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STEM: Design, Implement and Evaluate

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This paper explains the importance of STEM education. It describes the STEM variations being offered – STEAM, STEMM and D-STEM – and evaluates their role in the STEM curriculum in secondary education. The research methodology involved an action research project where the newly-created STEM process was implemented in secondary schools with classes from the key learning areas of science, technology, engineering and mathematics. Each student experienced the STEM process twice with a range of different problems to solve. Both teachers and students kept reflective journals and a purposeful sample were interviewed about their reflections on experiences, problem-based learning (PBL) and assessment of their STEM process and solution. The practicalities of implementing various STEM programs in secondary schools are discussed and the paper then goes on to seek coherency through a conceptual framework for integrating STEM education in schools. This paper suggests that the STEM process helps students solve problems throughout their life. It includes: 1. STEM skills, 2. Ideation and investigation, 3. Research, 4. Communicate, 5. Prototyping, 6. Evaluate, and 7. Manufacturing the final solution. A discussion ensues that explains how secondary students learn best in a STEM environment. This constructivist method of learning allows students to work in teams to solve problems, foster the development of skills such as self-initiative, cooperation, and learn to take a critical viewpoint. STEM students learn beyond technical knowledge, integrating project and problem-solving learning with an appreciation of the interplay between theory and practice. Suggestions for assessment of STEM learning are included. The future for STEM education is challenging and exciting for both students and their teachers. The introduction of STEM in schools has resulted in an increase in student engagement in STEM subjects and teachers are seeing the benefits of implementing a STEM curriculum that is applicable and relevant to students. STEM education enhances a student's learning experience through tapphelication of general principles and practices. When incorporated it will inspire creativity, inquisitive thinking, and teamwork.

Key Words: *Integrated STEM framework, STEM pedagogies, STEM education, STEM assessment, STEAM, DSTEM, Problem Based Learning*

What is STEM education?

STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy, and with it, STEM offers the ability to compete in the new economy (Holmlund, Lesseig & Slavit, 2018).

The American National Science Foundation originally developed the word STEM as an acronym for science, technology, engineering, and mathematics. Some people use this acronym as a definition of STEM education, but it is important to consider the varied meanings that different groups may have for STEM and STEM education. While it may not be necessary, or even feasible, to coalesce around one common definition of STEM education, we argue that without some shared understandings across a system, it is difficult to design and implement curriculum and instruction to promote successful STEM learning for all students. (Holmlund et.al., 2018). Ring-Whalen, Dare, Roehrig, Titu and Crotty (2018) explain that it is important that teachers, administrators, school districts, and policy-making agencies consider their own conceptions of integrated STEM to operate better as advocates for STEM at the local level. Teachers are then faced with the difficult task of determining what integrated STEM education means for them at a personal and practical level, bound by STEM practices within an authentic context for the purpose of connecting these subjects to enhance student learning. This involves using these subjects together, as one, to solve problems in innovative ways.

In Australia, "Since 2001, the No Child Left Behind Act of 2001 has emphasized regular testing in mathematics and later on science, although science was never part of the 'adequate yearly progress' requirement that holds schools accountable for students progress from year to year (Havice, W., Havice, P., Waugaman, C., & Walker, K. 2018). During that time there was little or no integration of subjects and little attention was given to technology or engineering for females. Current attempts to provide integrated STEM education is viewed as an effort to combine some or all of the disciplines of science, technology, engineering, and mathematics into one class, unit, or lesson that is based on connections between the subjects and real-world problems. Further, the academics were sure that the students would gain more value if they integrated mathematical, technological, and engineering approaches into teaching science in the classroom (Wahono & Chun Yeng Chang 2019).

The degree to which STEM is integrated in schools is dependent upon a range of factors. A fully-integrated STEM curriculum is most easily achieved in primary schools (Stage 1, 2 & 3), where students remain with a single teacher for a large portion of the day (Holmlund, et.al., 2018).

An embedded STEM curriculum is feasible at the secondary level. Within a broad context, the embedded approach to STEM instruction may be broadly defined as an approach to education in which domain knowledge is acquired through an emphasis on real-world situations and problem-solving techniques within social, cultural, and functional contexts (Lidinillah, Mulyana, Karlimah. & Hamdu 2019). Situated approaches that emphasize the learning of domain knowledge through expert-like activities and authentic problem solving in rich social, cultural, and functional contexts. The complete immersion and embedding STEM content in a secondary classroom/laboratory that enhances student understanding and application of material.

Why STEM is important?

STEM's potential is founded in its ability to improve a student's learning experience by assisting in the ability to transfer school-based learning to real and authentic situations in the individual's life. In other words, in the Australian policy context, STEM is not simply an approach to improving science, mathematics and technology education. Rather, it is a fundamental repositioning of the goals and objectives of formal education to better support national innovation (Lowrie, Leonard, Fitzgerald, 2018). Students can solve new problems and draw conclusions based upon previously learned principles applied through science, technology and engineering, and mathematics. It is suggested that implementing teaching strategies, such as problem-based learning through a STEM curriculum, may reinvigorate students' desires to understand the world around them and engage them in classroom instruction (Wyatt & Nunn, 2019). Teachers recognise and are concerned that students' enthusiasm for their own education is waning (Havice, et.al., 2018). Teachers' must reengage them in their studies because many are losing their natural inclination for learning. Havice, et.al.(2018) have found that students who are exposed to integrated problem-solving curriculum display increased engagement, creativity, satisfaction and express enjoyment in their learning. This is encouraging and teachers should use this in their classrooms to refocus and motivate their students.

The complexity of any global challenges including "climate change, overpopulation, resource management, agricultural production, health, biodiversity, and declining energy and water sources" needs an international approach, supported by further development in science and technology, to adequately address these challenges (Ring-Whalen, et.al.,20188). Real world connections emphasise making connections to the real world as a way to provide relevancy and student engagement (Ring-Whalen. et.al., 2018). The environmental and social impacts of the twenty-first century in turn jeopardise global security and economic stability reach beyond just helping students achieve high scores in math and science assessments; students are expected to generate solutions for problems by using 21st century knowledge and skills. At this point, the research concludes that students' interest, attitude, and achievements were affected positively when STEM disciplines were integrated (Tekerek & Karakaya, 2018). Improving

STEM education is driven increasingly by economic concerns in developing and emerging countries. The rationale for investment in STEM education relates mainly to its association with improved economic outcomes (Ismail, 2018). Educators must help students prepare for this global shift. In response to these challenges, Australia is experiencing STEM educational reforms.

