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An Integrated STEM Framework for Facilitating Statistics Instruction

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Abstract
The spirit of innovation in education has become part of the methods used to reform the way knowledge is learned. Many researchers and educators have continuously made significant efforts to encourage the use of a STEM-integrated approach in the classroom. However, several obstacles exist, such as a lack of teaching resources and pedagogical content knowledge, when teachers want to incorporate the approach into mathematics classrooms. Thus, the Malaysian Statistics Module for Form Four Students (MySTAT4) module was developed to nurture teachers' and students' statistical thinking and inventive skills such as reasoning, critical thinking, and creativity. In this paper, we present the conceptual framework of the MySTAT4 module and demonstrate a brief lesson for teaching and learning a statistics topic based on the approach. Through a content analysis method, we reviewed and analysed literature and documents on STEM-integrated approaches and statistics topics to produce the MySTAT4 framework that connects problem-solving and problem-based learning. The framework is suitable for assisting the STEM and mathematics education communities in developing, providing standard lesson materials and assessment tools, and innovating integrated pedagogical approaches to statistics topics. By utilising the framework, both practitioners and researchers can adapt a common foundation that relates the ways, steps, processes, and activities of problem-solving across interdisciplinary domains into a single point of reference.
Keywords: Integrated STEM, Problem-solving, Engineering-Design Process, Statistics Instruction

Introduction

The global socio-economic landscape worldwide has changed due to innovation and the acceleration of knowledge based on the mobile internet, big data, the Internet of Things (IoT), and the rapid pace of the Industrial Revolution 4.0 (IR4.0). Therefore, Malaysia needs to produce students to be innovators in the science, technology, engineering, and mathematics (STEM) field to compete in the 21st-century employment market. STEM literate students can identify, apply, and integrate STEM concepts to understand more complex problems and generate innovations to solve problems. In addition, to strengthen the STEM ecosystem by focusing on getting more students engaged in STEM learning and activities in the hopes that they will continue in STEM courses and career paths to meet the demand for STEM jobs. Thus, in the long run, to increase the STEM literacy of society as a whole.

In the last few decades, the United States, the United Kingdom, France, Russia, Finland, China, and Australia have focused on developing a national strategic plan for STEM areas. For instance, the National STEM Learning Centre was created in the United Kingdom to act as a facility that offers continuous training specifically for STEM instructors to increase student participation in STEM fields and encourage students to choose STEM-related occupations (Niemi, 2015). Finland and the United States have also implemented the *Luonnontieteet Matematiikka* (LUMA) Centre and the Federal STEM Education Strategic Plan to promote mathematics, science, and technology competency. To improve STEM literacy, students need basic mathematics and science knowledge.

Integrating STEM in natural settings may be as complex as the global issues that need a new generation of STEM experts. According to educational studies, teachers struggle to draw links across STEM subjects. Consequently, students are often uninterested in science and mathematics when taught in a way that lacks linkages to interdisciplinary ideas and practical applications (Kelley & Knowles, 2016). For instance, mathematics has a unique and important role in education (Gafoor & Kurukkan, 2015). It plays a role in developing the human mindset, leading a strategic and systematic reasoning process, and solving problems in daily life (Phonapichat et al., 2014). Mathematics also supports the learning of STEM fields such as technology, science, and engineering as well as a non-STEM field such as social sciences, finance, logistics, and economics to make predictions, and decisions, solve problems systematically and is needed as a tool for learning science and technology and STEM integration (English 2016; English 2017; English & King, 2019; Gafoor & Kurukkan, 2015; Maas et al., 2019).

Although the demand for STEM-related careers will be very high in the future, students' performance, interest, and inclination toward STEM subjects, especially mathematics and science, have become a significant concern (Academy of Sciences Malaysia, 2018). The PISA 2018 report showed that students' mathematical thinking and reasoning performance is unsatisfactory (Organisation for Economic Co-operation and Development [OECD], 2019). For all OECD countries, only 2.4% of students mastered the process of mathematical thinking and reasoning. This indicates that students must do arithmetic and observe patterns, logic, and processes when solving a given problem.

In today's world, statistics are rapidly gaining prominence and attention. Statistics is essential for advancing research, economics, politics, schools, and universities (Garfield et al., 2015; Smith et al., 2019; Watson et al., 2020). Most school curricula include Statistics as a component of the mathematics discipline. Statistics may promote the integration of STEM fields (Watson et al., 2020). This is achievable owing to its incorporation into a specific STEM curriculum and its usefulness in building learning experiences using statistics as a pedagogical framework. Aside from this, the basic idea of variation, which supports statistics, is the beginning point for relevant STEM activity. Statistics provides a method for integrating STEM from the outset of students' educational experiences due to the ability of the statistical practice to aid in making judgments based on data acquired across these disciplines (Watson et al., 2020). In addition to the general need for a statistically literate population, the growing recognition of the importance of STEM fields for solving a nation's economic and environmental problems and the emergence of the field of Data Science increase the pressure to hire more professional statisticians.

