Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

The Integration of Science Technology Engineering and Mathematics (STEM) in Home Science: Teachers' Understanding and Challenges

Rahimah Jamaluddin[1,*], Nor Haslinda Mohd Shah[2], Mohd Hazwan Mohd Puad[1], Enio Kang Mohd Sufian Kang[1], Rosnani Jusoh[1]

[1] Faculty of Educational Studies, Universiti Putra Malaysia, Serdang, Malaysia
[2] SMK Doktor Burhanuddin, Taiping Perak, Malaysia

ARTICLE INFO

Article history:
Received 21 January 2023
Received in revised form 14 June 2023
Accepted 21 June 2023
Available online 4 July 2023

Keywords:
STEM teaching; Home Science Education; Sains Rumah Tangga

ABSTRACT

The integration of Science Technology Engineering and Mathematics (STEM) education was introduced in Home Science subjects in the year 2017. It aims to enable Home Science students to be competitive in facing the challenges of the 21st century. However, the integration of STEM was not fully implemented due to time constraint, lack of STEM knowledge, as well as heavy workload among the teachers. This study was conducted to explore the integration of STEM among Home Science teachers. Three research questions were derived. Firstly, by exploring Home Science teachers' understanding of STEM and the challenges faced by them in integrating STEM. This qualitative case study involved three Home Science Teachers in Larut Matang and Selama District, Perak. The research informants were selected by using purposive sampling technique. Data were collected using semi-structured interviews. The findings indicated that Home Science teachers understand the concept of STEM integration. They successfully integrate elements of Science and Mathematics, but lack the knowledge to integrate the elements of technology and engineering in Home Science. Only certain topics were chosen to inculcate the STEM elements. Findings also showed that the teachers are not confident in planning STEM projects because there is no guidance and course given to them. Three main challenges faced by the teachers are time constraint, no allocation or budget, and limited creativity to implement STEM projects. The involvement of Home Science teachers in STEM-related activities organised by the District Education Office, State Education Department, or with STEM organisations need to be increased to make sure they get enough exposure to STEM integration in the classroom. Comprehensive training should also be given to Home Science teachers through a continuous Professional Learning Community (PLC) to improve their level of competence in teaching STEM.

1. Introduction

In the next twenty years, the need for manpower in the field of research and the digital industry will dominate the employment industry. Even most IR4.0 jobs involve STEM knowledge and skills

* *Corresponding author.*
E-mail address: imah_upm@upm.edu.my

https://doi.org/10.37934/araset.31.2.4250

(EPU, 2021). In relation to this matter, the government has taken an initial step by introducing STEM education in the Standard Secondary School Curriculum (KSSM). The integration of STEM education in the Assessment Curriculum Standard Document (DSKP) is one of the agendas in the Malaysian Education Development Plan (PPPM) 2013-2025 [1]. STEM education, in the context of Malaysia, refers to education that is based on the concept of educating students in four main fields, namely Science, Technology, Engineering, and Mathematics. This is achieved by integrating the four fields through learning applications to solve problems in the context of the real world [2]. PPPM has outlined STEM education not only in Mathematics and Science subjects, but also involving specialised elective subjects (MPEI), namely Communication Graphics, Home Science, Agriculture, Design, Computer Science, Sports Science, and Basic Sustainability [3]. Some of the policies seen to support this noble desire are 60% Science: 40% Literature Policy (60:40 Policy), Vision 2020, PPPM 2013-2025, as well as the National Science, Technology, and Innovation Policy, in addition to the operation of the National STEM Centre which began in May 2018.

This government's intention is in line with the practice of neighbouring countries such as Singapore that includes STEM disciplines in their curriculum to produce workforce resources in STEM fields, such as engineers, biotechnology and scientists [4,5]. In fact, the United States also applies STEM education in Technical and Vocational Education (TVE) to provide a skilled and professional workforce in the IR4.0 industry. This is because STEM education has the potential to motivate students in their studies to be able to engage in STEM-related activities for their future careers [6]. Actions taken by the government are also seen to be in line with the recommendations of the National Society of Professional Engineers which suggest that all citizens, even if they are not STEM professionals, need to have the skills and competence to deal with the challenges of the society based on information and high technology [7].