Havice et.al. (2018), have confirmed that students become enthusiastic when problem-based instruction is incorporated. Children now expect real-world connections to what they are learning, or else they may completely disengage. They explain the brain learns through association and analysis. Therefore, it is recommended that teachers adopt a variety of methods of instruction, including one in which the students are actively engaged in the learning process. Integrative STEM education provides children with opportunities for educational engagement and achievement. This approach to education involves problem-based and project-based learning that allows students the opportunity to explore real-world problems simultaneously developing cross-curriculum skills while working in small, collaborative groups. Children now expect real-world connections to what they are learning, or else they may completely disengage. When utilising an inquiry and problem-based method of instruction, the teacher spurs student creativity through questions, and students respond through collaborative discussion. Ugrass's 2018 study found that student views on STEM education demonstrated that they considered STEM education as instructive, entertaining, creative and motivating. Furthermore, the students stated that STEM education improved their creativity and motivation towards the courses and contributed to their career choices.

STEM education has been considered for over a decade in Australia and there has been a gradual increase in the number of teachers successfully implementing STEM education. This may be partially attributed to increased STEM funding for research and education. The urgency to improve achievement in science, technology, engineering and mathematics education is evident by the massive educational reforms within the STEM education disciplines (NESA, 2017).

Variations to the STEM profile

Driven by genuine or perceived current and future shortages in the STEM workforce, many education systems and policy makers around the globe are occupied with advancing competencies in STEM domains. However, the views on the nature and development of proficiencies in STEM education are diverse, and increased focus on integration raises new concerns and needs for further research (English, 2017). Many variations to the traditional STEM concept have been proposed. Those with the strongest justifications include STEAM, STEMM and D-STEM.

STEAM

Frequently, STEM subjects are taught disconnected from the arts, creativity, and design common rhetoric, which suggests that STEM education in the United States is in crisis, with waning student performance on standards and decreasing interest in these disciplines. This is despite increased attention to and systemic glorification of STEM in education, often at the exclusion of the arts. To explain this disconnect, scholars have pointed to the siloed structure of school disciplines. The arts are often sidelined as frivolous or discretionary to STEM goals, and students believe that disciplines are disconnected from each other and from their world. As interest in the sciences plummets, an integration of the arts into STEM has reinvigorated STEM-based learning as it turns to STEAM education (Mishra, 2018).

The STEAM educators believe that the value of creativity and arts-based learning in STEAM education (STEAM education stands for science, technology, engineering, art and mathematics, lies in the premise that exceptional thinkers in fields like science or math are also highly creative individuals who are deeply influenced by an interest in, and knowledge of, music, the arts and similar areas. While strengthening the emphasis on STEM education, the community's call for increasing humanities and arts education has become stronger and stronger. Humanities and arts can not only increase the interest of STEM, but more importantly, it will be beneficial to the cultivation of qualified citizens who will develop in the future (Setiawan & Saputri, 2019). They postulate that the future integrated STEAM education can not only promote the cognitive development of students, but also promote their emotional and spiritual realm, enhance their critical thinking and problem-solving skills, and cultivate their creativity. In light of this, there is a strong global movement that demands that STEAM must become an essential paradigm for creative and artistically infused teaching and learning in STEM education.

In the historical accounts of great scientists and mathematicians, it is clear that the boundaries between art and science or music and math are more fluid than conventional learning paradigms suggest. When STE(A)M education model, which is used in developed European countries is evaluated in terms of its results, it is seen that the sharp boundaries between science, technology, engineering, mathematics and art disappear. “The future of innovative thinking in STEM disciplines relies on breaking down the distinction between disciplines traditionally seen as creative like the arts or music, and STEM disciplines traditionally seen as more rigid or logical-mathematical (Yeniasır & Gökbulut 2018). The field of arts-based teaching leads to more motivated, engaged, and effective disciplinary learning in STEM areas (Niedermeyer, J. (2018).

Henriksen, Fisser & Mishra (2016) explain that the force behind technology is innovation, which is driven by human creativity. For this reason, teaching and learning should naturally embed both technology and creativity as they are eternally connected. As we move into a complex 21st century world, multifaceted issues and complex problems served by scientific thinkers today require 21st century professionals who go beyond disciplinary content and are also creative thinkers who can work between disciplines. Most STEM projects aim to engage student motivation by presenting students with real-world-like problems that require interdisciplinary knowledge and abilities to solve problems, often collaboratively.

During such problem-solving, students make connections among STEM disciplines, develop 21st century competencies as they think critically and creatively, and develop appreciation and interest in STEM disciplines (Ah-Namand & Osman, 2018). It is clear that STEM disciplines can benefit from an artistic infusion that connects disciplines in ways that are powerful and motivating for learning. By focusing on the contested spaces between these disciplines, the distinctiveness and potential of various interdisciplinary agendas can be better understood. In turn, ways of recognising, embracing and prioritising different forms of disciplinary knowledge can be identified in the spaces between disciplinary curriculum and pedagogy (MacDonald, Hunter, Wise & Fraser, 2019). Yet, Australian educational policy has increasingly and unfortunately tended to devalue the arts in education overall.

STEMM

STEMM education as a variation of STEM education is the learning of science, technology, engineering mathematics and medicine in an interdisciplinary or integrated approach.STEM enables greater collaboration between the disciplines of science, technology, engineering, mathematics, and medicine. STEMM is a national movement is an integral part of our educational process to prepare students in an increasingly global economy.

The purpose of STEMM education is to provide students with the best opportunity to make sense of the skills needed as a whole, rather than in bits and pieces. It removes the traditional barriers between contents and builds understanding as it is applied in the global economy. STEMM exists in every corner of the world as students connect their knowledge with engineering, lab research, manufacturing, doctors, graphic arts, performing arts and an endless number of other innovative jobs.

STEMM's academic goals include: to increase exposure and awareness of STEMM pathways and careers in all content areas; to strengthen partnerships between workforce and their future employees; and to encourage and foster our existing curriculum to support higher-order thinking through inquiry-based learning. Students gain and apply knowledge, deepen their understanding and develop creative and critical-thinking skills within an authentic context.

STEMM disciplines are critical to Australia's future. As business and government leaders readily recognise, STEMM skills are increasingly vital to helping business innovate, to create jobs and growth, and importantly, to improve our quality of life.

D-STEM
D-STEM refers to using design as the problem-solving focus within science, technology, engineering and mathematics. The D-STEM movement advocates that adding design to STEM learning means that this method of teaching will add authenticity to the process, further increasing student engagement.

The Western Australian Government's report, Effective Teaching (2009), found that design opportunities give learners a chance to tangibly wrestle with and apply their understanding of concepts, including STEM. Design allows both student and teachers to do this work in contexts that are more familiar to them. For example, they may design, make and evaluate self-propelled vehicle, functioning garden ecosystems, or experiment with building projects using or creating a design process.

When implementing D-STEM practices, one needs to be aware that design work involves higher-order critical thinking and planning. Within the design process, teachers must highlight STEM concepts, identify the problem and how the problem is an issue for the individual, the local community or at a global society level. They must entice creative problem identification and solutions, draw on community and expert knowledge, and reinforce the practices of iteration, prototyping, failure analysis, and working within design criteria and constraints.

