International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

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Integrating science, technology, engineering and mathematics (stem) into TVET programs toward early childhood education in Unitar international university, Malaysia

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International Journal of Science and Research Archive, 2024, 12(02), 2167–2181

Publication history: Received on 06 July 2024; revised on 14 August 2024; accepted on 17 August 2024

Article DOI: https://doi.org/10.30574/ijsra.2024.12.2.1514

Abstract

This study aims to explain the effectiveness of combining STEM (Science, Technology, Engineering, and Mathematics) on the effects of integrating Science, Technology, Engineering and Mathematics (STEM) programs towards early childhood education by combining STEM elements at a young age that will improve skills children and prepare them for future technical and vocational pathways and the effectiveness of such programs in fostering interest in learning and curiosity about STEM subjects. Qualitative methods were fully used by using purposive sampling of the participants with 2 teachers of children with more than 10 years of experience and the data transcribed was analyzed manually from audio recordings. The findings of the study prove that there is a significant improvement in cognitive skills, problem solving and creativity. Therefore, in line with the demands of 21st century skills, it is very important to revise the children's education curriculum by integrating STEM into the TVET program as an important step towards preparing children to succeed in the rapidly developing global landscape.

Keywords: Integrating STEM; Program TVET; Early Childhood Education; Children Cognitive

1. Introduction

Many countries today suggest the integration of Science, Technology, Engineering and Mathematics (STEM) education into education, especially from the Technical and Vocational Education and Training (TVET) sector and TVET programs are well known throughout modern countries. However, it is very rare that TVET programs are linked to early childhood education programs which are efforts and early approaches to transformative to foster the cognitive development of children at a young age (Amegah, A., 2022). The TVET program is only widely applied in tertiary education and higher education, this effort must have a good impact on all students, but it is more systematic and effective if the TVET program is introduced at an early stage and to children who are indeed a solid foundation in making children who are perfect for a country and for the future in addition to fostering an interest in learning and a deeper desire for STEM.

According to Rezaei et al., (2023), by integrating STEM into the TVET program, it is easier to educate, supervise and teach children in addition to evaluating the impact on development domains especially their cognitive aspects. The need for STEM in TVET programs in early childhood education, with this being able to measure any changes in more creative and effective thinking skills, problem solving skills, and develop the overall cognitive domain in general. By understanding the importance of cognitive development in childhood, educators and policy makers need to play a role in ensuring the effectiveness of STEM in early childhood education TVET programs (Chear, & Arifin, 2024).

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Depending on how the integrated STEM education approach in the TVET program towards early childhood education can influence positive perception, strong curiosity and students' passion for science, technology, engineering and mathematics with more enthusiasm (Zulkafli, Ishar,& Janius, 2024). In addition, by maintaining and fostering in the field of STEM since childhood, the need for a specific curriculum that can contribute to the success of STEM integration involving hands-on activities, interactive methods and providing children with teaching strategies that maximize the benefits of STEM integration into the program Early childhood TVET.

According to Hanafi, Ahmad, Mansor, & Mustafa, (2023), state in Malaysia in particular, it is very rare to see efforts to integrate STEM education into TVET programs in Early Childhood education. However, various efforts and support from the government and the community towards STEM initiatives, TVET and the Children's Education Program are combined, which aims to develop the cognitive skills of children in general, and in addition to identifying how effective pedagogical learning strategies are through the application STEM and TVET. Therefore, the initiative through this research seeks to create a learning foundation and an initial overview of the integration of STEM into the TVET program into early childhood education.

1.1. Problem Background

Integrating STEM (Science, Technology, Engineering and Mathematics) education into Early Childhood Technical and Vocational Education and Training (TVET) programs in Malaysia presents several challenges and problems. The Malaysian education system has placed more emphasis on memorization and exam-based assessment, which may not be in line with the hands-on and experiential learning approach advocated by STEM education. Changing the pedagogical paradigm to promote critical thinking and problem-solving skills at an early age requires a significant overhaul of the existing curriculum (Sipon, Othman, Rahim, Norwai, & Ahmad, 2021).

In addition, according to Ziad, (2021), there is a lack of qualified teachers with expertise in both early childhood education and STEM disciplines. Training and professional development programs need to be established to equip educators with the necessary skills to effectively integrate STEM concepts into their teaching methods. This requires collaboration between education authorities, teacher training institutions and industry partners to ensure a holistic and relevant approach.

Infrastructure and resource limitations also pose significant challenges. Many schools, especially in rural areas, lack the necessary facilities, equipment, and materials to support STEM education (Idris, Govindasamy & Nachiappan, 2023). Ensuring equitable access to these resources across different regions is crucial to avoid exacerbating existing educational disparities. Cultural perceptions of early childhood education may further hinder the integration of STEM in TVET programs. There might be resistance from parents and communities who traditionally prioritize academic achievements over skills-based learning. Raising awareness about the long-term benefits of STEM education and its positive impact on children's cognitive development is essential to gain societal acceptance.

To address these issues, a multi-stakeholder approach involving government bodies, educational institutions, industry players, and communities is vital. Establishing pilot programs, investing in teacher training, upgrading infrastructure, and fostering a cultural shift towards valuing STEM in early childhood education are integral steps towards successfully integrating STEM into TVET programs in Malaysia.

Previous research from (Akgunduz, & Mesutoglu, 2021), states the absence of the implementation of STEM elements into early childhood education that risks limiting the skills and preparation of children with basic skills and the same when the experience of an adult. STEM education not only provides children with specific technical skills, but also centered on the development of critical thinking, problem solving and analytical skills. Without exposure to STEM elements, children may not have the ability to face challenges methodically and creatively. These skills are important not only for technical and vocational paths, but also for success in a rapidly evolving technology-driven world (Abu Khurma, Al Darayseh & Alramamneh, 2022). Therefore, the importance of these STEM elements in children can cause them to be interested in STEM-related fields and then facilitate their academic journey. As the job market increasingly demands skills in STEM-related fields, a deficiency in early STEM education can result in a workforce ill-equipped to meet the demands of a technologically advancing society. This limitation may hinder a country's competitiveness in the global economy, as industries evolve towards automation and innovation.

Lack of early exposure to STEM can create a significant skill gap especially in rural and urban areas, this makes it difficult for children in general and adults in particular to compete and develop careers in skill-based, technology, science and AI or computer-based fields (Simanjuntak, Suseno, Setiadi, Lustyantie & Barus, 2022). In addition, the absence of STEM elements in children's programs directly limits all domains of their development, in addition to hindering interest and

ultimately limiting children's readiness for future technical and vocational paths (Chen, Huang & Wu, 2021). The emphasis on STEM in children's programs makes a very meaningful contribution to children in addition to inculcating scientific values, instilling technological skills and thinking based on problem solving.

