

ADEQUACY OF THE MARITIME EDUCATION AND TRAINING (MET) MATHEMATICS CURRICULUM IN SUPPORTING STEAM SKILLS DEVELOPMENT

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ABSTRACT

The integration of Science, Technology, Engineering, Arts, and Mathematics (STEAM) has become a dominant educational paradigm for developing the twenty-first-century skills required for innovation-driven, technologically complex, and interdisciplinary industries. The maritime sector, characterized by rapid technological change, digitalization, automation, and sustainability imperatives, increasingly demands graduates who possess not only technical competence but also creativity, systems thinking, problem-solving, and adaptive capacity. In Maritime Education and Training (MET), mathematics plays a pivotal role in underpinning STEAM skill development, yet concerns persist regarding the adequacy of existing mathematics curricula in fostering these competencies. This article examines the adequacy of the MET mathematics curriculum in supporting STEAM skills development, using the Marine Engineering programme at the Regional Maritime University (RMU), Ghana, as a case study. Anchored in STEAM education theory, integrated curriculum perspectives, and employability-oriented skills discourse, the article synthesizes empirical evidence from students and graduates and situates the findings within international research on engineering and vocational education. The findings suggest that while the MET mathematics curriculum provides a strong foundation for technical and analytical skills, it is less effective in explicitly supporting creativity, interdisciplinary integration, and applied problem-solving associated with STEAM. The article argues for a reconceptualization of MET mathematics curricula to move beyond content coverage toward intentional STEAM-aligned pedagogy, assessment, and curriculum integration.

Keywords: MET mathematics, STEAM education, curriculum adequacy, marine engineering, skills development, higher education

1.0 INTRODUCTION

1.1 Background of the study

Curriculum design and education, in general, are considered as derived from industry demand, where MET institutions are suppliers of human capital for the maritime industry. Needless to say, the overall aim of a curriculum in such a scenario would be to fit the existing processes of the maritime industry. In practical terms this standpoint means that the aim and learning outcomes of a course have to be relevant to on-the-job responsibilities and, therefore, are defined by the way the maritime industry operates and its needs (Fisher & Muirhead, 2005).

Education and training systems should, however, not only be built to satisfy the needs of the industry, but also to lay a foundation to improve industrial practices.

Curricula incorporate the planned interaction of students/trainees with instructional content, materials, resources, and processes for evaluating the attainment of educational objectives. According to Oliva (1997), curricula may be split into several categories: the explicit, the implicit (including the hidden), the excluded and the extra-curricular. It must, however, be pointed out that the curriculum process in maritime education is extremely complex and particular, with many components and interactions. The Maritime Education and Training demand the involvement in programs and syllabus development of those who possess an intimate knowledge of both maritime and educational processes.

It is essential that the curricula comply not only with actual and future maritime sector needs, but also possible changes on labor market regarding job requirements, especially in developing countries to enable maritime professionals to explore further roles and expand the involvement in shipping and related maritime industries. Curriculum design and program or practice modules, as a basic element therefore requires reorientation to address pertinent issues of concern to the industry. For sufficiency of MET functions, a new MET concept, which would encompass teaching/learning methods aimed at enabling students to acquire useful knowledge and skills in an ever-changing environment, is required (McKeown, Hopkins, Rizi, & Chrystalbridge, 2002). A progressive education and training regime is one that faces weaknesses and is able to react positively to them hence the need to reorient existing education programs or practices is as a result of the pertinent issues of concern to the industry. Effective instructional methodologies include opportunities for the students to understand educational concepts in a manner that is both relevant for today's fast paced world and also personalized in order to apply the learning to tomorrow's world.

To Albanese and Mitchell (1993), a well-established precept of educational psychology is that people are most strongly motivated to learn things they clearly perceive a need to know. Instead of beginning with general principles and eventually getting to applications, the instruction begins with specifics (a set of observations or experimental data to interpret, a case study to analyze, or a complex real) world problem to solve. As the students attempt to analyze the data or scenario or solve the problem, they generate a need for facts, rules, procedures, and guiding principles, at which point they are either presented with the needed information or helped to discover it themselves.

The focus of education today should be on the personalization and application of relevant knowledge rather than simply being filled-in with random facts. Nevertheless, the focus of most classrooms still involves the "data dumping" mentality. For students to be prepared for the world of today and tomorrow, the role of the instructor has to meet the needs of current culture. Since the teacher is the single most important factor in student success, it would make sense to focus on this role in today's culture. Cerit et al. (2004) argue that the poor quality of seafarers from most maritime institutions is because the education curriculum is not structured based on Problem Based Learning. According to them, the dynamism in the maritime sector in terms of technological developments and multiplicity of activities does not make maritime education curricula based on general objectives effective.