D-STEM practice can contribute to solving community-based problems and engage the interests of students who may not see the relevance of STEM in their lives. Design projects conducted by youth and communities can lead to engaged D-STEM learning, broadened definitions of engineering, and leverage a wider range of design-related professional and everyday practices.

Research method
The aim of this research is twofold. Firstly, it is to seek coherency through the use of a conceptual framework for integrated STEM education and secondly to create and evaluate a common assessment marking criteria grid to be used across a range of authentic problems.
This research determines the effectiveness of using the STEM process as a teaching strategy in an integrated STEM classroom with multiple classes rotating on a roster through specialist teachers in science, technology, engineering and mathematics. A common grid is used to assess the student's progress in their personal abilities, their problem-solving skills and their evaluative abilities.

The research methodology involved an action research project where the newly-created STEM process and assessment was implemented across 170 students who were 12–13 years of age and eight teachers from the key learning areas of science, technology, engineering and mathematics. Each student experienced the modified STEM process twice with a range of authentic problems. Both the teachers and the students kept reflective journals each week for the 10-week term and a purposeful sample of 20 students were selected to complete a survey, participate in an interview regarding their survey response and weekly reflections on experiences, problem-based learning (PBL) and assessment of their STEM education as well as comments surrounding motivation, satisfaction and enjoyment.

The practicalities of STEM in classrooms

The current buzz surrounding STEM disciplines and their economic importance is justified. However, research shows that secondary schools are recognising problems with competing agendas and with teachers not having expertise in all STEM areas. They instead rely on their own expertise and teach STEM with a focus on their own subject strengths. For example, a science teacher who is teaching STEM places the greater subject emphasis on science and reduces the focus on the other areas, just as an engineering teacher places the greater subject emphasis on engineering and reduces the focus on the other areas.

Teaching STEM from a comprehensive, integrated, holistic approach is not possible in all circumstances in secondary schools due to traditional teacher training that could limit the content taught in STEM, as well as timetabling of lessons. In primary schools the teaching of STEM, where all subjects are included, is more successful as primary teaches graduate in a number of subjects and their cross-curriculum education allows the comprehensive teaching of STEM. The author posits that all STEM teachers require some basic necessary knowledge in science, technology, engineering and mathematics and the problem and extensive experience in research and problem solving before providing authentic, real-life problems can be solved using design applications and STEM practices with current holistic, technological applications. In secondary schools currently, many STEM practices lack locating all domains and teaching intersections that are necessary for STEM integration.

Ring-Whalen et.al. (2018) acknowledge that there are limits to teaching integrated STEM education in the classroom. These limitations were defined as time (both to plan and the amount of time to implement) and money. Some view this approach too focused on career pathways with emphasis on STEM practices and authentic application of STEM knowledge, and many educators' approach towards integrated STEM can best be described as exploratory. There is a feeling in many schools across the globe that when educators push to improve STEM as a discipline, there are negative impacts on other courses. This is not currently substantiated by research and the opposite appears to be true. While the STEM disciplines are important, focus on them can move away from other areas, including multimedia technologies and art education. Art education is, on occasion, being replaced by more in vogue disciplines such as STEM. STEAM has become an essential paradigm for creative and artistically-infused teaching and learning in STEM disciplines (Henriksen et.al. 2016).

It is difficult for secondary teachers to teach STEM because teachers often have difficulty teaching through integration and an integrated approach needs pedagogical training (Rifandi & Rahmi, 2019). Yet, design and arts-infused instruction in STEM disciplines is often not the norm in the educational system, and educational policies often make it difficult for teachers to teach this way without deviating from the mandatory outcomes-driven curriculum.

Seeking coherency through a conceptual framework for integrated STEM education

Now is the time to make STEM literacy for all students an educational priority in all educational settings. Practices and education advisers in Australia advocate for purposefully integrating STEM by providing deeper connections among the STEM domains. We need to move STEM educators forward by creating a common language of STEM integration for research and practice.

Integrated approaches to STEM are increasingly popular, but remain challenging and elusive. There is much hope that integrated approaches to STEM education can help the next generation of students to solve real-world problems by applying concepts that cut across disciplines, as well as develop capacities of critical thinking, collaboration, and creativity. Problem and project-based learning allows students the opportunity to explore real-world problems simultaneously developing cross-curriculum skills while working in small, collaborative groups (Havice et.al. 2018).

Sadly, most teachers have received training in only one or two disciplines at a tertiary level and most schools and classes at all levels still have separate departments and class periods for STEM subjects. A greater emphasis should be placed on how teachers are educated to weave together STEM concepts in their classrooms. Shifting to an integrative STEM education approach cannot occur overnight and cannot occur without training for current and future teachers. There is a gap in the literature on how the field of education equips teaching professionals with the skills to teach integrative STEM education. This gap is evident when we consider how mid-career and seasoned educators learn integrative STEM education principles, especially when they were previously trained to understand and operate under a different teaching model (Wang, Yap, Goh, K. 2017). Therein lies a significant challenge for educators and administrators interested in promoting integrated STEM education for students (Shernoff, Suparna, Bressler & Ginsberg, 2017).

In order to overcome this challenge, it is necessary to align the common practices for each STEM subject. The common STEM practices used by the different subjects are listed in Table 1: Science, Technology, Engineering and Mathematical Practices below. Surely if common practices as suggested in the table below were taught by all faculties, the teaching of STEM would be aligned across the subjects, in the curriculum, and across schools.

Table 1: Science, Technology, Engineering and Mathematical Practices

Science	Technology	Engineering	Mathematics	Teaching STEM
Begins with a question about a phenomenon.	Begins with building skills that will be used when creating a design solution.	Begins with a problem, need, or desire that leads to an engineered solution.	Makes sense of the problem and persevere in solving them.	Develops the necessary STEM skills before investigating the problem and all surrounding phenomenon.
Using models to develop explanations about natural phenomena.	Identifying criteria, constraints/limitations, problem specifications, written as design brief.	Begins with a problem, need, or desire that leads to an engineered solution.	Students explains the meaning of a problem and suggest solution entry points.	Develops technological understandings about Computer apps and problem solving.
Scientific investigation in field or lab using a systematic approach.	Evaluation and application of secondary research findings regarding existing solutions.	Engineering investigation to obtain data necessary for identifying criteria and constraints and to test design ideas.	Reasons abstractly and quantitatively.	Develops necessary engineering skills and understandings about engineering know-how and problem solving,
Analysing and interpreting data from scientific investigations using a range of tools for analysis and pattern location. (Tabulation, graphical interpretation, visualisation, and statistical analysis)	Investigation for the purpose of application-designing and running models, reading and learning from existing and developing technologies and innovations.	Analysing and interpreting data collected from tests of designs and investigations to locate optimal design solutions.	Mathematically proficient students are able to decontextualise – to create abstractions of a situation and represent it as symbols and manipulate.	Develops mathematical understandings about problem solving, abstract reasoning, decontextualising, abstractions and manipulations.
Mathematical and computational thinking are fundamental tools for representing variables and their relationships, allowing for making predictions, testing theory, and locating patterns or correlations.	Teamwork, collaboration across teams to communicate the visualisation of design ideas.	Mathematical and computational thinking are integral to design by allowing engineers to run tests and mathematical models to assess the performance of a design solution before prototyping.	Construct viable arguments and critique the reasoning of others based on the evidence provided.	Provides background information about the design brief. Ideation through inspiration, focus and motivation re the design brief. Sketch initial ideas and thoughts.

