

Importance of Assessing Chemistry Teacher Competency in Stem Integrated Education in Malaysia

Thilagavathy Sethuramah, Mohd Effendi Ewan Mohd Matore,
Zanathon Iksan

Faculty of Education, Universiti Kebangsaan Malaysia

Email: thilagasara1978@gmail.com, zanaton.iksan@ukm.edu.my

Corresponding Author Email: effendi@ukm.edu.my

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Abstract

Ever since its establishment, STEM has been a famous topic in education internationally because it brings positive impacts to society therefore competency of teachers is important for student development and ensures the quality of learning among students. In Malaysia, STEM education has been implemented to raise teachers' and students' interest, motivation, and attitude in STEM and career awareness corresponding to the STEM field. Therefore, this paper aims to identify the importance of assessing chemistry teacher competency in STEM integrated education in Malaysia. This paper has referred to a few studies that have been undertaken in Malaysia and other countries from the year 2015 to the present regarding the importance of assessment for the chemistry teacher to integrate STEM in the teaching and learning process. The main importance of assessing chemistry teacher competency in STEM integrated education in Malaysia is to determine the prevalence, acceptance, and growth of STEM among academics, including teachers, researchers, and educational policymakers. The discussion also involves teachers' competency, level of knowledge, and skills among chemistry teachers to integrate STEM during the teaching and learning process and also the attitude of the teacher toward integrating STEM. The discussion can improve chemistry teacher competency by giving awareness to teachers and administrators. Therefore, it is advised that a study be conducted to assess chemistry teacher competency in implementing and integrating STEM during teaching and learning to prepare pre-service and in-service teachers.

Keywords: Teacher's Competency, STEM Education, Chemistry, Integrated Education, Assessment, Malaysia

Introduction

The world is presently experiencing the 4th industrial revolution in the twenty-first century as a result of civilization's continued growth. As a result of the contemporary, every part of life including school is being adapted to a fast-paced and competitive framework (Gleason, 2018). One of the most important factors impacting student achievement is teacher

competency (Gustafsson, 2003). Individuals with chosen qualities can only be raised by teachers who have embraced these characteristics themselves. We must keep in mind that the quality of any educational system is directly proportionate to the quality of its educators (Barber & Mourshed, 2007; Schleicher, 2011; Schleicher, 2016). Teachers play a critical role in the educational system. Similarly, teachers are on the frontline of STEM implementation in all nations, particularly teachers of science disciplines. Teacher competency is defined as the depth of knowledge, skills, and attitudes that appear as knowledgeable and responsible actions when performing tasks as agents of learning.

Competency is a high-quality standard of effort being put out by a worker to attain any target or goal. Chouhan and Srivastava (2014), mentioned that school teachers must acquire teaching competencies in response to rapid changes, particularly in the use of technology. By focusing on planned training of these abilities, teacher competencies in teaching such as methodology, classroom management, and other performance contributing to achievement can be improved. Competency is defined as an individual's ability, skill, and strength to accomplish any given work. Weinert (2001) proposed that competence is multifaceted. Competence, according to Chouhan and Srivastava (2014), defines competence as a "personal quality or combination of habits that leads to successful or outstanding job performance." Researchers pushed for essential competencies required for good work performance, and these qualities would be tested through a range of tests (Barry, 2020). Foss et al (2021) noticed that competencies are the qualities that add "obvious economic value" to on-the-job personal efforts that IQ scores may not anticipate and hence do not compute professional achievement; he, therefore, advocated that alternative measures of capability be established. Teacher competency is linked to high-quality learning and needs to be assessed in teaching competence.

Assessing teachers' professional abilities as a critical factor of effective teaching is gaining popularity. Assessment is an essential component of education (OECD, 2005). Similarly, STEM education assessment is critical to a country's educational advancement. The primary goal of educational evaluation is to improve the quality of education itself, both on a small (classroom) and big scale (national curriculum). Assessment is used in STEM education to determine the dissemination, acceptance, and growth of STEM among academics, including teachers, researchers, and education policymakers (Meng et al., 2013). Assessment will reveal limitations, difficulties, and even challenges associated with STEM adoption. These fundamental concerns indicate a serious challenge, particularly for academics and governments attempting to improve STEM education and thus increase student enrollment in STEM subjects at both the secondary and tertiary levels (Leong et al., 2016).