The essence of STEM in TVET programs can usually encourage children to be more skilled, talented, and have more mature and critical thinking through asking questions, finding solutions, and thinking creatively and which is important to overcome complex challenges in many aspects of life in a full future challenge. Through TVET programs from STEM that are applied and adapted in early childhood education programs that are specifically designed, indeed, to instill children's interest in learning and a sense of curiosity about all core subjects and based on technology and science. Therefore, the need for research on the integration of STEM into the TVET program into the early childhood education program in Sabah especially because this application initiative can lay a strong foundation of learning and teaching for children to produce a very competitive, talented person and an important product for the country. Along with the development of technology and science and relying on the skills of the 21st century, it is very appropriate if the integration of the STEM system into the TVET program of the early childhood education program is implemented at a rapid pace, especially in the beloved country of Malaysia.

1.2. Problem Statement

The effectiveness of the integration and adaptation of the essence of STEM into the Technical and Vocational (TVET) program for early childhood education programs has not been able to be identified in depth, considering that it has never been directly practiced and implemented in Sabah or the rest of Malaysia. However, there are many past studies such as the study by Simanjuntak, Suseno, Setiadi, Lustyantie & Barus (2022), who believe that the existing TVET curriculum is able and has a positive impact on the development of early practical skills, subjects from the STEM program can develop holistically against children. However, the weakness of the expertise aspect of qualified child educators further prevents integration from being carried out smoothly. In addition, it requires adequate complete facilities and infrastructure. Perceptions from the community should also be considered, because there are some communities that prioritize academic achievement over skill-based learning which prevents the acceptance of STEM in TVET programs for early childhood education. This, to some extent, doubts the effectiveness and implications of the integration and application of STEM into the TVET program for early childhood education programs. This research is important to clarify and ensure that the centralization of these programs can produce children with skills based on technology, science, computing, mathematics, mechanical and vocational skills in the future.

The absence of incorporating Science, Technology, Engineering, and Mathematics (STEM) elements during early childhood education poses a critical challenge in preparing children for future technical and vocational pathways. Without exposure to STEM concepts at a young age, children may lack essential problem-solving, critical thinking, and analytical skills, hindering their readiness for evolving industries (Nikolopoulou, 2023). The current educational framework often emphasizes rote memorization over hands-on, experiential learning, contributing to a gap in practical skills needed for technical vocations. Additionally, the shortage of qualified educators' adept at integrating STEM into early childhood education further compounds the issue. Addressing this challenge is pivotal to ensuring that young learners are adequately equipped with the foundational skills essential for success in future technical and vocational pursuits.

The lack of assimilation of science, technology, engineering, and mathematics (STEM) into children's education is one of the most critical factors in preparing children to take technical and vocational education in the future. If children are not exposed to any aspect of STEM at an early age, they may miss out on the basic problem solving, critical thinking and analytical skills that will prepare them for any growing industry. Normal education systems are almost always oriented towards rote learning rather than practical experience; therefore, it lacks practice in basic skills relevant to technical trading. Additionally, the lack of competent educators qualified to integrate STEM into the early childhood education environment further compounds this issue. The ability to change this situation is very relevant to enable young students to have the basic competencies that will help them succeed in technical and vocational paths later in life (Wan, Jiang & Zhan, 2021).

1.4. Research Objectives

- To identify the impact of integrating Science, Technology, Engineering, and Mathematics (STEM) education into early childhood TVET programs toward children cognitive development.
- To identify how to incorporate STEM elements through TVET programs at a young age toward children's skills and prepare them for future technical and vocational pathways.

2. Literature review

2.1. STEM education integration into Early Childhood Technical and Vocational Education and Training (TVET) in Malaysia

Although the potential to integrate STEM education into Early Childhood Technical and Vocational Education and Training (TVET) is high in Malaysia, available statistics should still be analyzed in trying to make this integration effective. There is hardly any availability of data on the statistics concerning early childhood TVET STEM integration in Malaysia, since this is a very new approach within the country. Global and country-level indicators give very invaluable ideas.

The effectiveness of STEM education integration can be determined through student achievement and interest (Jia, Rasul, & Jalaludin, 2024). Different studies conducted across different countries have shown that very early exposure to STEM education makes a huge difference in increasing children's interest and achievement in these subjects. For example, the study conducted by the National Science Foundation in the USA showed that early education in STEM is influential in later STEM performance and interests among children. Although there may not be so much data available that is related specifically to Malaysia, some trends can be predicted because of the universal impact of early childhood education. Increased student engagement in and enthusiasm for STEM subjects in Malaysian early childhood settings would likely mirror these global findings.

As stated by Ahmid, S. S., Tiew, C. C., & Abdullah, M. N. L. Y. (2023), another critical aspect is the preparedness and professional development of teachers. The Malaysian Education Blueprint makes a case that, from 2013 to 2025, there will be a focus on building in teachers the required skills and knowledge to effectively teach STEM. Schools that have participated in such initiatives as the "STEM Mentor-Mentee" program have reported that teacher confidence was raised and so was student engagement in STEM activities. The findings therefore emphasize the need to invest in the training of teachers if STEM education is to be effectively integrated. Effective teachers can create active and conducive classroom learning environments that allow children to explore and cultivate deeper skills in critical thinking.

Notable, equally important to the effectiveness of STEM education integration are resource allocation and infrastructure. According to the Ministry of Education Malaysia, schools that have sufficient STEM resources see better student performance in STEM subjects (Alam, Reza, Ogawa, & Ahsan, 2024). The government has, over the recent past, increased the budget allocation towards STEM education to enhance such resources in schools. It is an especially important investment in providing a stimulating environment in which active play and experiments can take place in things very important in young children's engagement with STEM subjects.

Another critical factor is parental and community involvement. Evidence has been found that parental involvement can massively increase children's interest and achievement in STEM. Programs that engage parents in their children's learning of STEM have proved promising, either through workshops or at-home activities (Yakop, Ishar, & Janius, 2024). While Malaysian statistics may not be available, global data do indicate that this type of involvement is a defining characteristic of successful initiatives on the early years of STEM education. Involvement of parents and the community will be able to create a coherent learning environment reaching out of the school classroom and helping reinforce, at home, concepts learned in STEM.

The longitudinal impact of early STEM education is also important. According to the Organization for Economic Co-operation and Development, countries that do so within the early years of STEM, including the components of TVET, reap long-term benefits like higher enrollments in STEM courses at higher levels of education and better labor market outcomes in these same fields (Janius, Hassan, Atan, & Idris, 2018). The view of Malaysia on early childhood STEM education is likely to go these ways as programs mature. With a great foundation in STEM inculcated at an early age, Malaysia will have raised a group of learners with the skill base and knowledge to be successful in a fast-changing world.

While specific data for the effectiveness of STEM education integration into Early Childhood TVET in Malaysia may be quite scant, global and national indicators show otherwise (Ismail, & Yusof, 2023). These initiatives will ultimately be effective based on key roles such as student achievement and interest, teacher preparedness, resource allocation, parental involvement, and long-term impacts. Further investment in all these areas, coupled with complete research and data collection, shall be important in measuring effectively and improving the integration of STEM education into Malaysia's early childhood TVET. The specified factors, if dealt with, will enable Malaysia to set its young learners effectively for the challenges and opportunities lying ahead.