In traditional marine engineering programmes, there has seldom been an approach used to provide instantaneous feedback on formative assessments. Modern e-learning strategies are beginning to make an impact within the previously conservative maritime education and training sector, as it is recognized that they provide an effective way to increase student skills and competences (Jurian, Chitoroiu, & Buibas, 2006). Edathil, Ranmuthugala, Bowles & Brooks (2014) clearly indicated that real-time formative feedback enhanced motivation and self-directed learning and improved performance of the students. It further proved that mathematics is not a barrier to learning when learners are self-directed and motivated, particularly when the relevance of mathematics in engineering studies is realized by learners through integrated theory and practical applications. Edathil, Ranmuthugala, Bowles & Brooks (2014) suggest that minimal mathematics or just-in-time mathematics strategies alone are not sufficient to enhance learning of mathematics in engineering. It further indicated that classroom learning must be supplemented by flexible learning approaches. Although real-time “product feedback” improved performance, it was learnt that this product feedback needs to be supplemented by “process feedback” in real-time to make formative assessments more effective and meaningful. “I believe that linear algebra is the most important subject in college mathematics. Isaac Newton would not agree! But he isn’t teaching mathematics in the 21st Century” (Strang, 2004, p58). Strang (2004) is not alone in thinking that linear algebra has a prominent place in today’s undergraduate mathematics curriculum.

Linear algebra also introduces students to discrete mathematics, algorithmic thinking, a modicum of abstraction, moderate sophistication in notation, and simple proofs. Linear algebra, according to Strang (2004) helps students develop facility with visualization, see connections among mathematical areas, and appreciate the power of abstract thinking. According to Klingbeil, et al., (2005), in addition to Linear Algebra, courses such as Applied Statistics and Data Analysis; Calculus, Sequence, Complex Variables; Differential Equations; Discrete Structures; Geometry; History of Mathematics; Abstract Algebra; Modeling; Number Theory; Numerical Analysis; Partial Differential Equations; Probability and Stochastic Processes; Real Analysis; Topology; and many more must be considered in designing an engineering curriculum. Klingbeil, et al., (2005) argue that almost all core engineering courses have their basis on mathematics and as such their contents need to be appraised in line with what/which mathematics course the students need to take as a prerequisite. The maritime sector exemplifies such complexity. Contemporary maritime operations are shaped by digital navigation systems, automation, data analytics, environmental regulations, renewable energy integration, and sustainability-driven innovations within the blue economy. Marine engineers are expected to interpret complex systems, troubleshoot technologically advanced equipment, collaborate across disciplines, and adapt to evolving regulatory and environmental demands. These expectations align closely with STEAM competencies, including analytical reasoning, technological literacy, creativity, communication, and systems thinking.

1.2 Problem statement

Within Maritime Education and Training (MET), mathematics remains a foundational subject underpinning engineering analysis, modelling, design, and operational decision-making. However, persistent concerns have been raised regarding whether traditional mathematics curricula adequately support the development of broader STEAM skills required for contemporary maritime practice. Mathematics is often taught as an abstract, standalone subject,

emphasizing procedural mastery rather than interdisciplinary application, creativity, or problem-based learning. While previous research has examined the relevance of mathematics curricula to professional practice, relatively little attention has been paid to their adequacy in supporting STEAM skills development within MET contexts. Adequacy, in this sense, extends beyond content sufficiency to encompass alignment with pedagogical goals, skills outcomes, and industry expectations.

Evaluating curriculum adequacy therefore requires attention to both structural design and learner experience. MET mathematics curricula traditionally emphasize topics such as calculus, differential equations, linear algebra, statistics, and applied mechanics. These topics are essential for understanding marine engineering systems, including propulsion, stability, fluid dynamics, and power generation. At RMU, the mathematics curriculum is structured to support progression into core engineering courses. However, like many MET institutions, mathematics is often taught in the early stages of the programme, with limited explicit integration into later professional courses. This separation can weaken students' ability to perceive mathematics as a living component of STEAM practice. This study, therefore, investigates the adequacy of the MET mathematics curriculum in supporting STEAM skills development, using the Marine Engineering programme at the Regional Maritime University, Ghana, as an empirical case.

1.3 Research Objectives

The following specific objectives were followed in the study

- i. To evaluate the extent to which the current MET mathematics curriculum supports the development of core STEAM competencies among Marine Engineering students.
- ii. To examine students' and graduates' perceptions of the effectiveness of the MET mathematics curriculum in fostering interdisciplinary integration and applied problem-solving skills required in the maritime industry.
- iii. To propose curriculum and pedagogical reforms that align the MET mathematics curriculum with STEAM-oriented education and industry demands in the maritime sector.

