Applied Mathematics & Information Sciences
An International Journal

http://dx.doi.org/10.18576/amis/170108

The Effect of Realistic Mathematics Education on Undergraduate Freshmen Students' Mathematical Competencies

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Received: 22 Sep. 2022, Revised: 22 Nov. 2022, Accepted: 23 Dec. 2022
Published online: 1 Jan. 2023

Abstract: One of the ultimate objectives of the Saudi Vision 2030 is to reduce the country's dependence on the oil industry and construct a competitive, knowledge-based economy through developing the education system. Mathematics is the base of all scientific disciplines and technology. The recent trends of mathematics education reform have been shifted internationally towards mathematical competencies. This study aims to improve undergraduate freshmen students' mathematical thinking, reasoning, representation, and handling mathematical symbols and formalism competencies through the implementation of the "Realistic Mathematics Education" learning strategy. An RME-based pre-calculus course has been implemented in a six-week quasi-experiment involving a total of 39 students in the treatment group and 44 students in the control group. The results illustrated that RME has a significant positive effect on students' mathematical competencies. Handling mathematical symbols and formalism was the highest accomplished competency, while representation competency was the lowest accomplished. In general, there were no significant differences between any pair of the four competencies, except for the representation and handling mathematical symbols and formalism competencies. It is recommended for the Saudi universities to adopt RME learning strategy, and to consider the competency-based learning to improve students' mathematical competencies, Thereby, to be able to fulfil the market requirements with qualified human resources.

Keywords: Mathematical competencies, Vision 2030, Realistic Mathematics Education, Undergraduate freshmen

1 Introduction

Education in Saudi Arabia is receiving an exceptional level of attention, as one of the ultimate objectives of the Saudi Vision 2030 is to reduce the country's dependence on the petroleum industry by developing an education system that can fulfill market needs, thereby constructing an internationally competitive, knowledge-based economy [1,2]. Mathematics is the basis for the development of modern technology and other scientific fields [3]. Learning mathematics helps students develop their critical thinking skills, improves their ability to solve problems, and provides them with the skills they need to apply what they know in everyday situations [4]. Therefore, recent trends of education development and reform in most countries have been directed towards mathematical competencies [5], and the main goal of mathematics education has also been shifted to improving students' mathematical competence to a level that goes beyond procedural and conceptual knowledge [6]. According to Khoshaim [7], many university students are found to be mathematically deficient. Moreover, this weakness is detected at earlier levels of education. On a number of international standardized tests, like the Program for International Students' Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS), Saudi students' results were not satisfactory [8,9]. According to the Saudi literature, Alshehri [10] indicated that the level of middle school students' acquisition of mathematical thinking competency is 40.71%, which is less than 75% of the accepted educational measures. Alotaibi [11] reported

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that high school students have low levels of mathematical thinking and reasoning competencies. It has been argued that students who struggle to understand mathematical concepts may do so because they are unable to connect those concepts to real-world problems [12]. Alreshidi [13] indicated that mathematics has always been taught in Saudi schools as a separate subject. Students attend higher education without being aware of the relevance of mathematics to other disciplines or how to apply it to daily life problems. It has been stated that mathematics at the college level is taught in a conventional way, in which a teacher-centered approach is dominant [14]. College-level mathematics courses are conceptual and more abstract, while students are more comfortable with routine procedural problems and are inadequately trained for analytical and logical thinking [15]. While some students may be able to maintain their progress in their academic programs, others may neglect to cope, so they change their major or drop out. In general, high dropout rates are a serious concern because they can impose an economic burden on society [7]. This study intends to enrich the experience of teaching mathematics to undergraduate freshmen. As Several studies confirmed the positive effect of (RME) or Realistic Mathematics Education on different mathematical competencies, this study proposes RME as an intervention that is expected to improve students' mathematical competencies, namely: mathematical thinking, reasoning, representation, and handling mathematical symbols and formalism.

1.1 Realistic Mathematics Education

The theory of RME as an instructional design was rooted in the Netherlands in the 1970s during a global effort to enhance mathematical thinking [16]. RME is an educational method that was originally suggested by Freudenthal in 1983 [16]. The major goal of this theory is to prepare students to approach mathematical concepts as researchers and inventors. Freudenthal's suggestion of RME shows how strongly he disagreed with the standard mathematics education at the time, when mathematics was still taught as a collection of disconnected abstract ideas. RME is a theoretical approach of education that sees mathematics as a human activity rather than a pre-made structure [17]. From Freudental's point of view, students should learn mathematics through "mathematization", a continuously based process of mathematically authentic contextual problems [16]. Both horizontal and vertical mathematization are processes that are involved in mathematization. In horizontal mathematization, a learner converts a practical issue into a mathematical issue via inductive reasoning, experimentation, and observation. Some of the actions that define it include finding the specific mathematics in a broader context, detecting relationships, and structuring, formulating, and picturing a problem in many ways. The use of natural language and symbolic expressions in word problems encourages horizontal mathematization. Students restructure and (re)construct inside the realm of mathematical symbols during vertical mathematization. This includes resolving the issue, making the solution broad, and formalizing it even further. Refining mathematical models, utilizing various models, mixing and integrating models, and generalizing are all characteristics of vertical mathematization [18].

1.2 Characteristics of Realistic Mathematics Education

A learning process is said to be RME-based, in accordance with Lestari and Surya [19], if it demonstrates the following five RME characteristics: (i) the use of real-life context; (ii) the use of mathematizing models; (iii) the use of production, construction, and results solely from students; (iv) the use of interactions from the teaching process; and (v) the use of intertwinement, or the connection of various learning plots.

1.3 Previous Studies on Realistic Mathematics Education

Numerous studies have been carried out to assess the impact of RME implementation on various dependent variables. For instance, a study conducted in Indonesia by Zakaria and Syamaun [20] found that the Realistic Mathematics Education approach has a positive impact on raising students' mathematical achievement. RME's impact on students' cognitive development was the subject of a study by Laurens et al. [21]. The results showed that both the experimental and control groups' cognitive performance had increased, but the RME group had outperformed the conventional learning group in terms of cognitive achievement. According to Astuti et al. [22], the Realistic Mathematic Education (RME) method significantly affects students' mathematics learning results since students who were taught mathematics using the RME approach had superior mathematical learning outcomes than students who were taught using the scientific approach. There are discrepancies between students who studied using the RME technique and students who studied using traditional method, according to the findings of Fauzana et al. [23], when it comes to the development of mathematical literacy skills.