In the context of Home Science subjects, the Standard Curriculum and Assessment Document (DSKP) is a reference used for the implementation of STEM. The integration of Mathematical Engineering Science Technology (STEM) education in Home Science subjects is one of the government's efforts to apply 21st century skills through the Malaysian Education Development Plan (PPPM) 2013-2025 [1] This initiative aims to enable Home Science students to be competitive in facing the challenges of the 21st century. From 2017, the subject of Home Science has been grouped into the Science and Applied Technology elective for upper secondary level. Through this recommendation, teachers need to plan teaching and learning by integrating three elements, namely STEM knowledge, STEM skills, and STEM values. The integration of STEM into teaching and learning is in line with the profile of the 21st century students who are the aspirations of the Ministry of Education and Culture. Students who are knowledgeable, resilient, into teamwork, good at communicating, patriotic, thoughtful, curious, and principled [3].

To achieve the nation's educational goals, teachers are the backbone of change. According to Han *et al.,* teacher readiness is important in making teaching more meaningful. Therefore, [9] stated that to increase interest and continued desire in the STEM field, teachers should understand and have existing knowledge about STEM education. The integration of STEM in teaching and learning can be implemented by cultivating STEM practices through inquiry strategies, problem-solving, and projects in the context of the real world [3].

There are several weaknesses identified among Home Science teachers in integrating STEM education. The first is in terms of exposure to STEM. Short-term courses and in-service training for STEM education are often conducted for Science and Mathematics teachers. Home Science teachers obtained STEM information through the DSKP briefing when it was first introduced. However, short-term courses related to STEM are almost never conducted for Home Science teachers specifically. Even teachers are bound by 'Finish syllabus syndrome' which is a challenge for teachers to integrate

STEM elements. This is due to teachers and students being and to bound into the exam-oriented system [10] which requires them to finish the syllabus. Because of that, teachers do not have enough time and what is worse, they are also burdened with other workloads [11].

According to the Minister of Science, Technology, and Innovation, the Ministry of Education Report in 2020 showed that only 47.18 percent of upper secondary level students across the country chose STEM as their field of study. Of that number, 26.6 percent chose Technical and Vocational Education and Training (TVET). This decline could be linked to teachers' integrated STEM teaching practices which were reported to still be at a moderate level [12], not comprehensive [13], and not enough to meet the needs of the students [14]. The students were also reported to lack understanding of the teachers' delivery method and thus, causing them to lose interest in STEM [15-17]. In addition, teacher guidance methods that were not suitable for the students' abilities also contributed to the deterioration of their academic performance [16,18]. The practice of teacher-centred teaching approach that is still pioneered by teachers was also an obstacle to the development of the students' HOTs [1].

Past studies revealed that teachers' knowledge and attitudes about STEM education have a significant relationship with teachers' willingness to implement STEM education [19]. Changes implemented in the education system sometimes affect the teachers' acceptance to implement them. If teachers cannot fully understand the reforms introduced by the ministry, then the effect is, STEM teaching implemented by the teachers will be different from what has been set [20]. In addition, sometimes, teachers find it difficult to accept the changes because they mull over the changes to be outside of their normalcy. Teachers will also feel burdened to carry out STEM teaching and learning due to other factors such as time constraint to make preparation before class [21–23] and focusing on completing students' hands on practical projects [6,17,24].

Exposure to STEM Education in Home Science was carried out during the upgrading of KSSM subjects based on the latest measure in the Standard Secondary School Curriculum (KSSM). Although there are many studies on the integration of STEM in subjects, studies on STEM in Home Science subjects are fewer. Most studies are focused on pure Science and Mathematics subjects. There is a gap involving the study of STEM in Home Science. Hence, the exploration of the integration of STEM teaching in the subject of Home Science needs to be done. It is important to understand the extent of its implementation in teaching and learning and what are the challenges faced by teachers in schools. This article focuses on exploring teachers' understanding of STEM, as well as the challenges faced by Home Science teachers.