1.4 Research Questions

The study was guided by the following research questions:

- i. To what extent does the current MET mathematics curriculum support the development of core STEAM competencies (technical competence, analytical reasoning, problem-solving, creativity, and systems thinking) among Marine Engineering students?
- ii. How do students and graduates perceive the effectiveness of the MET mathematics curriculum in fostering interdisciplinary integration and applied problem-solving skills relevant to the maritime industry?
- iii. What curriculum and pedagogical reforms are necessary to align the MET mathematics curriculum with STEAM principles and the evolving technological and sustainability demands of the maritime sector?

1.5 Significance of the study

By situating the analysis within STEAM education theory and global MET discourse, the study contributes to ongoing debates on curriculum reform, skills development, and innovation in higher maritime education and training.

2.0 LITERATURE REVIEW

Technology has the potential to impact the content of the mathematics curriculum in schools as well as the methods used to teach it. Hence any attempt to describe a new mathematics curriculum must give some consideration to the reforms attempted over the years. These curricula can be seen as alternating shifts in emphasis between conceptual understanding and computational or symbolic manipulation skills. Following the launch of Sputnik and the subsequent passage of the Elementary and Secondary Education Act (in USA), the curricular reforms known as new mathematics were developed in the 1960s (Usiskin, 2010).

The question of how to best teach mathematics in an engineering programme has been considered by a number of researchers (Lingefjord, 2002). With its inclusion of topics such as set theory and instruction based upon formal thinking strategies of professional mathematicians, new mathematics was confusing to teachers and parents alike (Schoenfeld, 2007). Its increased emphasis on conceptual understanding also took some time away from traditional drill and practice activities. This led to a counter-movement that pushed for a back-to-basics curriculum in the 1970s. The back-to-basics movement sought to re-establish the centrality of computational and symbolic manipulation skills that were perceived as underemphasized in the new mathematics (Schoenfeld, 2007). The back-to-basics curriculum left many students without the deep conceptual understanding of mathematics necessary to solve a wide variety of problems (Schoenfeld, 2004).

A problem-posing approach aligns with Jonassen's (1999) statement that "Students learn domain content in order to solve the problem, rather than solving the problem as an application of learning" (p. 218) Problem-Posing. Since Silver (1994) identified students' problem posing as an area of interest in mathematics education, an increasing number of educators and researchers have advocated the integration of problem posing into mathematics curriculum (Cai, 2005; Ellerton, 1986; Silver & Cai, 1996). Research studies about problem posing also sprouted. Problem posing was found to promote students' problem-solving skills, augment their attitudes toward math, improve the development of mathematical thinking, and enhance creativity (Cai & Cifarelli, 2005; English, 1998; Silver, 1994, 1997).

Although problem posing is closely related to problem solving, it could bring mathematical learning to a higher level. English (2009) recognized a limitation of problem solving, especially traditional word problems, "While not denying the importance of these types of problems in the curriculum, they do not adequately address the mathematical knowledge, processes, representational fluency, and communication skills that our students need for the 21st century" (p. 352). In response, Bonotto (2013) maintained, "the problem-posing process represents one of the forms of authentic mathematical inquiry, which, if suitably implemented in classroom activities, could move well beyond the limitations of word problems...." (p. 38). Recent research has started to show the benefit of merging students' real-life experiences with their classroom learning.

Advocates (Gravemeijer, 1994) of Realistic Mathematics Education stressed that mathematics learning in school should involve problem situations experientially real to students. Yet, little success was achieved toward building meaningful connections between students' lives in and out of school (Goldman & Booker, 2009). Middle school mathematics seems to emphasize students' development of procedural efficiency (Civil, 2002). McDermott and Webber (1998) petitioned for mathematics moments "to overlap systematically with the lives of children" (p. 323). Students should be encouraged to capture their real-life mathematical phenomena and bring them to the classroom for problem conceptualization and solution. This approach could not only help them to view informal occurrences through a mathematical lens but better engage them in problem-posing and -solving activities in a contextualized manner. In the long run, such activities could cultivate students' mathematical habits of mind in order to make connections between mathematical ideas and contexts outside classrooms. Besides having the students capture and conceptualize mathematical problems from their everyday experiences, realistic situations for problem solving can also be introduced by the teacher.