2.2. Factors in ensuring the effectiveness of STEM education integration into Early Childhood Technical and Vocational Education and Training (TVET) in Malaysia

Integrating STEM into early childhood TVET in Malaysia essentially means developing an engaging, hands-on curriculum and provisions for extensive teacher training. Adequate infrastructure and resources, such as labs and technology, are needed. Public awareness and advocacy garner support, while public-private partnerships offer practical expertise. Inclusive approaches ensure accessibility to all and hence promote diversity, breaking down barriers that can hinder the growth of a strong foundation in STEM from an early age (DeCoito, & Briona, 2023).

Cognitive Development. STEM integration in early childhood TVET programs enhances the components of a child's cognitive development: critical thinking, problem solving and analytical skills. As such, it lays a very important foundation for future technical and vocational pathways, thereby meeting the strong cognitive demands of STEM-related careers.

Engagement and Interest. Another way to measure STEM integration in early childhood is through the level of engagement and interest. Successful programs capture children's curiosity and generate genuine interest in STEM subjects. This is essential for ensuring their learning and career choices.

Teacher Preparation and Training. However, the effectiveness of STEM integration depends on the readiness and training of teachers. Only those who have received the right training to acquire the knowledge and skills to incorporate STEM into their teaching mode will be able to implement STEM effectively in early childhood TVET programs.

Infrastructure and Resources. Adequate infrastructure and resources, with age-appropriate materials, equipment and facilities, are among the essential requirements for STEM integration. Otherwise, lack of resources will deprive children of experiential learning and thus affect the effectiveness of STEM education in early childhood TVET.

Industry Relevance. The effectiveness of STEM education in early childhood TVET programs can be identified based on how well the programs adapt to current and future industry needs. This therefore means that programs that provide children with STEM skills and knowledge will enhance their employability, thereby contributing to the development of a workforce capable of meeting the demands of a technology-driven economy.

There is a compelling case in Malaysia for a comprehensive assessment of STEM integration into early childhood TVET programs, considering the cognitive, pedagogical and infrastructural dimensions. This means that students at this foundation level of learning must be well prepared to take technical and vocational pathways in the evolving landscape of STEM-related fields (Ali, Jaaffar & Ali, 2021).

2.3. STEM Toward Children Theories

In the context of STEM education for children in Malaysia, here are three notable theories that have gained recognition are (Cavas & Cavas, 2020, Nardo, 2021 & Waite-Stupiansky, 2022).

Constructivism Jean Piaget's theory. Emphasizes the active role of children in constructing their individual understanding of the world through direct experience and inquiry. In the context of STEM, constructivism encourages a learning environment that supports problem solving, experimentation, and discovery very much in line with the hands-on, experiential approach developed in STEM education.

Vygotsky's Sociocultural Theory Lev Vygotsky's theory. Emphasizes that the learning of knowledge occurs through social and cultural interactions. In the typical Malaysian setting, where collaborative learning is highly valued, this theory supports the idea of encouraging children to learn collaboratively in STEM activities. This can be achieved by designing group projects and engaging children in cooperative problem solving to deepen their understanding of STEM concepts in a social and cultural context.

Theory of Multiple Intelligences Proposed by Howard Gardner. The theory posits that there are multiple intelligences present in an individual apart from traditional measures of ability such as IQ. In the context of STEM education in Malaysia, the understanding and development of different types of intelligence can be tailored to Malaysian children who have a more diverse and inclusive approach to STEM learning.

These theories offer a framework for educators and policymakers in Malaysia to design STEM programs that are aligned with children's cognitive development, social interaction, and multiple intelligences. Theories need to be understood

before one can integrate them into STEM education initiatives so that a more effective and tailored approach can be taken to instill interest in learning and curiosity about STEM subjects among Malaysian children.

2.4. Children Skill Development Through Stem Programs

Children's skill development through STEM (Science, Technology, Engineering, and Mathematics) programs is a critical component of education, focusing on fostering essential competencies from an early age. STEM education emphasizes a multidisciplinary approach, nurturing skills that are vital for success in the modern world. One key aspect of skill development through STEM programs is the cultivation of critical thinking and problem-solving abilities. Children engage in hands-on activities, experiments, and projects that require them to analyze, evaluate, and find solutions to real-world challenges (Janius, Ishar, Yusof, Bang, Sid & Wong, 2023). This process enhances their ability to think logically and approach problems with creativity and innovation. STEM programs also contribute significantly to the development of mathematical and scientific literacy. Through practical applications, children gain a deeper understanding of mathematical concepts and scientific principles. This not only lays a strong foundation for future academic pursuits but also instills confidence and comfort in dealing with quantitative and analytical aspects of various disciplines.

Moreover, STEM education promotes effective communication and collaboration skills. Many STEM activities involve group work and collaborative projects, requiring children to express their ideas, listen to others, and work collectively to achieve common goals. These interpersonal skills are invaluable in both academic and professional settings.

In the context of technology and engineering, STEM programs expose children to coding, robotics, and various technological tools. This early exposure helps in developing digital literacy and comfort with technology, which is increasingly essential in today's digital age. Additionally, hands-on engineering projects instill problem-solving skills and creativity, fostering an early interest in engineering concepts.

The integration of STEM into early childhood education contributes to a holistic approach to skill development (MacDonald, Huser, Sikder & Danaia, 2020). It not only prepares children for potential STEM careers but also equips them with transferable skills applicable in diverse fields. The ability to adapt to new challenges, think critically, collaborate effectively, and embrace technological advancements positions children for success in a rapidly evolving global landscape (Janius, Ishar, Bang, Sid & Wong, 2023). Overall, STEM programs play a crucial role in shaping the skill sets of the next generation, empowering children to thrive academically, professionally, and personally.

2.5. STEM Toward Early Childhood Education in Malaysian

According to Ong, E. T. (2022), STEM education in Malaysia indeed has been playing a very significant role in shaping the educational landscape of these children. Malaysia's system of education has recognized the importance of developing STEM-based skills from a very tender age to prepare these children for the challenges associated with a world unfolding at a very fast rate of development in terms of technology.

Malaysia, for example, has over the years taken real, vigorous initiatives towards promotion at both the primary and secondary levels in the education sub-sectors. An increased emphasis on STEM at school seems to ensure higher-order thinking skills, problem-solving abilities, and a good foundation in scientific and mathematical concepts from students' very early life stages (Ismawi, Ishar, & Janius, 2022). These are the probable reasons that make the STEM education policies incorporated within the specially formulated policies and programs by the government advance in leaps and bounds with the inclusion of these features in the curriculum.

For children in Malaysia, STEM learning becomes a process that extends beyond theoretical or classroom learning (Rahman, & Ismail, 2024). The approach is increasingly focused on doing hands-on and experiential activities that involve and allow children to put into practice the learned concepts in the areas of STEM. This makes a stronger connection with the theoretical aspects and increases love for learning and inquisitiveness about the world around them (Janius, Aniq, & Amdan, 2024). Articulation of STEM into education in Malaysia is also based on the country's economic aspirations. Knowing full well the importance of producing a skilled workforce that could greatly contribute to innovation and technological advancement, Malaysia decided to begin early the incorporation of STEM concepts so that it could bridge the gap and help set the future generation on the right path toward a career in science, engineering, technology, or related fields.

