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# Mathematical Competencies in Higher Education in Oman: A Critical Review

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**Abstract**
The paper addresses how the mathematics educators in Higher education can enhance the effectiveness of teaching and learning. It ventures into various pedagogies, curriculum evaluation, class environment and assessments strategies to be adopted to meet the needs, expectations and goals of the students for their further studies in higher education. The researcher develops a framework for mathematical competency that will help the policy makers to promote mathematics teaching and learning.

**Keywords:** Mathematical Competency; Assessment; Critical thinking; Evaluation; Oman

## I. INTRODUCTION

Mathematics is acknowledged as a very important subject worldwide [5]. Solid mathematics skills are a prerequisite for school achievement and success in the workplace. "Cognitive psychologists have discovered that humans have fixed limits on the attention and memory that can be used to solve problems. One way around these limits is to have certain components of a task become so routine and over-learned that they become automatic" [43]. Learning Mathematics increases critical thinking and logical reasoning [33]. Despite these facts the poor performance in mathematics has been a concern among the students, teachers, parents, policy makers and others [34]. One of the main reasons for this low achievement is the lack of motivation to study the subject. Many Studies conducted in different parts of the world indicate that one of the purposes of evaluation is to cultivate motivation in learners [4].

Students need mathematical proficiency to succeed in course work that provides a gateway to technological literacy and higher education. Once out of secondary school, all students need a broad range of basic mathematical understanding not only for their further studies but also in improving their job potential and decision making. According to National Association for the Education of Young Children (NAEYC) and the National Council of Teachers of Mathematics (NCTM), the nation should prepare young people equipped with mathematical tools to overcome the challenges and capitalize on those opportunities [14].

Over the last decade, the MENA region has seen significant progress in the education sector. The total number of students in the GCC education sector is expected to grow at a Compound Annual Growth Rate of 2.7% between 2011 and 2016, and reach 11.6 million in 2016[15]. MENA countries have largely reached full enrollment rates at the primary level [43] and made tremendous strides in closing the education gender gap, providing equitable access to primary education for boys and girls [10].

Despite these achievements, many countries in the MENA region continue to perform poorly in mathematics when compared internationally. According to Statistics of the Arab countries in the MENA region that have participated in standard assessments such as Trends in International Mathematics and Science Study (TIMSS) have consistently fallen at the bottom line in terms of performance, and large number of students in the region are not able to understand the basic mathematical competencies and as a result do not continue in secondary school [10]. Moreover, reports of many studies have also triggered debates that the falling standards of students' achievement in mathematics is due to the curriculum and the teaching of the subject [27], [33].

For Oman, the Ministry Of Education in Oman found that its necessary to use international evaluation standards to evaluate students' performance on Mathematics in order to compare student achievement in Mathematics in the educational systems of different cultural, economic and social backgrounds. According to TIMSS (Trends in International Mathematics and Science Study) 2007-2011 report the average mathematics achievement of eighth graders of Oman in the year 2011 was 366 compared 372 in the year 2007[39].The statistics not only indicates that Oman performed significantly below the international mean of 500 in Mathematics but also performed more poorly. The TIMSS assessments are conducted to improve the teaching and learning in mathematics for students around the world. The Arab global competitive index of 2013 indicated, that Oman ranked 86$^{th}$ in the areas of Math and Science [37]. It implicates that Oman will need to address a number of challenges in the field of Education in the areas of Math and Science[10] which can be achieved not only with effectiveness of teaching and learning, but also providing a good curriculum.

The paper aims to explore and reflect on the practice of teaching and learning mathematics in higher education in Oman. The paper will develop a framework for discussing mathematical competency which will help policy makers to promote mathematical teaching and learning.

Secondary sources from Ministry of Higher Education, and Oman National Centre of Statistics and information will be used to facilitate the critical review of the mathematical competency in higher education in Oman.

## II. LITERATURE REVIEW

Both national and international evaluations show that, on completion of basic education, many pupils' mathematics

knowledge and competencies fall short of the expected level [40]. Students have been trained to pass their school examinations and are unable to use their mathematics in the new contexts they are meeting at university. General Foundation program is designed to fill the gap between the secondary school and higher levels of education. The curriculum in the general foundation programme is designed to raise the academic capabilities of students prior to their entrance into higher education studies. The Ministry of Higher Education along with the Higher Education Institutes(HEI) are doing a lot to achieve the objectives of filling the gap. However, evidence suggests that these resources made available by the ministry of higher education and HEIS are not achieving the objectives [1]. Thus pointing at the educators to reflect on their own practices. Brookfield (1995) emphasizes that reflection is just not describing what we do, why we do things and to whether they have gone as expected, reasons why the teaching practices applied may have worked well, and how we might do them differently next time [8].