For instance, a class in the Algebra II curriculum can start with questions initiated by the teacher, such as, "How much money will I need to save in order to retire?" or "What will be the average price of a car in 10 years?" In order to answer these questions, students will find that they need to use exponential equations, a topic that already exists in the current content of the curriculum. Students can model the growth of realistic exponential growth situations using spreadsheets and an iterative process. They can move from their iterative model and inductive reasoning to a single equation and satisfy themselves that it is appropriate through deductive logic. In this way, exponential growth and decay concepts found in this unit can be integrated with the 21st Century financial literacy goal of knowing how to make appropriate personal economic choices. Compound interest is a starting point that can lead to present and future values, inflation, time value of money, and mortgage amortizations. Using real-life questions in this way will address the information literacy skills of accessing information efficiently and effectively and Use information accurately and effectively for the issue or problem at hand.

Similarly, connections can and should be made between different courses' content in the secondary math curriculum. Problem posing can serve as a connection for these learning progressions across grade levels. The content matter provides the opportunity to teach students, over the entire course of their secondary mathematics career, how to ask questions, pose problems, seek answers, and increase their mathematical knowledge. An example of a posed question for one such sequence, across a variety of secondary classes, is "What can we know about triangles?" Over the course of the curriculum, students have the opportunity to address this question several times, on increasingly deeper levels. During each re-visitation of the original problem, students should pose more detailed and specific questions to attempt to answer.

Problem situations can be designed to incorporate content from various domains identified by the 21st century themes and skills to allow the students to see the natural connection among these subject domains. For example, topics from health literacy can be integrated into a new mathematics curriculum, specifically probability and statistics. Each time a new strain of the flu is reported, how worried should students be that they might contract the illness? When a news report states there is an increase in traffic accidents in the week after the change to daylight savings time, what is the actual level of danger? And how does the increased risk

compare to other behaviors? By collecting information from multiple sources, students can calculate a range of probabilities for events while attaining the Information Literacy standard via its Evaluate information critically and competently and manage the flow of information from a wide variety of sources tasks. This topic can connect to health education as students learn what health or sanitary practices can reduce the risks they have calculated. Another example of a cross-curricular connection is to examine the statistics and mathematics behind polling and elections. The mathematical result of the statistics that underlie the collection of data for pre-election polls is dependent on the sampling and data collection procedures (Hollenbeck, Wray, & Fey, 2010).

When mathematics is connected to other curricular areas, it is important that arts and language arts not be omitted as non-mathematical. The Communication and Collaboration tasks of Articulate thoughts and ideas effectively using oral, written and nonverbal communication skills in a variety of forms and contexts and Use communication for a range of purposes (e.g. to inform, instruct, motivate and persuade) provide opportunities for connections to these subjects. While geometry has always had a connection to visual arts through shape and perspective, a connection between music and trigonometry is found when examining the frequencies of musical notes and how modeling different notes using sine or cosine functions. Additionally, a critical component of any mathematical or statistical argument is to place the finding into an understandable context. By explaining, in clear, logical, and precise language the meaning of mathematics or statistics, the student can apply lessons learned in language arts and speech (rhetoric) to the field of mathematics (Hollenbeck, Wray, & Fey, 2010).

It is a fact that changes to the mathematics curriculum have failed to have a lasting impact. This should be expected since the modern mathematics curriculum has evolved over decades and there is resistance to changing it. According to Schoenfeld (2004), there are parts of society that resist any changes to mathematics teaching that might de-emphasize traditional skills (e.g. computation, symbolic manipulation etc.). Yet, since both reformers and traditionalists in the “Math Wars” have areas of agreement in what mathematics should be taught, perhaps a more appropriate question to consider is “How will technology enhance the learning of the 21st CMC?” Computer-managed learning systems, similar to learning management systems, use computers to assess students’ mathematics levels, assign mathematics materials at appropriate levels, score tests on this material, and chart students’ progress, such as Accelerated Math. Comprehensive models combine computer-assisted instruction with non-computer activities (such as teacher-led instruction and cooperative learning), including Cognitive Tutor and I Can Learn.

Mobile technology allows for a mathematics e-book to become a dynamic tool rather than a static presentation of skills and concepts. Dynamic demonstrations of concepts, access to expert advice on problem solving methods, immediate feedback on practice problems, and dynamic concept exploration are just some of the possibilities. Fey, Hollenbeck, and Wray (2010) recognized that one most valuable contribution of computing technologies to mathematics is “in promoting multiple representations of data and relationships and connections or topics from different strands of the discipline.” (p. 273). These authors also envisioned embedding these functions into an electronic textbook. Across the range of computing technologies, e-textbooks should be equipped with sophisticated search engines, virtual manipulative, dynamic graphing, and calculation tools. In the earlier example about exponential equations, students would be

able model present and future values, inflation, time value of money, and mortgage amortizations by using a spreadsheet or graphing application immediately available via the e-textbook. Further, data such as yearly inflation rates could be downloaded from web sites directly hyperlinked in the text (Fey, Hollenbeck, & Wray, 2010).