2. Concept of STEM Education

STEM education is emphasised in the transformation of national education through the Malaysian Education Development Plan (PPPM) 2013-2025 [1]. Chronologically, STEM Education in Malaysia was designed in three phases (KPM 2015), which are wave 1 to 3 phases. In 2013-2015, which is Phase 1, STEM Education was first introduced by strengthening the curriculum, providing training to teachers, and using a multimode learning model. Then, in Phase 2, which was around 2016-2020, campaigns and collaborations with relevant agencies were actively implemented to foster community interest and awareness of STEM. Last year, starting from 2021-2025, was a phase where the STEM shift was enhanced to an excellent level through increased operational flexibility. The three STEM implementation methods recommended by the MoE are STEM as a field of study, the second STEM as a subject package, and the third STEM as a teaching and learning approach [25].

There are three elements to be achieved based on the STEM teaching and learning model, namely STEM knowledge, STEM skills, and STEM values. STEM knowledge refers to ideas, concepts,

principles, theories, and understanding in the field of STEM for all STEM subjects (KPM, 2016c). STEM skills focus on process skills and technical skills. Process skills refer to process skills in science, mathematics, design, and computational thinking, while technical skills involve psychomotor and manipulative skills [2]. STEM values and ethics are fostered to produce students with high character and personality. Figure 1 displays the STEM model as a teaching and learning approach.

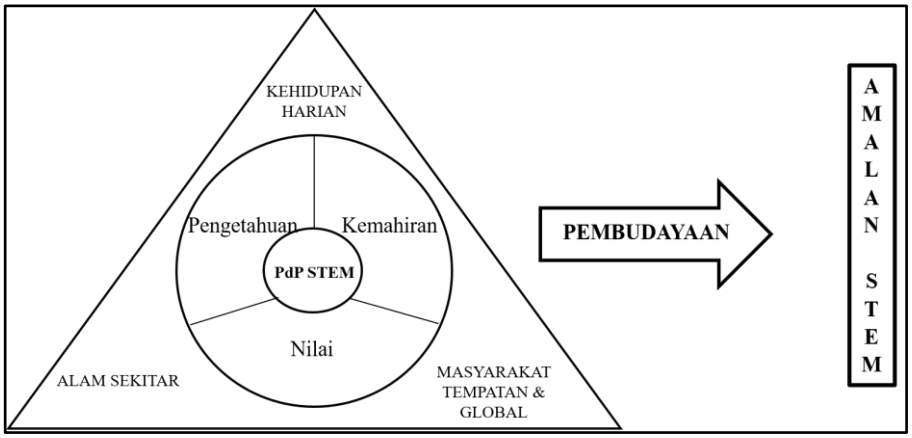

Fig. 1. STEM Model as a teaching and learning approach (source: (Panduan Pelaksanaan Sains, Teknologi, Kejuruteraan Dan Matematik (STEM) Dalam Pengajaran Dan Pembelajaran, 2016))

STEM in Malaysia has a far-reaching goal which is to prepare students to face challenges and be able to compete at the global level. Undoubtedly, schools are educational institutions that are a challenge to fuel the culture of STEM Education. Teachers, as implementers of STEM education, need to make changes by changing teaching methods that focus more on student-centred approach than teacher-centred approach. This aims to improve high-level thinking skills among students, as well as the 21st century skills [18]. According to past researchers, teachers used various approaches in teaching STEM at schools. These included the three approaches recommended by the [2], which are inquiry-based, problem-based, and project-based approaches (Ramli *et al.,*).

Teachers face various challenges, especially Home Science teachers in integrating STEM education. This is because STEM elements are not explicitly stated, but implicit in the subject content. This creates constraints in terms of implementation among Home Science teachers because they are not clear on how the elements of technology and engineering are embedded in the subject content. The same thing happened in other subjects such as Physics, Science, and Mathematics [14,26]. Therefore, knowledge about STEM, as well as exposure to various 'hands-on' activities needs to be given to teachers so that they can apply it in the classroom. Efforts to train these teachers must be carried out continuously so that STEM education will be a relevant approach in teaching and learning, not only at this time, but also in the long run. In addition, the training and professional courses implemented need to ensure equal participation and involvement among teachers with different teaching experiences and school locations, as well as consider teachers who teach other than Science and Mathematics subjects. We are now at the beginning of the 3rd Wave, so awareness of STEM needs to be strengthened holistically and its implementation expanded at all levels of education**.**

3. Methodology

This qualitative study used a case study design. The case study design was chosen because this study involved observations on Home Science teachers. This study included three Home Science

Teachers in Larut Matang and Selama District, Perak. The research informants were selected using purposive sampling technique. The sampling focused on certain characteristics and fitted the focus of the research. The selected informants were involved in the teaching of Home Science and had followed the KSSM Home Science curriculum.

