and the silica membranes. The SEM surface images of both the support and silica coated membrane are presented in Figure 11. Figure 12 shows the EDAX of the support and silica membrane respectively. The support and silica membranes were examine at the magnifications of 100 X and 400 X respectively with the scale of 10μm and 100μm for the silica mnembrane and support respectively. It was observed that the support was constituted of different elemental species including of $Al_2O_3$ and $TiO_2$.

However, it observed that $SiO_2$ was added to the other compounds already present in the support after the dip-

coating process as shown on the EDAX spectra in Figure 12. From the result of the spectra obtained in Figure 132 (left) it can be observed that the support surface exhibted a crack-free plain and clear surface which is an indication that the support was defect-free as confirmed also by the permeation analysis. However, from Figure 12 (right), it was noticed that there were tiny whitish particles on the surface of the coated support which was propounded to have have appeared as a result of silica ($SiO_2$) adhesion on the support surface (Figure 11-right)

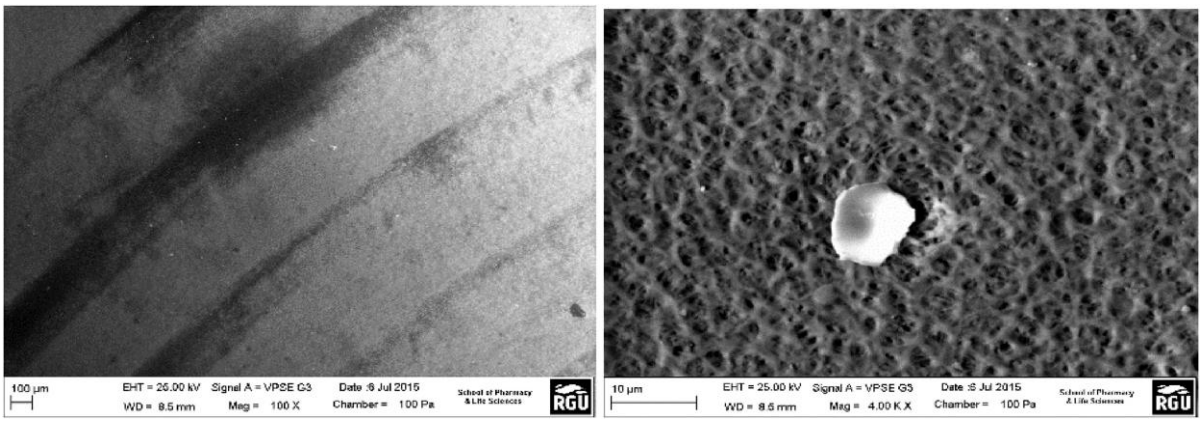



Figure 11. SEM Surface Images of Support (left) and SEM Surface Image of Silica Membrane (right)

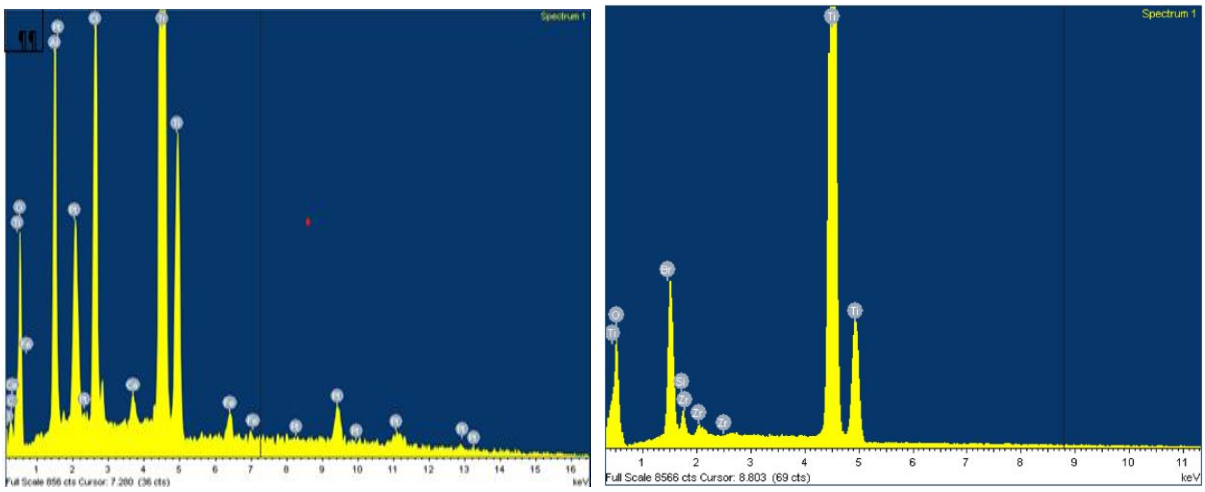



Figure 12. EDAX Spectra of Support (left) and Silica Membrane (right)

*Liquid Nitrogen Adsorption (BET and BJH)*

Figure 13 depicts the BET surface area whereas Figure 14 shows the BJH pore size of the 1st and 2nd dip-coated silica membrane that were used for the study. From Figure 13 (left) and 13 (right), it was observed that dip-coated membranes posses hysterisis on their curves which suggest that the membrane can undergo a capillary condensation in their mesopores. Figure 14a shows that the hysteresis of the 1st dip-coated membrane was more prominent compared with that of the 2nd dip-coated membrane shown in Figure 13 (right).

From the BJH results of the analysis presented in Figure 14 it is observed that both the 1st and 2nd dip-coated membranes possess a type IV and V isotherm which is in accordance with the mesoporous classification of the membranes. The surface area of the membrane was supposed to witness an increase after each dipping with a reduction in the pore size. The pore size of the silica membrane was analysed using the sum of resistance procedure developed by by Ulhorn and Burgraaf (1991). The pore size of the 1st dip was found to be 3.7 Å while that of the 2nd dip-coated membrane was 3.1 Å. As expected, it confirms that there was a reduction in the pore size of the membrane following the silica modification process as these values compare with the 150 Å of the support.

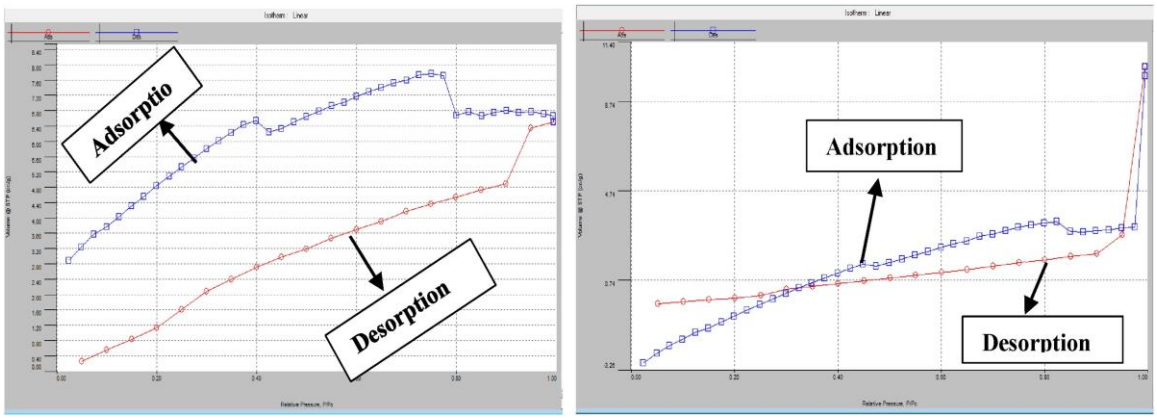



Figure 13. BET Surface Area of Support (left) and Silica Coated Membrane (right)

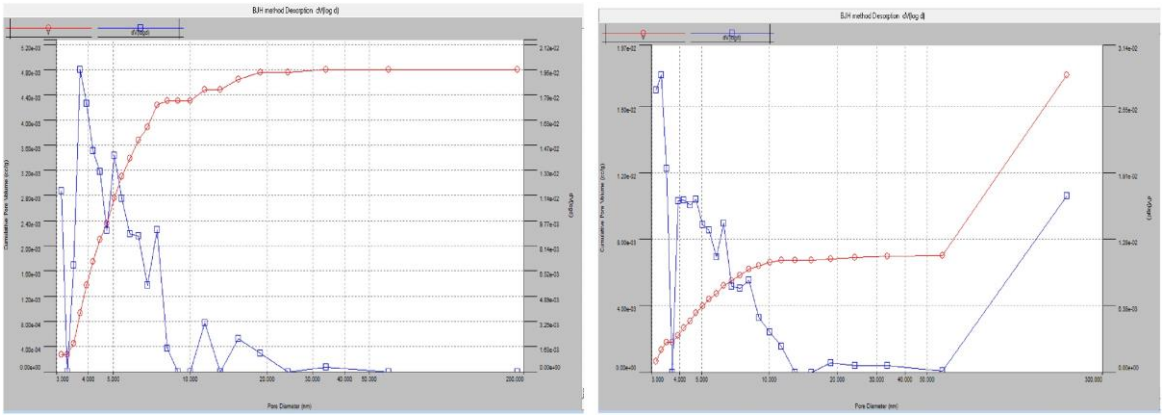


Figure 14. BJH Surface Area of Support (left) and Silica Coated Membrane (right)

*Contact Angle and Surface Free Energy or Interfacial Free Energy or Surface Energy*

In the scientific community, it is accepted that a surface is described as hydrophobic if its static water contact angle θ is >90º and is termed hydrophilic when θ is <90º. Figure 15 shows the Tensiometer contact angle measurement obtained by dropping model liquids in this case distilled water onto the ceramic support surface (left) NS Silica membrane surface (right). The contact angles formed by a single drop of 5uL distilled water were seen to be for the support (hydrophilic) and for the silica coating (hydrophobic) (see Table 3).

The surface free energy or interfacial free energy or surface energy is a quantitative evaluation of the disruption of the intermolecular bonds that take place in creation of a surface is created. In the physics of solids, surfaces must be intrinsically less energetically favorable than the bulk of a material (the atoms on the surface have more energy compared with the atoms in the bulk of the material), otherwise there would be a driving force for surfaces to be created, removing the bulk of the material. The surface energy may therefore be defined as the excess energy at the surface of a material compared to the bulk, or it is the work required to build an area of a particular surface. Another way to view the surface energy is to relate it to the work required to cut a bulk sample, creating two surfaces. There is "excess energy" as a result of the now-incomplete, unrealized bonding at the two surfaces.

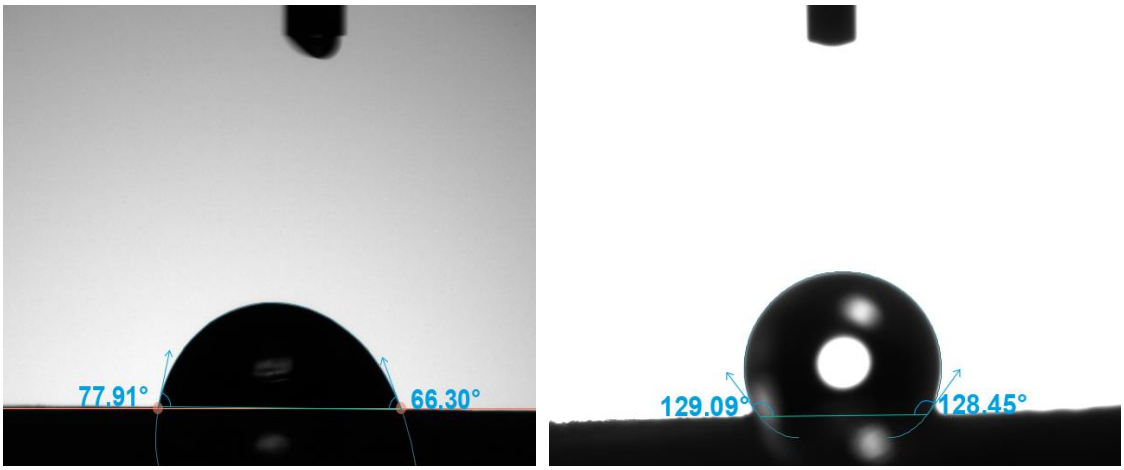



Figure 15. Contact Angle Measurements (0.2 seconds) for the Support (left) and Silica Coated Membrane (right)

Table 3. Experimental Results of Contact Angle for Silica Membrane and Support

| **Membrane (Pore size)** | | **Contact Angle [θ]** | | **Surface Free Energy ($y^{tot}$ [mN/m]/$y^{d}$ [mN/m])** | |
|---|---|---|---|---|---|
| **Support** | **Silica Coat** | **Support** | **Silica Coat** | **Support** | **Silica Coat** |
| 15nm | 3.7nm | 76.642 | 128.77 | 37.58/37.58 | 72.80/21.80 |

**Gas Transport Characteristics**

Figure 16 shows gas permeation plot versus feed pressures for the three gases considered. Due to its lowest molecular mass methane is observed at higher transmembrane pressure drop to be the most permeable of the three gases (see Figure 16) and shows that permeation rate is inversely proportional to the molecular mass of the gases through the uncoated support.

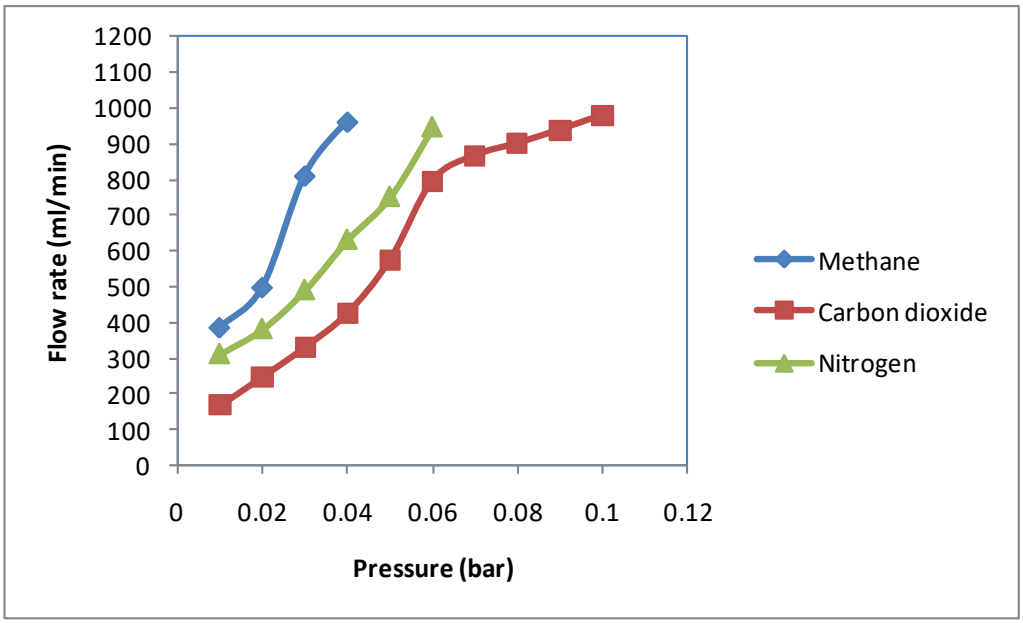



Figure 16. Gas Permeation through Support

*Effect of Dip-coating of Thin Top Layer on Permeation Flowrate*

As expected, gas permeation flow rates decreased with each modification. The experimental data for $CO_2$ transport through the support, 1st and 2nd dip is shown in Figure 17. Figure 17 is used to track the changes in flow rates for each coating and at different transmembrane pressure drop for the case of $CO_2$. Overall, each coating shows an appreciable drop in the flow rate, for instance, from 331 to 6.30 ml/min at 0.03 bars and from 575 to 7.80 ml/min at 0.05 bars, etc. This trend is an indication of severe alteration in permeability. Profiles for the progressive decrease in flow rates values for $N_2$ and $CH_4$ at different pressures follow a similar pattern to that of for $CO_2$.