1.4 Mathematical Competencies

The idea of mathematical competence first came to light in 1986, when Hiebert and Lefevre [24] made the case that students can achieve full mathematical proficiency if they maintain both conceptual and procedural knowledge as well as an understanding of how the two are related.

They spoke of the long-standing tradition in mathematics education where conceptual and procedural knowledge were seen as interrelated concepts and where scholars tended to disagree on which of these knowledge types should be introduced to students first. Competence was described by Niss and Højgaard [25] as ”the ability to apply knowledge and skills to master complex situations.” The notion of competence is commonly understood as ”context-specific,” which denotes that creating competences is based on experience in settings that are relevant to ”Domain-specific” challenges. A mathematical competency is described by Niss and Højgaard [25] as ”someone’s insightful preparedness to behave correctly in response to a specific type of mathematical difficulty in specified scenarios.”

Eight competencies were determined by Niss et al. [26], and they are divided into two groups. The first set of competencies refers to the ability to pose and respond to mathematical queries. This group encompasses reasoning, modeling, problem-solving, and mathematical thinking competencies. The ability to work with and manage mathematical language and tools is represented by the other category of competences, which also includes communication, representation, handling mathematical symbols and formalism, and the use of mathematical tools and aids [27]. Each competency category is described, along with its components, in the paragraphs that follow.

Posing and answering questions in and by means of mathematics

The four competencies belonging to this category are:

1. **Mathematical thinking competency:**
The ability to ”connect to and pose the types of generic questions that are considered characteristic of mathematics and relate to the nature of answers that may be anticipated to such inquiries” [25] is a requirement for this competency. It also requires the capability to relate to the multiple scopes of a mathematical notion, topic, or idea in various circumstances and the ability to discern between distinct forms and functions of mathematical statements (including definitions, claims, universal claims, existence claims, statements concerning cases, and conjectures), the ”abstractions” of theories and conceptions as well as the ”generalization” of statements are referred to as mathematical activity processes in the conclusion [25].
2. **Mathematical problem-solving competency:**
The capacity to recognise and resolve many kinds of mathematical issues in a range of mathematical fields is referred to as problem-solving competency [25]. It can also be described as the act of starting a task for which the solution technique is unknown [5]. The critical analysis and evaluation of one’s own and other people’s efforts to solve problems are the main objectives of this competency [25].
3. **Mathematical modelling competency:**
Understanding how to analyse and create models for non-mathematical situations is known as modelling competency. It emphasises the capacity for coping with questions, circumstances, and contexts outside of mathematics. It also emphasizes the ability of creating mathematical models’, in addition to critically analysing and evaluating available models or suggested ones, while taking facts, data, purposes, features, and properties of the extra-mathematical domain being modelled into consideration [25].
4. **Mathematical reasoning competency:**
The ability to analyse or create arguments, such as a series of statements connected by inferences and presented orally or in writing to support mathematical claims, is referred to as reasoning mathematically [25]. This competency includes both the ability to evaluate and critically analyse previous or proposed justification efforts as well as the capacity to constructively support mathematical statements. Reasoning competency can be defined as: mathematical explanations that explicitly support decisions and conclusions [5].

Handling the language, constructs, and tools of mathematics

Four other competencies classified under this category. They are listed as follows:

5. **Mathematical representation competency :** This competency highlights “the ability to interpret, translate, and move between a wide scale of representations of mathematical objects, relationships, phenomena, and processes” [25]. Additionally, it emphasises the capacity to select and use these representations in dealing with mathematical problems and circumstances [25].
6. **Handling mathematical symbols and formalism competency:** This capability is defined by specialists as the capacity to relate to and cope with mathematical symbols, symbolic expressions, and transformations [25]. as well as dealing with the rules and procedures that govern them. This competency focuses on introducing and using symbols and formalism in dealing with mathematical situations and contexts, whereas receptively it entails decoding and interpreting examples of symbolic expressions and transformations, in addition to formalism, that are already present [25].
7. **Mathematical communication competency:** Communication competency can be described as the ability to communicate or engage with, in, or about mathematics. The engagement in this context refers to “the process in which information is interchanged between individuals through a general system of symbols, signs, or behaviour” [5]. A sender, a receiver, and a medium in which both parties may handle the communicated information are the three main components of a communication process. The transmitter is typically the instructor, the textbook author, or it might be a student. The receiver is

typically a student or an instructor, and the medium can be either physical, like writing or gesturing, or aural, like speaking and listening [5].

8. **Mathematical aids and tools competency:** The ability to use tools and aids effectively in mathematical work, as well as the capacity to critically analyse one's own and other people's use of such tools and aids, comprise the fundamental component of this competency [25].

1.5 Previous Studies on Mathematical Competencies

The research concerning mathematical competencies can be classified into two types. The first focuses on competencies as a major object of research. The second type of research comprises studies where mathematical prowess serves as a tool for research for another objective. It's crucial to point out that a lot of study has been done in the past on certain abilities like modelling, representations, problem solving, and reasoning without ever using the word "competency" [26].

A study by Boesen et al. [5] examined Swedish national mathematics exams to determine how well they reflect these competencies and whether they might be used to alter education. The results demonstrated that all competencies are evaluated in the national exams. The tests do not adequately capture the multifaceted nature of the competencies because of the study's limited focus on the interpretation and evaluation components of the competencies. The perceived, real, and underlying causes of Grade 12 students' general mathematics competence level were examined in a second study by Mamolo and Sugano [28]. The results showed that while the senior high school students judged the three areas of general mathematics—including "Functions and their Graphs", "Business Mathematics", and "Logic"—to be satisfactory, the actual acquired competence was only fair. According to data, the teacher, the surroundings, low self-perception, and personal factors all affect students' degree of competence. The acquired competency, however, indicated that students have not yet mastered the essential competencies related to the subject. Only few studies tackled the topic of mathematical competencies such as the study of Alshehri[10], who described the level of middle school students' acquisition of mathematical thinking competency, and Alotaibi [11], who determined the mathematical thinking and reasoning competencies of high school students.