Research data were collected using semi-structured interviews to answer the research questions. Constructed interview questions were reviewed by a supervisory committee and underwent a validation process by experts in the field. The use of semi-structured interviews enabled the researcher to make immediate changes to the questions, the arrangement of the questions, or the way the questions were asked to the informants based on the reactions and responses of the respondents. In fact, this in-depth interview also allowed the researcher to ask additional questions based on the informants' answers to the previous questions to get further information.

Interviews were conducted using the Google Meet application and WhatsApp video calls. The interview sessions were recorded and then transcribed into texts to allow the researcher to analyse the answers from the informants. The tone of voice and conversation of the informants were also analysed to identify the findings of the interviews. This method was chosen because the present researchers had constraints to move from place-to-place due to the COVID-19 pandemic that has hit the country.

4. Finding and Discussions

4.1 Home Science Teachers' Understanding of STEM Concepts

The findings of the study discovered that Home Science teachers in Larut Matang and Selama still lack a holistic understanding of the STEM concepts. The concept of STEM integration as understood by the Home Science teachers is embedding the elements of Science, Technology, Engineering, and Mathematics in the content. In other words, when teaching and learning take place, the teacher needs to relate and highlight the elements of Science, Technology, Engineering, and Mathematics to the learning topic.

The informants were clear about how the elements of Science and Mathematics relate to the field of Home Science. However, they could not see the connection between the elements of Engineering and Technology in Home Science. The findings also showed that information can integrate STEM into some selected topics. For example, elements of Mathematics in food and nutrition topics, such as calculating the measurement of ingredients, calculating the Recommended Dietary Allowance (RDA), and calculating food portions. The informants could also identify the creation of scientific elements in the topic of fabric and textile, for example in terms of the use of chemical ingredients in fabric manufacturing and dyes in the fabric construction process. However, the informant did not mention the Engineering and Technology elements in Home Science. In-depth interviews illustrated that the informants were not confident to integrate Engineering and Technology elements in Home Science because they themselves were not clear about those elements.

The findings of the interview also indicated that all informants agreed that STEM integration should be carried out in Home Science, especially involving elements of Mathematics and Science. This is because these two elements were spelled out in the DSKP and need to be implemented, in line with current knowledge needs, as well as equipped with 21st-century teaching and learning practices. Effective teaching is related to the teacher's ability to process and translate selected knowledge to facilitate student understanding [17,27].

The concept of STEM integration was found to be poorly understood by Home Science teachers because the finding indicated that the teachers only associated Science and Mathematics to teaching and learning.

4.2 Home Science Teacher Challenges in Integrating STEM

The three main challenges faced by teachers are time constraints, financial allocation, and limited creativity to implement STEM education. The nature of Home Science subjects involves psychomotor skills that require students to complete sewing and cooking practical tasks. In relation to that, teachers are unable to plan and implement STEM education due to the limited allocation of time for various school activities. All three informants agreed that time constraint is the main challenge for them. This finding is in line with the findings of [21,23,28] who found that teachers face time constraints to prepare for STEM education because they need to focus on completing students' practical projects [12]. Therefore, dynamic planning needs to be done if teachers want to implement STEM. This is because they are also burdened with other essential tasks [6,29].

The second challenge is in terms of the lack of financial allocation from the school to implement STEM projects. Based on the Assessment Curriculum Standard Document, teachers need to implement one STEM project each year. This project must embrace elements of Science, Mathematics, Engineering, and Technology. Teachers need to plan teaching and learning activities that use inquiry strategies, problem-solving, or projects in the context of the real world [3] This second challenge is closely related to the third challenge which is limited creativity. This is due to the lack of clarity about the implementation of STEM projects and the lack of sufficient knowledge about STEM concepts. These two factors caused teachers to feel awkward at implementing STEM projects. This finding supported findings from previous studies that also discovered teacher knowledge, skills, and attitudes are not yet fully prepared to implement STEM in teaching [23,30–32]

Based on the interviews, teachers stated that they need money to buy materials and equipment to carry out STEM projects. Related to this, teachers' creativity in designing STEM projects plays a significant role that can reduce costs. Teachers can create projects that do not require any cost and only use recycled materials available at home. This finding also gave the impression that Home Science teachers are less involved in STEM-related activities at the district and state levels. Therefore, the idea of integrating STEM into Home Science is difficult to implement. Lack of understanding of best practices for integrating STEM in Home Science also causes teachers to lack creativity in planning STEM projects.