In spite of the government's excellent initiative and Oman Academic Accreditation Authority quality assurance strategies, Oman is not able to achieve the standards in international Mathematics Exams like Trends in International Mathematics and Science Study (TIMSS), administered by the International Association for the Evaluation of Educational Achievement in the secondary school level. Thus not achieving mathematical competency. Numerous studies have been conducted to investigate the reasons, General Foundation Programme failed to improve students' skill in English, mathematics and IT to fit them for graduate academics studies. Some identified that that the biggest challenge facing HEIs is the low level of the English language of school graduates [1]. Some criticize the existing teaching methodology while other criticized the contents of courses is the main cause of failure of the General Foundation Programme. It has been observed that despite the various efforts, the quality of education in terms of knowledge acquisition and skills seems to be missing and is not up to the desired level. And this can be achieved not only with the help of teacher's knowledge delivery mechanisms but also the reception of knowledge by the students. A multiple of causes for the students low achievement in mathematics has been attributed to: difficulty in understanding the specialized mathematical language [2]-[4],[25]-[28], ineffective, teacher-centered teaching methods and learners' negative attitudes towards the subject [20],[23], Learners lack of motivation to learn the subject[16] and lack of mathematics syllabus coverage[35]. Bouhlila (2011) ponders the reasons behind the differences in achievement from the cultural viewpoint and finds the students' attitude as one of the factors behind the poor results in the Middle East and North African (MENA) countries [7]. To address the persistent issues of quality of education the government recommended a collaborative study to be jointly conducted by the ministry of Higher Education and World Bank. The report [22] recommends that there are many factors that influence the quality of educational outcomes. The Ministry of Education (MOE), in particular, has a central role to play in optimizing education system performance in Oman. There are two broad priorities suggested by this report: (1) creating a culture of high standards; and (2) developing the pedagogical capacity of the teaching force. These are the driving factors which stresses the need to improve mathematical competencies in higher education.

"Fig. 1", develops a framework for discussing mathematics competency including the responsibilities of the teacher as well as the student to achieve it. Therefore the model can be recommended by the teachers as well as students in Mathematics teaching and learning in order to achieve the academic skills, thus improving quality education.

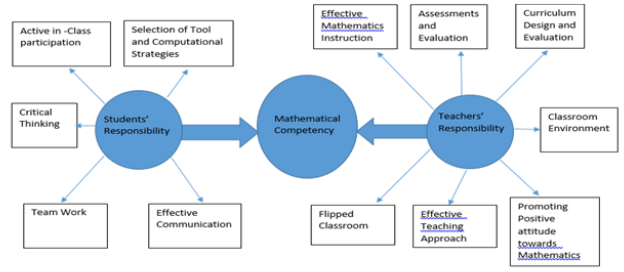


*Fig.1: FRAMEWORK FOR MATHEMATICAL COMPETENCY*

### *A. Effective Mathematics Instruction*

Current research in mathematics teaching and learning recognizes that children learn more mathematics when instruction is based on their ways of thinking and engages them in problem solving [45]-[46].Effective mathematics instruction is one of the main indicators of students' understanding and if the instructions delivered by the educator is not understood by the student then there is a great hindrance in learning.

**Effective mathematics instruction involves**

- engaging students in problem solving, reasoning, reflecting, connecting and communicating
- acknowledging diversified ways of mathematical thinking, reasoning, connecting and developing new concepts
- providing materials and resources to help students represent problem-situations with a variety of representations and tools
- providing opportunities for student-student as well as teacher-student interaction
- providing timely feedback with opportunities to act on feedback and plan for further improvement in teaching
- focusing on key concepts in the mathematics curriculum
- providing assessment and evaluation in mathematics that is fair, transparent and competitive
- connecting mathematical ideas to the real life situations

### *B. Assessments and Evaluation*

To develop quality mathematics and science classroom assessments, aspects of capability (such as mastery of content knowledge, reasoning capability, performance skills, and disposition capabilities) require a range of assessment tools