Statistics is generally concerned with acquiring knowledge from data and problem-solving rather than methodology (Watson et al., 2019). Guidelines for Assessment and Instruction in Statistics Education (GAISE) recognized that variation is the fundamental feature underpinning the entire practice: (1) formulate questions with variability in mind, (ii) collect data with variability in mind, (iii) analyze data with variability in mind, and (iv) interpret Results with variability in mind.

Despite increased demand, many students and teachers find statistics difficult and unpleasant (Lavidas et al., 2020). Based on previous studies, some of the problems identified in the teaching and learning of statistics were; (1) Many statistical notions and principles are complex and/or counterintuitive. Motivating pupils to understand statistics is challenging; (2) Many students struggle with the arithmetic behind statistics (fractions, decimals, algebraic formulae), which hinders their learning; (3) Context in many statistical questions may mislead students, prompting them to depend on their experiences and frequently inaccurate intuitions rather than a statistical approach, and (4) Students connect statistics with arithmetic and anticipate numbers, formulas, and one proper solution. They dislike messy facts, diverse interpretations based on assumptions, and excessive writing and communication (Ben-Zvi & Garfield, 2004; Garfield et al., 2015). Several issues have led to initiatives to improve statistics education at all levels. These variables include new data exploration tools, changes in technology usage and availability at home and work, and increasing awareness of the consequences of not developing students' statistical thinking and reasoning (Garfield et al., 2015). According to Smith et al. (2019) and Watson et al. (2020), integrated within a STEM framework, the Practice of Statistics teaches students how the data they gather may be evaluated in more rigorous ways to increase their comprehension of the subject they are studying and offers a powerful method for resolving questions given in any STEM field. STEM investigations provide the context and variance that imply and compel students to use statistics. This approach helps students raise a real-world issue or problem, devise a strategy, gather data, represent, analyze, interpret, and reach a conclusion with some ambiguity (Smith et al., 2019; Watson et al., 2020).

Table 1
Difficulty level of learning topics in DSKP Mathematics Form Four

Learning topic	**Student**		**Teacher**	
	M	**SD**	**M**	**SD**
Quadratic Functions and Equations in One Variable	2.65	.911	2.8770	.88883
Number Bases	2.17	.881	2.3722	.74337
Logical Reasoning	2.82	.909	2.7896	.86288
Operations on Set	2.74	.893	2.5922	.77840
Network in Graph Theory	3.08	.902	3.0744	.88510
Linear Inequalities in Two Variables	3.04	.951	2.8414	.87020
Graphs of Motion	3.06	.935	3.0647	.83492
Measures of Dispersion for Ungrouped Data	3.02	.978	3.0259	.88235
Statistics of Combined Events	3.19	.960	3.1683	.91745
Consumer Mathematics: Financial Management	3.19	.981	3.1586	.86646

In the Malaysian context, most teachers need hands-on training to integrate STEM fields into school. According to Science Outlook 2017, 47% of the 16,115 STEM secondary school teachers in Malaysia who participated in the survey had never attended STEM-related training or been exposed to STEM-focused teaching materials (Academy of Sciences Malaysia, 2018). We believe the teachers' expertise significantly impacts the quality of education that would provide students with a proper learning environment and social-emotional support. A preliminary survey was conducted using 309 teachers and 1159 students from all over Malaysia. The survey found that statistic statistics was one of the challenging topics in the Form Four Mathematics Curriculum and Assessment Standards Document (DSKP). Table 1 shows the mean scores of difficulty levels of each title.

STEM Integration

The integration or combination of STEM subjects is one of the ways or platforms to help students gain meaning and interest in STEM fields and STEM-related careers. According to context, researchers differ in the language and terminology used to describe STEM integration. Commonly used terms are STEM integration, integrated STEM, integrative STEM, and interdisciplinary STEM (Moore et al., 2020). One of the common themes or definitions researchers use is that STEM integration focuses on problems in a real-world context (Moore et al., 2020).

STEM integration is often described as a new approach in the 21st Century. The integration process can help develop STEM literacy and 21st-century skills with creativity, curiosity, collaboration, and critical thinking (Shahali et al., 2017; Sias et al., 2017; Ugras & Genc, 2018; Money & Knobloch, 2018). Some researchers argued that STEM problems are not only applicable to the real-world context; STEM lessons and problems need to be explicitly related to students and the community. The aim is to allow students to see their potential in STEM-related careers and the implications of STEM fields in their lives (Moore & Smith 2013; Ryu et al., 2018; Ugras & Genc, 2018). Several researchers agree that integration in school subjects can make students' subjects and problems more interesting and applicable (Berland & Steingut, 2016; Corlu & Aydin, 2016; Ugras & Genc, 2018).