From this review (Cheung & Slavin, 2013), it is clear that the most effective technologies implemented in mathematics classes are supplemental in nature so that the curriculum stayed the same. Moreover, the effect of the technologies had been marginal. Although the findings for this meta-analysis study could be disappointing, we still believe that technology tools can facilitate the implementation of the 21st CMC and in turn gradually improve students' math learning experiences and outcome. Mobile technologies, in particular, have the capability to carry out this mission. Again, because of the unique affordances including permanence, accessibility, immediacy and portability, mobile technologies could be uniquely qualified for bringing mathematical problem situations student encounter off campus into the formal learning environment. Research on mobile practices of youth aged 13–17 shows that taking photos and videos with mobile devices is the second most popular activity after texting (Lenhart, Ling, Campbell, & Purcell, 2010). The unique features of mobile devices, such as permanence and portability allow students to collect pieces of their valued contexts with them.

3.0 METHODOLOGY

A mixed method research methodology was used to develop theory on students, graduates and lecturers' perceptions of the relevance of the mathematics curriculum of Marine Engineering Department of Regional Maritime University and its adequacy to support STEAM development skills. A discussion of the procedure, study participants, data collection, and interview questions outlined the specifics of how the study was conducted and who participated in the study. In all 41 respondents were interviewed. This involved 12 staff of the university and 20 students and 9 graduates. All study participants contributed to this theory by sharing their experiences in the STEM /STEAM classroom, workplace and their perspectives of what helped them stay motivated to study mathematics in school and whether their mathematics curriculum is adequate enough for the development of the STEM/STEAM skills. Data was analyzed using simple percentages and thematic analysis methods.

4.0 DATA ANALYSIS AND DISCUSSION

4.1 Students' views about how the MET mathematics content that could be reviewed to support STEM/STEAM learning.

The call for Science, Technology, Engineering, Arts and Mathematics (STEAM) education implementation in the university is premised on the argument that 'for education to be holistic, it must be 'artistic' and serve as a catalyst to propel socio- economic development. STEAM education, as defined in the literature review, is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, arts and mathematics in contexts that make connections among school, community, work, and the global enterprise.

(i) MET mathematics curriculum and delivery

The extent to which students and lecturers of the MET institution experienced STEAM education was investigated using interview guides, students, graduates and lecturers to elicit their knowledge about STEAM education and whether or not the lecturers engaged students in the classroom in such STEAM education activities as inquiry-based problem-solving activities, project-based, problem-solving activities and engineering and technology career-focused discussions. Table 1 shows the responses of the participants on their STEAM education experiences in the mathematics curriculum.

Table 1: Responses of participants' STEAM education experience in the engineering programme

S/N	Respondents' <i>STEAM</i> education experiences	YES*	NO
1	Have you ever heard the term “STEAM education”? Has it ever been discussed in class with you before?	0 (0)	29 (100)
2	Do your lecturers take you through inquiry-based, problem-solving activities in the classroom?	6 (20.7)	23 (79.3)
3	Do your lecturers take you through career-focused discussions in your classroom?	2 (6.9)	27 (93.1)
4	Do you participate in co-curricular activities involving project-based, problem-solving activities?	6 (20.7)	23 (79.3)
5	Do you have courses in your programme that involve discussions or introductions to careers in engineering and technology?	5 (17.2)	24 (82.8)
6	Do your lecturers come together to discuss, plan and engage you in problem solving activities?	0 (0)	29 (100)

*Percentages in parenthesis

The participants' responses to the STEAM education experiences in the mathematics curriculum presented in Table 1 indicate that there is little or no STEAM awareness among the graduates and students of the university. When the interviewees who were students and graduates of the school were asked whether they have ever heard of the term STEAM education, an interviewee (student number 1) rather asked the question:

‘Is it a new technical programme of study or what...? ...I know of NVTI, and TVET, but do not know of STEM or STEAM...’.

Some lecturers, however, indicated they had heard of the term STEM or STEAM before but do not know of its relevance in the marine engineering programme they offer nor how to relate it to the individual courses they teach.

One interview, lecturer number 1 remarked:

‘...I heard of the term before and I thought it is part of an American educational system for K-12 but never linked it to our education system here....’

When the respondents were, again, asked to indicate whether their lecturers take them through inquiry-based, problem-solving activities in the classroom, about 79.3% of them indicated that their lecturers did not or rarely took them through inquiry-based problem-solving activities and co-curricular activities involving project-based, problem solving activities which are meant to expose them to STEAM skills acquisition. Student number 2 responded:

‘No...It is not practical enough. We mostly learn theory. Sometimes, we do not see the relevance of certain courses too. I think they (our lecturers) should be enlightened properly in every course....’