1.6 Realistic Mathematics Education and Mathematical Competencies

Regarding the research conducted to study the effect of RME on students' different mathematical competencies, the findings of Palinussa [29] indicated that achievements and improvement in critical mathematical thinking skills of students . According to Yuanita and Zakaria [30], RME has had a positive impact on students' ability to solve problems, and there are noticeable variations between the treatment and control groups in terms of problem-solving abilities. The usage of RME can enhance mathematical belief, problem-solving abilities, and representation skills, according to Yuanita et al. [31], who highlight the significance of mathematical representation competency as a mediator between mathematical belief and problem solving. The RME technique successfully helps students develop their own concepts from contexts or experiences from real-life. Additionally, Basuki and Wijaya [32] have noted a discernible difference in the students' reasoning abilities between those who learnt with worksheets based on the RME technique and those who learned with worksheets based on the conventional approach. It was stated that, students' worksheet that has been created based on Realistic Mathematics Education is productive toward reasoning ability. Other research findings confirmed the positive effect of the RME approach on students' ability to representation mathematical entities and on their communication competency as well. The results of Without regard to the students' gender, Fauzan et al. [33] demonstrated that students' mathematical representational skills were higher when they were taught using RME than when they were taught using the standard approach. Moreover, based on the results of Trisnawati et al. [34] mathematics learning done with RME approach can develop mathematical communication ability of the students. There is a lack of research done to directly examine the effect of RME on using mathematical symbols and formalism competency, that several research focused on the effect of RME on improving students' mathematical literacy, which includes decoding and interpreting skills. Mathematical literacy is defined as "the ability to apply and develop mathematical abilities in solving problems in everyday life" [23]. The key aspects of mathematical literacy that must be considered are the ability to formulate context-specific problems, as well as the capacity to apply and interpret in varied situations [23]. However, the complex connection between mathematical literacy and mathematical competence must be made clear. The core of mathematical literacy is the capacity to apply mathematics to practical situations to deal with mathematics-intensive elements of the daily, social, and societal world that an average person inhabits. Mathematical knowledge and competencies are undoubtedly needed for this, but they are not exhausted. The application of mathematics in all of its forms, whether or not it is functionally relevant to day-to-day life, is covered by mathematical competences. In other words, exercising mathematical literacy does not involve all of a person's mathematical competencies [26].

Regarding the Saudi context, Khalil [35] conducted a study to determine the effect of teaching an RME-based course on (PYP) students' academic performance and attitude towards mathematics. (PYP) or Preparatory Year Program is a one full academic year of preparation providing a set of non-credit course that focus on mathematics, English language proficiency, computational skills, and personal development skills [7]. The PYP has been established by the Saudi Ministry of Education about 10 years ago to bridge the gap between school education and tertiary education, as its aim is inspecting accepted applicants to point out the less qualified students and prepare those with limited deficiencies for colleges [36]. This program is obligatory in all Saudi public and private universities. However, it is important to mention that starting from 2017, some private universities have decided to cancel the PYP as a distinct program and embed it among their academic programs. It is believed that the goal of such embedding is to relate PYP to academic majors [15]. Therefore, students at such universities are still studying the same remedial courses (PYP courses), but instead of being named PYP students, they are called freshmen. Findings of Khalil's study [35] reported that RME has positively affected students' performance as well as their attitude towards mathematics. The current study focuses on students' mathematical competencies rather than general performance, due to the need to reform mathematics education in Saudi Arabia, and the scarcity of research done to discuss undergraduate students mathematical competencies. Hence, this research proposes to implement RME learning strategy as an intervention that may enhance the teaching and learning experience and improve undergraduate freshmen students' mathematical thinking, reasoning, representation, and handling mathematical symbols and formalism. This implementation will be done through a quasi-experimental design.

The current study sample is inclusive to students who attended business and administration college. The rational of this selection is that school of business and administration does not require high qualifications for admission, which means that students who attend such school represent a diversity of backgrounds, experiences, and levels of mathematical competencies. This diversity will make the study sample better to be tested.

It is believed that relating mathematical concepts to a real-life context related to the students' major, with respect to RME characteristics will lead to deep understanding, which may improve students' mathematical competencies. Therefore, producing competent graduates, who are capable to the labour market. This study seeks to answer the following questions:

1. What are the extents of undergraduate freshmen students' mathematical thinking, reasoning, representation, and handling mathematical symbols and formalism competencies before the implementation of RME?
2. Is there any significant difference between the treatment and control groups in their accomplishment of the four mathematical competencies before the implement of RME?
3. Is there any improvement in mathematical thinking, reasoning, representation, and handling mathematical symbols and formalism competencies of students' of both groups after completing the pre-calculus course?
4. Is there any significant difference between the independent groups (RME learning strategy and conventional strategy) in the post-test scores?
5. Are there any significant differences in the treatment group students' accomplishment of the four mathematical competencies after the implementation of RME?

2 Materials and Methods

The aim of this study is evaluating the effect of RME on undergraduate freshmen students' mathematical competencies. This aim can be achieved by the employment of a quantitative research method, namely a quasi-experimental design. In this type of research, experimental treatments are given overtime to a group of sample subjects [37]. Accordingly, this research adopted a quasi-experimental design of pre-test post-test, non-randomised control group type, which has its root in the work of Campbell and Stanley in 1966 [38].

2.1 Sampling and Study Context

This study sample was selected from a college of business administration in private university in Jeddah, Saudi Arabia. Attendees of this college must take a mathematics placement test to determine their legibility to register in a course of business mathematics. Students who fail this test must complete a pre-calculus course (Math099), which is an introductory course that provides the students with the necessarily algebraic skills needed to succeed in the other quantitative courses of the university. Usually, around 60% fail this test. Hence, the study sample was selected from the students who registered in math099.

There were four math099 sections. Each section contains 19 to 24 students. Therefore, the treatment group consisted of 39 students from 2 sections, and the control group consisted of 44 students from the other 2 sections.

2.2 Instrumentation

This study uses a quasi-experimental design with three components: a pre-test, a post-test, and an RME-based pre-calculus course. Mathematical proficiency can be evaluated by "typical written exams," "technology supported assessments" such multiple-choice questions

(MCQs), or a composite of these, according to Ivanov [39]. Four mathematical competencies—mathematical thinking, reasoning, representation, and use of mathematical symbols and formalism—are evaluated by the pre-test and post-test items. Since competencies like problem-solving and modelling can be evaluated through experiments employing software or numerical calculations [39], these competencies are not measured by the exam items. A pre-test and post-test cannot be used to measure communication proficiency because it can be evaluated during in-class activities and tasks [39]. Additionally, during tests, students are not permitted to utilise calculators, the internet, or any other informational resources. Therefore, competencies of communication and using mathematical aids and tools are not of this study's scope. The ADDIE approach, which has five phases: analysis, design, development, implementation, and evaluation, is used to build the research instrument. The ADDIE paradigm is frequently employed in the creation of curricula, products, and tools in a variety of industries, including online continuing education and library instruction [40]. ADDIE model was used in several research conducted on RME such as [41,42,43, 44,45]

2.3 ADDIE Phases of RME Module

2.3.1 Phase I: Analysis

In this phase, interviews with six instructors of math099 were conducted to develop a deep understanding about the pre-calculus course and its way of delivery, and to obtain an impression about students' mathematical competencies and the difficulties they might have regarding this course. This analysis helped to select the appropriate topics, tasks, and activities that will be given to the students, as well as the rationale behind the selections. The topics that have been chosen based on the instructors' recommendations were sets, linear equations, and functions. In the interviews, the instructors mentioned that these topics are directly related to business subjects.