At the high school level, chemistry teachers at the least levels possibly practiced traditional, lecture-type teaching (Stains et al., 2018), which isn't the teaching technique encouraged to enhance STEM education and increase student engagement in STEM (Felder & Brent, 2016). Furthermore, many chemistry teachers don't seem to be trained to show chemistry. They either had training in other areas of teaching, like biology teaching, as do over 1/2 of secondary-level chemistry teachers (Rushton et al., 2014), or they received training in chemistry but not in teaching it, as do the bulk of post-secondary teachers. Because that's the sole instructional information they need, teachers in these situations draw even more from their experiences as chemistry students. Chemistry teachers require assistance in comprehending and visualizing how chemistry may well be taught through effective student-centered strategies.

Chemistry is the study of the nature, content, structure, preparations, qualities, and applications of diverse types of matter, as well as how substances behave or react under various energy conditions and when in touch with one another. Chemistry is one of the science subjects that has a large impact on society. It prepares students for the actual world of work by providing them with career choices such as chemistry, medicine, pharmacy, and food environmental studies and science (Mahdi, 2014). These provide employment chances in a variety of industries economy, particularly in the petroleum industry, metallurgy, ceramics, glass, plastics, cement, medicines, food, and other materials and beverages, fertilizers, transportation, and educational services industries, and so on. Chemistry is a complex and difficult subject to learn, which makes teaching it even more difficult. In nature, chemistry is abstract and learners cannot see atoms, in addition to controlling them individually or in small groups of individuals to look at their behavior. Furthermore, as Johnstone (1991) points out, chemistry will be challenging because of the three levels of representation between which chemists shift: symbolic, macroscopic, and sub-microscopic. Besides, among various Science and arithmetic subjects, Chemistry is thought of as a major tool for national development, and sustainability of the economic wealth of recent societies. Effective chemistry teachers must be aware of tools and methods that allow students to right away engage with and comprehend the challenging nature of chemistry.

Finally, scientists often say, chemistry is that the center of science. General chemistry, whether 'essential' or not, could be a gateway course to several other STEM disciplines, majors, and degrees (Cooper, 2010). If we desire a more diverse group of STEM students, we must assess chemistry educators to try and do their best.

Importance of Integrated STEM Education

According to Ramli and Talib (2017), STEM (Science, Technology, Engineering, and Mathematics) awareness was started in 1957 with the establishment of Sputnik by the Soviet Union. Since then, the need for science, technology, engineering, and mathematics to be combined has been recognized by the world, and numerous countries around the world have begun exploring STEM to be competent among developed countries. In particular, the major component of the success of labor related to STEM is the education sector. However, STEM education does not have a unique concept, which it has various definitions among several scholars, such as an interdisciplinary approach where academic knowledge is connected to practical lessons in a particular context, a teaching method that merges the teaching of math and science subjects, a meta-discipline without content boundaries between subjects, or an acronym for Science, Technology, Engineering and Mathematics (Trang et al., 2021).

STEM education is known as a tool in breaking the boundaries among Science, Technology, Engineering, and Mathematics so that students can utilize it in solving everyday problems, where it also helps students in increasing their interest to select careers related to STEM as their first choice in the future. This statement can be supported by *Figure 1*, which shows that the STEM approach covers the application of skills, knowledge, and values of STEM, to solve problems in the environment, daily life, and society (Ramli & Talib, 2017). With the integration of STEM in education, the STEM content is taught with more disciplines under a genuine context, attaining the objective of linking these subjects to improve students' learning (Kelley & Knowles, 2016). Besides, it is proposed by Bryan et al (2015) that STEM integration includes the learning and teaching of the content practices of disciplinary knowledge that involve mathematics and science via the combination of the engineering design of relevant technologies and the practices of engineering.