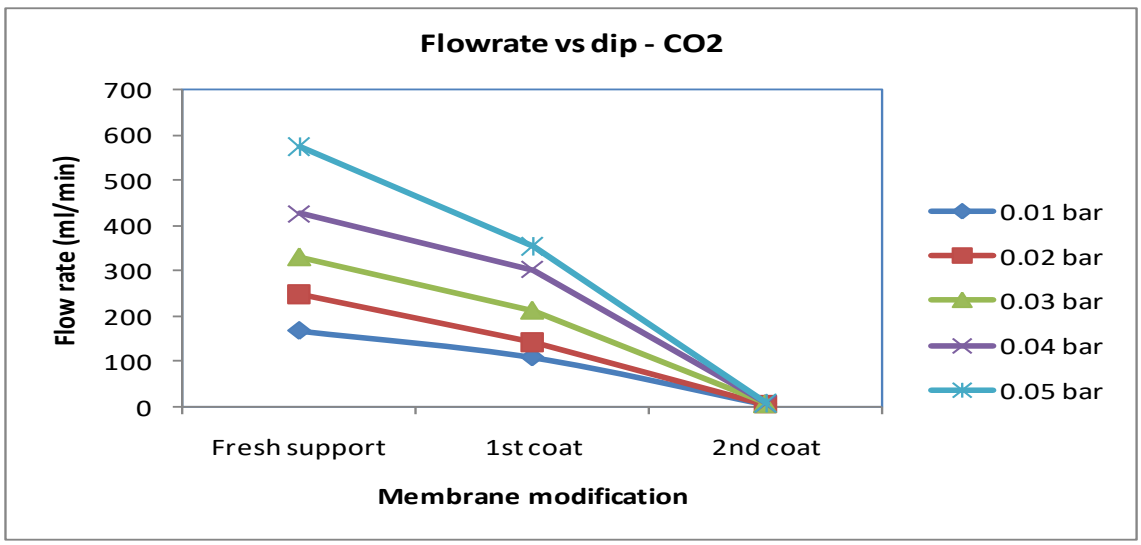



Figure 17. Effect of Number of Thin Top Layer Coating on Flowrate

**Effect of Pressure on Flowrate of $CO_2$ and $N_2$ through Support and Modified Support**

Gas transport results of the experiments conducted are shown in Table 4 for the support, 1st dipping and 2nd dipping respectively at a transmembrane pressure drop of 0.01 to 0.05 bar at room temperature (20° C).

Table 4. Effect of Support Modification on Flow Rate of and $N_2$

| Pressure (bar) | Permeate flowrate (ml/min) | | | | | |
|---|---|---|---|---|---|---|
| | Fresh support | | 1st coating | | 2nd coating | |
| | $CO_2$ | $N_2$ | $CO_2$ | $N_2$ | $CO_2$ | $N_2$ |
| 0.01 | 168 | 311 | 109 | 120 | 4.49 | 0.0 |
| 0.02 | 248 | 381 | 142 | 165 | 5.14 | 0.0 |
| 0.03 | 331 | 490 | 213 | 233 | 6.30 | 0.0 |
| 0.04 | 426 | 631 | 303 | 273 | 6.75 | 0.0 |
| 0.05 | 575 | 751 | 355 | 334 | 7.80 | 1.07 |

Experiments were carried out by measurement of crossflow permeation, as described in detail elsewhere (GOBINA, E, US 7048778, 2006). The permeation is defined as the ratio of the transmission flux (quantity of gas crossing a unit area in unit time; in $mol.m^{-2}.s^{-1}$) and the (partial) pressure difference in $mol.m^{-2}.s^{-1}.Pa^{-1}$ (= $1.344 \times 10^{-7}$ $ml.min^{-1}.cm^{-2}.bar^{-1}$ = 1.93 X $10^{-8}.m^3.m^{-2}.day^{-1}.bar^{-1}$). Gas permeation rates through these membranes are relatively high, mainly due to the very thin top-layers which are in the order of 50-100 nm.

**Membrane Perm-selectivity of $CO_2$ over $N_2$**

The performance of the membrane for separation of a given binary gas mixture of components **$CO_2$** and **$N_2$** is typically expressed as follows.

$$\alpha CO_2/N_2 = P_{CO2}/P_{N2} \quad (11)$$

The ratio ($P_{CO2}/P_{N2}$) is often referred to as the perm-selectivity of the membrane and in the ideal case (ideal gas conditions) it is also referred to as the ideal membrane selectivity. Using equation (5.5) we can calculate values of selectivity as shown in Table 5. $CO_2$ separation factors are between infinity (∞) and 7.29 over the transmembrane pressure drop of 0.01-0.05 bar. For potential DAC applications, our silica membranes offer unique advantages, such as relatively high selectivity at low pressure drop as summarised in Table 5, and high stability under weathering atmospheric conditions in chemically aggressive atmosphere. As a result, these membranes are considered a viable material for the separation of $CO_2$ directly from air. Additionally, no liquid or solid consumables are needed once deployed. Indeed, unlike other ceramic membranes, which are affected by the low-temperature phase transition, silica shows reasonable thermal, chemical, and structural stability in both oxidising and reducing environments. Structurally, it can be modified by using different affordable methods and conditions.

Table 5. Membrane Perm Selectivity of $CO_2$ over $N_2$

| Pressure (bar) | Permeate flowrate (ml/min) | | |
|---|---|---|---|
| | Fresh support | 1st coating | 2nd coating |
| | Flowrate Ratio ($\alpha CO_2/N_2$) | Flowrate Ratio ($\alpha CO_2/N_2$) | Flowrate Ratio ($\alpha CO_2/N_2$) |
| 0.01 | 0.54 | 0.90 | ∞ |
| 0.02 | 0.65 | 0.86 | ∞ |
| 0.03 | 0.68 | 0.91 | ∞ |
| 0.04 | 0.67 | 1.11 | ∞ |
| 0.05 | 0.77 | 1.06 | 7.29 |

**Membrane Separation based on Viscosity**

Viscosity is a parameter which plays a major role in determining the rate of Diffusion. Diffusion involves the extension of molecules or atoms from a higher to lower concentration region and viscosity represents the intermolecular friction of a fluid which hinders its motion. Clearly, as Table 6 shows viscous flow mechanism is not in operation in this pressure drop range.

Table 6. Effect of Pressure and Support modification on Flow Rate and Inverse Viscosity Ratio of $CO_2$ and $N_2$

| Pressure (bar) | Permeate flowrate (ml/min) | | | | | |
|---|---|---|---|---|---|---|
| | Fresh support | | 1st coating | | 2nd coating | |
| | Flowrate Ratio ($CO_2/N_2$) | Inverse Viscosity Ratio $(\eta_{CO_2}/\eta_{N_2})^{-1}$ | Flowrate Ratio ($CO_2/N_2$) | Inverse Viscosity Ratio $(\eta_{CO_2}/\eta_{N_2})^{-1}$ | Flowrate Ratio ($CO_2/N_2$) | Inverse Viscosity Ratio $(\eta_{CO_2}/\eta_{N_2})^{-1}$ |
| 0.01 | 0.54 | 1.19 | 0.90 | 1.19 | ∞ | 1.19 |
| 0.02 | 0.65 | 1.19 | 0.86 | 1.19 | ∞ | 1.19 |
| 0.03 | 0.68 | 1.19 | 0.91 | 1.19 | ∞ | 1.19 |
| 0.04 | 0.67 | 1.19 | 1.11 | 1.19 | ∞ | 1.19 |
| 0.05 | 0.77 | 1.19 | 1.06 | 1.19 | 7.29 | 1.19 |

**Membrane Separation based on Molecular Weight**

Knudsen diffusion is a selective transport mechanism because the diffusion flux is inversely proportional to the square root of the molecular weight of a species. Thus, the mean molecular velocity decreases with an increase in molecular weight. The increase in the flux with increasing temperature is because the concentration of an ideal gas (p/RT) is inversely proportional to temperature. Clearly, as Table 7 shows Knudsen mechanism is not in operation in this pressure drop range.

Table 7. Effect of Pressure and Support Modification on Flow Rate and Square Root of Inverse Molecular Weight Ratio of $CO_2$ and $N_2$

| Pressure (bar) | Permeate flowrate (ml/min) and Square Root of Inverse Molecular Weight Ratio | | | | | |
|---|---|---|---|---|---|---|
| | Fresh support | | 1st coating | | 2nd coating | |
| | Flowrate Ratio ($CO_2/N_2$) | Square Root of Inverse Molecular Weight Ratio $(MWCO_2/MWN_2)^{-0.5}$ | Flowrate Ratio ($CO_2/N_2$) | Square Root of Inverse Molecular Weight Ratio $(MWCO_2/MWN_2)^{-0.5}$ | Flowrate Ratio ($CO_2/N_2$) | Square Root of Inverse Molecular Weight Ratio $(MWCO_2/MWN_2)^{-0.5}$ |
| 0.01 | 0.54 | 0.80 | 0.90 | 0.80 | ∞ | 0.80 |
| 0.02 | 0.65 | 0.80 | 0.86 | 0.80 | ∞ | 0.80 |
| 0.03 | 0.68 | 0.80 | 0.91 | 0.80 | ∞ | 0.80 |
| 0.04 | 0.67 | 0.80 | 1.11 | 0.80 | ∞ | 0.80 |
| 0.05 | 0.77 | 0.80 | 1.06 | 0.80 | 7.29 | 0.80 |

**$CO_2$ Separation Based on Adsorption, Surface Flow, and Kinetic Diameter**

Microporous silica membranes can sometimes mimic transport properties of zeolites and carbon molecular sieves which selectively separate molecules based on pore size and polarity and are thus highly tuneable to specific gas separation processes. As shown in Table 8 $CO_2$ is highly polarised than $N_2$ and has a smaller kinetic diameter (3.3 Å), compared with (3.64 Å). It is also strongly adsorbed on silica than $N_2$ and less viscous (15 μPa.s) compared to 17.9 μPa.s for $N_2$. Table 8 also shows that $CO_2$ has a smaller kinetic diameter which facilities its transport through available free volume and diffusion pathways in the silica matrix.

Table 8. Gas Properties used to help explain the High $CO_2$ Perm-selectivity over $N_2$

| Gas | Molecular mass (g/mol) | Kinetic diameter (Å) | Viscosity, @1 atm, 300 K (μPa.s) | Density (kg/m$^3$) | Critical Temperature (°C) | Critical Pressure (bar) | Condensability (K) | Polarizability (Å) |
|---|---|---|---|---|---|---|---|---|
| **$CO_2$** | 44.01 | 3.30 | 15.0 | 1.842[1)] 1.977[2)] | 31.2 | 35.0 | 195.0 | 1.9 |
| **$CH_4$** | 16.04 | 3.80 | 11.1 | 0.7 – 0.9[2)] | -82.6 | 46.5 | 149.0 | 2.6 |
| **$N_2$** | 28.01 | 3.64 | 17.9 | 1.165[1)] 1.2506[2)] | -147.0 | 34.0 | 71.0 | 1.4 |
| **Air** | 28.96 | --- | 18.6 | 1.205[1)] 1.293[2)] | -140.5 | 37.9 | --- | --- |

[1)]NTP – Normal Temperature and Pressure - is defined as *20°C (293.15 K, 68°F)* and *1 atm (101.325 kN/m$^2$ = 101.325 kPa = 14.7 psia = 0 psig, 30 in Hg = 760 torr)*

[2)] STP - Standard Temperature and Pressure - is defined as *0°C (273.15 K, 32°F)* and *1 atm (101.325 kN/m$^2$ = 101.325 kPa = 14.7 psia = 0 psig, 30 in Hg = 760 torr)*

$CO_2$ with higher critical temperature shows the higher condensability which facilitates gas solubility in silica. Higher permeability of $CH_4$ in comparison to $N_2$ beside its larger kinetic diameter can be attributed to the higher condensability of $CH_4$. In general, smaller molecules (small kinetic diameter) and those with stronger

membrane-adsorption properties are adsorbed onto membranes resulting in larger selectivity. The capacity to discriminate based on both molecular size (kinetic diameter) and adsorption affinity makes microporous silica an attractive candidate for $CO_2$ separation from $N_2$ and $CH_4$.

Depending on the nature of the silica selected as the sorbent it can possess small cages of (~5.1×5.1 Å) that are accessible through smaller apertures of (~3.5×3.5Å). Such aperture size is comparable with the kinetic diameters of $CO_2$ (3.30 Å), $CH_4$ (3.80 Å) and $N_2$ (3.64 Å). This suggests the possibility of kinetic separation of the $CO_2/N_2$ mixture in the atmosphere by exploiting the diffusion rate difference of $CO_2$ and $N_2$ through the micro-channels of silica. However, another important mechanism is in operation responsible for excluding $N_2$ and that is adsorption.

**Permeation Models of $CO_2$ and $N_2$ in the Silica Micropores**

The coated silica membrane shows that permeation is rates reduce with increasing number of dips especially after the second dip. Figure 18 displays the postulated transport of $CO_2$ and $N_2$ through silica micropores. Figure 18 schematically describes a typical micropore that shows gas permeation through the silica membrane mimicking a Y-type zeolite ($CO_2$ molecules are adsorbed on the membrane surface and then migrate into the pores by surface diffusion).