Constructing scientific theory to provide explanations is a goal for scientists. The explanation must ground the phenomenon in evidence.	Experimenting with and understanding materials, tools, techniques and design ideas.	Constructing and designing solutions using a systematic approach to solving engineering problems based upon knowledge and models of the material world.	Model with Mathematics.	Secondary research: investigates the authentic problem in terms of design ideas, tools, materials and techniques, as well as innovations and sustainability.
Argument evidence provide a line of reasoning explaining a natural phenomenon.	Prioritising design factors and criteria, negotiating and optimising the design solution.	Designed solutions are optimised by balancing constraints and criteria off existing conditions.	Appropriate tools strategically.	Applies scientific, technological, engineering and mathematical thinking to models/prototype.
Scientists defend explanations and formulate evidence based on data, and examine ideas with expert understandings.	Investigation of innovative and sustainable design solutions, materials, tools and techniques.	Arguments with evidence is key to engineering for locating the best possible solutions to a problem.	Attend to precision.	Final solution is communicated through sketches and written manufacturing procedures.
Informed decision making, reporting on justifying conclusions.	Informed decision making, reporting on and justifying design decisions.	The best solution is based on a systematic approach: comparing alternatives, formulating evidence from tests, and revising the design solutions.	Look for and make use of structure.	Manufacturing of the design solution.
Iteration toward understanding.	Communication of ideas, design decisions, justifications, explanations, design rules through sketching the iteration toward a solution.		Look for and express regularity in repeated reasoning.	Evaluation of function, aesthetics, quality, innovation, sustainability and the integration of scientific, technological, engineering, authentic, mathematical and

				problem-solving principles.
Explaining scientifically.	Written procedure for manufacturing the solution.			
Investigation planning.	Manufacture of models and evaluation of possible solution Explaining the positives and negatives and refining solutions.			
Teamwork, collaboration across teams, giving credit.	Evaluation of the final solution justifying the product through the positives and negatives and refining solutions.			
Kolodner 2002	Trevallion, 2020	Kolodner 2002	Kolodner 2002	Trevallion, 2020

Given the growing interest in, and relevance of, integrated approaches to STEM education, there is an urgent desire to understand the challenges and obstacles in developing and implementing integrated STEM curricula and instruction.

Shernoff et.al. (2017) explains that on-the-ground challenges and supports are necessary among those who would work most directly to implement integrated STEM curricula and programs of instruction for K-12 education. This is of critical importance, given the significant variation across individuals, schools, and disciplines with respect to current understandings of integrated STEM education and its core components. The author is of the understanding that skills must be taught before a problem can be solved. In order to resolve a STEM problem, all those undertaking the challenging problem must be skilled in all STEM areas including science, technology, engineering and mathematics.

STEM education literature justifies the teaching of STEM concepts in a context delivered in project, problem, and design-based approaches. Greater emphasis should be placed on how teachers are trained to weave together STEM concepts in their classrooms. Further study is needed to better understand how andragogy can be used to teach integrative STEM education concepts to educators and administrators. Better meeting the learning needs of education professionals could further support providing quality integrative STEM education into the pedagogical practices of all teachers (Havice, et.al. 2018). In integrated STEM education there is an emphasis on "real-life contexts and the development of proto-types or models to similar authentic problem-solving or decision-making scenarios" (Fraser, Earle, Fitzallen, 2019). Such an approach is different from traditional STEM pedagogies and cannot be pursued without significant deviations in both curricula and conventional teaching methods. The successful integration of creative arts and other disciplinary approaches in STEM teaching and learning contexts requires teachers capable of learning how to teach alternative disciplinary approaches, as well as an evidence base that justifies this (MacDonald et.al. 2019). It proves advantageous if integrated STEM educators learned the STEM subject concepts and STEM practices outlined above before attempting to solve a STEM dilemma in an integrated fashion.

Efforts are needed to improve teacher understanding and readiness of teachers and schools in designing and implementing STEM learning in elementary schools. The teacher is expected to be able to develop STEM learning that starts from the development of the design principle, to the necessary learning materials, to the implementation. Current research concerning teachers' development of integrated STEM lessons and curriculum units is limited; further, research connecting teachers' conceptions of integrated STEM to curriculum writing is lacking (Lidinillah, et.al. 2019). However, this is an area of STEM integration that lends itself to further research, especially regarding how integrated STEM curricula are implemented in the classroom. Further research is needed as to how these conceptions are enacted in the classroom, as it is possible that the individual conceptions may be more apparent in individual practice compared to a co-written curriculum (Ring-Whalen, et.al. 2018).

In the above, Table 1, it can be seen that when solving a STEM problem, each STEM subject has a different starting point: science begins with a question about phenomenon; technology begins with skills that will be used when creating a design solution; engineering begins with a problem, need, or desire that leads to an engineered solution; and mathematics makes sense of the problem and perseveres in solving them. The author posits that when teaching STEM education, it is necessary to develop skills and technological understandings about all four areas, then integrate and combine these to develop a range of the necessary STEM skills and understandings that will be used within the STEM process to solve the STEM-based problem.

STEM implementation practices in a secondary school

The development of STEM teaching pedagogues by Walker, Moore, Guzey & Sorge, B. (2018) included the integration of eight essential tenets of quality STEM integration environments and nine indicators from the framework for quality K-12 engineering education. The eight essential tenets of quality STEM integration environments were identified from a research review. The tenets include having students:
(1) engage with a personally meaningful and motivating context;
(2) participate in a design task with a compelling purpose that involves problem-solving skills and ties to context;
(3) learn from failure and have the opportunity to redesign;

(4) learn appropriate standards-based mathematics and/or science content;
(5) explore content with student-centered, research-based pedagogies;
(6) participate in teamwork and communication skills;
(7) use evidence-based reasoning to integrate engineering with mathematics and/or science; and
(8) engage in engineering design throughout the unit.