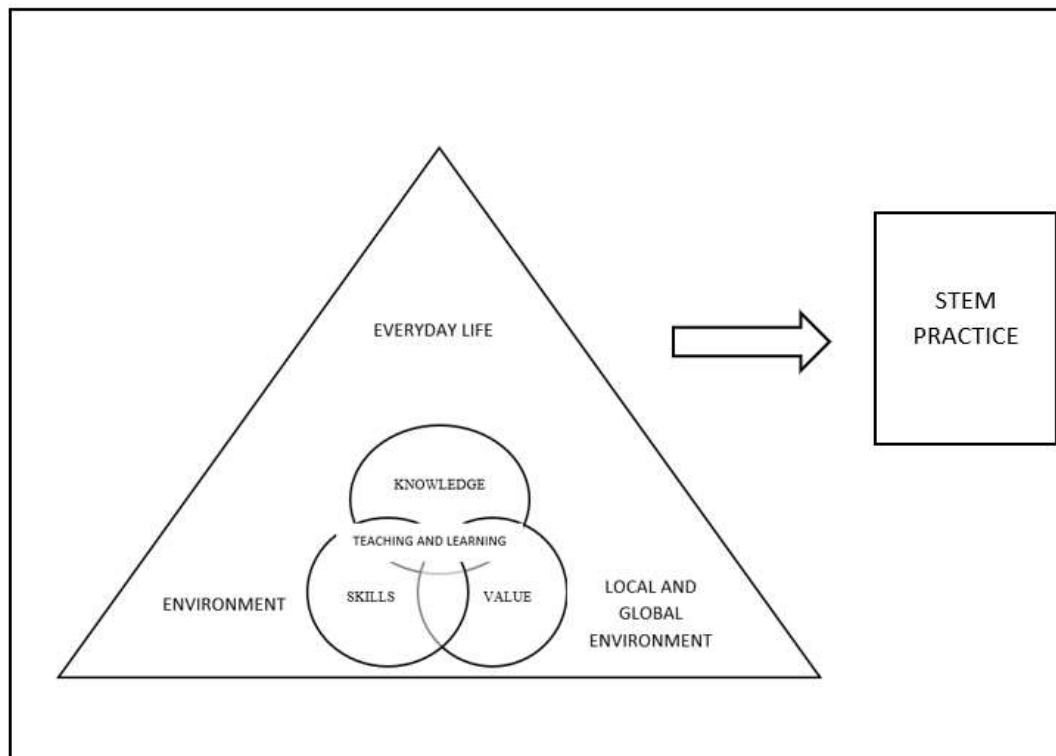


Figure 1: STEM as a teaching and learning approach
Source: (Ramli & Talib, 2017)

Furthermore, there is a need for qualified STEM professionals in society to maintain competitive economically in the international market, as well as to achieve contemporary demands like verifying sustainable and sufficient energy, deliberate technology development, and efficient healthcare. Additionally, in the highly technological and information-based society today, everyone should own the competencies and skills in dealing with the related challenges, thus STEM should be an educational priority for every student. The use of integrated STEM education likewise offers less fragmented, more relevant, and more stimulating experiences for learners, which can also enhance students' non-cognitive learning outcomes, including interest in STEM and motivation regarding STEM learning (Thibaut et al., 2018).

Implementation of Integrated STEM Education in Malaysia

In recent years, there is a rise in STEM education being an integrated academic discipline because its necessity is recognized for the sake of meeting future economic and social challenges. Therefore, a global STEM-focused educational movement has been spawned (Kelly and Knowles, 2016). Following the development in global science education, which is STEM education, the landscape of science education in Malaysia has likewise been influenced. This can be proved by the fact that STEM education has been introduced to the country through the Malaysia Education Blueprint 2016-2020, along to raise teachers' and students' interest, motivation, and attitude in STEM, as well as career awareness corresponding to the STEM field. To accommodate the philosophy of STEM education, the Ministry of Education (MOE) has even revised the national science curriculum (Mahmud et al., 2018). Nevertheless, the idea and concept of STEM education are still new in Malaysia even though it has been contemplated in the USA for a long time (Bahrum et al., 2017).

STEM education has been valued by Malaysia due to the goal of transforming into a developed country, attaining the targeted amount of STEM workforce, and meeting the demands and challenges of a STEM-driven economy. For example, based on the New Economic Model (NEM) introduced by the Malaysian government, the goal of creating 1.3 million jobs in STEM disciplines in different sectors by 2020 was shown, which was to allow infrastructure and support the development of industrial clusters. In particular, to achieve the demand for human capital trained in STEM with human capital, infrastructure, and resources related to STEM, the educational system's value chain needs to be in sync as it is an important pillar in this endeavor (Shahali et al., 2017). Moreover, the goal of STEM education in Malaysia is to generate future skilled workers in this high-demanding field. As reported by the Academy of Sciences Malaysia in 2015, Malaysia has been experiencing an acute need in offering a minimum of one million workers jobs in the fields corresponding to Science and Technology, where half of them is required to graduate with at least a diploma or degree in corresponding science fields (Ramli & Talib, 2017).