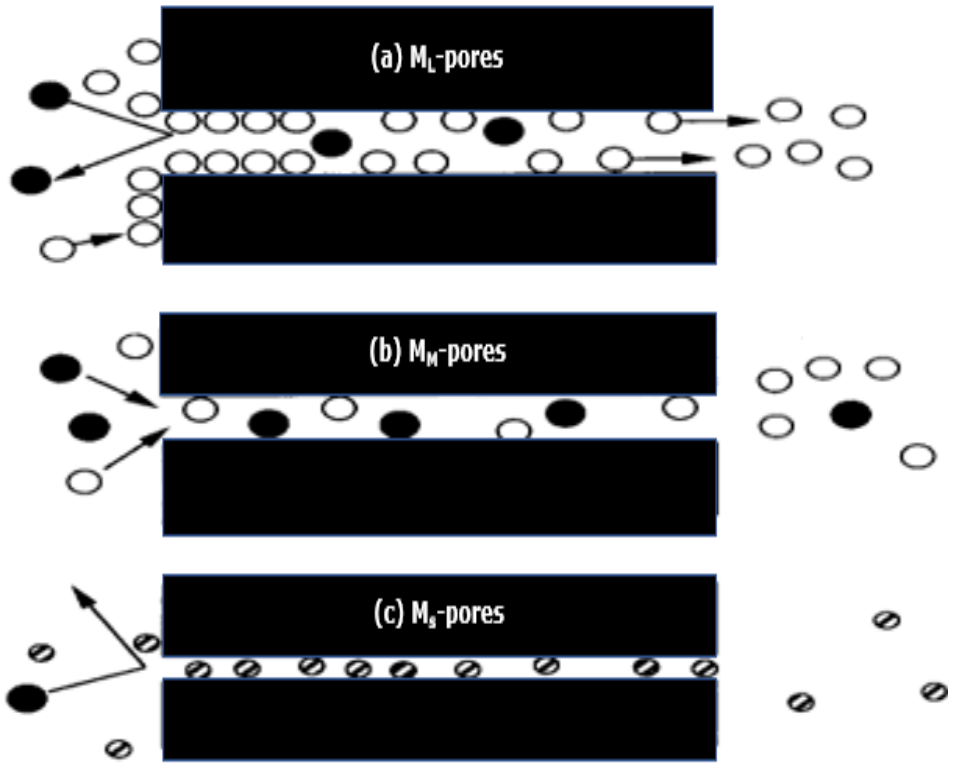



Figure 18. Permeation Models in Micropores; (a) $M_L$-pores, (b) $M_M$-pores and (c) $M_S$-pores ( ○ -$CO_2$; ● -$N_2$ and ⊘ -He or $H_2$)

Adsorbed $CO_2$ molecules restrict the openings of micropores and prevent non-adsorptive $N_2$ from accessing the pores by a translation--collision mechanism. When pressure is increased permeances $N_2$ were increased but $CO_2/N_2$ perm-selectivity remained at a high level. This type of membrane possesses crystalline pores of order of 0.74 nm, which permits the permeation described above. These micropores are referred to as $M_L$-pores (large pores). For the case of $M_M$ pores as pressure is increased above 0.04 bar, $N_2$ is forced through $M_M$ crystalline pores and cracks. In $M_S$ pores only helium (He) and hydrogen ($H_2$) can permeate through Ms-pores (small pores), which are the most abundant and are impermeable to $CO_2$ and larger gas molecules. $CO_2$ and $N_2$ permeate through pores in which $CO_2$ and $N_2$ are barely able to pass one another (referred to as $M_M$-pores). Pores which belong to Knudsen diffusion regime (K-pores) are extremely scarce in this membrane. In this case, the diffusion rate is determined by the slowest permeating component, $N_2$ through $M_M$-pores. The separation in silica membranes is therefore thought to be controlled by the diffusion in the porous structure of the silica and by adsorption–desorption phenomena. Attenuated total reflectance Fourier transform infrared (ATR/FTIR) spectroscopy on both the support and silica-coated support.

## Discussion

The capture of carbon dioxide ($CO_2$) directly from air (DAC) has attracted significant interest in recent times. The National Oceanic and Atmospheric Administration (NOAA) have calculated its long-time $CO_2$ concentration at its atmospheric monitoring station, Mauna Loa, Hawaii, averaging 421 parts per million (ppm) for the month of May 2022 which is when the $CO_2$ gas hits its yearly high (NOAA, 2022).

### Comparison of Membrane and Conventional DAC Systems

Figure 19 compares the membrane DAC approach with the traditional processes currently being used. Therefore, chemical reactions with sorbents used in traditional DAC are very slow at these $CO_2$ concentrations and there is also the difficulty of getting the adsorbed $CO_2$ out again in a more sustainable capture-and-desorption cycles, which can be very energy intensive. Even leading efforts to build traditional DAC plants, such as those using potassium hydroxide (KOH), sodium hydroxide (NaOH) and calcium hydroxide ($Ca(OH)_2$) suffer serious efficiency issues and incur huge recovery costs, making the hunt for new DAC processes notably urgent.

Despite these drawbacks progress is being made on these traditional DAC systems (despite these drawbacks more effort is current being exacted in simplifying these traditional DAC system process to make it more efficient). Swiss climate tech company Climeworks announced on 28 June 2022 that it has broken ground on its biggest new DAC plant yet named Mammoth, with the capacity to capture up to 4,000 tons of $CO_2$ per year, for storage in basalt formations. More recently a U.S. climate tech company CarbonCapture Inc. in an exclusive partnership with premier carbon storage company Frontier Carbon Solutions announced on September 16, 2022, that it has plans to build the world's largest carbon capture facility in Wyoming, U.S., called Project Bison

which will capture 5,000 tons of $CO_2$ per year.

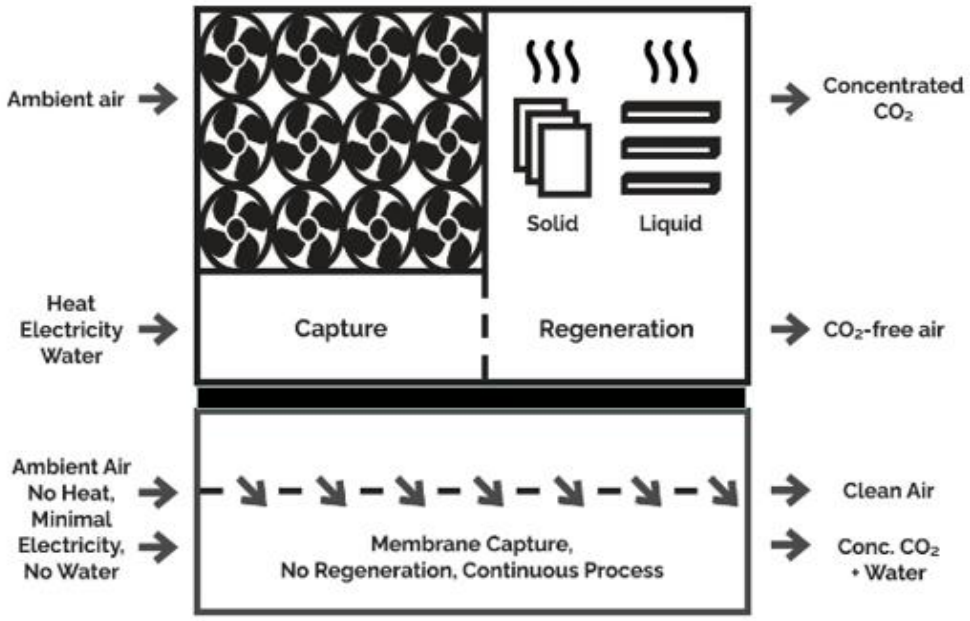



Figure 19. Comparison of Membrane and Conventional DAC Systems (Gobina et al., 2022)

**DAC Membrane System Integration with Renewable Energy and $CO_2$ Utilisation**

In this research technical approaches to capture $CO_2$ from ambient air involving the use of a filter with a transport mechanism as described in previous section have been presented. In practice, moving the air through the filter requires energy as well. For example, to generate sufficient $CO_2$ partial pressures say 0.02 bar in the air feed, the air must be compressed to 50 bars so that 50x0.000421 = 0.02195 bar and if we are to get a $CO_2$ partial pressure of 0.04 bar the feed air must be compressed to 100 bars so that 0.000421x100 = 0.0421 bar. Therefore, although our filters need only a tiny transmembrane pressure drop (0.01-0.04 bar) to produce pure $CO_2$ the feed air needs high total feed pressure of between 25-100 bars to generate the required $CO_2$ partial pressure. One option is to force the air through the membrane using large fans as is currently being done with adsorbents and solution-based DAC systems. In our silica-alumina composite membrane filters, fans/blowers cannot generate the required pressures of 50-100 bars. Due to this we can capture $CO_2$ from ambient air by using a compressor to bring the air to 50-100 bars. The use of large fans to push air through the filters as shown in Figure 20 can be used in adsorptive surface flow porous membrane systems that we are currently developing at the Centre. Since the transmembrane pressure drop is low, these porous membrane systems can be integrated with intermittent or variable renewable energy using power electronics-based inverters that convert DC electricity to grid-compatible AC power to then power fans/blowers. The increasing availability of low-cost variable renewable energy (VRE), the deployment of distributed energy resources, advances in digitalisation and growing opportunities for electrification will drive the increasing prominence of VRE and is among the most important drivers of power system transformation globally. The properties of VRE interact with the broader power system, giving rise to several relevant system integration challenges. These challenges do not appear abruptly, but rather

increase over time along with the increase in VRE penetration. With these systems it is possible to create redundancy in the system by calibrating power intensity with power requirements such that at full power all the membrane units are working and at low power one membrane unit is functional.

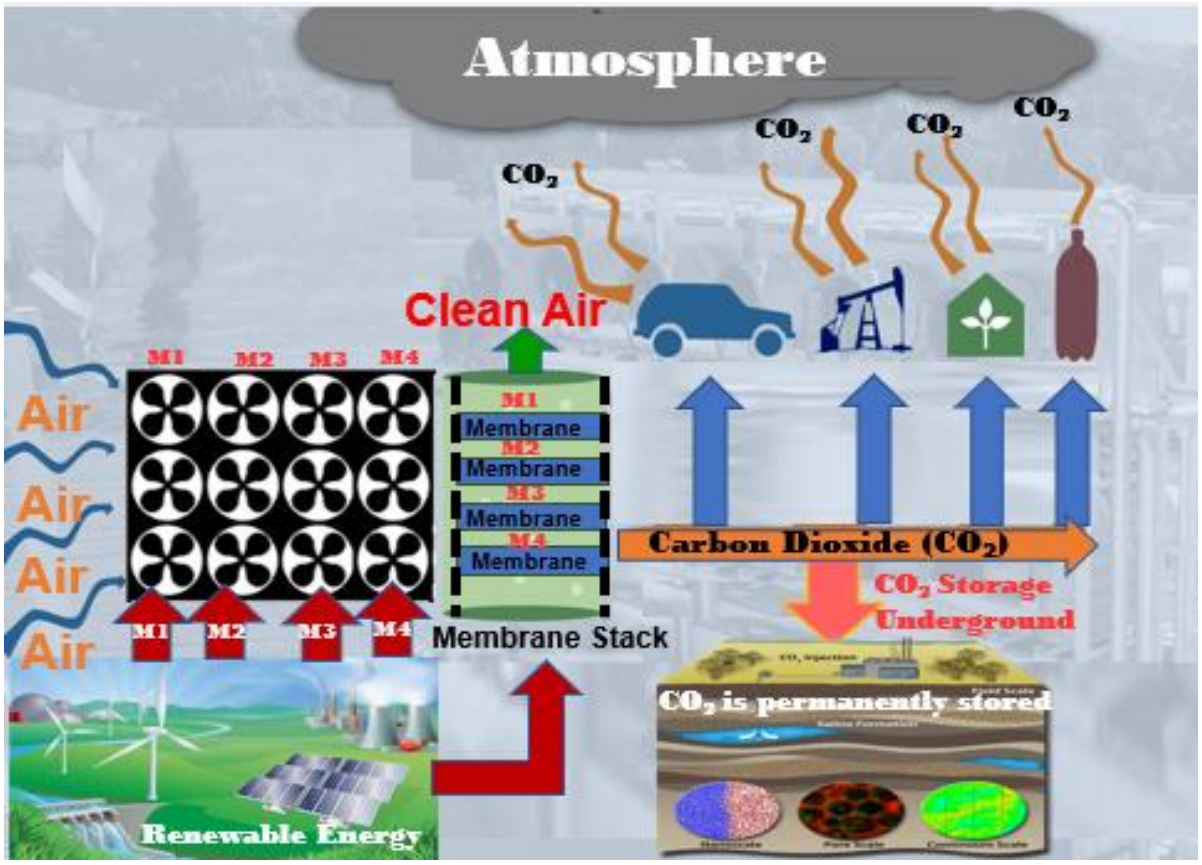



Figure 20. Direct Air Capture Porous Membrane Integration with Renewable Energy and Utilisation

## Conclusions and Further Work

This work is the first of its kind to present a membrane approach with repeatable experimental data on the possibility of DAC. Thıs has been achieved through a careful selection of a combination of 15 nm pore support and 2 sequential dip coatings of silica elastomer sol leading to the creation of composite silica membrane that has one of the highest $CO_2$ perm-selectivity reported in literature. This compares with that reported to date for silica membranes of 300 (Tsai, T., Tam, S-Y., Lu, Y., Brinker, C.J., 2000). In explaining the high $CO_2$ perm-selectivity shown in our 2nd dip-coated membrane in this study, we have found that it is a combination of adsorption and surface diffusion; and these processes are pressure sensitive such that at pressures between 0.01-0.04 bar, adsorption and surface diffusion are controlling $CO_2$ flow. However, as pressure is increased above 0.04 bar, any trapped $N_2$ inside the pores undergo laminar flow and begin to permeate the membrane. The membranes were used to study the permeation of $CO_2$ and $N_2$ single gases at room temperature and calculate the perm-selectivity $CO_2$ of over $N_2$ based on the ratio of flowrates, viscosity, molecular weight, and kinetic

diameters respectively. It was found that only two successive dip coatings were sufficient to completely block $N_2$ permeation through the membrane between 0.01-0.04 bar transmembrane pressure drop. Under these conditions only $CO_2$ permeates the membrane. This is significant in view of the low concentration of $CO_2$ in ambient air (~421 ppm). The significance of such a prospect means that if porous membrane systems currently being developed by this group become successful, renewable energy can be integrated with $CO_2$ porous membrane capture system to further reduce legacy carbon and eliminate carbon footprint of the capture process itself. Work is currently being carried out to optimise the pore-modification method, undertake ambient air stream experiments and model the gas transport mechanism.