2.3.2 Phase II: Design

The main aim of this phase is designing the structure of the RME learning strategy based on the CLOs (Course Learning Outcomes), the characteristics of the RME learning strategy, and a context suitable for business and administration field. Considering that in the experiment of Edo and Tasik [46], an RME-based mathematics course has been designed using a context appropriate for vocational college students. Interviews with five business and administration practitioners were conducted to help create an authentic business context for the topics selected. Fully descriptive documents regarding the research instrument were prepared to confirm its validity and reliability. The forms contain detailed explanation about the designed course and its components such as CLOs, tasks, and activities that must be done either by instructor or students, aligned with the RME characteristics. Table 1 shows a sample of the RME-based course components. Moreover, a validity confirmation survey and a list of pre-test and post-test questions aligned with the mathematical competencies each question measures and justifications for each selection was prepared. The list of each test consisted of 24 items that varied between multiple choice (MCQs) and open-ended questions. Some of the questions were PISA-like edited from Zulkardi et al [47] and Putri and Zulkardi [48], while the rest were regular conceptual or procedural question inspired from the university mathematics placement test. Table 2 dispose some of the pre-test items with the mathematical competencies each question measures and the type of each question. The selections of questions that measure each mathematical competency was set as follows: all 24 questions measure mathematical thinking. 14 questions measure reasoning competency. 18 questions measure the representation competency, and another set of 18 questions measure handling mathematical symbols and formalism competency.

Testing Validity of The Module

Four PhD holder-experts in mathematics education and mathematics assistant professors were required to validate the instrument. After that, an intra-class correlation coefficient of the two-way random-effect model was conducted to determine inter-rater reliability. The result indicated a Cronbach's alpha of 0.82 which reflects a high reliability based on the feedback. Thus, an average measure of 0.801, was obtained which is considered a good indicator of inter-rater reliability [49, 50]

Experts were also asked to confirm the selection of questions that measure each competency. Then, the PAA (Percentage of Absolute Agreement) was calculated to obtain the score of the inter-rater reliability of the experts rating. PAA was calculated using the formula below:

$$PAA = \frac{\text{Number of concordant responses}}{\text{total number of responses}} X100 \quad (1)$$

PAA yielded a value of 84.02%, which occurs between 75% and 90% ,Thus it reflects an acceptable level of agreement [49].

2.3.3 Phase III: Development

In this phase the RME-based course components have been developed on actual platform. This included constructing the mathematical tasks and activities, the pre-test and post-test on Black Board.

2.3.4 Phase IV: Implementation

This phase includes two stages. In the first stage, the pilot study was conducted to guarantee the success in the conduct of experiment and to confirm the reliability of the instrument. The goal of this step is to check whether the students can enter Black Board easily, and whether they can understand the items of the pre- test and post-test created in Black Board. Twelve freshmen students were involved in the pilot study, which has been conducted on two sessions. In the first session, students were asked to respond to the pre-test, whereas in the second one, they were given a lecture based on the RME strategy. Interviews with the pilot study participants were conducted to reliability purposes. All interviews have been recorded. Most responses positively supported the RME- based class, and confirmed how interesting the class was, which drew their attention and increase their enthusiasm to engage in the activities.

In the second stage, the actual implementation of the research experiment was conducted. It took 6 weeks to complete the selected topics. 18 hours of classes in addition to 2 hours for running the tests.

2.3.5 Phase V: Evaluation

In the phase of evaluation, there are two stages: formative evaluation and summative evaluation. In Stage I, results of the pilot study were evaluated. The results obtained confirmed the reliability of the research instrument as follows:

Testing Reliability of The RME Module

To test reliability of the pre-test and post-tests, Cronbach's Alpha for Multiple Choice Test was conducted. It yields a value of 0.813, which is considered high reliable. Moreover, the interviews of the pilot study participants were analysed. The results confirm the instrument reliability, that 91.6% of them assure the clarity and well-preparedness of instrument materials. Stage II illustrate the summative evaluation, which is the results of the real experiment.

3 Results and Discussion

3.1 Pre-Test Results

To answer the first research question, which was: "what is the extent of undergraduate freshmen students' mathematical thinking, reasoning, representation, and handling mathematical symbols and formalism competencies before the implement of RME?" Two hypotheses were set: H_0; $\mu = \mu_{(0)}$ H_1; $\mu \neq \mu_0$ $\mu_0 = 0.6$ (total score of MC)

The pre-test was conducted for the study groups. The test grades were collected 4 times based on the selection of questions that measure each competency. Therefore, the total of the mathematical thinking competency is 24. The total of the reasoning competency is 14. The total of the representation competency as well as the handling mathematical symbols and formalism is 18. A one-sample t-test was conducted four times to compare the means of the four groups of competencies in the pre-test to a hypothesized mean. The latter was set to be representing 60% of the total score of each competency, as this percentage represents the passing rate. Therefore, the standardized mean for mathematical thinking is $\mu = 14.4$, $\mu = 8.4$ for reasoning competency, and $\mu = 10.8$ for both representation and handling mathematical symbols and formalism competencies. The one-sample t-test results can be summarized in table 3. The means of both groups (treatment and control) in the four sections of the pre-test that measures the four mathematical competencies targeted in this study are significantly different than the hypothesized mean. In other words, all means are below 60% of the total score of each competency. For example, in mathematical thinking competency, the treatment group's mean is $M = 7.4615 < \mu = 14.4$. Moreover, an independent t-test was conducted to detect if there is any significant difference between the means of the two groups (treatment and control) in each competency. Therefore, the independent t-test was conducted four times. The hypotheses set for this question were:

H_0: $\mu_T = \mu_C$, H_1:$\mu_T \neq \mu_C$

In all four t-test conducted between the independent groups to compare students' achievement in the four mentioned mathematical competencies, no significant difference was found, which means that null hypothesis was accepted. For example, there is no significant difference in the achievement of reasoning competency between the 39 participants of the treatment group ($M = 4.2307, ST = 2.6503$), and the 44 participants of the control group ($M = 4.1363, ST = 1.7991$), $t(66) = 0.1874, p = 0.8518$. Similar results were obtained in the comparison of both groups in the rest of the mathematical competencies sections. Table 4 illustrates the independent t-test results of treatment group and control group in the pre-test scores. The table presents the mean and standard deviation of each group in the four sections of the pre-test along with the p-value resulted from the t-test.