It can be concluded that these three challenges are seen to be closely related to the support received by teachers. This study also found that informants did not obtain support from any party. This was stated by one of the informants as follows: "Information about STEM-teaching was conveyed during the new KSSM curriculum implementation. After that, there is no support to do STEM-related projects". The implementation of STEM in Home Science becomes more complex as some of the teachers were non-option teachers. This finding is in line with the study of Ismail *et al.,* who reported that teachers did not receive support from school administrators. There were even school administrators who did not understand the concept of integrating STEM in schools. Surprisingly, the informants also stated that the integration of STEM in Home Science does not have any influence either on the students' Home Science achievement or the enhancement of Science and Mathematics skills. This is an excuse for teachers not to carry out STEM projects in class. In fact, the study also found that Home Science teachers did not realise the existence of the BSTEM Home Science module published in 2017 by the Curriculum Development Division. This module was prepared as a guideline for the teachers to implement STEM projects for the Home Science subject.

Hence, to build a competitive scientific community, every teacher needs to play a significant role in achieving the goals of education. Teachers do not only teach, but must ensure the success of transformation in education

5. Conclusions

The findings of this study showed that STEM integration among Home Science teachers in Larut Matang and Selama, Perak is not well implemented. The findings of the study showed that teachers do not know the current developments related to STEM education and are not knowledgeable about the best practices of STEM integration. This scenario illustrates that Home Science teachers are still in the first wave of PPM, whereas now Malaysian education has stepped into the third wave. These findings have important implications where ongoing training and exposure to STEM should be given to the teachers. This finding revealed that there is leakage of information from the top management to the implementation level. Therefore, this scenario needs to be addressed immediately.

Efforts to identify Home Science teachers who successfully implement best practices in integrating STEM need to be highlighted and publicised at the level of the District Education Office and the State Education Department. This can indirectly give extension of ideas to other Home Science teachers in integrating STEM into their teaching and learning practices more effectively. The involvement of Home Science teachers in STEM-related activities organised by the District Education Office and the State Education Department, or with STEM organisations need to be enhanced to ensure that they get sufficient exposure to STEM teaching in the classroom.

Hence, this study has implications for teachers and education officials such as the District Education Office to not focus STEM training on Science and Mathematics teachers only. Nonetheless, comprehensive training should also be provided to Home Science teachers through ongoing Professional Learning Communities (PLCs) to improve their level of competence in STEM teaching. The implications of this study include providing an overview of STEM integration for Home Science teachers in terms of understanding STEM concepts, STEM applications, and the challenges faced. Home Science teachers need to improve their professionalism, including deepening STEM knowledge so that STEM teaching can be well integrated and further achieve national aspirations.

Last but not least, STEM education introduced and embedded in Home Science subjects is very important to prepare the next generation in facing the challenges of globalisation. Undoubtedly, cooking and sewing skills are important, and at the heart of Home Science subjects. However, if teachers can encourage students to apply STEM knowledge, skills, and values, this will be an added value for their future development.

Acknowledgement

This research was not funded by any grant.

References

[1] Malaysia, Kementerian Pendidikan. "Pelan pembangunan pendidikan Malaysia 2013-2025." (2013).
[2] Malaysia, Kementerian Pendidikan. "Panduan pelaksanaan sains, teknologi, kejuruteraan dan matematik (STEM) dalam pengajaran dan pembelajaran." *Putrajaya: Kementerian Pendidikan Malaysia* (2016).
[3] Ekonomi, Unit Perancang. "Rancangan Malaysia Kedua Belas." *Putrajaya: Unit Perancang Ekonomi* (2021).
[4] Banks, Frank, and David Barlex. *Teaching STEM in the secondary school: Helping teachers meet the challenge*. Routledge, 2020. https://doi.org/10.4324/9780429317736
[5] Ramli, Nur Farhana, and Othman Talib. "Can education institution implement STEM? From Malaysian teachers' view." *International Journal of Academic Research in Business and Social Sciences* 7, no. 3 (2017): 721-732.