Besides, the STEM education in Malaysia is becoming even more inclusive and equitable. There are efforts to ensure that every child, irrespective of his background and geographical location, gets access to quality STEM education (Aziz, & Mahmud, 2023). Only then can there be the growth of a more balanced workforce able to contribute to development

in different spheres of life (Fadel, Ishar, Jabor, Ahyan & Janius, 2022). STEM education goes along with the development of a child, whose inception pegs way back to early exposure to science, technology, engineering, and mathematics. Seeking to empower their youth with knowledge and competencies through the cultivation of STEM capabilities from an early age, Malaysia aims at creating young people who can become successful in the globally competitive environment and contribute towards national development.

3. Research methodology

The kindergartens that were picked adopt different approaches and, at the same time, with equal emphasis, make use of STEM applications into the TVET programs apart from offering comprehensive development of children academically, spiritually, and socio-emotionally. This study will be purely qualitative, involving interviewing of 2 teachers in each of the kindergartens chosen, with at least 10 years of experience in their respective kindergartens. The data obtained from this research were analyzed manually, using qualitative methods of recording the interview sessions with the subjects and data transcription. The data coding was done to make themes, and documentations and absorptions methods were used for additional information. The research also proposed a model of guidelines to enhance its understanding.

4. Data analysis

4.1. Sampling Background

The study participants were selected from teachers with at least 10 years of experience who are conversant with the application of STEM and TVET programs within the context of early childhood education.

4.2. Impact of integrating Science, Technology, Engineering, and Mathematics (STEM) education into early childhood TVET programs toward children cognitive development

Answer from teacher 1, question 1. *"I do this in my classroom through multiple hands-on concrete activities that allow for explorations and experiments. For example, planting and growing experiments connect with science; coding apps are technology; structure building with blocks is engineering; measuring ingredients to cook connects to math. One other kind of project we did was something called the "Mini Weather Station." The children built different weather instruments and recorded data. Since the implementation of STEM, children have been developing problem-solving and critical thinking skills. They have been curious, systematic in solving problems, connecting concepts, and working together. Integration has, therefore, contributed to their cognitive development and developed a love for learning".*

Answer from teacher 2, question 2. *"My children really respond well to activities and lessons that have something to do with STEM. They usually tend to show a lot of curiosity and are more involved with activities related to STEM rather than with non-STEM ones. In the STEM projects, they seem quite thrilled and keen on getting involved in doing, asking a lot and showing interest in the concept they could possibly investigate into further. I find high-order ideas are understood more easily if introduced through some kinetic, inquiry-based STEM activity. Their problem-solving skills come to the fore, and they work collaboratively with greater zest. It means that STEM activities call for greater depths of interest and cognitive engagement than do traditional lessons".*

Answer from teacher 2, question 3. *"Through experience, early exposure to STEM education greatly enhances the cognitive development of children in quite a few aspects: better problem-solving skills and critical thinking, with a better foundation for reasoning. For example, when children design and build bridges using blocks as part of a project, they are testing different designs and seeing why their structures fell apart, all the while looking for solutions from one another. In this activity, these children did improve on their critical thinking and solving problems in a coherent manner".*

"For instance, how children so easily pick up sequencing and logical thinking when we used coding apps: arranging commands to achieve a certain outcome in the game would not only make them understand cause and effect but also how to increase their confidence while approaching complex problems. The activities work together to build curiosity, problem-solving skills, and logical thinking—ingredients for cognitive development".

4.3. Incorporate STEM elements through TVET programs at a young age toward children's skills and prepare them for future technical and vocational pathways

Answer from teacher 1, question 1. *"I shall incorporate STEM components within a TVET curriculum for little children by engaging them in hands-on experiments on plant growth, which will teach them science; coding apps where children are*

taught aspects of technology; building projects using blocks that will teach them the aspects of engineering; and counting/sorting exercises in math. These activities develop foundational technical skills through which critical thinking and problem-solving are enhanced, with an understanding of cause-and-effect relationships. Building projects will teach, for instance, principles of balance and stability, while coding activities enhance logical reasoning".

"Since these activities that focus on STEM were implemented, I have witnessed great strides children make in terms of hands-on and technological skills. Children have become surer with tools, their coordination is better, and they work effectively according to procedures. Their problem-solving skills are higher since they experiment and change their attempts according to observation. These activities will most strongly help in establishing future technical and vocational pathways".

Answer from teacher 1, question 2. "*Exposing children to STEM education as early as possible through TVET programs prepares them for future technical and vocational pathways. This is achieved by enhancing their critical thinking, problem-solving skills, and technical competencies that mainly relate to the construction of projects and coding. This creates better understanding of the basics of engineering and technology, hence laying a foundation for advanced learning".*

"For example, the child who was initially engaged by simple coding games goes ahead to perform complex programming, showing further interest in pursuing computer science careers. In the same breath, children engaged in construction activities develop an interest in engineering, characterized by increasing complexity in design projects. This early foundation breeds passion in these STEM fields and results in very advanced competencies with clearer career aspirations in technical and vocational areas.

Answer from teacher 2, question 3. *"Making sure STEM activities are relevant and engaging, I design lessons that connect to real-world applications. For example, we will illustrate engineering principles with simple machines using everyday materials, and work on coding apps to solve practical problems, such as creating a digital story or game".*

"One such example was when children designed and constructed a mini "weather station" with instruments created on their own. Recording weather data, analyzing patterns for applied math and science in a real-world setting, and simple circuits to light up LEDs all function to allow children to understand how electrical engineering works. Activities like these make the abstractions of STEM concrete and relevant in real life, showing them precisely how their learning translates into practice".

5. Discussion

5.1. Impact of integrating Science, Technology, Engineering, and Mathematics (STEM) education into early childhood TVET programs toward children's cognitive development

Implementing Science, Technology, Engineering, and Mathematics in Early Childhood Technical and Vocational Education and Training may have very significant positive effects on the cognitive development of children. Here are several ways by which this might be of importance.

Enhancing the development of critical thinking and solving problems. STEM education encourages children to become critical thinkers and creative problem solvers. Most of the activities are based on assessing situations, considering options, and developing solutions, which enhance their cognitive processes in the process. Through TVET, children can engage in many practical skills with realistic applications, especially through the ability to apply critical thinking within a wide array of contexts.

Encourages Curiosity and Exploration. Components of science and technology in STEM evoke curiosity and motivate children to learn more about their surroundings. While doing so, they help in developing inquiry-based learning, where children learn to ask questions and seek answers. Engineering activities that most of the time involve building and designing can fire up a child's imagination and curiosity about how things work.