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## References

Fujikawa S, Ariyoshi M, Selyanchyn R, Kunitake T. (2019), Ultra-fast, selective $CO_2$ permeation by free-standing siloxane nanomembranes. Chem Lett., 48, 1351–1354. https://doi.org/10.1246/cl.190558

Gobina, E. (2006) A Membrane Apparatus and Method for separating gases, United States of America Granted Patent No. US 7048778, 23-May-2006, https://patents.justia.com/inventor/edward-gobina

Gobina, E., Giwa, A., and Ben-Aron, A. (2022) Unconventional membranes for direct air carbon capture. Membrane technology [online], 2022(7). https://doi.org/10.12968/S0958-2118(22)70077-8

Kolodji, B. (Monday, April 1, 2019 - 1:30pm-1:52pm) Direct Air Capture with Membranes for Crop Carbon Enrichment Proceedings of the AIChE Spring Meeting and Global Congress on Process Safety, 20A, https://www.aiche.org/conferences/aiche-spring-meeting-and-global-congress-on-process-safety/2019/proceeding/paper/20a-direct-air-capture-membranes-crop-carbon-enrichment).

LENNTECH, https://www.lenntech.com/ceramic-membranes-features.htm).

Liguori, S. and Wilcox, J. (2017) Chapter 11 - Silica Membranes Application for Carbon Dioxide Separation,

Editor(s): Angelo Basile, Kmran Ghasemzadeh, Current Trends and Future Developments on (Bio-) Membrane Elsevier, 265-294, https://doi.org/10.1016/B978-0-444-63866-3.00011-X.

NOAA, (June 3, 2022) Carbon dioxide now more than 50% higher than pre-industrial levels, https://www.noaa.gov/news-release/carbon-dioxide-now-more-than-50-higher-than-pre-industrial-levels#:~:text=Carbon%20dioxide%20measured%20at%20NOAA%E2%80%99s%20Mauna%20Loa%20Atmospheric,the%20University%20of%20California%20San%20Diego%20announced%20today

Qin, W., Peng, C., Wu, J. (art A, 2017) PA sacrificial-interlayer technique for single-step coating preparation of highly permeable alumina membrane, Ceramics International, 43(1) 901-904, https://doi.org/10.1016/j.ceramint.2016.09.206].

Shi, W., Yang, C., Qiu, M., Chen, X., and Fan, Y. (2022). A new method for preparing α-alumina ultrafiltration

membrane at low sintering temperature, Journal of Membrane Science, 642, 119992. https://doi.org/10.1016/j.memsci.2021.119992.

Sieverts, A. (1929) The Absorption of Gases by Metals, Zeitschrift für Metallkunde, 21, 37–46, https://www.sciencedirect.com/topics/engineering/sieverts-law

Tsai, T., Tam, S-Y., Lu, Y., Brinker, C.J. (2000) Dual-layer asymmetric microporous silica membranes, Journal of Membrane Science, 169(2) 255-268, https://doi.org/10.1016/S0376-7388(99)00343-9).

Ulhorn, R.J.R. and Burgraaf, A.J. (1991) Gas separatios with inorganic membranes, in Inorganic Membranes: Synthesis, Characteristics and Applications, edited by R.R. Bhave (Van Nostrand Reinhold, New York, 1991), pp. 155–176

Watson, S. K. (June 7, 2022) There's more carbon dioxide in the air than ever before in human history, Popular Science. https://www.popsci.com/environment/co2-emissions-highest-history/#:~:text=Before%20the%20Industrial%20Revolution%2C%20carbon%20dioxide%20levels%20sat,ppm%2C%20which%20was%20first%20breached%20in%20May%201986./

Yin, X., Guan, K., Gao, P., Peng, C., and Wu, J. (2018) A preparation method for the highly permeable ceramic microfiltration membrane – precursor film firing method, *RSC Adv.*, *8*(8) 2906–2914, DOI: 10.1039/c7ra12314k.

Yoo MJ, Kim KH, Lee JH, Kim TW, Chung CW, Cho YH, et al. (2018) Ultrathin gutter layer for high-performance thin-film composite membranes for $CO_2$ separation. *J Memb Sci.*, *566*, 336–345. DOI: https://doi.org/10.1016/j.memsci.2018.09.017

Zhou S., Xue A., Zhang Y. *et al.*, (2015) Preparation of a new ceramic microfiltration membrane with a separation layer of attapulgite nanofibers. *Mater. Lett.*, 143, 27–30. DOI: 10.1016/j.matlet.2014.12.068.

# Analysis of Relationship of Machining Parameters with Steel Roughness AISI 1045 Annealed

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**Abstract**: This work aims to study feed (f) and nose radius (rε) machining parameters on the surface roughness of annealed AISI 1045 steel. The roughness parameters analyzed were the average roughness (Ra) and the roughness of the total height of the profile (Rt). A CNC lathe (Computer Numerical Control) was used to carry out the experimental tests, and a roughness meter was used for data acquisition. The tests were carried out using the type $2^2$ experimental design technique, in which the values of f and rε varied at two different levels. After data collection, commercial software capable of providing statistical data on the results obtained was used. Finally, it was verified that the advance growth caused an increase in the roughness parameters studied, and the increase in the tip radius caused a decrease in the roughness of the analyzed specimens. Such data obtained agree with what is described in the literature, but the roughness levels become closer to the equation generated through the statistical data.

**Keywords:** Turning, Roughness, Experimental Design

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## Introduction

Currently, the number of works related to the study of machining is growing more and more, the research carried out analyzes the response of tool variations together with the variation of machining parameters that act

during the process. The main focus of these researches is the improvement of the machining processes, either by improving the quality of the products or by reducing the necessary production time.

There are several cutting parameters in the machining process; the cutting speed (Vc) is the instantaneous tangential speed resulting from the rotation of the tool around the workpiece, the feed (f) is the distance traveled by the tool per revolution of the workpiece. The depth of cut (ap) is the thickness or penetration depth of the tool measured perpendicularly to the work plane, which is defined by the feed directions and the cutting speed of the tool (Dotto et al, 2014).

Roughness can be defined as a set of micro geometric errors characterized by the presence of bumps and indentations on the part's surface (Almeida et al, 2015). Surface roughness quality is an essential requirement of many workpieces in machining operations. This parameter is increasingly needed in automotive, aerospace, and mold applications. One of the most fundamental metal removal operations within the machining processes is the turning process, which is widely used in today's industry. Diniz et al (2014), Machado et al. (2009), and Grzesik (2017) state that the machining parameters that most influence the roughness Ra and Rt of the turned part is the feed along with the nose radius, as they contribute geometrically to the surface roughness of the part.

The surface roughness of a machined part can affect several functional attributes of the same, such as contact that can cause surface friction, light reflection, wear, ability to distribute and maintain a lubricant, heat transmission, resistance to fatigue in the material, etc. (Singh et al., 2016). Thus, surface roughness is one of the most important quality aspects in turning operations. Thus, there is a need to systematically optimize the process parameters to achieve the typical roughness characteristics using experimental methods and statistical models.

## Literature Review

A literature review on the surface roughness of turned parts was carried out. The researched works aimed to evaluate the influence of machining parameters on surface roughness; with this, it was possible to see the result of parameters such as feed, cutting speed, and depth of cut, in addition to the geometry of the tool on the surface roughness of the parts, after the turning process in different types of materials.

Chou and Song (2004) investigated the effects of tool nose radius on turning finish with ceramic tools. This study evaluated surface finish, tool wear, cutting forces, and white coatings under different machining conditions. The results show that higher values of the tool nose radius give a finer surface finish and considerable tool wear compared to tools with a smaller nose radius. The specific cutting energy also increased slightly with the tool nose radius.

Mital and Mehta (1988) surveyed developed surface prediction models and factors that influence surface roughness. They developed surface finish models for aluminum alloy 390, ductile cast iron, medium carbon alloy steel 4130, and Inconel 718 for a wide range of machining conditions defined by cutting speed, feed and

tool nose radius. The statistical analysis of the experimental data indicated that the type of metal, the feed rate, and the tool nose radius strongly influence the surface finish. However, feed and tool nose radius effects on surface finish were generally consistent for all materials.

Singh et al. (2016) analyzed the effect of cutting conditions (feed, speed, and depth of cut) in addition to the nose radius on the surface roughness of aluminum (6061) that underwent the dry turning process. Finally, the authors identified that the tip radius was the most significant parameter, and the surface roughness value decreased with the increase of the tip radius.

Ranganath and Vipin (2014) performed an experimental investigation and parametric analysis of surface roughness in CNC turning. The main parameters discussed were cutting speed, feed, depth of cut, nose radius, and rake angle. The experiments were carried out using the factorial method of experimental design (DOE) to study the impact of turning parameters on the surface roughness of machined parts. The following conclusions were made based on the results obtained and the analysis performed: Increasing the cutting speed improved the surface finish, thus decreasing the average surface roughness value.

Increasing the depth of cut negatively affected the surface finish to a small extent, but as the depth of cut increased beyond a specific value, the roughness decreased. A slight increase in feed caused a significant increase in surface finish compared to the same amount of growth in the depth of cut. The surface roughness also decreased as the tip radius increased. As the back slope angle increased, the surface roughness decreased, and the surface finishes improved. Finally, the authors concluded that feed was the most influential factor, followed by the depth of cut, cutting speed, nose radius, and inclination angle.

Vikram and Ratnam (2012) investigated the machining parameters that affect the roughness of surfaces produced by the dry turning process using EN8 steel, an aluminum alloy, and a copper alloy. The authors analyzed the influence of cutting speed, feed, and material hardness. The results showed that feed is the most influential factor in surface roughness, followed by cutting speed and material hardness.

Nascimento et al. (2015) analyzed the influence of the nose radius and the depth of cut on the surface roughness of the aeronautical alloy AL2011F after the turning process. The authors found that the greater radius of the tip resulted in a lower surface roughness value; with the greater depth of cut, an increase in this variable was also observed.

Several academic works were studied to evaluate the surface roughness of different cutting parameters and the tool nose radius. An experimental design was adopted for this work to assess the input variables in the surface roughness of annealed ABNT 1045 steel.

## Experimental Procedures

The type of experimental design has an essential effect on the number of experiments that will be needed. Thus, it is important to have an adequate design for the experiments to be carried out. In this work, a $2^K$-type factorial design was used, where the variables analyzed varied in two distinct values. In this study, two parameters were selected: feed and nose radius. These parameters were chosen because Equations 1 and 2 by Diniz et al (2014), Machado et al. (2009), and Grzesik (2017) describe because, according to the authors, the theoretical maximum values of the roughness parameters Ra and Rt depend directly on the feed and the nose radius of the tool used in the turning process.

$$Rt = \frac{f^2}{8r\varepsilon}$$

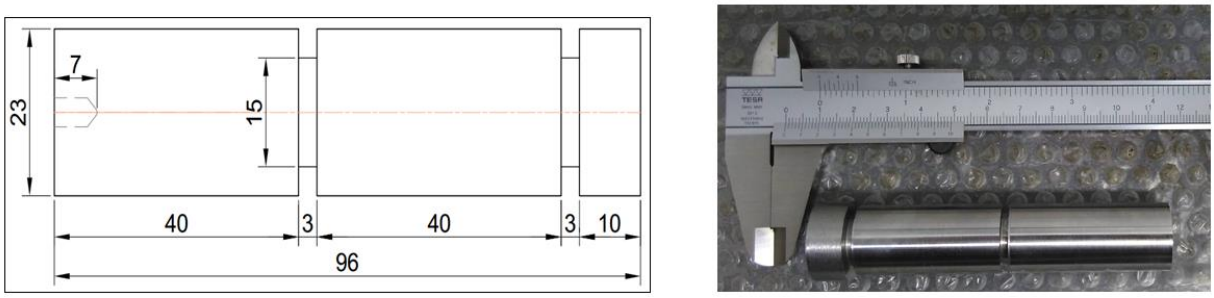
(1) $$Ra = \frac{f^2}{18\sqrt{3}r\varepsilon}$$

(2)

### Preparation of Specimens

AISI 1045 steel was selected for carrying out the work, considering that it is already widespread in the current market, being widely used in general-purpose manufacturing components where mechanical strength superior to that of conventional low-carbon steels is required. Before making the specimens, the steel billet underwent annealing heat treatment before carrying out the experiments.

To make it possible to carry out the experiments, a total of two specimens of annealed ABNT 1045 steel were made; they were designed so that it was possible to perform two tests at a time on each specimen. Each of the specimens has channels that divide it into three parts because, according to Junior (2013), the non-use of the media in the specimen can generate burrs that can cause damage to the tool and the part. This may affect the roughness results obtained. Figure (1) shows the designed and developed specimen, respectively.




(a) (b)

Figure 1. (a) Projected Specimen; (b) Developed Specimen

**Machine Tools**

All experiments were performed on a CNC lathe model Diplomat 3001 (Fig. (2)), using cutting fluid as coolant. A counter tip was used in each test to reduce the vibration caused during the machining process.


Figure 2. CNC Lathe used in the Experiments

At the end of each test, a rugosimeter model TR 200 (Fig. (3)) was used to acquire the roughness parameters Ra and Rt values.

Figure 3. Rugosimeter measuring the Roughness of a Specimen

For data collection, the rugosimeter was configured to work with a cut-off of 0.8 mm, each measurement was performed three times, with each check rotating the axis, causing the collection to be performed at three different points. The final result was the arithmetic mean of the three measurements.

**Development of Experiments**

According to Montgomery (2009), a designed experiment is a test, or series of tests, in which purposeful changes are made to the input variables of a process (cutoff parameters) so that we can observe and identify corresponding changes in the response of a process output (surface roughness). The experiments were carried out following a $2^K$-type experimental design, where the input variables alternate between the maximum and minimum value. Three replicas were performed in each experiment, totaling 12 experimental trials. For each repetition of the tests, a new cutting edge was used. Figure (4) illustrates the experimental design scheme used. The development of the experiments was carried out following the following structure:

- Materials analyzed:
  - Two specimens.
- Independent variables:

- Feed;
- Radius nose.

- Response variables:
  - Roughness Ra;
  - Roughness Rt.

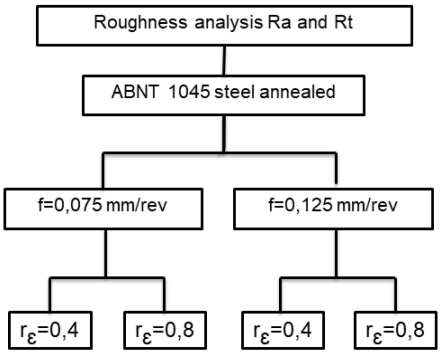



Figure 4. Experimental Design used for Roughness Evaluation

## Results

The machining results can be seen in Table 1. Table 2 presents the arithmetic mean of the roughness obtained experimentally.