On the issue of career focused discussions, 93.1% of them indicated that there was nothing like that in the mathematics curriculum as well as in its delivery during lectures. One of the student interviewees, student number 3, lamented:

‘... in a few cases where these career-focused discussions took place, it was either one of us (student/class) put up a careless attitude which infuriated a lecturer thereby forcing him/her to talk about our future as well as what we were losing due to our bad behaviour; or such a lecturer was sharing life experience’.

Lecturers through focus-group interview for validation of the report unanimously confirmed and explained that time factor, workload, and more so, the different time allocations for lecturers’ lessons, do not permit them to provide STEAM (upon explanation by the researcher) education experiences to the students in the mathematics curriculum delivery. Below is an extract of what lecturer number 2 said:

‘...you see! You have a lesson to teach, how would you complete your course outline if you waste the time discussing students’ future? “In any case, career success is for the university counsellor, not me as a lecturer’.

The views of this lecturer were very discouraging as he entirely places his work only in the classroom for teaching his core mandate, not realizing that teaching is holistic.

(ii) School records

School records, such as courses registered by the students (apart from first year orientation programme) also show that there are no deliberate courses that are designed for MET career-based education and how such contents affect career choices of the students or graduates. About 82.8% of the respondents did not see any deliberate efforts being made for their career development apart from the theoretical structure of their school curriculum. The remaining 17.2% of interviewees who said there were courses for career development, referred to their workshop practice as career-focused practical courses. The students were, however, not too happy with the way the workshop practice is being taught in the department as one of them, student number 4 remarked:

‘It is not helpful at all and I am confident of the future only by planning to do more for myself and not because of the training I am receiving, because the process of the training is not helping and I see it limited as well...’

This interviewee has realized the need to support himself in the attainment of his educational goals.

4.2 Students' views about MET mathematics content that should be reviewed to support STEM/ STEAM learning

The analysis of the data gathered revealed that the University's department provides science, technology, engineering and mathematics (STEM) based training, but there was no deliberate programme that enhances acquisition of STEM/STEAM development skills; and that for mathematics to be adequate and congruent to the engineering education, the entire engineering programme needs a holistic upgrade to accommodate STEAM based contents.

Table 1 indicates that the students and graduates who responded to this set of questions never even heard of the term STEM/STEAM during their period of training showing a 100% NO to the question, "Have you ever heard the term "STEAM education"? Has it ever been discussed in class with you before?" About 93.1% of the respondents responded that their lecturers never took them through career-focused discussions in the classroom. This observation became apparent because, though the curriculum is structured with STEM relevant contents (not all, though), the delivery was not STEM conscious.

Students, generally, were of the view that there is no coherence in the way the various STEM based courses lecturers deliver their lectures to them and suggested that there is the need for their lecturers to come together to discuss how they should fuse the various courses contents to reflect STEAM skills development. Students lamented that their course does not engage them in any career-based problem-solving discussions in the classrooms which eventually disconnect them from the real world. The respondents explained that even though the university requests them to embark on internship programmes, their individual lecturers should first orient them on the realities out there.

4.3 Lecturers' views about how the MET mathematics content could be reviewed to support STEM/STEAM learning

On the question of whether the existing curriculum is relevant on its own merit, the lecturers in a focus-group discussion (interview) generally were of the view that there is the need for updating the mathematics curriculum by adding some new topics that are modern-world driven without removing any of the existing topics in the current curriculum. The respondents, some of whom were mathematics lecturers, however, agreed that there are obsolete subtopics in some of the courses within each curriculum. From the data gathered, especially from the graduates, topics such as Rolle's Theorem, Power series and McLaurin series in Mathematics I have little industrial relevance. In the case of Mathematics III, topics such as multiple integrals, Ordinary differential equations (i.e. first order differential equations; and Second Order Differential equations) were seen by the students as having little industrial relevance and therefore the entire curriculum should be reviewed. At a focus group discussion, one lecturer interviewee, lecturer number 4 advised that due to modernity, there may be the need to update the curriculum by including new areas/topics to the existing curriculum. Lecturer number 4 stated:

‘... where there is the need to add new topics, and due to time constraints, delivery modes of such contents could be upgraded to allow the curriculum accommodate new topics without removing any of the existing topics...’

It must be noted here that not all the interviewees accepted the claim that curriculum content lacked industrial relevance in the twenty first century.