Improve Mathematical Thinking. Mathematics is an inherent part of STEM and is known for giving early exposure to children concerning numeral and spatial understanding. Math activities enable children to recognize patterns and shapes and learn primary arithmetic, which are core cognitive skills. Besides, being an excellent way of practically utilizing the math learned, their meaningful reinforcement occurs e.g. measurement of ingredients for cooking, measurement of material for construction in any TVET course. Most of the projects that would be undertaken in engineering or technology would be practical, such as block building, or simulation projects, in the case of the use of simple tools. By this, fine motor skills would be enhanced, and hand-eye coordination would be developed. The same

physical skills related to cognitive development would be developed through TVET activities such as crafting, sewing, and the operation of basic machines.

Encourages Collaboration and Communication. Most of the activities involved in STEM are collaborative, and children learn to work together, communicate with each other, and exchange ideas. This teaming allows for social and cognitive skills like understanding different perspectives or clearly putting thoughts into words. Often embedded in the TVET programs are group projects or peer learning, further supporting the development of these essential skills.

Build confidence and resilience. Successful completion of STEM-related tasks can help improve confidence and a growth mindset in children. They learn that with persistence and effort, success is achievable and that is core to development in terms of cognition and self. Practical challenges during TVET programs teach resilience and adaptability as children learn how to handle failures and setbacks in a constructive way.

Improves Memory and Information Processing. Participation in STEM activities requires memory of instructions, following sequences, and processing information effectively. These activities enhance short- and long-term memory. Repetitive practice in TVET activities and application reinforce these cognitive processes, making these more solid.

Integration of STEM education into early childhood TVET programs can therefore be a holistic way to cognitive development, fully arming these young learners with the preparedness they require for sustainable lives.

5.2. Incorporate STEM elements through TVET programs at a young age toward children's skills and prepare them for future technical and vocational pathways

Early exposure to technical and vocational education and training programs in the field of STEM sets children along the path towards technical and vocational education (Janius, & Amdan, 2024a). STEM simply describes an education that develops a young child's scientific curiosity, technological literacy, engineering thinking, and mathematical reasoning. This module at an early age introduces the child to critical thinking and creativity, inculcating a love for learning. It requires designing appropriate age curricula, training teachers in techniques to teach, and allocating sufficient resources, with an exhortation to greater parental involvement. Through such an integrated approach, this will make learning STEM enjoyable and within reach. Teachers equipped with professional development can inspire; adequate resources and parental support can combine to enhance the learning experience.

Thus, children gain crucial skills like technical abilities, solving problems, analytical thinking, creativity, digital literacy, collaboration, communication, adaptability, confidence, and resilience. These are the very skills that make people successful in a modern workplace (Janius, & Amdan, 2024b). For example, hands-on projects in engineering will improve their fine motor skills and give them the skill of teamwork. Technology lessons can help in making them digitally literate and adaptable. Programs sparks a crucial discussion on the evolving nature of education and its role in preparing the workforce for the future. This integration challenges traditional notions of when and how STEM subjects should be introduced, emphasizing the importance of early exposure to these disciplines.

This discussion is the recognition that children are natural learners with an innate curiosity about the world. By introducing STEM elements into TVET programs at an early age, educators tap into this curiosity, fostering a foundation for a lifelong interest in science, technology, engineering, and mathematics. According to (Janius, Ishar, Bang, Sid & Wong, 2023 & Janius, Jahadi, Abdullah, & Ling, 2023), early childhood is a critical period for brain development, and integrating STEM education during this phase provides a unique opportunity to shape cognitive abilities and analytical thinking.

Moreover, the discussion revolves around the evolving demands of the job market. In an era driven by technological advancements, there is a growing need for a workforce well-versed in STEM skills. Early exposure to STEM in TVET programs ensures that students develop the foundational skills required for success in a rapidly changing job landscape. It aligns education with the demands of the contemporary workforce, enhancing the employability of individuals from an early stage (Janius, 2023).

The interdisciplinary nature of STEM subjects also plays a central role in the discourse. Integrating science, technology, engineering, and mathematics in early childhood education promotes a holistic understanding of complex problems (Mustafa, Shah, Hashim & Desa, 2022). It encourages students to think critically, solve problems creatively, and approach challenges with a multifaceted perspective. This discussion underscores the necessity of breaking down traditional subject barriers and adopting an interdisciplinary approach to education to better prepare students for the dynamic nature of the modern world. In addition, the integration of STEM education into Early Childhood TVET

Programs prompts a critical conversation about adapting educational approaches to meet the needs of a rapidly changing world (Janius, Aniq, & Amdan, 2024). It emphasizes the importance of nurturing young minds, aligning education with workforce demands, and fostering interdisciplinary skills that are essential for success in the 21st century (Agaoglu & Demİr, 2020). The future of children shaped by STEM education holds immense promise and potential. As young minds are exposed to Science, Technology, Engineering, and Mathematics from an early age, they are equipped with the tools to navigate and contribute to an increasingly technology-driven world.

STEM education not only imparts technical skills but also cultivates critical thinking, problem-solving abilities, and a mindset of continuous learning (DeCoito, I & Briona, 2023). Children immersed in STEM become adept at adapting to new challenges, fostering resilience and creativity. These foundational skills position them as active contributors to innovation and technological advancement, essential elements in the rapidly evolving global landscape. Furthermore, a STEM-focused education opens doors to diverse and rewarding career paths. Whether in traditional STEM fields or emerging industries, these children are well-prepared to tackle complex problems, drive innovation, and make meaningful contributions to society. The future workforce requires individuals with the capacity to understand and leverage technology, and STEM-educated children are poised to fill this demand, ensuring their relevance and competitiveness in the job market (Rotatori, D., Lee, E & Sleeva, 2021).

According to (Cabello, Martínez, Armijo & Maldonado, 2021), the future of children immersed in STEM education is one of empowerment, versatility, and adaptability. These young individuals are not only prepared for the challenges of tomorrow but also positioned to shape and lead the technological advancements that will define the future. It is imperative that all stakeholders and practitioners in education, industry, and government join hands to contribute and support the development of STEM (Science, Technology, Engineering, and Mathematics) programs for the sake of children's future. The collaboration of these key players is essential to ensure a comprehensive and effective integration of STEM education into the educational landscape.

Educational institutions play a pivotal role in designing and implementing STEM programs that align with evolving curricular needs. Teachers and educators must receive adequate training and resources to effectively deliver STEM education, fostering an environment where children can develop essential skills from an early age (Kelley, Knowles, Holland, & Han, 2020). Industry stakeholders, recognizing the long-term benefits of a STEM-educated workforce, should actively engage in partnerships with educational institutions. Providing mentorship, internships, and real-world application of STEM concepts enhances the practical relevance of education, preparing students for the demands of the professional world.

This, in essence, is the ground for laying a strong foundation for STEM through TVET in children for their future careers. In this way, it not only sets up the child towards technical and vocational pathways but also purports to lifelong learning and holistic development. Early years of STEM education will, therefore, set up the child with skills and a mindset to sail through in a changing world.