Table 1. Experimentally obtained Roughness Results

| AISI 1045 annealed steel | | | | | | |
|---|---|---|---|---|---|---|
| **Replicas** | **Essay** | **interactions** | **Feed (mm/rev)** | **Radius nose (mm)** | **Ra (µm)** | **Rt (µm)** |
| 1 | 1 | [1] | 0,075 | 0,4 | 0,782 | 6,172 |
| | 2 | a | 0,125 | 0,4 | 0,843 | 5,192 |
| | 3 | b | 0,075 | 0,8 | 0,384 | 2,692 |
| | 4 | ab | 0,125 | 0,8 | 0,559 | 3,712 |
| 2 | 5 | [1] | 0,075 | 0,4 | 0,66 | 4,265 |
| | 6 | a | 0,125 | 0,4 | 1,33 | 8,419 |
| | 7 | b | 0,075 | 0,8 | 0,477 | 3,599 |
| | 8 | ab | 0,125 | 0,8 | 0,701 | 4,566 |
| 3 | 9 | [1] | 0,075 | 0,4 | 0,463 | 3,44 |
| | 10 | a | 0,125 | 0,4 | 0,645 | 4,946 |
| | 11 | b | 0,075 | 0,8 | 0,657 | 4,626 |
| | 12 | ab | 0,125 | 0,8 | 1,101 | 5,992 |

Table 2. Arithmetic Mean of the Roughness Values obtained from the Tests

| Replicas | Feed (mm/rev) | Radius nose (mm) | Ra (µm) | Rt (µm) |
|---|---|---|---|---|
| [1] | 0,075 | 0,4 | 0,635 | 4,625 |
| a | 0,125 | 0,4 | 0,939 | 6,185 |
| b | 0,075 | 0,8 | 0,506 | 3,639 |
| ab | 0,125 | 0,8 | 0,787 | 4,75 |

The results obtained in the experiments and shown in Table (1) were used as input in a commercial software that performed the necessary analyzes for the study. The arithmetic mean of the three replicas was used when entering the data into the software. Thus, it was possible to obtain the response surface, the linear regression coefficients, and the mathematical model of the experiments.

**Experimental Roughness Analysis**

The roughness response surfaces Ra and Rt, obtained from the experimental results, can be seen in Figures 5 and 6, respectively. It can be seen that the roughness increases as the feed increases and decreases when the nose radius increases.

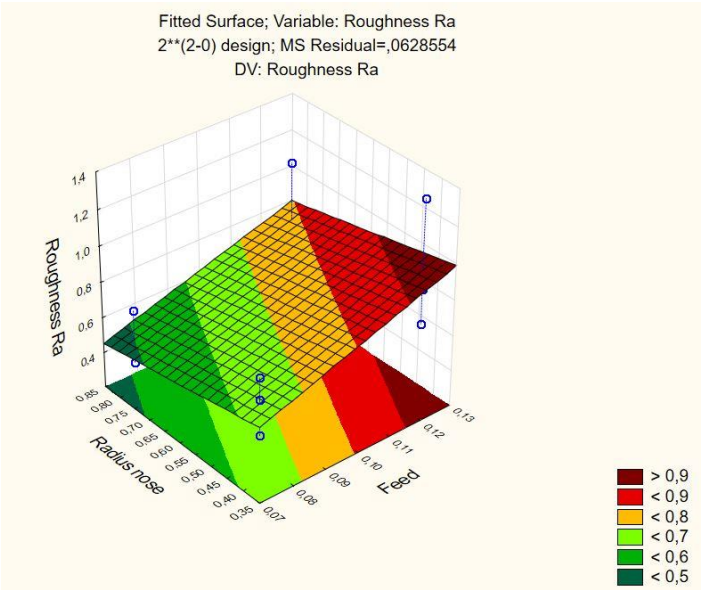



Figure 5. Roughness Response Surface Ra of Annealed Steel

The Pareto chart shows the level of influence of each of the parameters analyzed in the process; in this case, the advance was the parameter with the most significant influence on the surface roughness of the studied specimens. Figure 7 shows the Pareto diagram of the roughness parameters Ra and Rt, respectively.

The regression coefficients are provided in Table 3 and 4 for constructing the mathematical models of Ra and Rt. The mathematical models obtained are displayed in Equations (3) and (4).

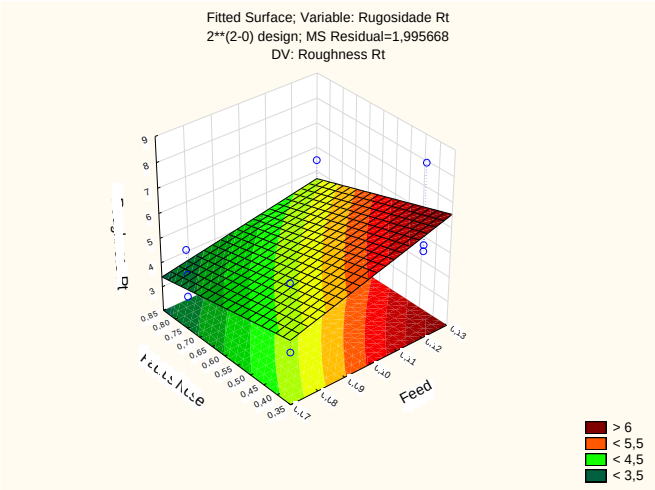
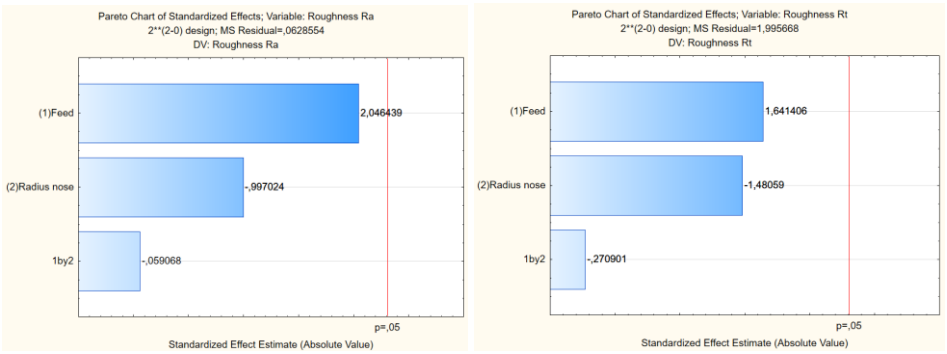



Figure 6. Roughness Response Surface Rt of Annealed Steel




(a) (b)

Figure 7. Pareto Chart of Roughness Ra (a) and Rt (b)

Table 3. Roughness Regression Coefficients Ra

| Factor | Regr. Coefficients; Var.: Roughness Ra; R-sqr=,39327; Adj:,16575; 2**(2-0) design; MS Residual=,0628554 DV: Roughness Ra | | | | | |
|---|---|---|---|---|---|---|
| | Regression coefficients | Std. Err. | T(8) | p | -95,% Cnf.Limt | +95,% Cnf.Limt |
| Mean/Interc | 0,288167 | 0,94364 | 0,305379 | 0,767872 | -1,8879 | 2,46420 |
| Feed | 6,437333 | 9,15463 | 0,703178 | 0,501892 | -14,6733 | 27,54794 |
| Radius nose | -0,275292 | 1,49202 | -0,184509 | 0,858206 | -3,7159 | 3,16532 |
| 1 by 2 | -0,855000 | 14,47474 | -0,059068 | 0,954346 | -34,2338 | 32,52381 |

Ra = 0,288167+6,437333*feed-0,275292*radius nose–0,855*feed*radius nose (3)

Table 4. Roughness regression coefficients Rt.

| Factor | Regr. Coefficients; Var.:Roughness Rt; R-sqr=,3827; Adj:,15122; 2**(2-0) design; MS Residual=1,995668 DV: Roughness Rt | | | | | |
|---|---|---|---|---|---|---|
| | Regression coefficients | Std. Err. | T(8) | p | -95,% Cnf.Limt | +95,% Cnf.Limt |
| Mean/Interc | 2,6103 | 5,31714 | 0,490922 | 0,636664 | -9,651 | 14,8716 |
| Feed | 40,0320 | 51,58382 | 0,776057 | 0,460041 | -78,920 | 158,9845 |
| Radius nose | -0,8095 | 8,40713 | -0,096282 | 0,925665 | -20,196 | 18,5774 |
| 1 by 2 | -22,0950 | 81,56117 | -0,270901 | 0,793326 | -210,175 | 165,9854 |

Rt= 2,6103+40,032*feed-0,8095*radius nose-22,095*feed*radius nose (4)

From the mathematical models obtained, the theoretical Ra and Rt values described in Eqs. (1) and (2) were compared with the mathematical models found experimentally. Tables 5, 6, and 7 present the results obtained.

Table 5. Comparative the Mathematical Model and the Theoretical Model

| Feed (mm/rev) | Radius nose | Ra | Ra(theoretical) | Rt | Rt(theoretical) |
|---|---|---|---|---|---|
| 0,075 | 0,4 | 0,6352 | 0,45105 | 4,62605 | 1,75781 |
| 0,09 | 0,5 | 0,691406 | 0,51962 | 4,814155 | 2,025 |
| 0,1 | 0,6 | 0,715425 | 0,53458 | 4,8021 | 2,08333 |
| 0,11 | 0,7 | 0,737734 | 0,55444 | 4,745855 | 2,16071 |
| 0,125 | 0,8 | 0,7871 | 0,62647 | 4,7572 | 2,44141 |

Table 6. Results between Models analyzing the Variation of the Feed

| Feed (mm/rev) | Radius nose | Ra | Ra(theoretical) | Rt | Rt(theoretical) |
|---|---|---|---|---|---|
| 0,075 | 0,4 | 0,6352 | 0,45105 | 4,62605 | 1,75781 |
| 0,09 | 0,4 | 0,72663 | 0,64952 | 5,09396 | 2,53125 |
| 0,1 | 0,4 | 0,787584 | 0,80188 | 5,4059 | 3,125 |
| 0,11 | 0,4 | 0,848537 | 0,97027 | 5,71784 | 3,78125 |
| 0,125 | 0,4 | 0,939967 | 1,25293 | 6,18575 | 4,88281 |

Table 7. Results between Models analyzing the Variation of the Radius Nose

| Feed (mm/rev) | Radius nose | Ra | Ra(theoretical) | Rt | Rt(theoretical) |
|---|---|---|---|---|---|
| 0,075 | 0,4 | 0,6352 | 0,45105 | 4,62605 | 1,75781 |
| 0,075 | 0,5 | 0,601258 | 0,36084 | 4,3793875 | 1,40625 |
| 0,075 | 0,6 | 0,567317 | 0,3007 | 4,132725 | 1,17188 |
| 0,075 | 0,7 | 0,533375 | 0,25775 | 3,8860625 | 1,00446 |
| 0,075 | 0,8 | 0,499433 | 0,22553 | 3,6394 | 0,87891 |

## Conclusion

From the analysis of the data obtained in the practice tests, it was possible to notice that the increase of the feed causes an increase in the surface roughness of the machined surface. Regarding the nose radius, the increase in it caused a decrease in the surface roughness of the part; this can be explained due to the geometric contribution of the region since the rise in the nose radius provides a greater area of workpiece-tool contact, thus causing an improvement in the surface roughness of the specimens. Finally, the results obtained experimentally faithfully followed equations (3) and (4) described in work.

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## References

Almeida, S. L. R., Filho, M. S., Stipkovic, M. A., Bordinassi, C., & Delijaicov, S., (2015) Modelo numérico experimental da rugosidade no fresamento frontal de acabamento do aço AISI 4140 endurecido. *Congresso de Métodos Numéricos em Engenharia*, Lisboa.

Chou, Y. K., & Song, H. (2004). Tool nose radius effects on finish hard turning. *Journal of Materials Processing Technology*, v. 148, n. 2, p. 259–268.

Diniz, A. E., & Marcondes, F. C., & Coppini, N. L., (2014). *Tecnologia da usinagem dos materiais.* Ed. Artliber, 9° Ed., São Paulo.

Dotto, A. R., Seimetz, A. C., Carlin, A. C., Führ, H. K., Gelatti, M. R., & Alves, V. J., (2014). *Influência das condições de usinagem por torneamento na rugosidade da peça.* 4° semana de engenharia e economia Fahor.

Grzesik, W., (2017) "Advanced Machinig Processes of Metallic Materials" Ed. Elsevier, 2° Ed., Cambridge.

Junior, C. A. O., (2013) *Torneamento do aço inoxidável super duplex UNS S32750 e influência na resistência à corrosão*. (Masters Dissertation), Unicamp, São Paulo.

Machado, A. R., Abrão, A. M., Coelho, R. T., & Silva, M. B., (2009). *Teoria da usinagem dos materiais* Ed. BLUCHER, 1° Ed. São Paulo.

Mital, A., & Mehta, M., (1988) *Surface finish prediction models for fine turning.* International Journal of Production Research, v. 26, n. 12, p. 1861–1876.

Montgomery, D. C., (2009). *Introdução ao controle estatístico da qualidade*. Ed. LTC, 4° Ed., Rio de Janeiro.

Nascimento, M. R., Toloczko, F. R., Suyama, D. I., & Hassui, A. (2015). *Estudo comparativo entre a influência do raio de ponta no torneamento da liga AL2011F.* 8° Congresso Brasileiro de Engenharia de Fabricação, Bahia.

Ranganath. M. S., (2014). *Experimental investigation and parametric studies of surface roughness analysis in*

*CNC turning*. Ijmer, v. 4, n. 10, p. 49–58.

Singh, D., Chadha, V., & Msingari, R., (2016). *Effect of nose radius on surface roughness during CNC turning using response surface methodology*. International Journal of Recent Advances in Mechanical Engineering, v. 5, n. 2, p. 31–45.

Vikram, K. A., & Ratnam, C. (2012). *Empirical model for surface roughness in hard turning based on analysis of machining parameters and hardness values of various engineering materials*. v. 2, n. 3, p. 3091–3097.