3.2 Post-Test Results

To answer the question "is there any improvement in students' mathematical thinking, reasoning, representation, and handling mathematical symbols and formalism competencies after completing the pre-calculus course?" The hypotheses of this question are:

H_0: $\mu_1 = \mu_2$, H_1: $\mu_1 \neq \mu_2$

The results of the dependent t-test that was conducted to compare students' grades of both groups (treatment and control) in the pre-test and post-test indicated that there is a significant difference between the pre-test and post-test grades in all sections of the tests that measure the four mathematical competencies of this study, which means that null hypothesis was rejected in all four conducts of the t-test.

Starting with the treatment group, the results from the pre-test in mathematical thinking competency ($M = 7.4615, SD = 2.2350$) and post-test ($M = 19.1282, SD = 3.6214$) indicated that there is a significant difference between the means of grades in both tests, resulted in an improvement in achievement of mathematical thinking competency, $t(38) = -14.9987$, $p = 1.51065E - 17$. In reasoning competency, the results from the pre-test ($M = 4.2307, ST = 2.6503$) and post-test ($M = 10.9743, ST = 2.3450$) also show a significant difference between the two tests, $t(38) = -10.3311$, $p = 1.36964E - 12$. Similar results obtained regarding the representation competency between the pre-test ($M = 5.9487, ST = 2.5438$) and post-test ($M = 12.7435, ST = 2.7020$), $t(38) = -12.7281, p = 2.80891E - 15$, and the competency of handling mathematical symbols and formalism ($M = 5.6923, ST = 2.4511$) for the pre-test and the post-test ($M = 14.4615, ST = 2.7226$), $t(38) = -16.1135$, $p = 1.42182E - 18$. Table 5 displays the dependent t-test results of the treatment group's pre-test and post-test scores.

Regarding the control group, the results of mathematical competency section in the pre-test ($M = 7.0909, ST = 2.3508$) and the post-test ($M = 12.25, ST = 5.0491$) indicated a significant difference between the means of the two tests, $t(43) = -6.9389$, $p = 1.57751E - 08$). Moving to the reasoning competency, a significant difference was also detected between the pre-test ($M = 4.1363, ST = 1,7991$) and post-test ($M = 7, ST = 3.0575$),$t(43) = -5.8255$, $p = 6.55587E - 07$. Another significant difference was found between the pre-test section of representation competency ($M = 5.9090, ST = 2.1110$) and the post-test ($M = 8.9545, ST = 3.8757$), $t(43) = -5.2948$, $p = 3.83359E - 06$. Finally, the competency of handling mathematical symbols and formalism pre-test ($M = 5.7954, ST = 2.0638$) and post-test ($M = 9.2045, ST = 4.0781$) illustrated similar results,$t(43) = -5.5085$, $p = 1.88684E - 06$. The results of the dependent t-test conducted to compare the means of the grades in both test for the control group can be summarized in Table 6.

3.3 Effect of RME Module on Students' Mathematical Competencies

The fourth question of this study was: "is there any significant difference between the independent groups (RME learning strategy and conventional strategy) in the post-test scores?" To answer this question, tow hypotheses were set as follows:

H_0: $\mu_T = \mu_C$, H_1: $\mu_T \neq \mu_C$

An independent t-test was conducted four times to compare the results of the post-test of both groups (treatment and control) in the four sections of the tests that measure the four mathematical competencies mentioned previously in this study. The results indicated a significant difference between the means of the students' grades of both groups in all four sections of the tests. In other words, the means of the treatment group in all four mathematical competencies were significantly higher than the means of the control group. For example, the 39 participants of the treatment group ($M = 19.1282, SD = 3.6214$) had significantly better results in mathematical thinking than the 44 participants of the control group ($M = 12.25, ST = 5.0491$), $t(78) = 7.1878$, $p = 3.45116E - 10$). In addition, reasoning competency's results of the treatment group ($M = 10.9743, ST = 2.3450$) was also significantly better than the results of the control group ($M = 7, ST = 3.0575$), $t(81) = 6.7758$, $p = 1.82021E - 09$. In representation competency, the results also leaded to reject the null hypothesis, that treatment group ($M = 12.7435, ST = 2.7020$) and the control group (M=8.9545,ST=3.8757) were significantly different, $t(77) = 5.2115$, $p = 1.52433E - 06$. Similar results were reported for handling mathematical symbols and formalism competency between the treatment group ($M = 14.4615, ST = 2.7226$) and the control group ($M = 9.2045, ST = 4.0781$), $t(76) = 6.9748$, $p = 9.79088E - 10$. Table 7 reveals the previously stated results.

3.4 Accomplishment of mathematical competencies

"Are there any significant differences among the treatment group student' accomplishment of the four mathematical competencies after the implementation of RME?" To answer this question, a one-way ANOVA was conducted. The hypotheses set for this part of the statistical analysis was as follows:

H_0: $\mu_1 = \mu_2$, H_1: $\mu_1 \neq \mu_2$

Results of single-factor ANOVA indicated that there is a significant difference between the means of mathematical competencies in the post test, but this type of statistical tests cannot exactly determine where this difference occurs. Hence, a post-hoc test was conducted to determine where the group differences lie. The hypotheses of this test are as same as the one-way ANOVA. According to Armstrong [51], Bonferroni correction should be considered if many tests are carried out without pre-planned hypotheses to establish any results that may be significant. Thus, P-value was corrected to 0.00833 using Bonferroni method. Results illustrated that there are no significant differences between each pair of mathematical competencies except for mathematical representation and handling mathematical symbols and formalism competencies. It can be concluded that the mean of representation competency (M=12.7436) is statistically lower than the mean of handling mathematical symbols and formalism competency (M=14.4615). Table 8 illustrates the results of the post-hoc test.