[40]. The information gathered through the assessments are used as a feedback to the students to improve their learning.
Assessment is the process of gathering information from a variety of sources including assignments, day-to-day class participation, demonstrations, and tests that reflects how well a student is achieving the curriculum objectives and outcomes in a module. Evaluation refers to the process of judging the quality of student work on the basis of established criteria, and assigning a value to represent that quality. Assessment should support the learning of mathematics and furnish useful information to both teachers and students [14].Assessment and Evaluation will be based on the curriculum expectations and the achievement levels.
Teachers need to frame assessments based on the indicators of Bloom's revised Taxonomy of Mathematics involving Remembering, Understanding, Applying, Analyzing, Evaluating and Creating to develop students to become better problem solvers and meet the international assessment standards[6].
The Levels of cognitive skills to be assessed in academic assessments should be distributed as follows [6]

| Cognitive Questions | Learning Objectives |
|---|---|
| Lower Order | Remember & Understand |
| Intermediate Order | Apply & Analyse |
| Higher Order | Evaluate & Create |

### *C. Curricullum Evaluation*

A good curriculum is very important for learning mathematics. The curriculum is a document defining the objectives, learning outcomes, and content of the module. The ministry of education in Oman defines curriculum as a series of processes, skills and attitudes that transcends the prescribed teaching curricula and is disseminated through classroom activities and out of class activities. The curriculum should consists of high quality materials and integrate mathematics content within the context of students' learning experiences in other disciplines. Evaluation of a curriculum is imperative in ensuring best practice and ensure that the services provided were meeting the needs of the students.Curriculum evaluation is an attempt to know whether the courses and learning opportunities developed and organized in a way to produce the desired results of meeting the objectives of the module and what strategies be adopted to improve on the delivery of the curriculum. The curriculum could be evaluated by an external/internal party and the feedback received should be used to improve the contents of the curriculum. National Council of Teachers Mathematics (NCTM) principles highlight the need for well-designed curricula as well as the need for quality teacher preparation that provides teachers with core mathematics knowledge [17]. Curriculum evaluation is an internal as well as external activity. The internal evaluation can be conducted by the various units viz., quality assurance unit or a special task force within the institution. The external evaluation can be done by external examiners from other institutions and OAAA. These processes examine the effectiveness of curriculum content, existing pedagogies and teaching approaches, textbooks and instructional materials.

### *D. Classroom Environment*

The transition from secondary school to tertiary education is very important for students' development of confidence and competence. The students' behavior in the class is significantly related to teacher support, student-teacher interaction, teachers' attitude and behavior towards the students. Many studies reported the need of encouraging the students to develop a positive attitude towards the subject and the teachers support in this context is very important. This in turn is very important for the development of confidence in the students [13],[21],[32],[42].Teacher's role in a mathematics class is to foster the communication skills. Classroom discussions not only motivate students' understanding but also provides them with opportunities to share and clarify ideas.
It is important that the classroom environment provide students opportunities to learn in diversified ways like individually, collectively, independently with teacher direction and through investigation involving practical experience.
In a supportive learning environment, students work in groups, formulate plans and develop their creativity and critical thinking. Students feel free to challenge the views of their teachers and fellow students and are equally prepared to be challenged by others without feeling disrespected or insulted. Students' feedback to the faculty member has to be handled carefully so that the faculty member responds positively and does not feel demoralized [33].

### *E. Promoting Positive Attitude Towards Mathematics*

Students with a higher perception of the learning environment and a more positive perception of their teachers have more positive attitudes towards mathematics [32].
Students having a supportive teacher promoting students feelings develop a positive attitude towards mathematics. Students' attitudes towards the module, have a significant effect on how they approach problem solving and how well they succeed in mathematics. Teachers can help students develop the confidence they need by demonstrating an inclination towards mathematics. Negative attitudes are the result of frequent and repeated failures or problems when dealing with mathematical tasks and these negative attitudes may become relatively permanent [24]. It is common for people to think that if they cannot solve problems quickly and easily, they must be inadequate. Teachers can help students understand that problem solving of almost any kind often requires a considerable amount of time and energy and a great deal of perseverance.

### *F. Flipped Classroom*

Mathematics demand lots of practice and problem solving skills compared to other courses. Hence students need to practice the skills even after their class hours. The traditional method of teacher student interaction in the classroom is slowly being changed to virtual environment so that the students learn easily outside the classroom. Flipped classroom methods can be used to access the study materials and practice the problems crossing the barriers of time and location. In a flipped class, students have access to teachers lecture much ahead of time. This in turn will help them to participate in the

classroom activities including seeking clarifications from teachers during the class.