# Factors Impacting Internationalization of Education: A Perspective

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**Abstract**: The purpose of this study is to highlight the factors affecting the realisation of internationalisation in education around the globe. The advanced world has generated a huge capital through opening their educational institutions to the world. Most emerging countries now aim to construct social capital through the internationalisation of education in their universities as well. This study mainly considers educational internationalisation in the middle east region and the Sultanate of Oman. The medium of instruction is assumed to be English and a globally accepted curriculum for different courses in higher education, which are considered essential for success. The student movements between different regions and cultures have caused multiple issues. Results of this study revealed several factors that have minor to significant impact on the internationalisation of education in the region. The work discusses these region-specific factors and their possible impacts. Consequently, addressing the highlighted challenges would pave the way for strategically responding to the skill gap the globalised knowledge-based economy demands.

**Keywords:** Internationalisation, Recognition, Education, Economy, Skill

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## Introduction

Globalisation is a process through which the different elements affecting the human race spread across national and cultural borders [Finardi et al., 2015]. The development of transportation and communication since the 18th

century has not only accelerated this process but also created greater interdependence between humans from different regions. Over time, the process has become complex and multifaceted [2 Fischer, S 2003; Scott, A. & M. Storper 2003]. In the wake of globalisation, education has not been exempt from its effects. The higher education system in Oman is striving to keep track of current global trends where education systems are linked across the globe. Modern theories are being practised to run its higher education business. [Alzadjali, A. H. 2019]. However, many challenges are faced by Oman Higher Education. The significant challenges and pressures are using English as a language for research and instruction, branding and reputation, competition for talents, a need to focus on international research and publications, recruiting international students and scholars, and revenue generation.

International affiliations and accreditations are widespread among higher education institutions in the Sultanate of Oman. Although the programmes are internationally recognised, one of the primary concerns is the English language. The students with low English proficiency struggled with their learning and understanding of lectures taught by mostly expatriate lecturers and comprehending assignments, examinations and graduation projects. Thus, it affects the graduate's overall learning outcomes and attributes, depriving the skill that a globalised knowledge-based economy demands. Furthermore, it has been observed that higher education growth strongly correlates with a country's economic growth [Finardi et al., 2015].

This paper discusses the conceptualisation and operationalisation of delivering an internationally focused programme of study in one of the institution in Oman by critically reflecting on using English as a language of instruction. Further, by analysing how the institution (University A) responded strategically to the internationalisation process and whether or not there is a mismatch between education and regional work requirements.

## Internationalisation Manifests itself in One of the Oman Institution

The UNIVERSITY 'A' is affiliated with the University 'B' in the UK. The University B has helped establish UNIVERSITY 'A' quality assurance framework and has validated its courses. Currently, UNIVERSITY 'A' and University 'B' involve collaboration in developing and monitoring programmes, modules and staff training and development.

UNIVERSITY 'A' programmes are accredited by the UK professional engineering bodies such as the Institute of Engineering and Technology (IET), Institution of Mechanical Engineers (IMechE), Energy Institute (EI), Royal Aeronautical Society (RAES), institute of civil engineers (ICE). Apart from the international accreditation bodies the college is in the accreditation process by Oman Academic Accreditation Authority (OAAA), which is mandatory as per the HE regulation of Oman.

In terms of internationalisation, UNIVERSITY 'A' chose affiliation with UK university, international

accreditation, recruiting international staff, implementing English as the medium of instruction and diversifying how the college presents itself to be viewed as "international".

The rationale for UNIVERSITY 'A's internationalisation strategy is not due to choice but was directed by the government policy. It was driven by the globalisation factor; political, economic, sociocultural, and educational reforms took place to contribute to Oman's knowledge economy. Referring to Potts, D (2016), UNIVERSITY 'A's internationalisation model is more "comprehensive internationalisation" of higher education. An approach in which all aspects of higher education are addressed in an integrated way, including quality assurance mechanisms, student learning outcomes procedures, and national and discipline accreditations.

Although the programmes are internationally recognised, one of the primary concerns was English language. The low-level English competence affects student's learning and understanding of lectures taught by mostly expatriate lecturers and comprehending assignments, examinations and graduation projects. Even if admission criteria stipulate a minimum threshold score for IELTS, it is still a concern. Thus, it affects the graduate's overall learning outcomes. A more detailed analysis can be read in the following section.

## Methodology

For the analysis of numeric data, a quantitative research approach was adopted. A study was carried out at UNIVERSITY 'A' to investigate the impact of internationalization on students' assessments. Two modules were selected, which were referred as modules A and B, to probe the impact of English language competency on teaching modules.

The module A has two artefact, artefact 1 is a 1000-word individual written report along with an oral presentation, and artefact 2 is a written exam. Module B has 3 artefacts; artefact 1 consists of project CW consists of continuous assessment, artefact 2 consists of 2 hours in class test consists of manual drawing and artefact 3 consists of 2 hours in class test A CAD (computer aided design) drawing to be produced. The descriptive statistical analysis used to analyse the acquired assessment data.

## Results and Discussion

Results in figure 1 highlights the student's assessment data for past 4 years. It is evident from results that in AY 18/19 and AY21/22 pass rate is almost similar however pass rate is high during AY 19/20 and AY 20/21 this is attributed to the COVID period when students took their exam through online (without strict invigilation). This module involves student's report writing skills and presenting their data through reflective writing. Figure 2 summarise the result data for the past 4 years for the module B. As it is described earlier that this module doesn't involve reflective writing skills, the assessment for this module only involves the designing skills of students. It can be seen from the result that the results are consistent throughout past 4 years. Figure 3 shows the

comparison of pass rate of module A and B. It can be seen from the results that module A has variation in passing rate around (20%). However module B showed consistency in the results.

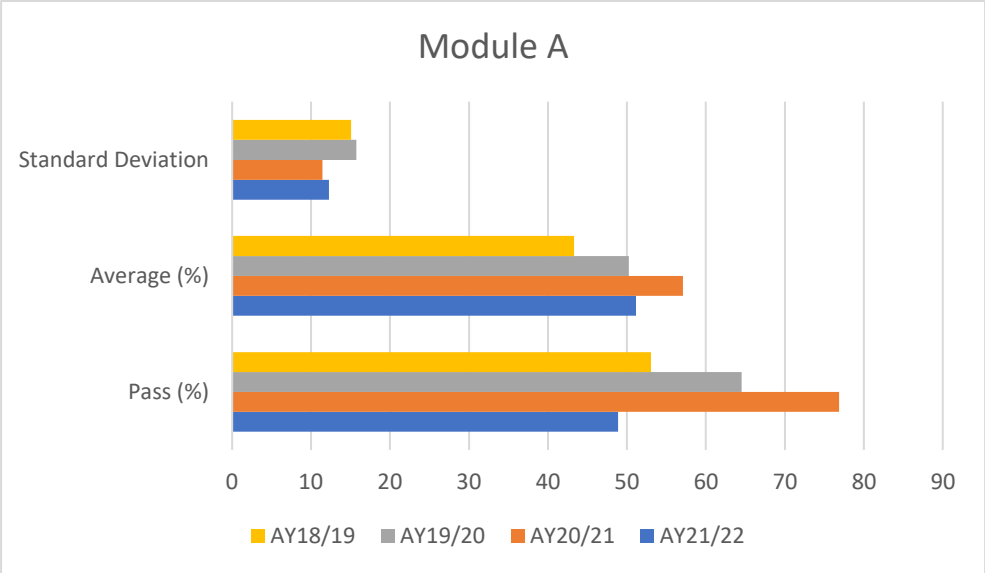


Figure 6. Assessment Data for Module A for Past 4 Academic Years

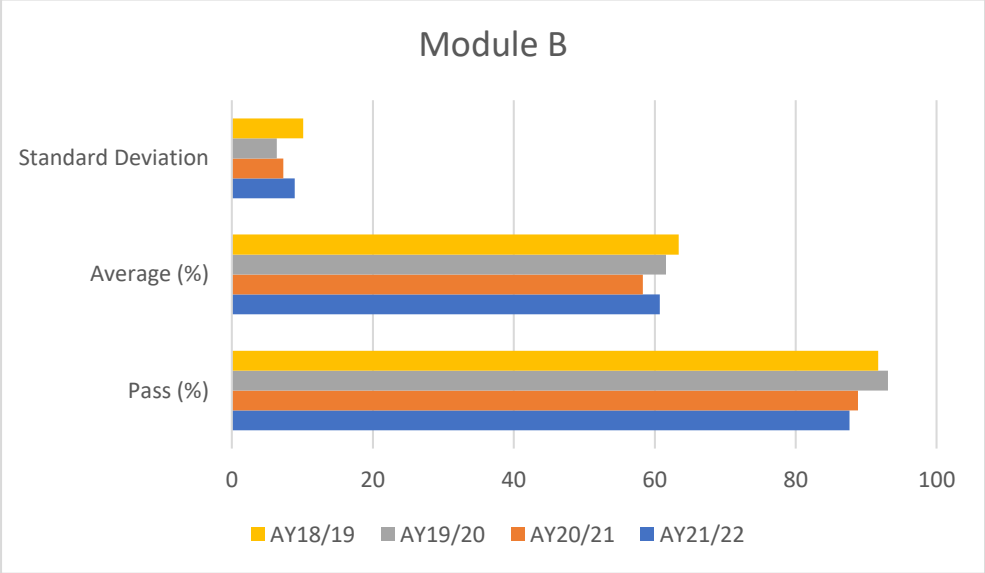


Figure 7. Assessment Data for Module B for Past 4 Years

From the results presented in Figure 1, 2 and 3, it can be inferred that UNIVERSITY 'A' should try to implement content infused language teaching (CILT) for its students. Lazargabaster (2008) argues that the experience is a real preparation for the 'internationalisation' of education, which includes all its demands and challenges and reflects contemporary ideas and practices. Al Issa (2014). UNIVERSITY 'A' should develop and implement a formal feedback mechanism for tracking its graduates to ensure that its programs are meeting the needs of employers according to its Mission and Vision.

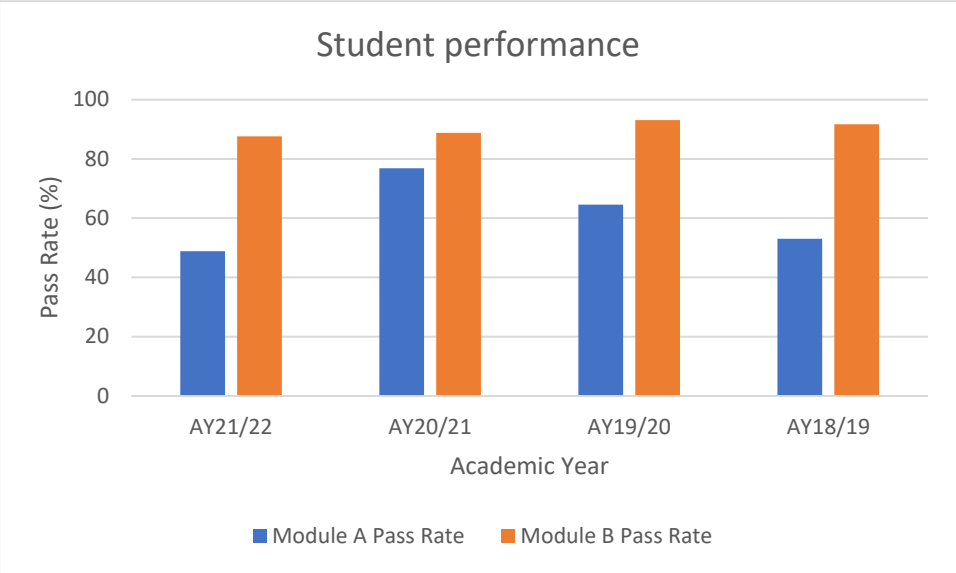


Figure 8. Comparison of Pass Rate of Module A and B

It should be noted that UNIVERSITY 'A' is fairly a young organisation which is still positioning itself in the educational market. The internationalisation activities at UNIVERSITY 'A' are still ongoing due to its external environment's compulsion for it to be self-sustainable and reputational to enjoy a competitive advantage.

**The institution's strategic response to the internationalisation of HE**

UNIVERSITY 'A's internationalisation strategy is mainly driven by academic and economic rationale. The strategy aligns with the characterisation by Ghasempoor et al. (2011) and Knight (2008), which in turn aligned with the Oman vision 2040.

Following is the vision statement of UNIVERSITY 'A' (UNIVERSITY 'A' Strategy 2014):

> *"The UNIVERSITY 'A' will be internationally positioned amongst the best all-service providers of military and technological education and training."*

One of the values related to internationalisation:

> *"Excellence to achieving the highest audited teaching quality standards and international professional recognition"*

UNIVERSITY 'A' developed the Vision and Values statements in 2011 during the formative phase of the development of the college. The statements set out to provide military and civilian personnel education in a single technological college of higher education.

It can be inferred from the vision statement that UNIVERSITY 'A' aspires to internationally position itself for

military and civilian technological education and training. However, it should be noted that no ranking system for military-specific institutions exists and therefore measuring or benchmarking their international position is not straightforward.

One clear strategy in the establishment of UNIVERSITY 'A' was the requirement to appoint an affiliate institution which had relevant experience and standing in the provision of programs aligned to the military requirements of UNIVERSITY 'A'. As a result, UNIVERSITY 'A' established an affiliation partnership with the University 'B', which has experience working with the armed forces in the United Kingdom.

The UNIVERSITY 'A' Articles of Governance related to Academic and Professional Partnerships stipulate that, 'all programmes [of study] will comply with the University 'B' [mature university] conferment requirements, the OQF (Oman Qualifications Framework) and the QAA (Quality Assurance Agency) education and quality framework and UK-SPEC' (MTC QA Portfolio, 2017. p.8). The two institutions work very closely together, and University 'B' has a clear role in validating the modules and programs offered by UNIVERSITY 'A' under a collaborative partnership arrangement. This ensures that academic standards are maintained in line with the affiliation agreement that University 'B' "is responsible for the academic standards of all Awards granted in its name". The Affiliation Agreement also requires University 'B' to review the performance of UNIVERSITY 'A' at least every three years. In 2016 UNIVERSITY 'A' and University 'B' agreed that both institutions should award a certificate to graduating students, in variance with the requirements of the original contractual agreement, which stipulated a single award from University 'B'. Therefore the scope of any changes is very restricted at the moment.

## Conclusion

Oman will have an enormous task in localising affiliated programs due to the quality gap. All stakeholders will require a collaborative effort to increase program quality. The policymakers must consider that profit motives are generally the drivers for private institutions and they must increase students' experience and quality of programming and meet national needs and values. For affiliated programmes, this presents challenges in supporting students to gain international recognition as global citizens in keeping with the expectations imposed on students by the government. The institutional strategy for countries like Oman should focus more on "Glocalisation" their programme to meet international quality standard graduate outcomes and global citizenship. However, they are limited to this since the majority of responsibilities would be a joint effort by both the Ministry of Higher Education (MOHE) and the institutions.