[6] Margot, Kelly C., and Todd Kettler. "Teachers' perception of STEM integration and education: a systematic literature review." *International Journal of STEM education* 6, no. 1 (2019): 1-16. https://doi.org/10.1186/s40594-018-0151-2

[7] BAKAR, Abu Yazid ABU, and Mohd Izwan MAHMUD. "Profiling of aspiration and interest towards STEM and TVET careers among lower secondary students: A Malaysian case study." *Journal for the Education of Gifted Young Scientists* 8, no. 1 (2020): 489-500. https://doi.org/10.17478/jegys.669034

[8] Han, Sunyoung, Bugrahan Yalvac, Mary M. Capraro, and Robert M. Capraro. "In-service teachers' implementation and understanding of STEM project based learning." *Eurasia Journal of Mathematics, Science and Technology Education* 11, no. 1 (2015): 63-76. https://doi.org/10.12973/eurasia.2015.1306a

[9] Rinke, Carol R., Wendy Gladstone-Brown, C. Ryan Kinlaw, and Jean Cappiello. "Characterizing STEM teacher education: Affordances and constraints of explicit STEM preparation for elementary teachers." *School Science and Mathematics* 116, no. 6 (2016): 300-309. https://doi.org/10.1111/ssm.12185

[10] Fitzallen, Noleine. "STEM Education: What Does Mathematics Have to Offer?." *Mathematics Education Research Group of Australasia* (2015).

[11] Mahmud, Muhammad Sofwan. "Pengintegrasian STEM dalam pengajaran matematik di sekolah rendah: Tinjauan literatur." *Jurnal Dunia Pendidikan* 3, no. 3 (2021): 179-188.

[12] Mahmud, Siti Nur Diyana, Nurfaradilla Mohamad Nasri, Mohd Ali Samsudin, and Lilia Halim. "Science teacher education in Malaysia: challenges and way forward." *Asia-pacific science education* 4, no. 1 (2018): 1-12. https://doi.org/10.1186/s41029-018-0026-3

[13] Mustafa, Norazla, Zaleha Ismail, Zaidatun Tasir, Mohd Nihra Haruzuan Mohamad Said, and Nihra Haruzuan Mohamad Mohd Said. "Teacher Readiness Towards Integrating Stem Education into Teaching and Learning." *European Proceedings of Social and Behavioural Sciences* 40 (2017). https://doi.org/10.15405/epsbs.2018.05.27

[14] Siew, Nyet Moi, Nazir Amir, and Chin Lu Chong. "The perceptions of pre-service and in-service teachers regarding a project-based STEM approach to teaching science." *SpringerPlus* 4, no. 1 (2015): 1-20. https://doi.org/10.1186/2193-1801-4-8

[15] Chang, YunJeong, and Seung Won Park. "Exploring Students' Perspectives of College STEM: An Analysis of Course Rating Websites." *International Journal of Teaching and Learning in Higher Education* 26, no. 1 (2014): 90-101.

[16] Nasir, Nurul Akmal Md, Muhamad Furkan Mat Salleh, Nor Syazwani Mohd, Mohamad Hisyam Ismail Rasid, and Parmjit Singh. "Enhancing STEM Pre-Service Teachers' Knowledge." (2019). https://doi.org/10.6007/IJARBSS/v9-i13/6998

[17] Ramli, N. F., O. Talib, U. K. Abdul Manaf, and S. A. Hassan. "Instructional approaches and challenges of STEM instructional implementation: A systematic review." In *Graduate Research in Education Seminar (GREduc 17) Universiti Putra Malaysia, Selangor, Malaysia*. 2017.

[18] Goliong, Losius, Mohd Khairuddin Abdullah, and Rosy Talin. "Kompetensi pegadogi guru dan prestasi akademik di sekolah-sekolah berprestasi rendah." *Jurnal Kurikulum, Bahagian Pembangunan Kurikulum, Kementerian Pendidikan Malaysia, Jilid* 3, no. 2018 (2018): 80-91.

[19] Hata, Nur Fatahiyah Mohamed, and Siti Nur Diyana Mahmud. "Kesediaan guru Sains dan Matematik dalam melaksanakan pendidikan STEM dari aspek pengetahuan, sikap dan pengalaman mengajar (Teachers' readiness in implementing STEM education from knowledge, attitude and teaching experience aspects)." *Akademika* 90, no. S3 (2020).