Apart from that, to attain the goal established by the state, the Malaysian government has integrated STEM development into various policies and has evolved particular STEM policies. One of the popular examples would be the 60:40 Science/Technical: Arts (60:40) Policy which was instituted by the Malaysia Higher Education Planning Committee in education, and the policy was implemented since the year of 1970. The policy defines the target of the Ministry of fulfilling the future demand of a developing nation, where the ratio of students with remarkable STEM education to those with more focus on the Arts that the ratio of science to arts needs to be 60:40 (Shahali et al., 2017).

Importance of Chemistry Education

Nowadays, science education has been a source of human source development in many countries since it leads to the enhancement of significant aspects of development like food, health, agriculture, and technology industries. In particular, being part of science education, Chemistry education plays a major tool for national development, as well as sustaining the economic wealth of modern societies. Hence, to maintain the prosperity of the country in the future, it is important to justify science skills among the young generations. Additionally, Chemistry education is important due because knowledge plays a central role in connecting Biology and medicine, earth science and environmental science, as well as Physics and Mathematics (Ikiao, 2019).

Moreover, Chemistry education is essential to improve the quality of teaching, development, and research, and also to ensure students are equipped with good knowledge to produce intensive products and services to meet humans' needs and wants in the food or health industries. Nevertheless, researchers found that the learning of Chemistry is disliked by a lot of students, especially in secondary education. This claim is supported by the reasons that learners tend to not perceive Chemistry to be relevant to themselves, as well as to the society they live in. Therefore, it is recommended by an existing educational policy that Chemistry teachers should make Chemistry education to be more relevant to students so that students will be more motivated and interested in Chemistry studies (Khanam, 2018).

Importance of Teaching Competencies Among Teachers

Indeed, the topic of teachers' competency has been a hot topic in the discussions of various researchers, to enhance the quality of education. This is because the competency of teachers is significant for the development of students and it ensures the quality of learning among students. The competency of teachers will help teachers to enhance their teaching techniques, as well as provide positive effects on the academic development and skills of students. Based on a qualitative study conducted by the Higher Education Leadership Academy (AKEPT) about teaching in Malaysia in 2011, more than 125 observations of teachers' competency in 41 schools all over Malaysia, there was only 12% of instruction in transmitting the teaching attained high standard that the teachers applied their pedagogical practices, while 38% of them attained satisfactory standard, and the rest of the 50% attained unfavorably. Furthermore, the research found that the practices of good teacher competency are directly related to parental involvement, and this relationship provides beneficial development to the students both academically and non-academically (Omar et al., 2018).

In the case of STEM education, in both teaching and learning, the borders between disciplines must be eliminated for the solution of proposed issues. Besides having the basic knowledge of the discipline, it is likewise necessary for teachers to be competent in implementation, measurement evaluation, and planning (Altan & Ercan, 2016). Niemi (2015) suggested that professional development, training, and briefing courses should be offered for in-service teachers so that their level of competency can maintain up-to-date with the trend at all times since teachers might encounter challenges in the implementation of STEM in schools without them (Siew et al., 2015). Moreover, being part of teachers' competency, communication is a significant component for teachers, where close communication among teachers, students, and parents will bring positive impacts to students that can encourage students to become more successful in their achievement (Omar et al., 2018).

Apart from that, competency is known to have a pivotal role, which involves skills, knowledge, and attitudes. Three of these characteristics and personalities are needed to be possessed by an individual to showcase his or her competence in attaining any appointed tasks or jobs. Indeed, the major objective of competency is to allow individuals to perform their jobs or tasks effectively at their optimum level. On top of that, skills that affect one's work performance are generally considered intelligence-based abilities which represent an individual's competency trait. Therefore, teachers are expected to realize that the competency traits will allow them to be certified as a teacher, as soon as they master the skills, knowledge, and attitudes of the subject matter and assigned teaching tasks. Additionally, competence is the attitude and knowledge which can carry out an activity, as well as build a set of solid skills based on one's achievements. The performances of teachers at work will then be increased once they have a high level of competence in conducting the responsibilities and duties of the classroom (Omar et al., 2020).

Importance of Assessments for Chemistry Teacher Competency in STEM

By research conducted by the Academy of Sciences in 2015, the number of students who pursued an education in the science stream dropped from 44% in 2011 to 21% in 2014, which these statistics shows the failure of achieving the target of the Higher Education Planning Committee regarding the 60:40 Science: Art Policy. Indeed, one of the significant factors of the lack of students' interest in STEM-related subjects is the attitudes and content

knowledge of teachers, where more qualified and passionate teachers can raise students' interest in STEM-related subjects instead (Ramli & Talib, 2017). For instance, various factors influence students' achievements, including teachers' beliefs and understanding of STEM integrated teaching, and interaction between teachers and students (Trang et al., 2021). Hence, it can be concluded that teachers' competency plays a significant role in the formation of interest in STEM among students.