Moreover, STEM integration is an effort to incorporate at least two of the four STEM disciplines into a classroom, unit, or lesson based on the relationship between subjects and real-world problems (Moore et al., 2014). Several studies define the number of disciplines included in STEM integration (Moore et al., 2020). Many define STEM integration as the unification of two disciplines (Brown & Bogiages, 2019; Debs & Kelley, 2015; Hong et al., 2019; Kelley & Knowles, 2016; Ntemngwa & Oliver, 2018; Thibaut et al. 2018) in which science is typically integrated with engineering (Barth et al., 2017; Berland & Steingut, 2016). Ah Nam and Osman (2018) also focused on engineering design by defining STEM integration as applying and integrating engineering practice with science and mathematics content and practice to plan and produce problem-solving technologies through collaboration and communication.

Although there are different definitions and models for integrating STEM content and practice, five features differentiate experiences in STEM learning from the aspects of lessons, activities, or courses that connect all STEM disciplines. The five features are (1) the content and practice of one or more disciplines of science and mathematics determine some key learning objectives, (2) the integrator is the practice of engineering and engineering design as a context, and (or) a component of the subject to be studied, (3) engineering design or practices related to relevant technologies require the application of scientific and mathematical concepts through design justification, (4) emphasis on 21st-century skills development and (5) teaching requires real-world problem solving through teamwork (Bybee 2013; National Academy of Engineering (NAE) & National Research Council [NRC], 2014; National Research Council [NRC], 2012; Partnership for 21st Century Learning, 2015; Sanders, 2009).

Wang and Knobloch (2018) described the levels of STEM integration as disciplinary, multidisciplinary, interdisciplinary, and transdisciplinary. The approach encompasses core concepts and skills taught separately but within the same theme. Introducing concepts and skills close to two or more disciplines deepens transdisciplinary approaches' understanding, skills, and application. Knowledge and skills from two or more disciplines are applied to real-world problems and projects. The goal is to shape the overall learning experience (English, 2016). The disciplinary level is not considered STEM integration. At the same time, the transdisciplinary is regarded as the highest level, where students need to establish connections between disciplines, careers, and STEM problems in the real world and their communities (Moore et al., 2020).

The multidisciplinary approach in STEM integration offers a sharing of the same theme learned by students in different instructional disciplines. The interdisciplinary relationship is highly limited to a specific theme only. Interdisciplinary integration provides an additional layer of curriculum integration as learning goals from multiple disciplines are combined into clear concepts. It does not require a team of teachers from each discipline; instead, only one teacher can form learning objectives from various disciplines to support in-depth learning of a concept. Finally, interdisciplinary integration allows students to respond to essential questions in a real-world context using 21st-century skills encompassing inquiry processes, problem-solving, critical thinking, creativity, and innovation. These skills allow teachers to position their mathematics and STEM conceptualizations flexibly and adaptable (English, 2016). The level of STEM integration is summarized in Table 2.

Table 2
Levels of STEM integration

Type of Integration	**Description**
Discipline	Content is studied in separate disciplinary classrooms
Multidisciplinary	Content is studied separately but linked through common themes
Interdisciplinary	Focus on interdisciplinary content and practice from two or more related disciplines through the same theme or problem
Transdisciplinary	Content from two or more disciplines is applied to real-world problems, focusing on learning

Problem-Based Learning

Problem-based learning (PBL) is student-centered learning in which students acquire knowledge through collaboration and problem-solving activities (Rehmat & Hartley, 2020). Teachers act as facilitators and guide students through investigative activities. PBL is an approach that replaces traditional teaching methods that can enhance 'students' conceptual knowledge, enhance high-level thinking skills and improve student achievement (Algebra & Gheith, 2016; Li & Lung, 2017; Merritt et al., 2017; Ikram et al., 2019; Rehmat & Hartley, 2020;

Ugras, 2019; Yew & Goh, 2016). The problem-solving process using various mathematical utilities such as numbers, polygons, and graphs supports arguments and explanations in mathematics. However, there are differences in representations and arguments for other STEM disciplines. For example, students argue from experimental evidence linked to scientific principles in a science subject. Meanwhile, many engineers say in design-based activities, testing, evaluation, and modification of the designs (Slavit et al., 2019).