[20] Han, Sunyoung, Robert Capraro, and Mary Margaret Capraro. "How science, technology, engineering, and mathematics (STEM) project-based learning (PBL) affects high, middle, and low achievers differently: The impact of student factors on achievement." *International Journal of Science and Mathematics Education* 13 (2015): 1089-1113. https://doi.org/10.1007/s10763-014-9526-0

[21] Shernoff, David J., Suparna Sinha, Denise M. Bressler, and Lynda Ginsburg. "Assessing teacher education and professional development needs for the implementation of integrated approaches to STEM education." *International Journal of STEM Education* 4 (2017): 1-16. https://doi.org/10.1186/s40594-017-0068-1

[22] Rahayu, Titik, Syafrimen Syafril, Kamisah Binti Othman, Lilia Halim, and Nova Erlina Yaumas. "Kualiti Guru, Isu Dan Cabaran Dalam Pembelajaran Stem." (2018). https://doi.org/10.31219/osf.io/jqcu6

[23] Jekri, Aminah, and Crispina Gregory K. Han. "Pembinaan dan Pengesahan Instrumen Pengetahuan, Afektif dan Motivasi Guru Sains terhadap Pengajaran dan Pembelajaran STEM (PAMPDPSTEM)." *International Journal of Education* 4, no. 32 (2019): 79-89. https://doi.org/10.35631/IJEPC.432009

[24] Ismail, Mohamad Hisyam, Muhamad Furkan Mat Salleh, and Nurul Akmal Md Nasir. "The issues and challenges in empowering STEM on science teachers in Malaysian secondary schools." *International Journal of Academic Research in Business and Social Sciences* 9, no. 13 (2019): 430-444. https://doi.org/10.6007/IJARBSS/v9-i13/6869

[25] Kementerian Pendidikan Malaysia. "*Jerayawara inisiatif perkukuhan STEM 2017: Pelaksanaan pendidikan Sains Teknologi Kejuruteraan dan Matematik (STEM)* Malaysia*."* Kementerian Pendidikan Malaysia, 2017.
[26] Bunyamin, Muhammad Abd Hadi, and Fred Finley. "STEM education in Malaysia: Reviewing the current physics curriculum." In *International Conference of Association for Science Teacher Education*. 2016.
[27] Sadler, Philip M., Gerhard Sonnert, Harold P. Coyle, Nancy Cook-Smith, and Jaimie L. Miller. "The influence of teachers' knowledge on student learning in middle school physical science classrooms." *American Educational Research Journal* 50, no. 5 (2013): 1020-1049. https://doi.org/10.3102/0002831213477680
[28] Kubat, Ulas. "The integration of STEM into science classes." *World Journal on Educational Technology: Current Issues* 10, no. 3 (2018): 165-173. https://doi.org/10.18844/wjet.v10i3.3557
[29] Shahali, Edy Hafizan Mohd, Ihsan Ismail, and Lilia Halim. "STEM education in Malaysia: Policy, trajectories and initiatives." *Asian Research Policy* 8, no. 2 (2017): 122-133.
[30] Mohd Senari, Nur Farah Diana and Osman, Kamisah "Revolutionalising Research Practices in Education and Human Resource Development i," in *Graduate Research in Education Seminar (GREduc) 2018,* Graduate Research in Education Seminar (GREduc), 2018, pp. 10–18.
[31] Terry, Emily Angelina Charles, Nurfaradilla Mohamad Nasri, and Ahmad Zamri Mansor. "Tahap pengetahuan dan kesediaan guru-guru Bahasa Iban sekolah rendah daerah Sri Aman terhadap penggunaan multimedia dalam pengajaran Bahasa Iban." *Jurnal Dunia Pendidikan* 3, no. 1 (2021): 342-354.
[32] Hata, Nur Fatahiyah Mohamed, and Siti Nur Diyana Mahmud. "Kesediaan guru Sains dan Matematik dalam melaksanakan pendidikan STEM dari aspek pengetahuan, sikap dan pengalaman mengajar (Teachers' readiness in implementing STEM education from knowledge, attitude and teaching experience aspects)." *Akademika* 90, no. S3 (2020).