The opponents in the study argued that the study might not have sampled from all professional practices in order to be fully convinced that a particular content is truly irrelevant to the maritime industry. For instance, lecturer number 2 queried;

‘How does one determine which topic is irrelevant? Lecturer 2 quizzed, stating that ... school learning is not always for immediate use and how can someone be sure that of all the students/graduates we produced, none is using/applying the so called obsolete topic for delivery of his/her job...?’

The interviewees contended that inasmuch as one might not be using the knowledge acquired now does not mean it is irrelevant. It is argued by these groups of interviewees that since universities are often conservative, changing the curriculum contents just to meet the trending needs of the modern society may not be the best decision. This is because the societal changes are often rhythmic and the back and forth may affect the credibility of the university due to inconsistency. The interviewees suggested that since one major way of responding to changing needs of a curriculum is the teaching staff development, the university should rather focus on staff training with the aim of equipping the staff to respond to the changing needs of the curriculum instead of changing the curriculum. In this regard, an interviewee, lecturer number 4 remarked:

‘...every modernity has its roots in an existing theoretical philosophy and that for a well-prepared staff the new development in the educational delivery can be presented without the change in the curriculum. For instance, algebra was virtually outmoded and about to be deleted from many mathematics curricula until the upsurge of computer technology; and this algebra now becomes the core element of educational curriculum for computer studies...’

The respondents agreed that technology has come to stay and brought about changes in the entire society including our schools. To them universities must respond to the needs of the society by revising their modes of teaching so as to provide its students with the modern cutting-edge training for effective take off by the trainees/graduates. Specifically, the interviewees stated that the various mathematics curricula need to undergo a thorough review in order to make it relevant to the modern trends of scientific advancements. They contend that a mathematics curriculum that recommends the use of chalk and duster for its delivery in the classroom in this modern world is indeed obsolete and should be replaced.

However, the opponents of the above position question vehemently the modalities to be employed to identify those so-called obsolete elements of the curriculum and how to select new ones for replacement. This group of interviewees contend with two main arguments: lecturer 4 argued;

‘...that universities are generally conservative in their set up and do not easily succumb to societal changes hence no need for the change in the curriculum’.

That means that the curriculum contents necessarily do not have to change in order to make way for new contents to be taught in schools. To this interviewee, lecturer number 4;

‘... lecturers can be prepared to present the new contents alongside the existing ones using the modern technology which can help realign the existing curriculum to accommodate the changing trends in the maritime industry...’

4.4 Joint meetings by teaching staff on Mathematics, technology and Science Learning

Another question for the interviewees was for them to indicate whether their lecturers do come together to discuss mathematics, technology and science learning or plan problem solving activities which require the application of content from a variety of content areas with them. The response was a 100% emphatic “No”. The students/graduates blamed the inability of their lecturers to do so on some of the reasons stated below in the explanation of student number 4:

‘There is no program organized to bring the students and lecturers together. There have not been any arrangements like that for the lecturers to have that meeting with us. I think also that the lecturers have not planned that on behalf of students...’.

The student number 5, discouraged by the system, concluded by saying:

‘I am not very confident because I am unaware as to how the training I am receiving is relevant in the work field. As at now I am still not knowledgeable enough on the career options available to me and how this training will put me towards that goal...’.

Another interviewee, student number 6, who wanted to take blame on behalf of the colleagues (students) regarding the inability of the lecturers to take them through career focused education explained that it was their lack of interest or lack of curiosity to engage the lecturers for career guidance sessions. Student number 6 said:

‘We have not been curious enough to inquire such information from our lecturers who, themselves, don’t find it interesting in the first place...’.

Some interviewees explained that there was little or no time to organize such events because lecturers are usually busy with their respective courses. To confirm the claim, one lecturer, lecturer number 3 clarified that

“...the issue of coming together as lecturers to discuss the future of students cannot be a course lecturer’s initiative. At best it should be a departmental or SRC programme where lecturers are invited to discuss issue(s) to that effect...”.

The lecturer number 3 continued by drawing the conclusion that:

“I will blame it on poor organizational skills of student leaders such as AMES/SRC to organize programmes where lecturers can be invited to expose students to career path discussions...”.

Again, student number 6 remarked that:

‘... poor students-lecturer relationship and reluctance from both parties. Some students were blamed for not opening up for lecturers for directions. Such students are also often tagged by the lecturers are bad and as such do not also get near lecturers... ‘.