5.3. Strategies and Initiatives Implemented and Integrate STEM Into Children's Education

Based on research by (Ortiz-Revilla, Greca & Arriassecq, 2022), several strategies and initiatives have been implemented to seamlessly integrate STEM into children's education:

5.3.1. Curricular Integration

Many educational systems worldwide are revising their curricula to include STEM components at all levels of education, including early childhood education. This involves designing appropriate age-of-school lessons and activities that expose children to fundamental STEM concepts through hands-on experiences and inquiry-based learning.

5.3.2. Teacher Professional Development

Training educators to effectively integrate STEM into their teaching practices is crucial. Professional development programs provide teachers with the necessary skills, resources, and pedagogical approaches to make STEM education engaging and accessible for children. This ensures that educators are well-prepared to facilitate meaningful STEM experiences in the classroom.

5.3.3. Public Awareness and Advocacy

Efforts to promote STEM education often include public awareness campaigns and advocacy initiatives. By informing parents, policymakers, and the community about the importance of STEM in children's education, there is increased

support for the integration of STEM programs into schools. This awareness fosters a collaborative approach to advancing STEM education.

5.3.4. Public-Private Partnerships

Collaboration between educational institutions and the private sector plays a vital role in incorporating STEM into children's education. Partnerships with industry leaders provide schools with access to expertise, resources, and real-world applications of STEM concepts, enriching the learning experience for children.

5.3.5. Extracurricular Activities and STEM Clubs

Beyond the classroom, extracurricular activities such as STEM clubs, competitions, and workshops offer additional opportunities for children to explore STEM in a more informal and interactive setting. These activities often focus on fostering creativity, teamwork, and problem-solving skills.

5.3.6. Investment in Infrastructure and Resources

Adequate infrastructure and resources, including laboratories, technology tools, and educational materials, are essential for successful STEM integration. Investment in these resources ensures that schools can provide children with hands-on experiences and exposure to cutting-edge technology.

5.3.7. Inclusive Approaches

Efforts are being made to ensure that STEM education is inclusive and accessible to all children, regardless of gender, socioeconomic background, or geographic location. This inclusivity is vital for promoting diversity in STEM fields and breaking down barriers to entry.

By combining these efforts, educators, policymakers, and stakeholders aim to create a comprehensive and effective framework for incorporating STEM into children's education, fostering a generation equipped with the skills and mindset needed for success in an increasingly complex and technologically driven world.

5.4. The Role of Malaysian Education Ministry

The Ministry of Education in many countries, including Malaysia, has recognized the significance of STEM (Science, Technology, Engineering, and Mathematics) education from early childhood (Mustafa, Shah, Hashim & Desa, 2022). Efforts have been initiated to integrate STEM programs into early childhood education to better prepare young learners for the challenges of the future.

The ministry typically develops guidelines and frameworks that emphasize the inclusion of STEM elements in the curriculum for preschools and early childhood education centers. This involves creating age-appropriate learning materials, activities, and resources that align with STEM principles while considering the developmental stages of young children. Professional development programs are often implemented to train early childhood educators in effectively delivering STEM content (Janius, & Amdan, 2024). Workshops, seminars, and training sessions equip teachers with the necessary skills to facilitate hands-on, inquiry-based learning experiences that stimulate children's curiosity and problem-solving abilities.

The Ministry of Education also collaborates with educational experts, stakeholders, and relevant organizations to ensure the successful implementation of STEM in early childhood education. Public awareness campaigns are often conducted to inform parents and communities about the importance of STEM and encourage their active involvement in supporting STEM-related activities for young children (Hassan, Janius, Atan & Idris, 2018).

Additionally, investments are made in developing age-appropriate infrastructure, educational technology, and learning materials to enhance the STEM learning environment in early childhood settings. By strategically integrating STEM into early childhood education, the Ministry of Education aims to lay a strong foundation for children's future academic and career success, fostering a generation equipped with the skills necessary for the evolving demands of the 21st century (Janius, Aniq, & Amdan, 2024). The effort to incorporate STEM (Science, Technology, Engineering, and Mathematics) into children's education is a global initiative driven by the recognition of the importance of preparing the younger generation for a technologically advanced and innovative-driven future.

Governments, as central regulators and policymakers, play a crucial role in creating an enabling environment for STEM education. Allocating resources, defining standards, and advocating for the importance of STEM programs in national

education agendas are fundamental steps in securing a sustainable and widespread implementation of STEM initiatives. Therefore, by fostering collaboration among educators, industry leaders, and policymakers, we can ensure that STEM programs are not only accessible but also of high quality, preparing children for the challenges and opportunities of the future. The collective commitment of all stakeholders is essential to lay the groundwork for a generation of young people equipped with the skills and knowledge needed to thrive in an increasingly STEM-oriented world.