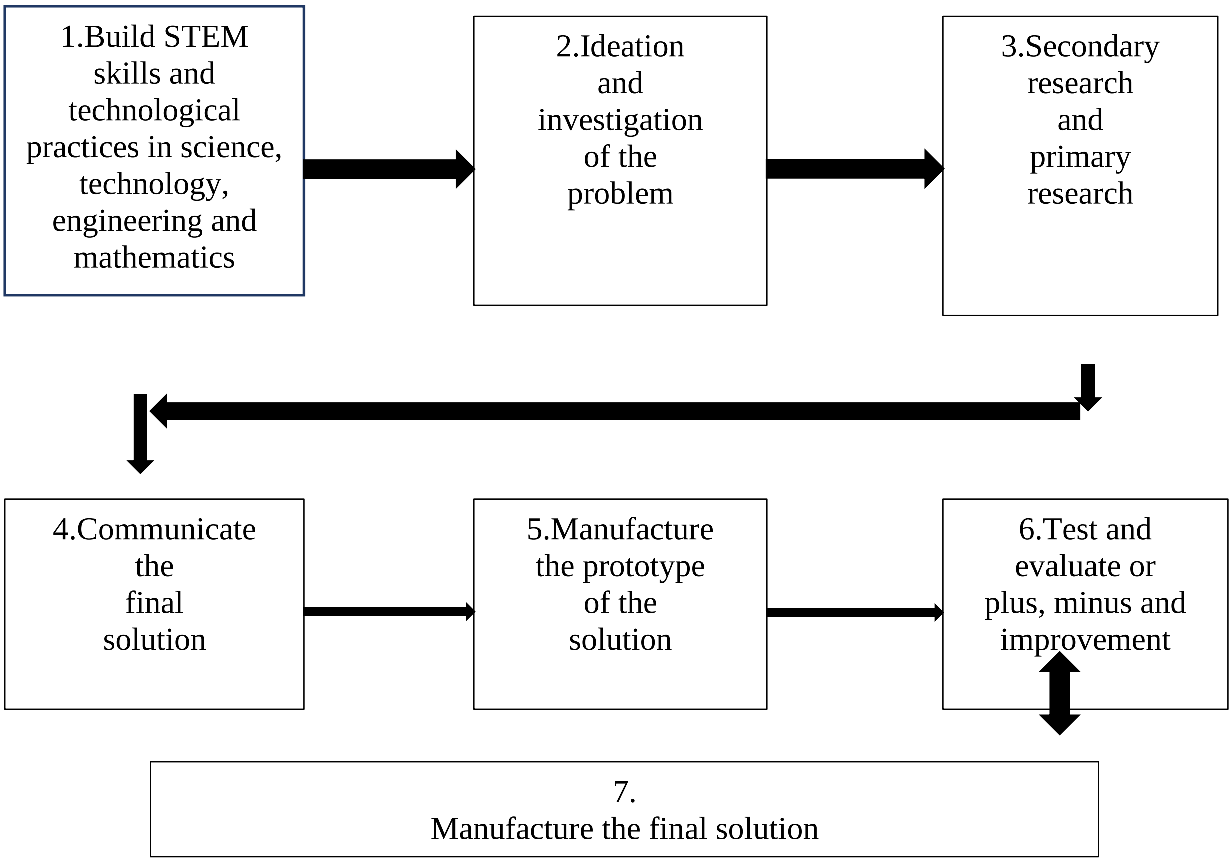
Each of these tenets are a focus within the STEM process presented in Table 2. These qualities have been integrated into The STEM Process created by Trevallion (2020). This process uses the concepts presented by Kologner cited in Zhang, Markopoulos & Bekker (2020), the characteristics of high-quality STEM programs found in Walker, et.al 2018, with Trevallion's 2020 holistic approach to STEM education. The STEM Process to be used in secondary schools is suggested below.

The STEM Process (Trevallion, 2020)

1. Develop STEM skills and technological practices in science, technology, engineering, mathematics, critical thinking, secondary and primary research.
2. Ideation and investigation of the problem
3. Secondary research and primary research
4. Communicate the final solution
5. Manufacture the prototype solution
6. Test and evaluate through plus, minus, improvement.
7. Manufacture the final solution.

This process when used in schools builds success in problem solving. When using problem-based learning, if the teacher teaches some starting skills and inspires and motivates the class by facilitating multi-directional problem investigations, the students can usually take it from these moving through the STEM process in order to solve the problem through the use of critical analysis.

Table 2: Action chart of The STEM Process



Explaining the STEM Process

1. **Develop STEM skills and technological practices in science, technology, engineering and mathematics**

Whilst it is ideal to present students with problems and allow them to create a solution, the reality in the secondary classrooms is many students do not know where to start. This research shows that when the classes are taught, some basic skills surrounding the problem – including research skills – may help to give them a starting point. The students who are working collaboratively, possibly for the first time, have a far greater chance of finding a solution.

Developing STEM skills and technological practices surrounding science, technology, engineering and mathematics makes a difference. It is not possible for some students to successfully solve STEM problems without firstly being taught the underlying skills, concepts and applications in science, technology, engineering and mathematics. Before being given an authentic problem to solve, the students must develop scientific investigation using a systematic approach, develop technological applications about ICT, computer apps and problem solving, develop the necessary engineering skills and understandings about engineering know-how and problem solving and develop mathematical understandings about problem solving, abstract reasoning, decontextualising, abstractions and manipulations. The inclusion and integration of skills from the technology, engineering, science and math curricula contribute to a quality STEM program (Walker, et.al. 2018).

2. Ideation and investigation of the problem

After the students have developed skills and understandings in these areas, they will be given an authentic problem to solve. This means that the problem needs to be real and something for which the students can relate. When providing information about this authentic problem, information must be included that provides background information surrounding the problem. This authentic and collaborative approach to learning uses strategies that connect students and educators with STEM fields and professionals (Walker, et.al. 2018). They will improve the creative and critical thinking needed in STEM challenges. A clear problem with a list of limitations relating to the materials, tools, techniques, ideas, cost and time. As the students focus on the problem, they must identify the areas of the problem that will require further investigation, then pull all of this data together in order to create a clear and concise understanding of the problem. The next step is to sketch the possible initial ideas and possible solutions using thumbnail or rough, hand drawn sketches. This ideation process is shown through the use of inspiration, focus and motivation surrounding the design brief.

The teacher's role when presenting the problem is to focus and motivate the students through inspiring them in a range of different directions. This involves directing the students to examine and investigate the problem from all directions, considering every aspect and impact related to the stakeholders. The teacher could at first scaffold the problem with a list of areas to explore before even considering a solution.

3. Secondary and primary research

The initial solutions are the first ideas that came into their head. These ideas need to be validated and improved. This occurs through the use of both secondary and primary research. Secondary research involves analysing existing information from other researchers work and may be found in magazines, journal articles, video clips and reputable internet sources. This is included to provide global and multi-perspective viewpoints (Walker, et.al. 2018).