Based on the literature, mathematical problems are classified into routine and non-routine problems (Bayazit, 2013). Some researchers categorize three mathematical problems: basic problems, advanced problems, and practical problems (Loc et al., 2020). Routine problems can be solved with four operations often used in life (Altun, 2014). Routine problems help students understand arithmetic operations, reinforce concepts and solve non-routine problems later. Non-routine problems cannot be solved quickly and require more than one solution strategy. This process will develop thinking among students (Altun, 2014). Problem-solving involves complex processes encompassing various mental processes and skills through high-level cognitive operational processes such as visualization, comprehension, reasoning, and analysis. Students can also plan solution strategies using appropriate mathematical skills and models (Usta, 2020).

Some researchers stated that two problems are commonly highlighted in mathematics learning: well-structured and ill-structured problems (Paradesa, 2018). A well-structured problem usually has more than one solution, and all relevant information is available. Unstructured problems have solutions that have multiple perspectives and require additional information to solve them (Mustafa, 2018; Paradesa, 2018). Mathematical problem-solving has two significant meanings in learning. As a teaching approach, it provides contextual problems as a starting point and subsequently understands mathematical concepts or principles. Mathematical problem-solving is achieved after learning and the solution is unknown. In this case, students need to integrate their knowledge by developing new understandings. This problem is non-routine and usually relates to real-life or real situations (Paradesa, 2018).

Problem-solving using Process Design Engineering (EDP)

Based on the literature review, the engineering design process (EDP) guides creative problem-solving, especially in a real-world context (Cunningham et al. 2018; Kelly & Knowles 2016; Long et al. 2020). The measures involved in EDP can enhance 'students' ability to apply science and mathematics concepts in problem-solving, and EDP refers to how science, technology, engineering, and mathematics are integrated with each engineering design task (English et al., 2017; English & King, 2015).

There are several models that previous researchers have attenuated to explain EDP. Cunningham (2009) and Cunningham et al. (2018) presented five phases involved in EDP: ask, plan, create, and improve, as shown in Table 3. Each phase is cyclical, indicating that students can independently determine which phase should be preceded. Nevertheless, Cunningham (2009) suggested that the phases in engineering design should be implemented in sequence to facilitate students to understand problem-solving activities more systematically. Repetitive activities and practices can represent the engineering design process at each design stage, such as solution planning, implementation, testing, and evaluation (Moore et al., 2014). Moore et al. (2014) also claimed that engineering practice requires the application of mathematics and science through the development and expansion of technology and, in turn, provides methods to integrate STEM disciplines meaningfully. This practice can provide a real-world context to teach mathematics and science through engineering design (Maiorca & Stohlmann, 2016). This is also agreed by many researchers who proclaim that engineering is an essential tool to integrate science, technology, and mathematics (Grubbs & Strimel, 2015).

Table 3
Phases of Engineering Design

Phase	Description
Ask	● Students think of a given problem ● Students extract information from a given problem
Imagine	● Students think of the subsequent step to solve the problem. ● Students think of mathematical concepts that are appropriate to a given problem situation. ● Teachers help provide ideas about the relevance of problems to mathematical concepts (Cunningham, 2009)
Plan	● Students choose the best solution strategy. ● Students discuss in groups to ensure that the chosen strategy can be implemented. ● At this stage, students create a plan by drawing diagrams or making representations so that they can be applied in the subsequent phase
Create	● Students translate sketch diagrams from the third phase into the final product of mathematics.
Improve	● Evaluation is conducted so that improvements can be made to produce a product that aligns with the question's requirements. ● At this phase, students only need to list the correct and incorrect solution steps that have been conducted. Then, students rectify the false steps.

Based on the EDP phase by TeachEngineering (2021), seven phases should be undergone to achieve the learning objectives, as shown in Figure 1.