Flipped classrooms are very much helpful to the students to revisit the lectures, when they don't understand the concepts. A growing number of faculty in educational institutions have started using flipped models in their modules. College of Applied Sciences Salalah is planning to use the concept of flipped classrooms for the network courses so that students will get more time for the lab practices and also they don't lose time for the conceptual topics [12].Thus Flipped classroom encourage students to pursue opportunities outside the classroom to extend and enrich their understanding of mathematics. The classroom time can be used more effectively and creatively [19].

### *G. . Teaching Approach*

Academics must begin to think about teaching and learning differently, in a scholarly way [30] in order to challenge their long-held conceptions. Effective mathematics teaching requires understanding what students know, need to learn and then challenging and supporting them to learn it well. Teachers need to use problems that provide a variety of opportunities for students to develop mathematical understanding through problem solving. Teaching beliefs emerge from experience and reflection as academics create their own teaching approaches over time. The 'learning-focused' approach is about teaching as facilitating students' learning and learning as knowledge construction, while the 'content-focused' approach concerns teaching as transmission of knowledge and learning as absorbing the transmitted information [36].These different areas of learning may involve various teaching and learning strategies. It is assumed, therefore, that the strategies teachers employ will vary according to the objective of the learning and the needs of the students.

### *H. Students' Responsibilities in Mathematics Education*

Students who are willing to make the effort required for learning the subject and who are able to apply themselves will soon discover that there is a direct relationship between this effort and their achievement in mathematics. However there will be some students who will find it difficult to take responsibility for their learning. For these students, the attention and encouragement of teachers can be extremely important factors for success. However, they need to be responsible for their own progress and learning is an important part of education for all students. Students are expected to learn and apply strategies that promote understanding of mathematical concepts and facilitate the application of skills. Team work enables students to share their experiences, different points of view and solutions to a problem. It develops the skills of sharing, leading, communicating, building trust and managing conflict. These skills are relevant to students' lives, not only in school and work, but also in family and personal relationship [29]. Opportunities should be provided to the students to relate knowledge and skills to wider contexts further motivating them to learn and to become lifelong learners. According to Connecticut State Board of Education Hartford, Encourage students to view mathematics as a language that helps them to organize and understand their world. They need to build upon personal experiences and prior learning to understand mathematical concepts and apply them to real life. The students should participate actively, think critically and communicate effectively about mathematical reasoning and solutions. Integrating of the module with the other modules will help them to develop connections between various modules, thus making learning easier. "Assessment for Higher Education Learning Outcomes" (AHELO) targets discipline-related competencies and generic skills (critical thinking, analytic reasoning, problem-solving, written communication) [18].Active in class participation, critical thinking and problem solving are the drivers for achieving mathematical competency

### *I. Selection of Tool And Computational Strategies*

Students need to develop the ability to select the appropriate electronic tools and computational strategies to perform mathematical tasks. Technology is useful in learning and doing mathematics. Although students must develop basic operational skills, calculators and computers can help them extend their capacity to analyse mathematical concepts. When students use calculators and computers in mathematics, they need to counter check using appropriate mental computation.

Computer and calculator are seen as important problem-solving tools. Computers and calculators are tools of mathematicians, and students should be given opportunities to select and use the particular applications that may be helpful while trying to solve problems. Problem solving often requires students to select an appropriate computational strategy. They may need to apply the written instructions for addition, subtraction, multiplication, or division or use technology for computation [38].

## III. FINDINGS AND IMPLICATIONS

The teachers should adopt various pedagogies and strategies to meet the objectives set in by the **Oman Academic Accreditation Authority** (**OAAA)** to ensure that students are equipped with the mathematical understanding and skills necessary to meet the cognitive and practical requirements of postsecondary or higher education studies in a variety of disciplines[24] bridging the gap between the secondary education and higher education. OAAA, within the Ministry of Education supports the development of the higher education sector through quality audits and accreditation processes.

An external observer, an expertise in the subject is needed to reflect on the educator's teaching practices. The feedback obtained through the lenses of the external observer will reflect on the teaching practice of the educator, thus reframing the techniques of teaching. Students' feedback is also considered as one of the factors reflecting teaching practice. It can be obtained through questionnaires, on course evaluations and feedback on teaching and learning, performance of the students and informal feedback.

A competent community of learners can be developed with the help of efficient educators' expertise in the subject capable of designing curriculum reflecting international standards,

clarity in communication and delivery of the course contents. Mathematics educators should motivate and stimulate the students and try to connect the module to their real lives. They should create a challenging and a comfortable learning environment with interactive sessions and support growth and interest in students' learning.

Further interventions may be conducted on the basis of the framework for achieving mathematical competency in higher education.

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