The students will carry out secondary research when exploring and evaluating existing solutions, and then justify the direction of their exploration. They will need to carry out primary research in the form of surveys, interviews, blogging, experiments, simulations and building prototypes to inform a deeper understanding. Primary research is information that you gather and share through interviews, surveys, case studies, testing and experimentation and other qualitative and/or quantitative data analysis techniques. Primary research is used to promote scientific inquiry and engineering design, include rigorous mathematics and science instruction (Walker, et.al. 2018). Secondary research is firstly used to investigate existing solutions to the authentic problem. Each solution needs to be evaluated in terms of solution ideas, materials, tools and techniques used. These ideas need to be evaluated in terms of the function, the aesthetics, innovation and sustainability of the solution. When added to initial sketches and ideas, these findings will improve the possible solution, allowing innovations to be included in the developing solution.

Primary Research may be carried out concurrently with secondary research. It is important to test materials and techniques to ensure that they are suitable for inclusion in the solution. Opinions and preferences on the possible solutions need to be gathered before a final solution is decided upon and manufactured. Primary research in online surveys may be used to ascertain the preferred size, cost, materials, and design in order to determine whether the design is viable and will be adopted by the consumer.

4. Communicate the solution

Before the solution can be prototyped and manufactured, it is necessary to communicate the final solution to the client and the stakeholders. This needs to be completed as a drawing – a technical drawing with measurements, a rendered sketch, a perspective drawing and use Computer Aided Drawing (CAD) as a clear medium for communication of the final idea. The final solution needs to be communicated to the stakeholder using hand drawn sketching, technical sketching with correct measurements, 2D CAD and 3D CAD.

The author suggests that the students should download the free education version of Creo 5. It has a great artificial reality component that will allow for 3D modelling and 3D printing of the students work. Another option would be to use the PTC Creo Academic Program. It is necessary to incorporate appropriate technologies to enhance learning (Walker, et.al. 2018). In addition to providing multiple sketches of the solution viewed from multiple angles, it is important to include a written procedure that details the manufacturing process in a step-by-step narrative. Images can be included to demonstrate techniques at important points. In this manner the final solution is communicated through sketches and written manufacturing procedures.

5. Manufacture a prototype of the solution

Once the solution is agreed upon, there is a need to produce a prototype. A prototype is made as a miniature-scale replica. Each step in manufacturing the prototype is recorded in order to repeat it during the final manufacturing stage. The prototype is created to ensure that each manufacturing step is correct and the model will be used to show the stakeholder in order to ensure that all stakeholders are agreed on the final solution. There is a need to apply scientific, technological, engineering and mathematical thinking to create models and/or prototypes of the final solution.

6. **Test, evaluate (Plus, Minus, Improve PMI)**

The prototype will be tested and evaluated in terms of function, aesthetics, quality, innovation, sustainability and the integration of scientific, technological, engineering, authentic, mathematical and problem-solving principles. Once the prototype is made, it must be tested to see whether the design criteria has been met and the solution is successful. After this point students will either continue to manufacture or redesign the prototype, overcoming design faults. The possible solution needs to be evaluated in terms of science, technology, engineering and mathematics. The pluses, minuses and improvements are decided upon. Improvements and changes can be made by anyone involved at this point, at a minimal cost. Once the changes are implemented and approved the solution can then be manufactured.

7. **Manufacture the final solution**

The final step in The STEM Process involves the manufacturing of the superior quality STEM solution. Once the prototype is made, it must be tested to see whether the design criteria has been met and the solution is successful. After this point students will either continue to manufacture or redesign the prototype to overcome design faults. This will involve the incorporation of strategies such as project-based learning, which provide formal and informal learning experiences (Walker, et.al. 2018).

The practicalities of teaching The STEM Process in secondary schools

Integrated approaches to STEM education are increasingly popular, but remain challenging and elusive. The STEM Process described above is suitable for use in secondary schools where teachers want to be involved in teaching STEM but share a common concern that they do not have all of the skills necessary in science, technology, engineering and mathematics to do the course justice. When teaching STEM in a secondary school, it would be taught to a year group as a cross curriculum, and could be a multi-teacher project. It is important to note that the role of a teacher in a classroom has changed. They are no longer the brains trust in the room as the children research content online. The teacher's role has become one of facilitator and motivator. Having said that, teachers frequently resist change and strive to remain the centre of the class. The following STEM teaching model suggests how staff, struggling with their new role may transition to student-centred teaching and learning.

In the following model, STEM is taught by four teachers: a science teacher, a technology teacher, an engineering teacher and a maths teacher, and the students are taught in four classes.

Week 1–4 sees each teacher teach their own subject content, allowing them to share their subject strengths and passions with their students. The student rotates for the first four weeks, allowing them to build skills in science, technology, engineering and mathematics.

In week 5 the staff present the students with a common or varying STEM problem to solve, written predominantly in the week 4 teacher's area of expertise. This must be decided before the semester begins in order for every teacher to have input into the problem's limitations.

From week 4, the students remain with the same teacher as they work through the design process.

In the final week, week 10, the students hold a seminar where they present their problem and each step of The STEM Process that was followed in order to reach a solution.

Each STEM group will have four teachers and four classes. An example of this implementation process in a single instance with four staff and 40 students is apparent in the table below. For larger cohorts of students, this implementation process can to be repeated concurrently in order to cover an entire group of stage 4 students.

Table 3: Model for implementing a STEM program in schools

School Term: Week	Science Content	Technology Content	Engineering Content	Mathematics Content	STEM Project
1	1	2	3	4	Skill Building
2	4	1	2	3	Skill Building
3	3	4	1	2	Skill Building
4	2	3	4	1	Skill Building
5	1	2	3	4	Identification and Investigation Problem
6	1	2	3	4	Secondary Research
7	1	2	3	4	Primary Research
8	1	2	3	4	Communicate final Idea
9	1	2	3	4	Prototyping / Model
10	1	2	3	4	Test, evaluate, PMI
11	1	2	3	4	Manufacturing
12	1	2	3	4	Manufacturing

Findings

Feedback from staff

The teaching staff commented on the high degree of student enthusiasm and engagement experienced in the STEM classroom. This supports Havice, et.al. (2018), who found that integrative STEM education provides children with opportunities for educational engagement and achievement. This approach to education involves problem-based and project-based learning that allows students the opportunity to explore real-world problems while simultaneously developing cross-curriculum skills while working in small, collaborative groups.