At an earlier stage of this study, the pre-test was conducted to determine the extent of students' mathematical competencies. The data has been collected and analysed with a one-sample t-test, as the aim was to compare students' scores in all four sections of the test to a hypothesized mean. This latter mean was set to be the pass score, which is 60% of the total score of each section. The results revealed poor levels of achievement of mathematical thinking, reasoning, representation and handling mathematical symbols and formalism competencies. Then, a comparison between the scores of treatment group and the control group in each section was also conducted using an independent measures t-test to confirm that both groups are at the same level of achievement of all four mathematical competencies intended to be measured in this study. The findings showed that there are no significant differences between the treatment group and the control group in their levels of achievement of each mathematical competency. Students' scribbles during the test were collected. It was surprising that most of them never show any explanation or steps of how they solve the test questions. The few samples of drafts show that many students struggled to relate the questions to different mathematical concepts such as ratio, linear equations, functions, sets, and other basic topics of algebra. Students' weak level of mathematical thinking competency reveals their limited abilities in analysing the question to determine the requirement and linking the provided data to draw a conclusion. The collected scribbles also illustrate poor levels of reasoning competency, that most students fail to logically justify their choices and eliminate the incorrect answers. Similar results were found regarding representation competency, as students' ability to represent provided information into a sort of drawing or graphing was very limited. evidence reflected little potential of distinguishment between mathematical symbols used at same topic, which explain students' low abilities of handling mathematical symbols and formalism. Moreover, students' abilities of performing arithmetic operations without using calculators were so limited.

Most of them struggles to recall simple formulas such as the ones used for finding the area or perimeter of a rectangle. See the steps done to solve question 1, in Fig 1. The student divided the perimeter by the difference between the width and length, which indicates weak ability of linking to the correct mathematical concept. This also reflects a weak reasoning competency as the student did not figure out that he/she is working on a rectangle, of which the sides are not equal. There is no evidence in this piece of paper for representation competency. Arithmetic operations performed in the questions from 1 to 5 were correct, which confirm, to some extent, this student's ability to handle mathematical symbols, despite of the incorrect formation of the equations used to solve the break-even and the ratio problems.

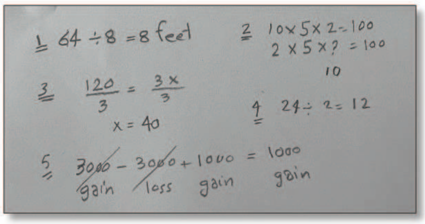

Fig. 1: A sample of a student's scribble from pre-test

After running the RME-based classes for 6 weeks (18 hours), the students took the post-test, which consisted of similar questions of the pre-test with minor differences in context and numbers. Students' responses of both groups were analysed using a dependent t-test first to explore if there is any improvement in their mathematical competencies. A significant difference between students' pre-test and post-test scores of both groups was detected, which means that the mathematical competencies of students from both groups have been improved by the end of the course. These results implies that both strategies (RME and conventional) have had a positive effect on students' mathematical competencies. Therefore, an independent measures t-test was conducted to compare both groups' scores of post-tests. This step was a must to investigate whether there is a significant difference between students' achievement of mathematical competencies in both groups. The findings confirmed the effectiveness of RME on students' mathematical competencies, as it indicated a significant difference between the post-test scores of both groups. In other words, if the conventional method of teaching positively affected students' mathematical competencies, RME has proven to be even more effective, as the differences between students' means in all mathematical competencies of both groups are clearly noticeable in addition to the statistical evidence. This, somehow, supports the findings of Laurens et al.[21], that was mentioned previously in this study. Students' scribbles of the post-test revealed a lot of what they acquired. Fig 2. Reflects coherent linking to mathematical concepts in all questions from 1 to 5. Adequate justifications provided showed a remarkable enhancement in mathematical thinking and reasoning competencies. These findings concur with the results of Palinussa [29] regarding the effect of RME on students' mathematical thinking, and the results of Basuki and Wijaya [32] regarding reasoning competency. Evidence that proof improvement in representation competency was also found. See question 1 and 4 in Fig 2, which support the findings of yuanita et al. [31] and Fauzan et al [33]. There are other indications of better handling of mathematical symbols and formalism competency shown in all 5 questions in the sample below. To the best of our knowledge, this study is the first to directly evaluate the effect of RME on using mathematical symbols and formalism competency identified by Niss et al. [26]. Several previous studies focused on examining the effect of RME on mathematical literacy, which includes "the ability to formulate and interpret mathematics in a variety of situations" [52]. Formulation and interpretation abilities are involved in using mathematical symbols and formalism competency.

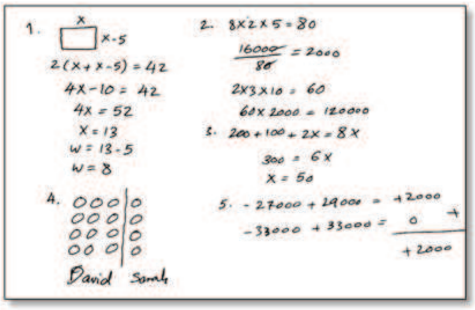

Fig. 2: A sample of a student's scribble from post-test

The means of students' scores in all competencies have distinctly increased. All means are statistically close with no significant differences between each pair of them, except for representation and handling mathematical symbols and formalism competencies. The findings indicated that students' mean of representation competency (70.79%) was the least among the four measured competencies. It was also statically lower than students' mean in the competency of handling mathematical symbols and formalism (80.34%). In fact, the latter was the greatest mean among all four competencies, as mathematical thinking competency comes next with a mean of (79.70%) followed by reasoning competency with (78.38%).