In addition, based on several studies, it was found that most science teachers struggle to make connections across the STEM disciplines and they lack exhaustive understanding of STEM, leading to the feeling of incompetency among science teachers (Mahmud et al., 2018). Besides, since a pedagogical shift to student-centered learning is required in STEM education, thus most of the instructions are experimental and inquiry-based teachers need to offer project-based lessons, which can stimulate innovation and critical thinking among students, as well as build their understanding of concepts and contents (Margot & Kettler, 2019). This phenomenon proves the need for assessments of teachers' competency, to maintain the standard of STEM education. It is because the key purpose of assessments is to evaluate an individual's success over a particular period, as well as to determine areas of success and vulnerability. Assessments are likewise utilized to create benchmarks to be met to achieve any strategic objectives of the party. For instance, assessment among teachers is to establish and meet the benchmark of providing the best learning experiences for students. Moreover, assessments can act as fundamental for the self-esteem of teachers, and the development or training of teachers (Salam, 2021).

There is a conflict between the increasing need for STEM education, which necessitates a pedagogical shift to student-centered learning in STEM integration, a dearth of STEM subject matter knowledge among teachers, and teacher desire to perform STEM education. Understanding the importance of assessing competency of teacher can help facilitate the implementation and success of STEM programs. Teachers' competence will contribute to favorable impact on students' academic progress and skills at the same time assisting teachers in improving their teaching ways. Any efforts to increase the quality of education will be ineffective unless they are supported by competent and professional instructors. In other words, improving educational quality should begin with teachers and end with teachers. Teachers must possess a diverse set of competencies to meet today's challenging difficulties especially in STEM integration. Teaching competency is an intrinsic component of a good training process that seeks to contribute to the well-being of a specific country or the globe as a whole and making STEM education accessible to everyone.

In Malaysia, the Ministry of Education of Malaysia (MOE) has started to pay attention to and make an effort into STEM education by empowering the significance of relationships between the competence and performance of teachers, to strengthen the quality of education. For instance, since 2014, a new teacher evaluation instrument has been utilized to evaluate teachers, in which teachers are being measured based on different dimensions, including assessment of learning and teaching, teacher's professional contribution to the community, and professional activities outside the classroom (Omar et al., 2018). Teaching chemistry and the backgrounds of many chemistry teachers need the development of ways to assist chemistry educators in improving their chemistry teaching in order to promote chemistry and STEM education.

Importance of Assessing Teacher's Knowledge and Skill

STEM classrooms need teachers with knowledge and pedagogies related to various STEM subjects, as well as the ability to develop new identities within their nation and school contexts. Assessing chemistry teacher competency can lead to effective teaching that can boost student motivation, engagement, and topic comprehension, learning, and achievement. It also tends to improve student equality (Valiandes, 2015), for example, by reducing the achievement difference between them (Valiandes, 2015).

On the other hand, being part of teachers' competency, the skills of teachers are essential in the implementation of STEM in schools, in which subjects such as Chemistry, Additional Mathematics, Computer Science, Physics, and Biology, just to mention a few, are usually being taught as STEM elective subjects in secondary school standard curriculum. Among these subjects, Chemistry is especially a difficult subject that students tend to have learning difficulties and misconceptions to understand scientific models. Studies also found that a lot of students at every level of education own misconceptions about basic chemical concepts even after years of instruction (Tümay, 2016). Besides, Chemistry is one of the subjects that is crucial to be educated because it can enhance the quality of teaching, development, research, and even ensure students to be earned with good knowledge so that they can meet humans' needs and wants regarding food and health industries through producing intensive products and services with knowledge of Chemistry (Khanam, 2018). This shows that Chemistry education indirectly affects the future of the country, proving the need for teachers' competency in the teaching of Chemistry.

Importance of Assessing Chemistry Teacher's Attitude

Teachers' views about teaching integrated STEM may be of particular importance in this regard. Previous research (Thibaut, Knipprath, Dehaene, & Depaepe, 2018b) has demonstrated that teachers' views toward STEM are related to their classroom practices when teaching it and that instructors with unfavorable attitudes toward STEM avoid teaching it (Appleton, 2003). As a result, a robust assessment of these attitudes and the factors that influence them could assist to develop the discipline and provide better guidance for integrated STEM education implementation.