## References

Al-Issa, A.S.M. (2014). Researching the uses of the english language in the law job market in the sultanate of oman: implications for policy-practice improvement. *Educ Res Policy Prac., 13*, 25–44. https://doi-

org.ezproxy1.bath.ac.uk/10.1007/s10671-013-9146-4.

Alzadjali, A. H. (2019). Policies and Initiatives for the Internationalisation of Higher Education in Oman.In F. Silman, F. Altinay Aksal, & Z. Altinay Gazi (Eds.), *Policies and Initiatives for the Internationalisation of Higher Education* (pp. 12-31). IGI Global. https://doi-org.ezproxy1.bath.ac.uk/10.4018/978-1-5225-5231-4.ch002

Finardi, K., & Rojo, R. (2015). Globalization, internationalization and education: what is the connection? *International e-journal of Advances in Education, 1*(1), 18-25.

Fischer, S. (2003). Globalization and its challenges. *American Economic Review, 93*(2), 1-30.

Ghasempoor, A., Liaghatdar, M. J., & Jafari, E. (2011). The internationalization of higher education: An effective approach for Iran higher education. *Higher Education Studies, 1*(2), 35-40.

Knight, J. (2008). *Higher education in turmoil: The changing world of internationalization.* Boston College Centre for International higher Education & Sense Publishers.

Lasagabaster, D. (2008). Foreign language competence in content and language integrated courses. *The Open Applied Linguistics Journal, 1*, 31–42.

Military Technological College (2017). *Quality Audit Portfolio*. (Accessed 6 May 2022)

Oman Vision 2040 (2020). Accesed on 12 May2022 from Oman2040-En.pdf

Potts, D., (2016). John Hudzik: Comprehensive internationalization: institutional pathways to success. *Higher Education, 72*(2), 259–261.

Scott, A., & Storper, M. (2003). Regions, globalization, development. *Regional studies, 37*(6-7), 579-593.

# Assessment of Resilience in the Cities in terms of Infrastructure and Ecosystem Baghdad as Case Study

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**Abstract**: Resilience as a theory is one of the most important contemporary trends in sustainable planning due to the many risks that cities are challenging. The most important of which are environmental, economic, social and other unexpected changes in the city and its urban elements that may threaten the stability of growth of those cities. Urban resilience represents a new concept in thinking to achieve sustainable development goals under dynamic changes and current or unexpected crises. Many international ideas have tried to define the city's resilience since 1973 until now by many parties, researchers and international organizations. These ideas are presented and briefly addressed to reach for a general concept of city resilience through research that fits the case study. The municipality of Baghdad in Iraq launched a project to prepare the city of Baghdad's resilient strategy. Therefore, this research aims to apply the concept of resilience to the city of Baghdad, evaluate and analyze the situation of the city, and measure the efficiency of the city in terms of resilience and the ability to withstand the issue of infrastructure and ecosystem.

**Keywords:** Theory of Resilience, Infrastructure, Ecosystems, Urban planning

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## Introduction

The theory of resilience theoretically appeared in 1973 for the first time in the ecological field as a concept that

refers to adaptation to the environment, as it is defined as the ability of the ecosystem to maintain the desired services in light of facing the risks of environmental changes and human exploitation (1973, Holling). In 2001, another definition of ecological resilience emerged as the ability of ecosystems and social systems to reduce disturbances and maintain the required processes (Carpenter,2001). In the same year, the concept of resilience appeared in another form, urban resilience, which means the city's ability to absorb disturbances while maintaining the functions of its services, infrastructure and superstructure, which is consistent with the idea of Ecological Resilience (Lance, 2001). In 2003, the term resilient cities appeared as an explicit term for the first time, and a resilient city is a city that has well-built infrastructure capable of dealing with and mitigating the effects of external changes and disturbances that occur in the urban and ecological system of cites (Godschalk, 2003). The concept expanded in 2004 to include the resilience of social systems, and in 2006 Resilience was introduced as a system of thinking necessary and essential for sustainability.

## Basic Principles of Resilient Cities

By using the analysis of the global assessment tools for the resilience of cities, all those tools have basic themes that the specialists considered the main principles of the resilience of cities. Each assessment tool addresses a specificity of the city and the issues it faces in the different sectors. From here, the article concluded that there are four basic principles developed by (ARUP) and supported by Rockefeller. As shown in (Figure 1) which represents the basic idea of resilience in cities, which confirms the definition of the city's resilience foundation for research (Sharifi, 2016): Health & wellbeing, Economy & Society, Infrastructure & Environment, Leadership & strategy.

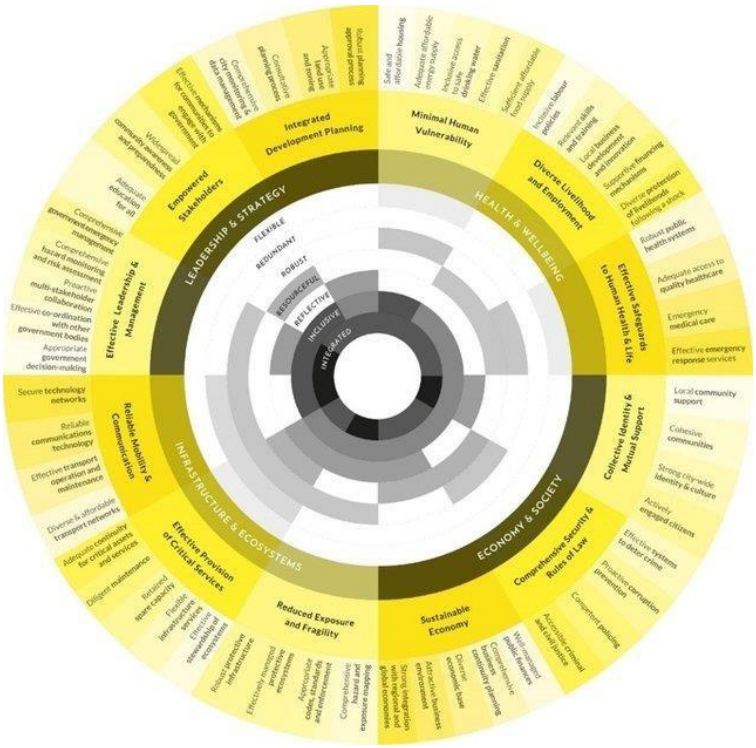


Figure 1. City Resilience Index (The Rockefeller Foundation and Arup (2016)

**Smart Parking**

Transport planning and coordination of buses and trains use smartphones to send traffic movement information directly to users. Smartphones help passengers and drivers to know the traffic situation and reduce road congestion. Also, sensors embedded in the road Real-time provide information about parking spots and notifications about whether there is an available space to park or not.

*Example*

San Francisco provides a service of information about the availability of parking spaces in real-time through applications of smartphones. Inhabitants can select free parking spots and prices through an accessible application (Figure 2).

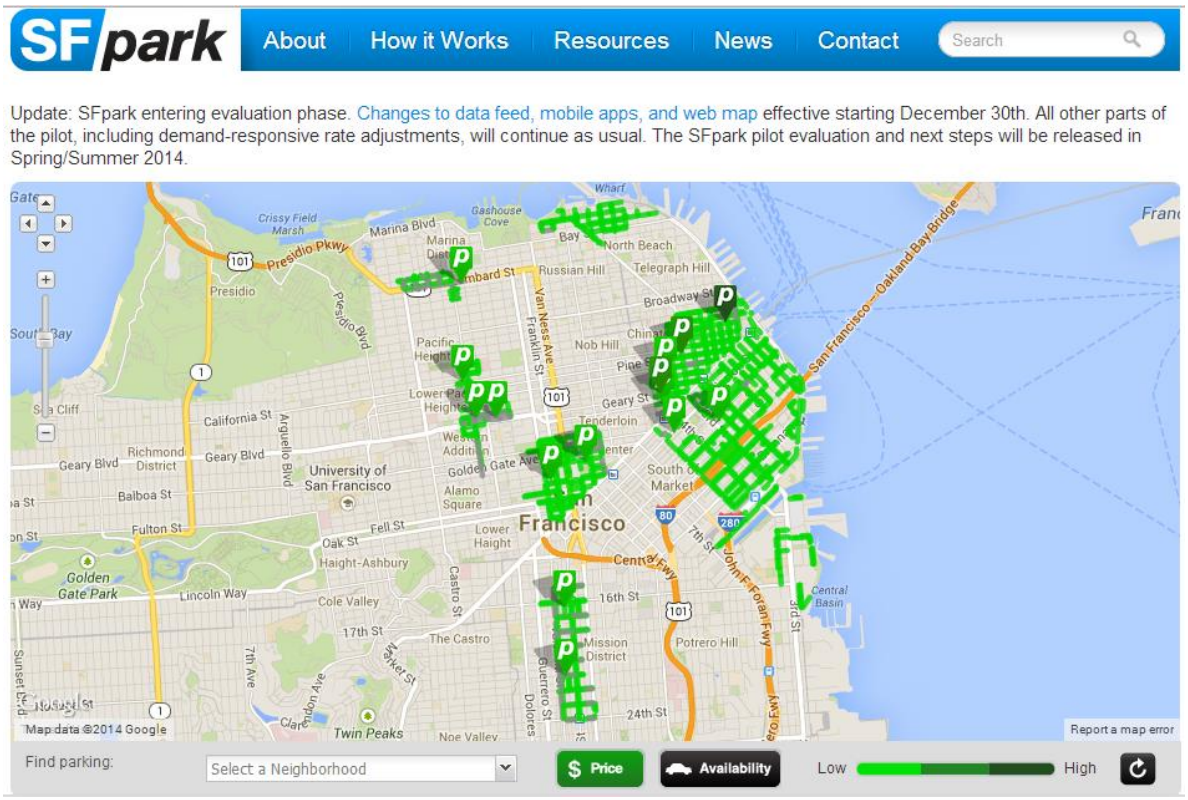


Figure 2. San Francisco's Parking (http://sfpark.org/)

**Fleet Management System (FMS)**

Fleet Management System is the solution to define the position of all vehicle service engines in real time. It also produces various reports for planning rides to encourage savings and improve the quality of service perceived by the citizens. The function of all fleet management systems is vehicle tracking through GPS. Once the fleet location, direction and speed are spotted by the GPS mechanisms, additional tracking capabilities transmit this

information to the fleet management software application. Users can see the real-time spots of their fleet on the map. This process responds quickly to events on the ground (www.hitachi-automotive).

*Examples*

Ottawa/Canada updated its services to the public to be safe, reliable and effective cost. Ottawa vehicles include buses, ambulances, fire trucks, equipment for snow removal and solid waste vehicles. Fleet management system ensures the provision of vehicle services in the city to fulfil their obligations to the public and get rid of the old cars at a suitable time. This system complies with the requirements of vehicle safety equipment. (http://ottawa.ca/en) (Figure 3).

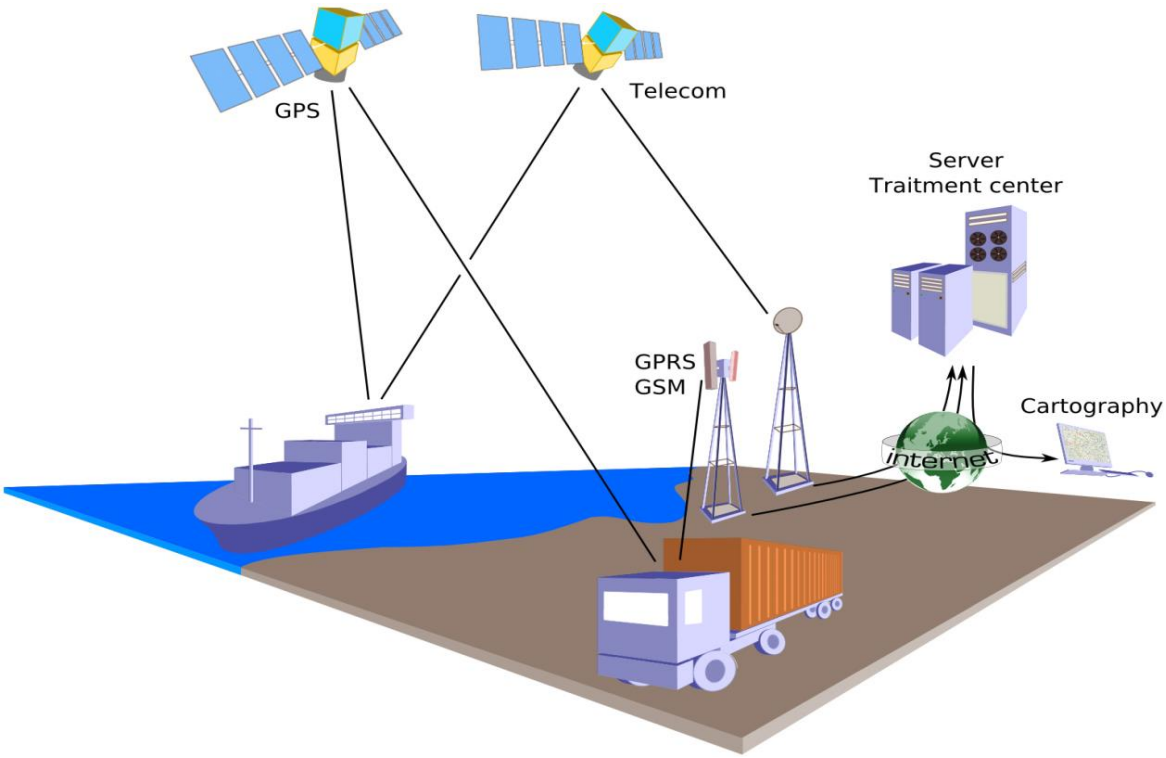


Figure 3. San Francisco's PARKING (http://sfpark.org/)

**Intelligent Transport System (ITS)**

Countries like Japan, U.S., Germany, and France have highways installed with many Intelligent Transport Systems (ITS). They are a new collection of techniques and methods to meet the challenges rising at the surface of transport. Applications of the intelligent transport system (ITS) meet the needs of today's traffic and improve the benefits of the transport system by reducing delays and allowing traffic to flow smoothly ( GPS World, 2014).