6. Model STEM Into TVET Programs Toward Early Childhood Education in UNITAR International University, Malaysia

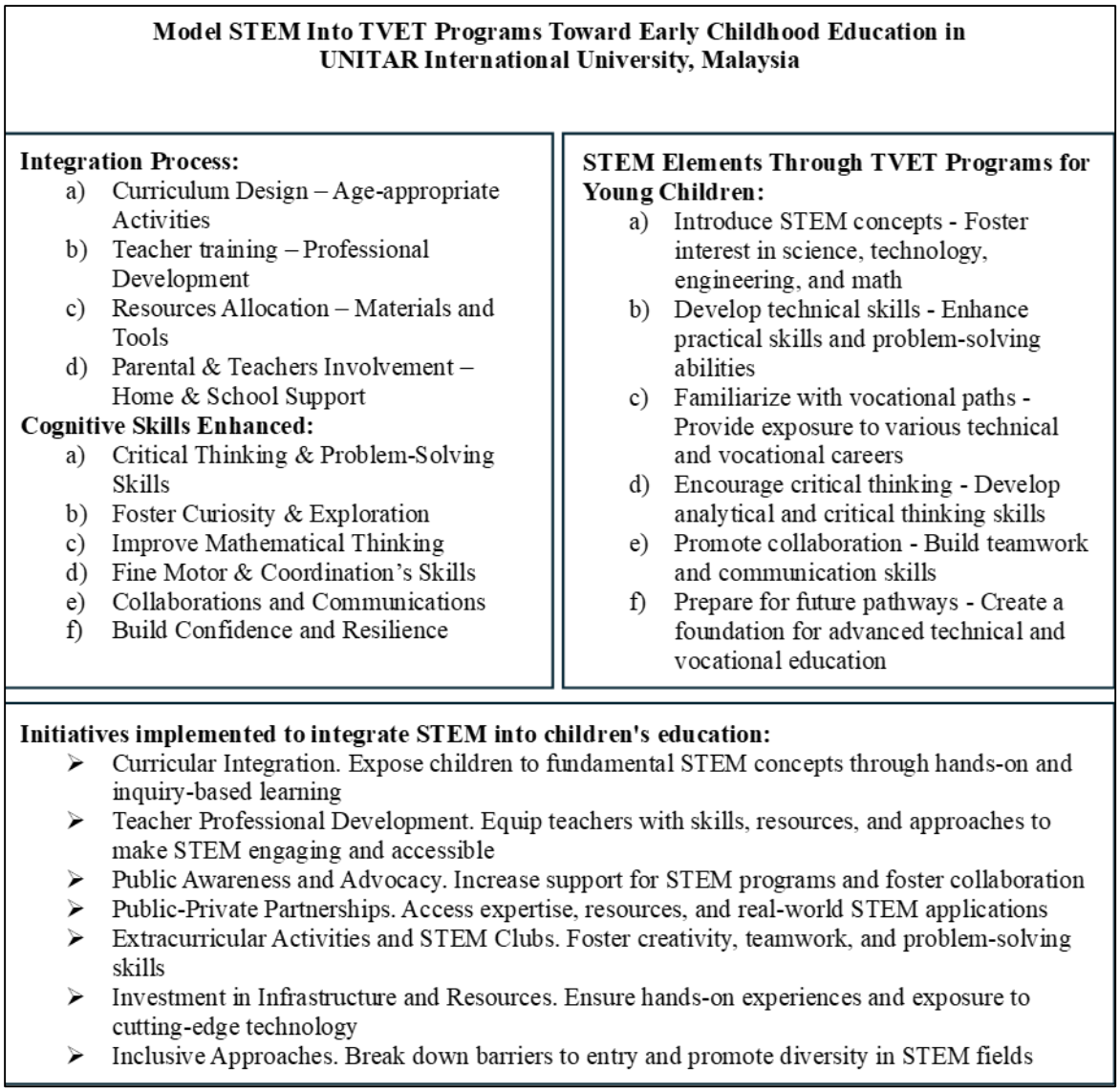

Figure 1 Model STEM Into TVET Programs Toward Early Childhood Education in UNITAR International University, Malaysia

Based on Figure 1 above, UNITAR International University in Malaysia, the need to integrate STEM into TVET would begin by revisiting early childhood curricula, entrenching hands-on activities to set a child on a trajectory toward scientific curiosity and technological literacy (Amdan, Janius, & Kasdiah, 2024 & Amdan, Janius, Jasman, & Kasdiah, 2024). At the same time, there must be proactive teacher professional development to ensure educators are equipped with the relevant skills to prepare exciting lessons on STEM. This is accompanied by organized awareness/advocacy campaigns undertaken at the national level, winning support from parents and the community. Partnerships among the public and private sectors ensure practical applications of STEM and expertise. Extracurricular activities in the form of STEM clubs and workshops develop creativity and problem-solving skills. That investment in infrastructure and

resources shall be made to ensure practice with hands-on experiences in inclusive approaches, thereby ensuring diversity in order that STEM truly is for each child.

7. Conclusion

This integration therefore gives an education approach that is transformational, very effective, and places STEM education at the core of Early Childhood TVET programs. Such integration will help learners develop curiosity-driven learning habits, promote interdisciplinarity, and line education with the demands of the new dynamic job market, ensuring that young learners acquire the core competencies of the 21st century. It helps not just in setting children on STEM-related career paths but in inculcating critical thinking, solving problems, and adaptability from a tender age. Coupled with the realization of the strong impact that technology and innovation have in our daily lives, the integration of STEM in early childhood TVET programs presents a strategic investment in the future by ensuring that the coming generations are well equipped to thrive in a dynamic and complex global landscape.

Compliance with ethical standards

Acknowledgments

The author would like to thank all the participants involved in this study.

Disclosure of conflict of interest

The author has no conflict of interest regarding the research, authorship or publication of this study.

Funding

This study and publication received a publication fee sponsorship from UNITAR International University, Malaysia.

Statement of ethical approval

The researchers used the research ethics guidelines provided by the Universiti Kebangsaan Malaysia Research Ethics Committee (RECUKM). All procedures performed in this study involving human subjects were conducted in accordance with the ethical standards of the institutional research committee. Permission and consent to participate in the study were also obtained from all guardians of the study participants.

Statement of informed consent

I Mohammad Aniq Bin Amdan, Mohammad Aidil Hazidi Bin Kasdiah, Nur Izzah Binti Harifin & Fatin Asyierah Nabila Binti Shamshol Bhari, voluntarily consent to participate in research conducted by Naldo janius at UNITAR International University, lot129, Alam Mesra, Plaza Utama (phase 3), Sulaman, 88400 Kota Kinabalu, Sabah, Malaysia, understanding its purpose, procedures, risks, confidentiality, and my right to withdraw.

References

[1] Amegah, A. (2022). Re-Imagining policy discourses concerning the participation of young women in STEM-related TVET in Ghana. *Journal of Vocational Education & Training*, 1-24.

[2] Ahmid, S. S., Tiew, C. C., & Abdullah, M. N. L. Y. (2023). The influence of innovative characteristics, work readiness, and vocational self-concept on employability of vocational college students. *International Journal for Research in Vocational Education and Training (IJRVET)*, *10*(3), 288-317.

[3] Alam, M. J., Reza, S. A., Ogawa, K., & Ahsan, A. H. M. (2024). Sustainable employment for vocational education and training graduates: the case of future skills matching in Bangladesh. *International Journal of Training Research*, 1-23.

[4] Aziz, N. A., & Mahmud, M. I. (2023). STEM education in Malaysia: Aligning educational initiatives with national economic goals. *Journal of Education and Development in Asia*, 15(3), 67-85. https://doi.org/10.1080/2331186X.2023.21056784o

[5] Agaoglu, O., & Demİr, M. (2020). The integration of 21st century skills into education: an evaluation based on an activity example. *Journal of Gifted Education and Creativity*, *7*(3), 105-114.

[6] Akgunduz, D., & Mesutoglu, C. (2021). Science, Technology, Engineering, and Mathematics Education for Industry 4.0 in Technical and Vocational High Schools: Investigation of Teacher Professional Development. *Science Education International*, *32*(2), 172-181.

[7] Abu Khurma, O., Al Darayseh, A., & Alramamneh, Y. (2022). A Framework for Incorporating the "Learning How to Learn" Approach in Teaching STEM Education. *Education Sciences*, *13*(1), 1.

[8] Ali, G., Jaaffar, A. R., & Ali, J. (2021). STEM education in Malaysia: Fulfilling SMEs' expectation. In *Modeling economic growth in contemporary Malaysia* (pp. 43-57). Emerald Publishing Limited.

[9] Cabello, V. M., Martínez, M. L., Armijo, S., & Maldonado, L. (2021). Promoting STEAM learning in the early years:"Pequeños Científicos" Program. *LUMAT: International Journal on Math, Science and Technology Education*, *9*(2), 33-62.

[10] CHEAR, S. L. S., & ARIFIN, M. (2024). Technical And Vocational Education and Training Prospect for Higher Learning Institution. *Quantum Journal of Social Sciences and Humanities*, *5*(3), 144-160.

[11] Chen, Y. L., Huang, L. F., & Wu, P. C. (2021). Preservice preschool teachers' self-efficacy in and need for STEM education professional development: STEM pedagogical belief as a mediator. *Early Childhood Education Journal*, *49*, 137-147.