Teachers' beliefs frequently restrict the proper implementation of their practices. Secondly, both desirable and undesirable beliefs have a high degree of stability. As a result, it is critical to assess teachers' views in order to support their positive beliefs and, as a result, successful teaching practices. Teachers also can utilize the information obtained from their assessment to customize instruction for the entire class as well as for individuals based on their knowledge and thinking patterns. At the same time can improve their teaching method and style to integrate STEM into the Teaching and learning process. Teachers will have a comprehensive understanding of the learning objectives in subject domains, as well as the normal learning pathways for achieving those objectives.

Techniques for enhancing instructors' interest in the workplace and during assessment strategies would improve the productive learning environment as well as the teachers' competence and skills. Assessment-based competency was used to assess someone's skill too. The assessment of teachers' attainment, development, and productivity reveals a positive feature relating to the educators' competency, working attitude, training, and all other supporting materials that aid in their competency building. Teachers' assessment, which also refers to the process of evaluating individual teachers' performance and/or

providing feedback to assist them to improve their practice, aims to strengthen their accountability. This acknowledgment suggests that teachers' administrators are encouraging them. Baier et al (2019) discovered that learners' academic performance and general progress and development are directly related to teachers' professional competency and correlated with teachers' efficacy views. Briefly, all of the situations above enhance the importance of assessments for teachers' competency, especially Chemistry teachers in STEM education (Ramli & Talib, 2017)

Implication

The implication is that there is a critical need to improve awareness among administrators and teachers. STEM education has been accepted by many in the field of technology education, yet there is a lack of knowledge of STEM education in schools. Giving importance to assessing chemistry teachers can lead to the action to increase STEM teacher preparation quality. Need for human capital in the high-tech industry, a country's higher education system should be customized to the needs of Industry 4.0. To sustain high economic growth and promote investment in a country therefore education system transformation is unavoidable. The education market frameworks will determine the conduct of market participants, which will have an impact on achievement and productivity. It is critical that we focus on teachers since they are important to the achievement of new reforms. The implication is that there is a significant need for government and teacher awareness raising in order to promote STEM education.

Limitation

There will be some limitations to this study. Firstly, focusing on the literature review for chemistry teachers in high school or secondary school only did not represent the entire chemistry teachers teaching in matriculation and colleges. The limitation also includes assessing the competency of chemistry teachers in integrating STEM in teaching and learning only and not the overall competency of the teacher. Another limitation is the importance is only discussed for the subject of chemistry only.

Recommendation for Future Research

There is several importance to assessing teachers, especially chemistry teachers in the integration of STEM as highlighted concerns based on the importance mentioned above. There are several steps that should be taken by education institutions or teachers to have the necessary competency to integrate STEM in the classroom during teaching and learning. The first step is to ensure or assess chemistry teachers' attitudes towards the implementation of integrated STEM. Gaining a wider awareness of these attitudes and the factors that influence them could assist to progress the subject and provide better recommendations for implementing integrated STEM education. Second, ensuring that chemistry teachers have the necessary knowledge and skills by doing comprehensive studies on their competency. Finally, concentrating on the development of assessment tools/instruments for assessing competency among chemistry teachers in integrating or implementing STEM during the teaching and learning process. A study should be done to compare the competencies of urban and rural teachers in integrating STEM education. The findings provide information that may be valuable to key stakeholders in the implementation of STEM integration education. Further review research may consider assessing the competency of the chemistry teacher in teaching and learning especially in practical work to enhance students' academic performance and

their ways of engagement. Further research review also can be considered for other STEM subjects like biology, physics, and mathematics. Studies are also needed at the policy level to reevaluate educational goals and policies in Asian countries while comparing them to policies in more progressive countries (e.g., the United States), in order to successfully promote a more consistent and integrated STEM curriculum.

Conclusion

In this case, to execute STEM lessons in the classroom, it is not enough for teachers to have basic knowledge in Science and Mathematics only, as problems in implementing STEM in lessons will occur if most teachers did not receive proper STEM training and assessment of the teacher's competency to find the actual problem among teachers. This research has made a various recommendation for resolving the problems and is significant for the development of students in that it ensures the quality of learning among students. It will aid in the planning to improve chemistry teacher competency. As a result, it will assist teachers in implementing and integrating STEM in the classroom. Teachers may become more aware of their competency level and difficulties if they engage in activities organized by the ministry and other relevant authorities or organizations that assist them in solving problems.

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