4.5 Discussion of Results

In short, the data analysis indicates that lecturers and students have a concern about the need for STEAM skills development. To the students, some of the elements or specific objectives of the various mathematics courses as well as the entire engineering programme should be reviewed to respond to STEAM movement since their discipline falls within the STEAM domain. The lecturers, on the other hand, were of the view that the identified contents of the existing mathematics curriculum by the students/graduates be maintained since no one can completely argue the irrelevance of a curriculum content. The lecturers, however, suggested that the staff should be trained with the new technology in the direction of the STEAM lesson delivery so as to adequately prepare the students towards STEAM job market. In so doing, the curriculum contents should rather be aligned towards STEAM skills development using the new technology of teaching and learning.

5.0 SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Findings

The study made following findings:

- i. There was 100% lack of awareness of STEAM education among students and graduates.
- ii. Most lecturers had only superficial awareness of STEM/STEAM education and did not see its relevance to the marine engineering programme.
- iii. STEAM concepts were never discussed in mathematics classes. Students expressed low confidence regarding how their mathematics training connects to maritime industry demands.
- iv. There were no structured interdisciplinary collaborations among mathematics, science, and engineering lecturers. The mathematics curriculum, though containing STEM-related content, was delivered in a non-STEAM-conscious manner.
- v. Students perceived the curriculum as overly theoretical with limited practical or industrial orientation. That is, workshop practice was not effectively structured to enhance career readiness. Career development initiatives were not institutionalized but left to individual lecturers or student leaders. Both students and lecturers cited time constraints, workload, and poor coordination as barriers.
- vi. There were no joint planning sessions among lecturers to integrate mathematics, technology, and science learning.

- vii. Students and graduates identified certain topics (e.g., Rolle's Theorem, Power Series, McLaurin Series, Multiple Integrals, Differential Equations) as having limited industrial relevance. Some lecturers agreed that certain subtopics may be obsolete. However, other lecturers strongly opposed removing any content arguing that universities are conservative institutions; and also because relevance may not be immediately visible as curriculum stability preserves academic credibility.
- viii. Many lecturers recommended upgrading teaching methods and technology use rather than removing existing content. There was consensus that chalk-and-duster pedagogy delivery methods are outdated hence the need for technology integration and modern teaching approaches for lesson delivery.

5.2 Conclusions

The study made the following conclusions:

- i. That the MET mathematics curriculum is structurally STEM-based but pedagogically non-STEAM-oriented. While the content aligns broadly with STEM disciplines, its delivery does not intentionally promote STEAM skills such as inquiry, innovation, interdisciplinary thinking, and career readiness.
- ii. That there is a systemic disconnect between mathematics instruction and maritime industry expectations. Students struggle to see the relevance of mathematics to their future careers due to lack of contextualization and real-world application.
- iii. That the absence of institutionalized career guidance and interdisciplinary collaboration weakens STEAM skill development. Career discussions and integrated planning are neither embedded in curriculum design nor coordinated at departmental level.
- iv. That curriculum reform debate reflects tension between academic conservatism and industry responsiveness. While students demand content modernization, lecturers emphasize curriculum stability and staff capacity development.
- v. That the most critical gap lies not only in the curriculum content but in curriculum delivery and institutional culture since effective STEAM integration requires both structural and pedagogical transformation.

5.3 Recommendations

Finally, the study recommends a dual strategy of handling the MET curriculum adequacy. These are, first, there should be a curriculum alignment with modern maritime industry demands, and a pedagogical transformation through staff capacity development and interdisciplinary collaboration. It is worthy to note that the success of STEAM integration in the MET mathematics curriculum will depend not merely on content revision, but on systemic institutional commitment to holistic engineering education.

Specifically, the study made the following recommendations:

- i. The university should formally adopt a STEAM integration framework to guide curriculum design, teaching strategies, and assessment practices.
- ii. There should be a structured committee to review the MET mathematics and engineering curriculum holistically to align it with modern maritime industry demands.

- iii. The department should introduce structured career seminars, maritime industry engagement sessions, and engineering career orientation courses within the programme.
- iv. The department should partner with maritime industries to validate curriculum relevance; offer industry-led lectures; and improve internship orientation.
- v. That rather than outright removal, abstract topics should be contextualized within maritime engineering application and taught using industry-based case studies integrated with simulation and modelling tools.
- vi. Promote Collaborative Lesson Planning (CLP) by encouraging regular departmental meetings for mathematics, science, and engineering lecturers to, harmonize course content, design interdisciplinary projects, and plan integrated assessments.
- vii. Develop platforms where students can ask career-related questions; engage lecturers informally and participate in innovation clubs and STEAM projects.
- viii. Establish structured mentorship systems to reduce relational gaps and encourage career discussions.
- ix. There should be comprehensive Staff Training in STEAM Pedagogy through organization of professional development workshops on inquiry-based learning, project-based learning, technology-enhanced mathematics instruction, as well as industry-relevant contextual teaching approaches.

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