*Example*

Japan activated ITS services in 1996 to provide drivers with public road information collected from road operators and traffic police centres without any fees (Figure 4). Japan implemented five million units of ITS to help drivers find an efficient way to their destination, thereby reducing traffic congestion, besides this service has contributed to the reduction of 2.4 million tons of CO2 emissions. Toyota, Honda and Nissan are the pioneers in providing users with traffic information based on detailed data from their investigations when the disaster of the 11th of March 2011 in Japan took place. Several roads in the North East destroyed. There is no general traffic information from the region, but after eight days after the disaster, drivers got the data from systems either through the website or via smartphones (Hayakawa, 2013)..

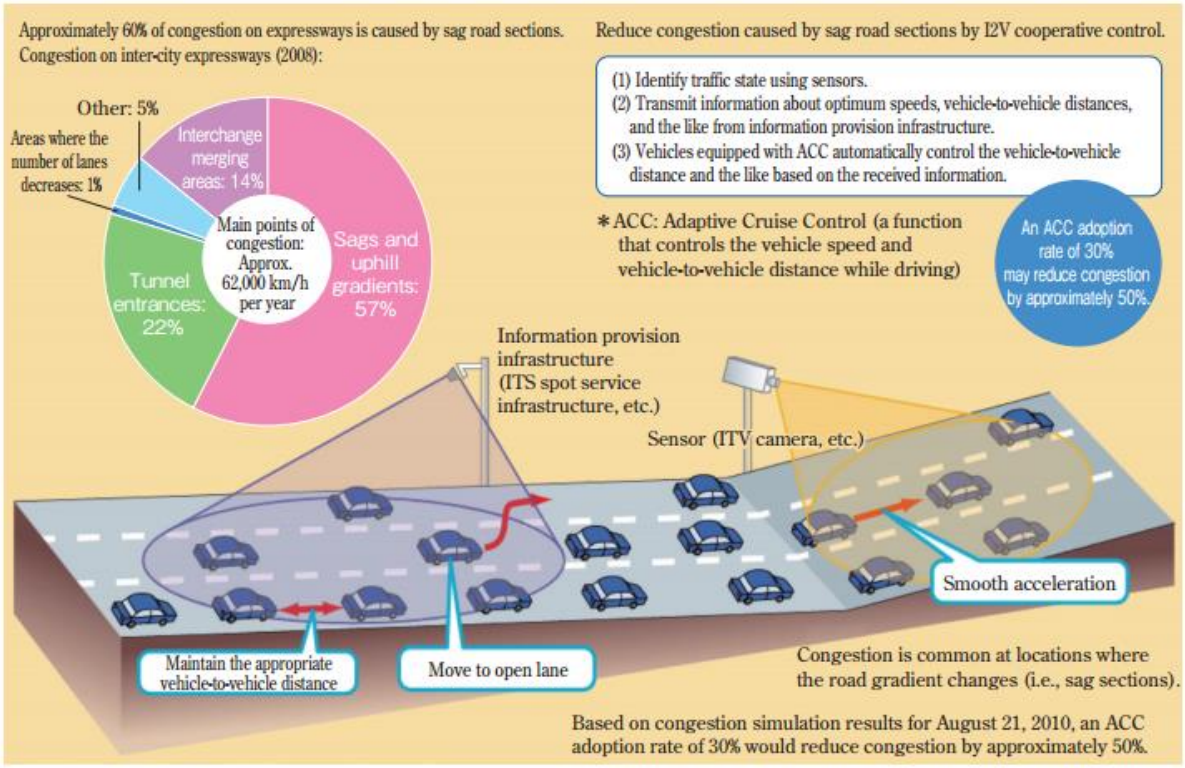


Figure 4. Intelligent Transport System (Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

**Traffic Management**

The provision of Smart traffic lights and sending traffic information to people by mobile; will improve the perception of citizens about travel best hours and also increase the use of public transportation performance which reduces the use of private vehicles and facilitates management of the road network, increases the public transport services quickly. As a result, this trait helps reduce emissions associated with each trip so that emissions from public transport are less than private vehicles.

*Example*

Barcelona has a mobile application that makes it easy to visualize traffic in real-time. It allows the user to determine the best route to avoid congestion and accidents and thus save time. The user can also see the images received by 30 cameras stationed around all regions, updated every five or ten minutes. (Figure 5).


Figure 5. Traffic Management (http://latitudefortyone.com/ten-reasons-why-barcelona-is-a-smart-city/)

**Public Bicycle**

A massive proportion of any traffic in a city is a large number of cars, vans and trucks. Therefore, using bikes would contribute to decreasing this proportion. Using a Public bicycle is essential in reducing the pressure on public transport and improving health. The roads' infrastructure should deploy throughout the city to share bikes for short periods with information in real-time about the availability and the reservation of the bikes at the station.

*Example*

The Copenhagen wheel project is a new mobility initiative in urban areas. This project is a responsive and elegant system that converts ordinary bikes into hybrid e-bikes by hyper-sensor units. Copenhagen wheel project allows you to capture the energy while cycling and braking and save it for when you need fuel; it also

shows by maps the pollution levels, traffic congestion and road conditions in real-time.
Smartphones control the Copenhagen wheel project. Riders can use their phones to open and lock their bikes, change gears and determine how much the engine can help. Also, the turn wheel sensor captures the level of effort and information on your surroundings, including road conditions, carbon monoxide, noise, ambient temperature and relative humidity.

Access to such data through the phone or the network is to help users plan routes or meet up with friends and share their riders' data (http://senseable.mit.edu/copenhagenwheel/). (Figure 6).

Figure 6. Copenhagen Wheel Project (http://senseable.mit.edu/copenhagenwheel/)

***Electric Vehicles Infrastructure***

These procedures aim to connect "smart mobility" to make functional mobility available with environmentally friendly effects. The best corporation processes carried out in cities and municipalities under this trait is the best meeting of transport requirements of inhabitants with intelligent usage in the city, resulting in a change from singular transit to mass transit and boosting the use of non-motorized transport such as bikes and electric cars. An electric vehicle network is a system of infrastructure charging stations and probably stations for recharging the battery electric car swap. The Governments, manufacturers and infrastructure providers distributed several stations to create such networks for charging infrastructure with real-time information from the nearest stations and make booking available in all periods and accessible from smartphone and web applications (Lee, 2013).

*Example*

Madrid allows users to hire electric cars (economical and environmentally friendly) and drive them throughout the city. Moreover, the City Council allows these cars to park in restricted areas and go through the residential areas of priority (Figure 7).


Figure 7. Madrid Electric Car (http://www.getyourguide.com/madrid-l46/madrid-electric-car-rental-with-gps-t39049/)

**Case Study**

Baghdad is the capital of Iraq, located on the bank of the Tigris River. Despite being the smallest province, It has the largest population, is the most crowded, and includes 14 districts. Baghdad has a unique culture and historical heritage. It has witnessed many events and changes over the past years. Therefore, this city transformed through environmental, social, economic and political aspects. For this purpose, the municipality of Baghdad launched a project called the Baghdad Resilient strategy to become the first institution to introduce the concept of contemporary resilience as an idea and a practical implementation procedure.

This article aims to apply the idea of resilience in the city of Baghdad by evaluating and analyzing the indicators to determine the current situation and measuring the efficiency of the city in terms of resilience and the ability to withstand the issue of infrastructure and ecosystem

*- In terms of infrastructure*

Years of conflict, delayed maintenance, lack of technical and managerial skills, and neglect have all caused the severe deterioration of Baghdad's infrastructure. Most of the city's population today has access to few services, and some rely on expensive alternatives to obtain electricity and water services. Therefore, the billing system and the generation of income from these services have deteriorated and should be a political priority. The environmental and health risks associated with water pollution and lack of care in removing solid materials and sanitation have become a burden on the health sector. In addition, the general deficit in services, especially electricity, has increased the lack of security and safety.

*- In terms of ecosystem*

The wars and the economic sanctions together led to a lack of attention and negligence of the environment for many years, which caused deteriorated environmental conditions, including water sources (quantity and quality), also poor management of water purification in municipalities. The system of ecological balances got worse through the death of trees in the forests, the progress of desertification and the loss of historical marshes. Neglecting these problems without radical solutions will affect the achievement of sustainable development

goals and become an obstacle to achieving a good quality of life.

**Global Tools for Assessing the City Resilience**

Many international organizations have applied resilience as a principle to solve the problems and limitations facing cities by using Resilience assessment tools, which are more than fifty global tools that enable cities to assess and achieve resilience.

*Choosing the CRF (Framework Resilience City) Assessment Tool to apply to the Case Study*

The assessment has two types of indicators:

A. The digital indicators can be obtained from the official data of the Iraqi Statistics Authority on the Internet and evaluated in comparison with the standards of CRF.
B. Descriptive indicators, in which the research relied on a questionnaire for a set of indicators that present the sub-goals related to the city of Baghdad's infrastructure and ecosystem. Four specialized engineers in the Iraqi Ministry of Planning took the questionnaire.

By analyzing the indicators values for the primary and secondary objectives, a set of weaknesses appeared that hinder the investigation resilience of goals for the principle of infrastructure and ecosystem;

- Lack of policies to manage risks and crises, especially concerning the danger of climate change for the city of Baghdad.
- Lack of effective management of ecosystems.
- Public services suffer from poor efficiency, which harms the city's sustainability.
- Inefficient sewage networks and inefficient management systems, and the lack of alternative plans for water sources in case of shortage of water resources.
- The lack of a developed public transportation network run by municipalities or the ministry of transportation with no alternative transportation options for residents other than individual transportation by their private cars.
- Inadequate supply of telecommunications lines and the Internetز
- The presence of informal areas that do not comply with building standards, in addition to the lack of an inventory of the risks to which the city is exposed and the vulnerability

Table 1. CRF (Framework Resilience City Assessment (modified by Author

| Value | Indicators | Goals | Categorie |
|---|---|---|---|
| N/A | Environmental stewardship | Reduced exposure and fragility | Infrastructure & ecosystems |
| N/A | Appropriate infrastructure | | |
| N/A | Effective land use planning | | |

| | | |
|---|---|---|
| 50% | Enforcement of planning regulations. | |
| 10% | Diversity of provision | Effective provision of critical services |
| 60% | Redundancy | |
| 40% | Active management and maintenance of ecosystems and infrastructure | |
| 20 | Contingency planning | |
| N/A | Diverse and affordable multi-modal transport systems | Reliable communications and mobility |
| N/A | Diverse and affordable communication technology (ICT) networks | |
| N/A | Contingency planning | |

## Conclusion & Recommendation

From studying, analyzing and evaluating the principles of resilience in the city of Baghdad using the CRF flexibility assessment tool, the importance of resilience assessment tools as directive tools emerged, as they play the role of analysis and evaluation of the city's work system from all sectors directed to achieving flexibility and then sustainable development. Weaknesses of the theme of infrastructure and ecosystem. The CRF assessment tool helps decision-makers and stakeholders identify the weak points and challenges facing Baghdad to develop policies and strategies to reach sustainability and prepare for the risks. In this article, I recommend planners, stakeholders, and decision-makers move towards the idea of resilience for the development of Baghdad city, as it is a more realistic, compatible and supportive thought for the sustainability criteria for cities, taking into account the dynamics of change in the current situation of the city and the risks and crises expected.

## References

Brusca, I.; Francesca Manes Rossi, F.; Aversano, N. (2016). Accountability and Transparency to Fight against Corruption: An International Comparative Analysis. Journal of Comparative Policy Analysis: Research and Practice. Volume 20, Issue. 5, pp. 486-504. https://doi.org/10.1080/13876988.2017.1393951

Coaffee, J. (2016). Terrorism, Risk and the Global City: towards Urban Resilience. Farnham: Ashgate.2009. Routledge, Mar 16, 2016 - Science - 376 pages.

Carpenter, S., Walker, B., Anderies, J. et al. (2001). From Metaphor to Measurement: Resilience of What to What? Journal of Ecosystems. Volume 4, Issue 8, pp 765–781. https://doi.org/10.1007/s10021-001-0045-9.

Godschalk, D. R. (2003). Urban hazard mitigation: Creating resilient cities. Journal of Natural Hazards Review. Vol. 4, Issue 3, pp. 136-143.

GPS World, Intelligent Transport Systems Market Report, 2014.

Available at: http://gpsworld.com/forecast-looks-at-intelligent-transport-systems/

Hayakawa, K. (2013), ‘‘Japan: Intelligente Transport Systemen in de logistiek,’’ Innovatie Attaché Tokio,Japan.

Holling, C. S. (1973). Resilience and stability of ecological systems. Annual Review of Ecology and Systematics, Vol. 4, pp. 1-23

Lance H. Gunderson, Craig Reece Allen, C. S. Holling. (2001). Foundations of Ecological Resilience. Island Press, Jul 16, 2012 - Science - 496 pages.

Lee, J., Phaal, R., Lee, S., Lee, H. (2013), An integrated service-device-technology roadmap for smart city development, Technol. Forecast. Soc. Chang. 80, 286–306.

Sharifi, A.; YoshikiYamagata, Y. (2016). On the suitability of assessment tools for guiding communities towards disaster resilience. International Journal of Disaster Risk Reduction. Volume 18, September 2016, Pages 115-124. https://doi.org/10.1016/j.ijdrr.2016.06.006.

Sharifi, A. (2016). A critical review of selected tools for assessing community resilience. Journal of Ecological Indicators. Volume 69, October 2016, Pages 629-647. https://doi.org/10.1016/j.ecolind.2016.05.023

The Rockefeller Foundation, ARUP. (2016). City Resilience Framework City Resilience Index. The Rockefeller Foundation, ARUP. Arup 13 Fitzroy Street London W1T 4BQ United Kingdom.

V04: Lützkendorf, T., & Balouktsi, M. (2017). Assessing a sustainable urban development: Typology of indicators and sources of information. Procedia Environmental Sciences, 38, 546-

553. https://www.sciencedirect.com/science/article/pii/S1878029617301263# (Links to an external site.)

V05: Elmqvist, T., Andersson, E., et al. (2019). Sustainability and resilience for transformation in the urban century. Nature sustainability, 2(4), 267-

273. https://www.researchgate.net/publication/332301102

Walker, B., Salt.D. (2012). Resilience Thinking: Sustaining Ecosystems and People in a Changing. Island Press, Jun 22, 2012 - Nature - 192 pages.

## Websites

https://www.mop.gov.iq/

https://amanatbaghdad.gov.iq/

http://cosit.gov.iq/en/

http://www.hitachi-automotive).

http://ottawa.ca/en).

http://sfpark.org/

http://latitudefortyone.com/ten-reasons-why-barcelona-is-a-smart-city/

http://senseable.mit.edu/copenhagenwheel/

http://senseable.mit.edu/copenhagenwheel/

http://www.getyourguide.com/madrid-l46/madrid-electric-car-rental-with-gps-t39049/