Children now expect real-world connections to what they are learning, or else they may completely disengage. Students who are exposed to integrated problem-solving curriculum display increased engagement, satisfaction and express enjoyment in their learning. One of the mathematics teachers stated that he was going to trial The STEM Process in his mathematics classroom – this is encouraging. Havice, et.al. (2018) explain that teachers should use this in their classrooms to refocus and motivate their students. A science teacher exclaimed that any global challenge – including climate change, overpopulation, resource management, agricultural production, health, biodiversity, and declining energy and water sources – could be taught using this approach. This supports Williams (2017) findings that an international approach, supported by further development in science and technology, could adequately address these challenges.

Three teachers expressed the idea that working in STEM and PBL had resulted in students achieving higher scores than they had previously achieved in mathematics and science. This was supported by research and findings from (Walker, et.al. 2018). An engineering teacher expressed that every term he teaches STEM, he does it a little better and is more passionate than the previous term. This may be partially attributed to increased STEM funding for research and education. The urgency to improve achievement in science, technology, engineering and mathematics education is evident by the massive educational reforms within the STEM education disciplines (NESA, 2017).

Feedback from students

STEM's potential is founded in its ability to improve a student's learning experience by assisting in the ability to transfer school-based learning to real and authentic situations in the individual's life. The STEM Process and STEM's potential is founded in its ability to improve a student's learning experience by assisting in the ability to transfer school-based learning to real and authentic situations in the individual's life (Nischang Cusanelli & Trevallion, 2020) as was evidenced in student responses such as "I loved that I got to solve a real problem and help someone." Another student said that she was looking forward to solving another problem because now, they knew how but they wanted to try some more. This is suggests that implementing teaching strategies, such as problem-based learning through a STEM curriculum, may reinvigorate students' desires to understand the world around them and engage them in classroom instruction (Havice, et.al. 2018).

A student said that she "loved doing this because there were so many ways to solve the problem and they were free to choose the ways that they enjoyed the most and working in a group gave us so many more ideas". This research confirms that students become enthusiastic when problem-based instruction is incorporated. She went on to say that, "The teacher kept asking us questions and every time he did, we had a brain melt down because there was so much to think about." These results explain that the teacher spurs student creativity through questions, and students respond through collaborative discussion.

Assessment within the STEM program

It is a widely held belief that STEM assessment is an educational design problem. Since assessment and learning go hand in hand, assessment is also a curriculum design problem. The goal is to establish a balance between formal summative assessment and student motivation to get the most out of PBL investigations. This struggle is not uncommon. The PBL approach has been successfully applied to teaching STEM thanks to its principles of group work, learning by solving real problems, and learning environments that emulate authentic market realities.

However, the lack of well-defined methodologies and processes for implementing the PBL approach represents a major challenge. This approach requires great flexibility and dynamism from all involved, whether in mapping content, in teacher performance, or laying out the process of how learners should go about solving problems. This paper suggests that The STEM Process can help in implementing PBL throughout its life cycle. That is: 1. STEM skills, 2. Ideation and investigation, 3. Research, 4. Communicate, 5. Prototyping, 6. Evaluate and 6. Manufacturing the final solution.

Assessing STEM

Roberts, Jorm, Gentilcore and Crossley (2017) indicated that peer assessment is only good for formative feedback and only within individual PBL groups, while Dos Santos (2017) proposed a new model for assessing PBL group collaboration and participation when learning about software engineering. The Dos Santos (2017) research found the PBL approach has been successfully applied to teaching software engineering thanks to its principles of group work, learning by solving real problems, and learning environments that match the market realities. The research has found that this approach is also appropriate to the assessment of STEM projects and has built up by the author. The following proforma is to be used when assessing students' progress in a STEM classroom. Project specific requirements can be added to each of the content areas if desired. The proposed STEM evaluation model has three levels: 1. Individual student assessment, 2. Problem based learning and 3. Reflective evaluation.

At Level 1 within a STEM classroom, students are at the centre of the learning process and are involved in real situations where they solve real, cross-disciplinary problems. This constructivist method of learning allows groups of students to collaborate in order to create innovative solutions. This promotes within students the development of skills such as self-initiative, cooperation, and learning to take a critical viewpoint.

At Level , the problem-based learning activity must involve "authentic assessment", which emphasises that the context and the problem need to be real. This is important because the assessment of student performance includes student collaboration and participation. Students are more focused and motivated if the problem is real and relatable. The assessment must be integrated with students' activities, including multiple and well-defined performance indicators created through structured and integrated units of development, with clear roles and responsibilities, supported by well-defined tools and processes. Level 2 focuses on assessing the problem-based learning approach using the STEM process.

At Level 3, reflective assessment – be it a written paper or an oral presentation – uses the *Revised Bloom's Taxonomy* by Anderson and Krathwohl. This taxonomy moves from the simplest to a more complex level of thought including the ability: to remember or reproduce ideas; to understand, explaining an idea/concept in one's own words; to apply knowledge to a new and concrete situation; to analyse, dividing information into parts, being able to understand the interrelationship between them; to evaluate based on criteria, standards, and norms and to create or synthesise a new vision or solution based on the knowledge and skills previously learned.

Assessment Model for Assessing STEM Learning

Level 1. Student Assessment. /30

Student Assessment	**Improvement Required <5**	**Satisfactory. 5-6**	**Accomplished. 7-8**	**Outstanding. 9-10**	**Total /30**
Self-Initiative and Autonomous Learning	A greater focus and stronger initiative is required. Tends to be distracted at times.	Mostly focused. Working as expected. Showing some initiative.	Mostly eager and focused. Working beyond expectation. Showing strong initiative.	Always eager and focused. Working way beyond expectation. Showing enormous initiative.	/10
Cooperation and Groupwork	Must contribute ideas. Is a group member.	Occasionally contributes original thought. Is a contributing group member.	Contributes original thought. Is a strong group member.	Often contributes original thought. Is an essential group member.	/10

	Must consider other's ideas.	Considers and or integrates ideas.	Often considers and or integrates other's ideas.	Always considers and integrates other's ideas.	
Critical Viewpoint	A stronger analysis of ideas is needed. A stronger contribution toward the solution is required.	Thoroughly discusses ideas. Integrates some groupwork. Contributes ideas toward the solutions.	Thoroughly evaluates ideas. Integrates most groupwork. Synthesises components of innovative solutions.	Thoroughly evaluates all ideas. Deeply integrates all groupwork. Synthesises innovative solutions.	/10