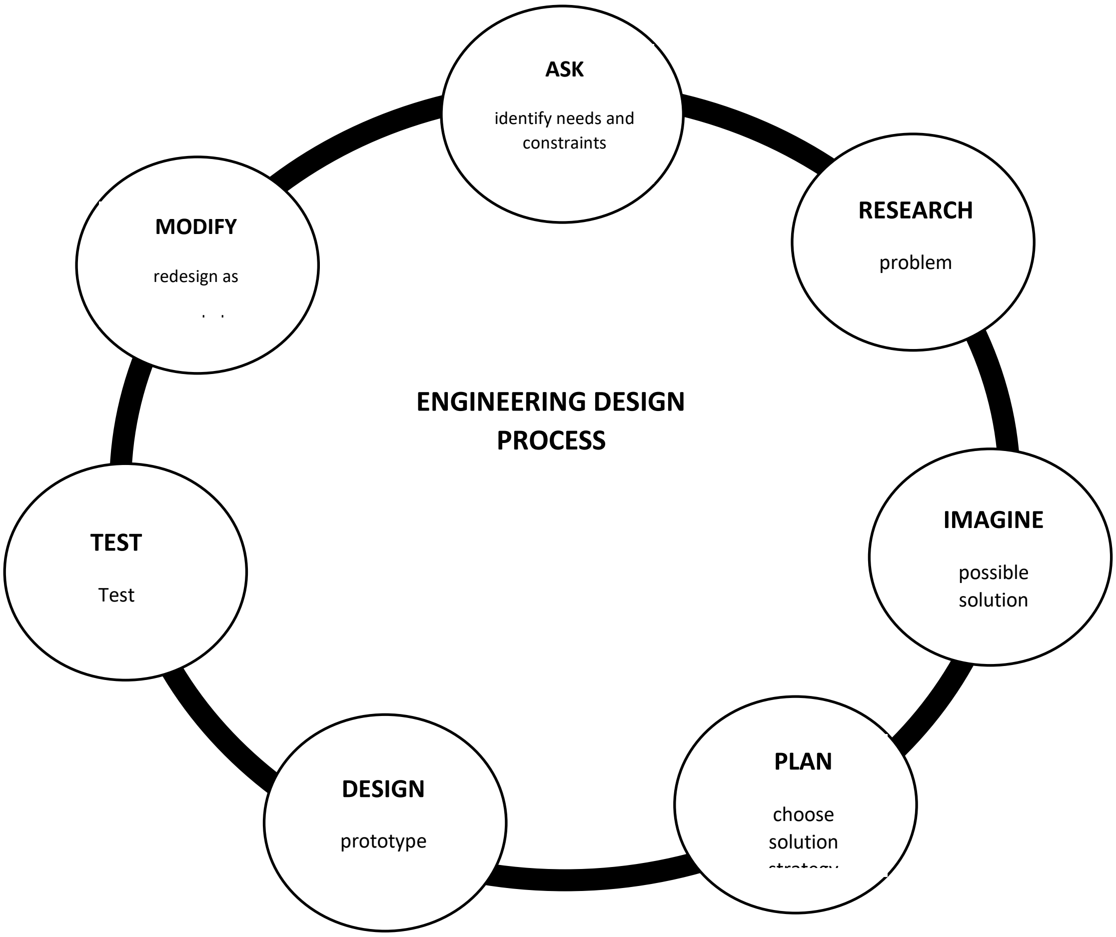

Figure 1 Engineering Design Process (TeachEngineering 2021)

Students will be asked critical questions about their solution or innovation for the asking phase, including what they need to accomplish, the purpose of the design or solution, limitations, and goals. For the research phase (problem), students must conduct brief research from various aspects and backgrounds, whether the solution ever existed and requires technology. The imagine phase requires students to discuss in groups to generate ideas for possible solutions to each situation and problem. In this process, group collaboration is crucial, and each student needs to encourage other members to create ideas. The planning phase is considered a relatively tricky phase, where all students in the group need to compare their ideas and choose the best solution.

Meanwhile, the design phase (create) requires students to build a prototype based on the selected design. Students need to use a very high level of creativity. In the testing phase, students must communicate and test whether the prototype or solution can solve the problem or achieve the objective. The last phase, to improve, requires students to improve each problem encountered.

EDP processes in mathematics T&L have not been widely implemented as many consider engineering practice only for engineers. EDP is an effective integrator for linking mathematics with other STEM disciplines. Although its implementation is not yet widespread, EDP appears to improve academic achievement and foster meaningful experiences among students (Fidai et al., 2020). This exposure allows students to experience and think like mathematicians and engineers (Brakoniecki et al., 2016; Pugalenthi, 2019).

Statistical Thinking
The activities in this module are designed to guide students toward forming statistical thinking, which is necessary for the classroom and the real-world context. Statistical thinking in the context of this study means understanding and using the context of a problem in forming an investigation and drawing conclusions, and recognizing and understanding the entire process (from posing questions to data collection to selecting analysis to hypothesis testing). Finally, statistical thinkers can criticize and evaluate the results of solved problems or statistical studies. The activities in the module are designed so that students are guided toward forming statistical thinking among students. The four levels of statistical thinking considered in this module are the Idiosyncratic level, the Transitional level, the Quantitative level, and the Analytical level. Aspects that will be seen include students' abilities in several things: analyzing, organizing, reducing, representing, and analyzing and interpreting data.

Inventive Thinking
The activities in the module are designed to guide students in forming inventive thinking, which is much needed in the classroom and problem-solving activities in real-world contexts. Inventive thinking is one of the habits of mind (minds of habit) listed by NCREL and Metiri Group (2003) in enGauge 21st Century Skills for 21st Century Learners. It is an effort in the form of mental (cognitive strategy and mental attitude that is systematic and deductive) and an attitude that is the primary catalyst for an individual to see a problem or challenge from a positive and manageable perspective. Inventive skills include adaptability and complexity management, self-regulation, curiosity, creativity, risk-taking, and higher-order thinking and reasoning.