[12] Cavas, B., & Cavas, P. (2020). Multiple intelligences theory—Howard Gardner. *Science Education in Theory and Practice: An Introductory Guide to Learning Theory*, 405-418.

[13] DeCoito, I., & Briona, L. K. (2023). Fostering an entrepreneurial mindset through project-based learning and digital technologies in STEM teacher education. In *Enhancing entrepreneurial mindsets through STEM education* (pp. 195-222). Cham: Springer International Publishing.

[14] DeCoito, I., & Briona, A. (2023). Integrating STEM education in early childhood: Challenges and opportunities. Journal of STEM Education Research and Innovation, 5(2), 123-145. https://doi.org/10.1007/s10956-023-09988-2

[15] Fadel, N. S. M., Ishar, M. I. M., Jabor, M. K., Ahyan, N. A. M., & Janius, N. (2022). Application of Soft Skills Among Prospective TVET Teachers to Face the Industrial Revolution 4.0. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, *7*(6), e001562-e001562.

[16] Hanafi, A. G., Ahmad, H. H., Mansor, M. F., & Mustafa, W. A. (2023). An Integrated Approach in Empowering Technical and Vocational Education and Training (TVET) for Malaysian Asnaf in the IR4. 0 Era. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, *30*(2), 255-271.

[17] Hassan, Z. B., Janius, N., Atan, N. A., & Idris, M. D. B. (2018). Assessment of Service Learning in Higher Education at Universiti Teknologi Malaysia. *Advanced Science Letters*, *24*(1), 30-33.

[18] Idris, R., Govindasamy, P., & Nachiappan, S. (2023). Challenge and Obstacles of STEM Education in Malaysia. *International Journal of Academic Research in Business and Social Sciences*, *13*(4), 820-828.

[19] Ismail, N., & Yusof, U. K. (2023). A systematic literature review: Recent techniques of predicting STEM stream students. *Computers and Education: Artificial Intelligence*, *5*, 100141.

[20] Ismawi, S. N. M., Ishar, M. I. M., & Janius, N. (2022). Workability Elements ff Post-Diploma Students in Construction Technology From Vocational Colleges in Malaysia. *Journal Teknikal & Kajian Sosial (JUTEKS)*, *21*(1).

[21] Janius, N., Ishar, M. I. M., Bang, P., Sid, R., & Wong, G. (2023). The Effects of Music towards the Mathematical Language Development of Children. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, *8*(4), e002249-e002249.

[22] Jia, L., Rasul, M. S., & Jalaludin, N. A. (2024). Design Thinking in TVET: Perspectives, Opportunities and Challenges. *International Journal of Academic Research in Progressive Education and Development*, *13*(1).

[23] Janius, N. (2023). Pemupukan Pendidikan Keusahawanan dalam diri Kanak-kanak Melalui Aktiviti Bermain di Tadika: Satu Tinjauan Literatur. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, *8*(5), e002306-e002306.

[24] Janius, N., Jahadi, N. E. H. B., Abdullah, S. N. L. B., & Ling, M. S. (2023). Kesedaran Pendidikan Keusahawanan Terhadap Kerjaya Kanak-Kanak di Masa Hadapan: Satu Tinjauan Literatur. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, *8*(5), e002286-e002286.

[25] Janius, N., Ishar, M. I. M., Yusof, Y., Bang, P., Sid, R., & Wong, G. (2023). Belajar Sambil Bermain di dalam Kelas Pada Peringkat Pendidikan Awal Kanak-Kanak. *Malaysian Journal of Social Sciences and Humanities (MJSSH)*, *8*(4), e002248-e002248.

[26] 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.

[27] Noel, E. A. (2023). The impact of entrepreneurship education in developing entrepreneurial intentions in TVET institutions in Trinidad and Tobago (Doctoral dissertation, Heriot-Watt University).

[28] Rahman, A. H., & Ismail, Z. (2024). Strategic integration of STEM education in Malaysia: Aligning with economic goals and workforce development. *Asian Journal of STEM Education*, 12(1), 34-52. https://doi.org/10.1007/s40979-024-00223-9

[29] Rezaei, N., Saghazadeh, A., Abdurrahman, A., Ciasullo, A., Liaptsev, A., Lighthill, B., ... & Chamot, Z. (2023). Integrated Education and Learning 2050. In *Integrated Education and Learning* (pp. 489-507). Cham: Springer International Publishing.

[30] Rotatori, D., Lee, E. J., & Sleeva, S. (2021). The evolution of the workforce during the fourth industrial revolution. *Human Resource Development International*, *24*(1), 92-103.

[31] Sipon, S., Othman, M. Z., Rahim, F., Norwai, N., & Ahmad, R. (2021). The Effects Of Integrating Stem Education Through Stem Module: Towards A Skilled Workforce And Consistent Learning Society.

[32] MacDonald, A., Huser, C., Sikder, S., & Danaia, L. (2020). Effective early childhood STEM education: Findings from the Little Scientists evaluation. *Early Childhood Education Journal*, *48*(3), 353-363.

[33] Mustafa, N. A., Shah, N. M., Hashim, N. W., & Desa, M. M. (2022). An overview of stem education and industry 4.0 for early childhood education in Malaysia. *Journal of Positive School Psychology*, 53-62.

[34] Nardo, A. (2021). Exploring a Vygotskian theory of education and its evolutionary foundations. *Educational Theory*, *71*(3), 331-352.

[35] Nikolopoulou, K. (2023). STEM activities for children aged 4–7 years: teachers' practices and views. *International Journal of Early Years Education*, *31*(3), 806-821.

[36] Ong, E. T. (2022). Science Education in Malaysia. In *Science Education in Countries Along the Belt & Road: Future Insights and New Requirements* (pp. 277-295). Singapore: Springer Nature Singapore.

[37] Ortiz-Revilla, J., Greca, I. M., & Arriassecq, I. (2022). A theoretical framework for integrated STEM education. *Science & Education*, *31*(2), 383-404.

[38] Simanjuntak, M. B., Suseno, M., Setiadi, S., Lustyantie, N., & Barus, I. R. G. R. G. (2022). Integration of Curricula (Curriculum 2013 and Cambridge Curriculum for Junior High School Level in Three Subjects) in Pandemic Situation. *Ideas: Jurnal Pendidikan, Sosial, dan Budaya*, *8*(1), 77-86.

[39] Wan, Z. H., Jiang, Y., & Zhan, Y. (2021). STEM education in early childhood: A review of empirical studies. *Early Education and Development*, *32*(7), 940-962.

[40] Waite-Stupiansky, S. (2022). Jean Piaget's constructivist theory of learning. In *Theories of early childhood education* (pp. 3-18). Routledge.

[41] Ziad, S. A. I. D. (2021). Integrating STEM in to TVET education programs in QATAR: Issues, concerns and prospects. *The Eurasia Proceedings of Educational and Social Sciences*, *23*, 15-24.