Level 2. Problem Based Learning /50

Problem Based Learning	**Improvement Required. <5**	**Satisfactory. 5-6**	**Accomplished. 7-8**	**Outstanding. 9-10**	**Total /50**
STEM Technical Knowledge	Improvement required in knowledge and/or application of science. Improvement required in knowledge and/or application of technology. Improvement required in knowledge and or application of engineering. Improvement required in knowledge and/or application of maths.	Basic technical knowledge and or application of science. Basic technical knowledge and or application of technology. Basic technical knowledge and or application of engineering. Basic technical knowledge and or application of mathematics.	Advanced technical knowledge and application of science. Advanced technical knowledge and application of technology. Advanced technical knowledge and application of engineering. Advanced technical knowledge and application of mathematics.	Outstanding technical knowledge and application of science. Outstanding technical knowledge and application of technology. Outstanding technical knowledge and application of engineering. Outstanding technical knowledge and application of mathematics.	
Problem and Ideation or Possible Solution Investigation	Greater problem investigation and research is needed. Greater solution investigation and research of possible solutions is required.	Solid problem investigation and research. Solid solution investigation and research of possible solutions.	Detailed problem investigation and research. Detailed solution investigation and research of possible authentic, original and innovative solutions.	Deep and thorough problem investigation and research. Deep and thorough solution investigation and research of possible authentic, original and innovative solutions.	
Communication	Satisfactory quality of a few of the following: oral, written,	Satisfactory quality of some of the following: oral, written,	Effective quality of many of the following: oral, written, graphic, technical, CAD and virtual	Highly effective, superior quality of all of the following: oral, written,	

	graphic, technical, CAD and virtual reality communication techniques.	graphic, technical, CAD and virtual reality communication techniques.	reality, communication techniques.	graphic, technical, CAD and virtual reality communication.	
Prototype	The prototype solution requires further consideration. The prototype requires a stronger evaluation and synthesised improvements.	Satisfactory prototype solution that is original or innovative**.** A satisfactory evaluation of the prototype with synthesised improvements.	High quality prototype solution that is original and innovative**.** An excellent evaluation of the prototype with innovative and original synthesised improvements.	Superior quality prototype solution that is original and innovative**.** An outstanding evaluation of the prototype with innovative and original synthesised improvements.	
Manufacture the Final Solution	Skills need to be further practiced The solution does not entirely work. Further attention to innovation is needed. The aesthetics need improvement.	Skills of a satisfactory quality have been demonstrated. The solution works. A satisfactory level of innovation is shown in design. The aesthetics are satisfactory.	Skills of an excellent quality have been demonstrated. The solution works well. An excellent level of innovation is shown in design. The aesthetics are excellent.	Skills of a superior quality have been demonstrated. The solution works very well. A superior level of innovation is shown in design. The aesthetics are outstanding.	
				TOTAL	**/50**

Level 3. Reflective Evaluation. /20

Reflective Evaluation	**Improvement Required. <5**	**Satisfactory 5-6**	**Accomplished 7-8**	**Outstanding 9-10**	**Total /20**
Ongoing Reflections	Occasionally throughout the problem-solving process, reflections using recall or comprehension were used.	At fairly regular intervals throughout the problem-solving process, reflections using discussion or analysis were used.	At mostly regular intervals throughout the problem-solving process, excellent reflections using evaluation and synthesis were used.	At regular intervals throughout the problem-solving process, outstanding reflections using evaluation and synthesis were used.	**/10**
Final Evaluation	Reflections using recall and some levels of comprehension. Limited comments linking the solution to few of the	Satisfactory reflections using discussion and or analysis. Reflections linking the solution to some of the following: innovation, original	Excellent reflections using evaluation and or synthesis. Some deep reflections linking the solution to most of the following:	Outstanding reflections using evaluation and synthesis. Deep and thorough reflections linking the solution to all	**/10**

	following: innovation, original thought, sustainability, the solution's criteria.	thought, sustainability, the solution's criteria.	innovation, original thought, sustainability, the solution's criteria.	of the following: innovation, original thought, sustainability and the solution's criteria.	
				Total	**/20**

Table 3: Assessment Model for Assessing STEM Learning

Despite the complexities of authentic STEM development scenarios, it is believed that the application of this assessment model is suitable for any project environment aimed at solving STEM problems in which groups of people collaborate and cooperate with clear goals to serve and meet the needs of real clients.

Conclusion

The future for STEM education is challenging and exciting for both students and teachers. The introduction of STEM in schools has resulted in an increase in student engagement in STEM subjects, and teachers are seeing the benefits of implementing a STEM curriculum that is applicable and relevant to students. With increased emphasis placed on the need for more STEM understandings, now is an ideal time to re-evaluate current STEM education curriculums to ensure they meet this demand. When STEM education curriculums include applicable and appropriate science, technology, engineering and mathematics information delivered through an authentic problem-solving approach, educators will become significant assets to the education system by generating a unique appreciation for specialised STEM knowledge through carefully-designed programs.

Incorporating effective design or problem-based instruction in STEM requires cross-discipline training. This has resulted in NESA and school administrators endorsing professional development, support staff, resources, activities and education initiatives through the provision of educational funding for teachers in an effort to implement STEM programs in their schools. Working in STEM teams, rotating students through skill development activities and allowing them to select the problem that they are most interested in solving will allow students and teachers to work together on the STEM initiatives in their school. Concurrently, the teachers can be undertaking professional development in areas that are not in their expertise, in order to build skills and understandings that will allow them to teach STEM classes as the only teacher.

STEM education is an integrated approach to education for the purpose of instilling creative problem-solving techniques in students and the development of future innovators. STEM education enhances a student's learning experience through application of general principles and practices. When incorporated properly, through the teaching of skills and concepts first, it should inspire creativity, inquisitive thinking, and teamwork. STEM is influenced by the subject content that is science, technology, engineering and mathematics, however, STEM students are expected to go beyond content knowledge. STEM requires students to have project experience and problem-solving skills whilst developing an appreciation of the interplay between theory and practice. From a STEM perspective, the importance of authentic problem-solving skills is essential.

In a learning situation, STEM students are given project-based practical, where the complexity of the task is carefully structured, ensuring the boundaries of the skills to be used were previously taught in the classroom. The practical learning environment should emulate authentic communities of practice. Within STEM classrooms, problem-based learning places students at the centre of the learning process and involves them in real situations. This constructivist method of learning allows students to work in teams to solve problems, fostering the development of skills such as self-initiative, cooperation, and learning to take a critical viewpoint.

STEM problem-based learning can be adopted effectively when guided by a well-defined process of planning, implementation, monitoring, and evaluation, so as to implement continuous improvements. This assessment cycle is divided into the steps to aid the diagnosis, analysis, and resolution of organisational problems. These process steps refer to an initial investigation of the authentic problem and possible innovative and original solutions that are communicated with the group orally, in writing, and using graphics, including technical drawing, CAD and virtual reality. Students will work autonomously on sections and bring the work to share with the group as they build a functioning prototype that will be considered, evaluated and improved upon taking corrective action to avoid possible failures and to improve the quality, efficiency, and effectiveness of the processes involved in the manufacturing of the final solution. As teachers, it is important that we are knowledgeable about the demands on our students. Learners in the 21st century will be required to exhibit understanding and skills that were unimaginable to us just a decade ago. STEM teachers have the responsibility of preparing students to be actively engaged in future endeavours.

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