5E BSCS Instructional Model
The 5E BSCS Instructional Model, also known as the BSCS (Biological Sciences Curriculum Standard), is used as a guide to design the Dispersion Measures teaching and learning (T & L) steps. This model comprises five phases: engagement, exploration, explanation, elaboration, and evaluation (Bybee, 2009). The 5E instructional model is one of the developed instructional practices based on constructivism (Turan & Matteson, 2021). In mathematics education, a more inquiry-based approach is meant to encourage students' participation and ownership of their learning and a "human perspective" of science as knowledge that is still being formed. Educators need to adopt instructional strategies that encourage students' active participation in acquiring conceptual knowledge of mathematical topics (Panaoura, 2018). The strategy is associated with enhanced communication, cooperation, creativity, sense-making, intellectual risk-taking, and mathematical depth of thought (Makar & Fielding-Well, 2018).

The theory underlying Problem-Based Learning through the engineering design process approach
Problem-based learning is underlined by constructivist learning theory.

Constructivism
The constructivist theory focuses on the role of students as builders of knowledge (Longden & Solomon, 1986; Wang, 2014). Among the significant theories that contributed to the growth of constructivism include the learning theories of Piaget, Vygotsky, and Bruner (Ah Nam, 2017). Piaget's theory explains how humans organize information into cognitive structures and how cognitive development occurs. According to Piaget, new information is organized

into existing cognitive structures (schemas) through two cognitive processes: assimilation and accommodation. Piaget insisted that both assimilation and accommodation processes are complementary and must coincide. This indicates that cognitive development can occur when cognitive imbalances or conflicts are resolved. The equilibrium process aims to restore balance or resolve conflicts through complementary assimilation and accommodation processes (Gatt & Vela, 2003). Vygotsky's learning theory explains that learning could be enhanced through social interaction and discovery. Vygotsky believed that learning is influenced by the social environment and emphasized the role of social interaction in learning and cognitive development. Collaboration between students and teachers or peers provides platform for students in the Proximal Development Zone (ZPD) to help them build knowledge (Gatt & Vela, 2003)

Meanwhile, Bruner believed that learning and problem-solving result from exploring new knowledge (Wen, 2018). If students discover their knowledge and relationships, they will gain an in-depth understanding. Briefly, the constructivist theory states that students interpret new information based on existing knowledge and then reconstruct it in a form acceptable to them. Cognitive conflict and idea structuring will occur through social interaction when students share ideas from their perspectives. However, no interaction would be beneficial if new information was presented to students traditionally. Instead, students should be allowed to explore new knowledge (Gatt & Vela, 2003)

Conceptual Framework of MySTAT4 Module

The PBL model was initially formed in medical education in the 1960s (Kardoyo et al., 2020; Merritt et al., 2017b). The model emphasized problem-based content structure, student-centered approaches, and explanation of knowledge through social interaction and became one of the most effective strategies in mathematics learning (Akyuz, 2020; Smith & Hung, 2017; Usta, 2020). Problem-solving requires active exploration of the world around us, efficient knowledge acquisition strategies for unknown situations, and creative application of knowledge that can be gathered during the process (OECD, 2019).

Based on the literature, mathematical problems are classified into routine and non-routine problems (Bayazit, 2013). Some researchers categorize three mathematical problems: basic, advanced, and practical problems (Loc et al. 2020), as well-structured and ill-structured problems (Paradesa, 2018). Routine problems can be solved with four operations often used in life (Altun, 2014). Routine problems help students understand arithmetic operations, reinforce concepts and solve non-routine problems later. Non-routine problems cannot be solved easily and require more than one solution strategy. This process will develop thinking among students (Altun, 2014). Problem-solving involves complex processes encompassing various mental processes and skills through high-level cognitive operational processes such as visualization, comprehension, reasoning, and analysis.

A literature review found that PBL is an appropriate teaching strategy to facilitate subject integration (Brears et al., 2011; Bryan et al., 2015). Students can improve their critical thinking ability through STEM-based PBL activities. STEM integration through the PBL approach can increase students' interest in STEM fields and increase creativity and curiosity. STEM integration is one approach that provides students with knowledge-rich interdisciplinary experience, fosters high-level thinking, and fosters positive attitudes in STEM field content (English et al., 2017; Moore & Smith, 2013; Roberts, 2013). Moreover, EDP guides creative problem-solving, especially in real-world contexts (Cunningham et al., 2018; Kelly & Knowles, 2016; Long et al., 2020). The measures involved in EDP can enhance 'students' ability to apply science and mathematics concepts in problem-solving, and EDP also refers to how science, technology, engineering, and mathematics are integrated into each engineering design task (English et al., 2017; English & King, 2015).