This study confirms the recommendation suggested by [35] for Saudi universities to adopt RME-based courses in teaching freshmen students or preparatory year program students, to improve university mathematics curriculum and textbooks based on the theory of RME, and to provide sufficient training for in-service and pre-service mathematics teachers to apply the introduction of RME in teaching mathematics for pre-college levels of education. Mahmoud and Alaraj [53] stated that in order to meet the current difficulties, educational curricula and instructional methods need to be revised. Focusing on competency-based learning, which emphasizes the mastery of quantifiable student outcomes, is also advised. Competency-based learning indicates that the assessment of students' development must be done based on their capacity to show mastery of present competences, that is, specific and measurable objectives that are made explicitly evident to them [54]. Competency-based learning differs from other mastery learning methodologies in that it has very strict standards for what qualifies as mastery. It places a strong emphasis on evaluating students on quantifiable competencies, which means that mastery of competencies in competency-based learning is dependent on both the capacity to apply newly acquired knowledge in practical contexts and a theoretical or conceptual understanding of the subject matter [54]. In contrast to the conventional approach to instruction, a competency-based learning strategy would lessen performance gaps among students with diverse levels of academic aptitude [55]. Since the study was inclusive to measure four mathematical competencies, namely: mathematical thinking, reasoning, representation, and handling mathematical symbols and formalism, it is strongly recommended for other studies to focus on the rest of mathematical competencies such as problem-solving, modelling, communication, and using mathematical aids and tools. It is important to mention that the study of Khalil [35] focused on permutation and combinatorics topics, whereas this study included sets, functions, and linear equations. Therefore, it is recommended to cover other mathematical concepts and scopes to enrich the mathematics curricula. It is believed that this work along with other that could be done on different samples of students and tackle different mathematical topics will enhance mathematics teaching and learning experience, as it is in general a proposal for a new direction in teaching and learning mathematics.

4 Acknowledgments

The first author thanks UBT for its financial assistance. The authors appreciate the anonymous referee's attentive observation and insightful suggestions, which helped to improve this paper.

References

[1] A. K. H. Alghamdi, The effects of an integrated curriculum on student achievement in Saudi Arabia, EURASIA Journal of Mathematics Science and Technology Education, 13, 6079–6100, (2017).

[2] M. Alabdulaziz, Changes needed in Saudi universities' mathematics curricula to satisfy the requirements of vision 2030, EURASIA Journal of Mathematics Science and Technology Education,15, (2019).

[3] B. Y. Yuniati, A. Armiati, and E. Musdi, The influence of realistic mathematics education (RME) approach with

the TANDUR on understanding the concepts and solving mathematical problems on grade 8 in smp negeri 1 pantai cermin, International Conference on Mathematics and Mathematics Education, Padang City, Indonesia, (2020)
[4] K. M. Alsharif and N. M. Alamri, Using teaching practices inventory to evaluate mathematics faculty teaching practices in higher education, International Journal of Instruction, 13, 139–150, (2020)
[5] J. Boesen, J. Lithner, and T. Palm, Assessing mathematical competencies: an analysis of Swedish national mathematics tests, Scandinavian Journal of Educational Research, 62, 109–124, (2016).
[6] A. Pettersen and G. A. Nortvedt, Identifying Competency Demands in Mathematical Tasks: Recognising What Matters, International Journal of Science and Mathematics Education, 16, 949–965, (2018).
[7] H. B. Khoshaim, High school graduates' readiness for tertiary education in Saudi Arabia, International Journal of Instruction , 10, 179–194, (2017).
[8] A. N. Alqifari, The extent of Saudi teachers' knowledge of TIMSS' policies and assessment practices, Journal of Contemporary Scientific Research (ISSN, 4, 8–21, (2020).
[9] A. Schleicher, PISA 2018 Lights and Interpretations, OECD, (2019).
[10] Z. F. Alshehri, The Level of Middle School Students' Acquisition of Productive Mathematical Thinking Competencies, Islamic University Journal for Educational and Psychological Studies, 26, 110-129, (2017)
[11] S. S. Alotaibi, Identifying the Relationship between Academic Self-motivation and the Mathematical Thinking: A Case Study of Secondary School Students, Universal Journal of Educational Research, 8, 7239–7245, (2020).
[12] Y. D. Arthur, E. K. Owusu, S. Asiedu-Addo, and A. K. Arhin, Connecting Mathematics To Real-Life Problems: A Teaching Quality That Improves Students' Mathematics Interest, IOSR Journal of Research and Method in Education (IOSR-JRME)., 8, 65–71, (2018).
[13] N. A. K. Alreshidi, Investigating problem-based learning in Saudi Arabian mathematics education: a TIMSS-related study, PhD thesis, University of Glasgow, UK, 2016.
[14] S. Albishi, Use of the flipped classroom instructional model in higher education: instructors' perspectives in Saudi Arabia, PhD thesis,Indiana State University, USA, (2018).
[15] H. B. Khoshaim, T. Ali, and A. B. Khoshaim, Preparatory Year: The Filter For Mathematically Intensive Programs,International Interdisciplinary Journal of Education, 7, 127-136, (2018).
[16] M. G. Moura-Silva, R. de O. Souza, T. O. Goncalves, and R. G. B. Borges, Realistic Mathematic Education: a theoretical-methodological approach to the teaching of mathematics in countryside schools, The Brazilian Scientific Journal of Rural Education, 5, 1–20, (2020).
[17] H. Fredriksen, Exploring Realistic Mathematics Education in a Flipped Classroom Context at the Tertiary Level, International Journal of Science and Mathematics Education, 19, 377–396, (2021).
[18] A. Jupri and P. Drijvers, Student difficulties in mathematizing word problems in Algebra, EURASIA Journal of Mathematics Science and Technology Education, 12, 2481–2502, (2016).
[19] L. Lestari and E. Surya, The Effectiveness of Realistic Mathematics Education Approach on Ability of Students' Mathematical Concept Understanding, International Journal of Sciences: Basic and Applied Research, 34, 91–100, (2017).
[20] E. Zakaria and M. Syamaun, The Effect of Realistic Mathematics Education Approach on Students' Achievement And Attitudes Towards Mathematics, Mathematics Education Trends and Research, 2017, 32–40, (2017)..
[21] T. Laurens, F. A. Batlolona, J. R. Batlolona, and M. Leasa, How does realistic mathematics education (RME) improve students' mathematics cognitive achievement?, EURASIA Journal of Mathematics Science and Technology Education, 14, 569–578, (2018).
[22] N. R. Astuti, Gunarhadi, and Mintasih, The Effect of RME on Mathematics Learning Outcomes Viewed Mathematic Communication Skills, International Journal of Educational Research Review, 5, 43–53, (2020).
[23] R. Fauzana, J. A. Dahlan, and A. Jupri, The influence of realistic mathematics education (RME) approach in enhancing students' mathematical literacy skills, Journal of Physics: Conference Series, 1521, (2020).
[24] J. Hiebert and P. Lefevre, Conceptual and procedural knowledge in mathematics: An introductory analysis, in Conceptual and Procedural Knowledge, 1st ed, Tylor and Frances Group, New York, 1–28, (1986).
[25] M. Niss and T. Højgaard, Mathematical competencies revisited, Educational Studies in Mathematics, 102, 9–28, (2019).
[26] M. Niss, R. Bruder, N. Planas, R. Turner, and J. A. Villa-Ochoa, Survey team on: conceptualisation of the role of competencies, knowing and knowledge in mathematics education research, ZDM Mathematics Education, 48, 611–632, (2016).
[27] J. Drábeková, T. Pechočiak, and V. Matušek, Mathematical competencies of students entering university studies. Case study of Slovakia, Mathematics in Education, Research and Applications, 4, 23–30, (2018).
[28] L. A. Mamolo and S. G. C. Sugano, Self-perceived and actual competencies of senior high school students in General Mathematics, Cogent Education, 7, (2020).
[29] A. L. Palinussa, Students' critical mathematical thinking skills and character: Experiments for junior high school students through realistic mathematics education culture-based, Journal on Mathematics Education, 4, 75–94, (2013).
[30] P. 1 Yuanita and E. ; Zakaria, The Effect of Realistic Mathematics Education (RME) Implementation to Mathematics Belief , Mathematics Representative and Mathematics Problem Solving, Advanced Science Letters, 22, 1989–1992, (2016).
[31] P. Yuanita, H. Zulnaidi, and E. Zakaria, The effectiveness of Realistic Mathematics Education approach: The role of mathematical representation as mediator between mathematical belief and problem solving, PLoS One, 13, 1–20, (2018).
[32] W. A. Basuki and A. Wijaya, Students worksheet based on realistic mathematics education: How the effect toward reasoning ability?, The 5th International Conference on Research, Implementation, and Education of Mathematics and Sciences, Yogyakarta, Indonesia, 1157, (2019).
[33] R. P. Fauzan, A.; Musdi, E.;Yani, The Influence of Realistic Mathematics Education (RME) Approach on Students'