There are many misconceptions about the definition of EDP. Due to the word engineering, many assume that only engineers can teach engineering. EDP is also often misunderstood as it requires a mere product or something to be built. In contrast, EDP is an ' 'engineer's perspective in solving working requirement problems in an engineering context. EDP evaluates solutions to various constraints and criteria using thinking, computer software, or mathematical solutions (Turner et al., 2016). Several studies have explained that EDP is generally defined at the school level as (1) defining a problem and identifying criteria and constraints to overcome it, (2) determining the number of possible solutions, and selecting a suitable strategy that best suits the needs of the problem, (3) optimizing solutions with systematic testing including the marginalization of less critical features (Lucas & Hanson, 2016; National Research Council, 2012).

In MySTAT4, students use EDP to develop ideas and solve the statistics problems presented. The EDP measures involve five processes, namely ask, imagine, plan, create and improve, which are modified from the model developed by Cunningham (2009), Cunningham et al. (2018), and TeachEngineering (2021). The EDP process is implemented in an elaborate phase involving teachers challenging and extending students' conceptual understanding and skills. Through new experiences, the students develop a deeper and broader understanding, more information, and adequate skills. Students apply their knowledge of the concept by conducting additional activities. Teachers implement teaching and learning processes based on the 5E instructional model (Bybee et al. 2006).

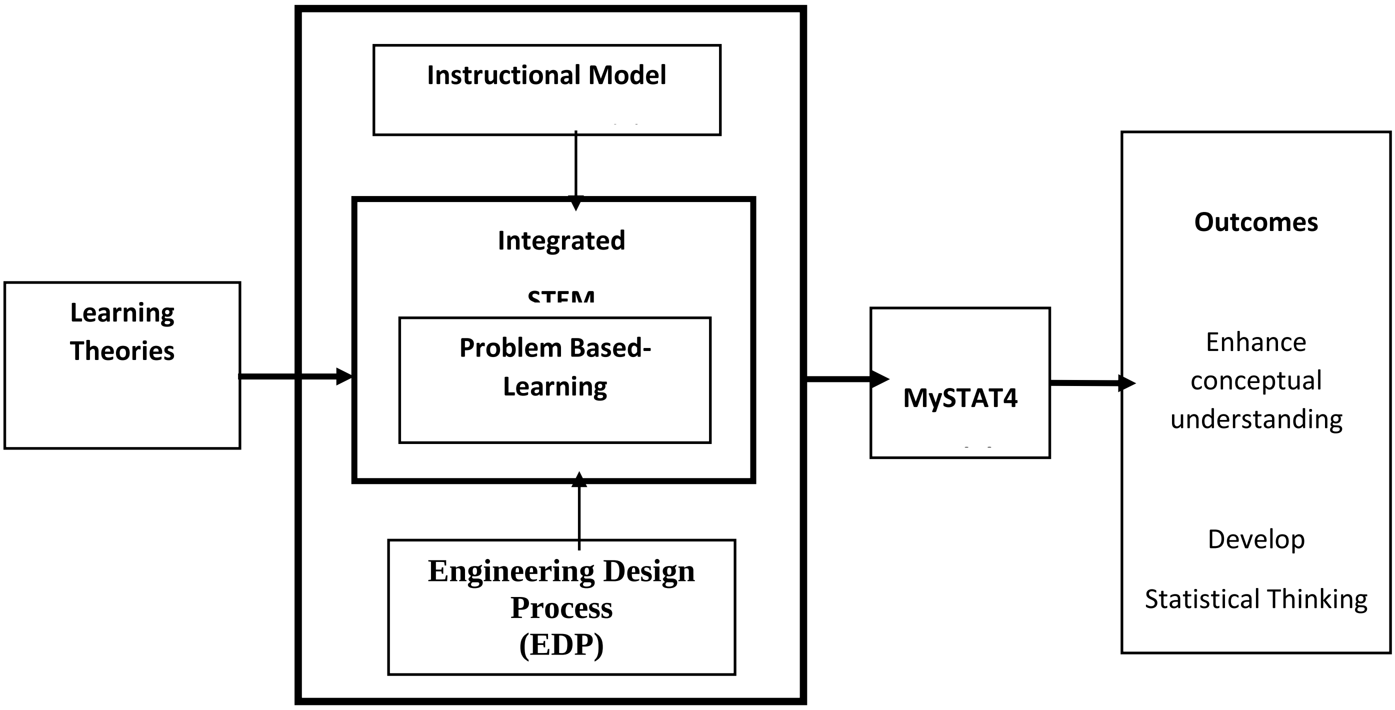

Figure 2 Conceptual framework of the study

Implementation of MySTAT4 Module

The following section presents a brief lesson about the MySTAT4 module on the teaching and learning of a specific unit in the statistics chapter.

Phase 1: Engagement

1. Students are given a daily situation/problem for the topic of statistics. Identify the natural phenomena in the video (video link provided earlier).
2. Discuss the causes of natural phenomena.
3. Discuss the effects of natural phenomena on human activities.
4. Make a connection between the field of statistics and meteorology (use of statistics in real situations).
5. Present the group's answers.
6. Students will discuss and compare ideas with friends in pairs and groups on the issues/problems presented.
7. At this phase, the teacher or a curriculum task accesses the 'learners' prior knowledge and helps them engage in a new concept through short activities that promote curiosity and elicit prior knowledge. The activity should make connections between past and present learning experiences, expose previous conceptions, and organize 'students' thinking toward the learning outcomes or current activities

Phase 2: Exploration and Explanation

1. Students will be given a real situation/problem.
2. Students perform *hands-on* and *mind-on* activities in groups based on the problem/situation given (Note: at the same time, students practice the skills needed in the activities).
3. Students are encouraged to engage in discussions and information seeking.
4. Students generate an explanation of each phenomenon.
5. Students are asked to report back with their findings.
6. Students also listen to the 'teacher's explanations. The key concepts involved are described with computer animation.
7. Students compare their ideas with the ' 'teacher's explanations.
8. The explanation phase focuses 'students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills, or behaviors. This phase also provides opportunities for teachers to introduce a concept, process, or skill directly. Leaners explain their understanding of the concept. An explanation from the teacher or the curriculum may guide them toward a deeper understanding, which is a critical part of this phase

***Phase 3: Elaboration* (Engineering Design Process)**

Ask	● Students think about the problems given ● Students extract information about what the problem/constraints are. ● Students brainstorm the design of the solution and select the best answer from their brainstorming session.

Imagine	● Students do the background research dan think of subsequent steps to solve a problem. ● Students think of mathematical concepts that are appropriate to a given problem situation. ● Brainstorm and explore a possible solution. ● Teachers help give ideas about the relevance of problems to mathematical concepts
Plan	● Students choose the best solution strategy. ● Students discuss in groups to ensure that the chosen strategy can be implemented. ● At this stage, students make plans by drawing diagrams or making representations so that they can be applied in the next phase ● In this process, students will develop and use information. ● State any underlying conditions that need to be made to determine the answer to the statistic problems. ● . Decide a model that will be used to match the problems.
Create	● Students translate sketch diagrams from the third phase into the final product of mathematics. ● Build a prototype/model/solutions/sketch diagram. ● Test it out. ● Collect and analyze data/feedback ● Conduct the trial. ● Record the results of the trial. ● Continue to run trials. Run a large number of trials. Remember to report the result of each trial. ● Summarize the results of the trials and conclude.
Improve	● Evaluation is performed for improvements to produce a product that aligns with the question's requirements. ● Students only need to list the correct and incorrect solution steps at this phase. Then, students need to rectify the false steps. ● Analyze feedback. ● Reflect and discuss what can work better (solutions). ● Modify/improve the solutions.

Phase 4: Evaluation

1. Students reflect upon the extent to which their understanding, abilities, and competencies have changed.
2. The evaluation phase encourages students to assess their understanding and abilities and provides opportunities for teachers to evaluate student progress toward achieving educational objectives.

Conclusion

Through the MySTAT4 module, students can solve statistical problems using EDP. They work in groups and apply the statistical knowledge learned to imagine, plan strategies, and solve and evaluate planned processes. Students are given autonomy to implement their plans based on the group's results; each member collectively assists and acts as a knowledge builder. During group discussions, students' misconceptions may come to the fore. This approach allows students to evaluate their knowledge and make decisions to reconstruct existing knowledge. These strategies involve problem-based learning, STEM integration, and student collaboration to provide an in-depth understanding of the mathematical knowledge learned. Integrating STEM through EDP in statistics activities helps students to understand how the data they acquired can be analyzed more rigorously, increasing their understanding of the issue being studied and giving a practical approach to addressing questions in any STEM field. These activities can foster statistical thinking among students. Students will know why, how, and the "big ideas" behind statistical investigations. These themes include variation's omnipresence and when and how to apply data analysis tools like numerical summaries and visual presentations.

Transformation of mathematics education needs to be implemented given the drastic changes in the world economic landscape by the 21st Century. Students need to master certain subjects, but they are also encouraged to learn and master various skills, such as more complex problem-solving skills, analytical thinking, and creativity to produce innovations, especially for community and global progress, and can collaborate and communicate with various parties in the future. Based on the literature review, STEM integration can help students master multiple specialized skills through an interdisciplinary approach such as the EDP. Although studies on integrating EDP in mathematics are not yet widespread, previous studies have proven that EDP provides students with early exposure to mathematics in real-world contexts and various aspects of life. Therefore, this study is expected to improve students' achievement and inventive thinking.

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