Mathematical Representation Ability, Advances in Social Science, Education and Humanities Research, 173, 9-12, (2019).
[34] T. Trisnawati, R. Pratiwi, and W. Waziana, The effect of realistic mathematics education on student's mathematical communication ability, Malikussaleh Malikussaleh Journal of Mathematics Learning (MJML), 1, 31-35, (2018).
[35] Y. F. Khalil, The Effect of Teaching an RME-Based Program on Preparatory Year Students' Performance and Attitude Towards Mathematics in Imam Mohammed Bin Saud University, College of Education Journal of Azhar University, 179, 599-563, (2018).
[36] M. H. S. Al Ashry, A Proposed Courses Structure for the Preparatory College Year, International Journal of Financial Research, 8, 53-63, (2017).
[37] J. w. Creswell, Qualitative, Quantitative, and Mixed Methods Approaches Research Design,SAGE Publications, Inc, Los Angeles, London, New Delhi, Singapore, Washington DC, 226, (2014).
[38] D. Campbell and J. Stanley, Experimental and Quasi-Experimental Design for Research, 15, (1966).
[39] A. Ivanov, Decision trees for evaluation of mathematical competencies in the higher education: A case study, Mathematics, 8, (2020).
[40] L. Cheung, Using the ADDIE Model of Instructional Design to Teach Chest Radiograph Interpretation, Journal of Biomedical Education, 2016, 1–6, (2016).
[41] A. C. P. Lestari and R. Ekawati, Development Of Education Comics Based Realistic Mathematics Education On Fraction Material, JRPIPM, 3, 15–23, (2019).
[42] C. Hikayat, Suparman, Y. Hairun, and H. Suharna, Design of Realistic Mathematics Education Approach to Improve Critical Thinking Skills, Universal Journal of Educational Research, 8, 2232–2244, (2020).
[43] J. Supriyanto, Suparman, and Y. Hairun, Design of Worksheets for RME Model to Improve Mathematical Communication, Universal Journal of Educational Research, 8, 1363–1371, (2020).
[44] E. M. S. Wijaya and R. Setiawan, RME-based Absolute Value Worksheet Design as an Effort to Improve Mathematical Thinking Ability of Tribhuwana Tunggadewi University Students, Mathematics Education Journals, 5, 185–191, (2021).
[45] L. L. Miranda, S. Suprihatiningsih, R. N. Friantini, K. Hermiati, and P. Annurwanda, Development of Mathematics Learning Module Based on Realistic Mathematics Education (RME) Approach in SPLDV Materials, Alpha Math, Journal of Mathematics Education, 8, 209–222, (2022).
[46] S. I. Edo and W. F. Tasik, Design research on applied Realistic Mathematics Education (RME) approach in teaching math for vocational college, Journal Pendidik. Vokasi, 9, 294–306, (2019).
[47] Zulkardi et al., How students work with pisa-like mathematical tasks using covid-19 context, Journal of Mathematics Education, 11, 405–416, (2020).
[48] R. I. I. Putri and Zulkardi, Designing piSA-like mathematics task using Asian games context, Journal of Mathematics Education, 11, 135–144, (2020)
[49] Shweta, R. C. Bajpai, and H. K. Chaturvedi, Evaluation of inter-rater agreement and inter-rater reliability for observational data: An overview of concepts and methods, Journal of the Indian Academy of Applied Psychology, 41, 20–27, (2015).
[50] S. E. Stemler, A comparison of consensus, consistency, and measurement approaches to estimating interrater reliability, Practical Assessment, Research and Evaluation, 9, (2004).
[51] R. A. Armstrong, When to use the Bonferroni correction, the journal of the British College of Ophthalmic Opticians (Optometrists), 34, 502–508, (2014).
[52] D. A. Santoso, A. Farid, and B. Ulum, Error Analysis of Students Working about Word Problem of Linear Program with NEA Procedure, International Conference on Mathematics: Education, Theory and Application, Surakarta, Indonesia 855, 1-8, (2017).
[53] S. Mahmoud and M. Alaraj,The Discrepancy between High School GPA and Qiyas Results among Saudi High School Students, IOSR Journal of Research and Method in Education, 8, 34-41, (2018)
[54] M. Henri, M. D. Johnson, and B. Nepal, A Review of Competency-Based Learning: Tools, Assessments, and Recommendations, Journal of Engineering Education, 106, 607–638, (2017).
[55] M. P. Rosales Almendra, Competency-Based Learning for Motivation and Academic Performance in a Pre-calculus Course, American Journal of Educational Research, 7, 54–59, (2019)

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