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The Needs Analysis in Developing Trig-GO App For Trigonometry Learning: A Qualitative Approach

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Abstract

The rapid development in the world of technology and communication has contributed directly to the teaching and learning process in schools. Therefore, a paradigm shift towards learning methods in the education system needs to be implemented to meet the educational aims of the 21st century. This is due to the current methods of delivery in teaching and learning are still conventional. Therefore, this study aims to develop Trig-GO apps for mathematics in secondary schools by focusing on the topic of trigonometry. The development process of this application is guided by the model of Dick, Carey and Carey. This paper describes the design and development of Trig-GO apps prototype based on Design and Development Research (DDR) methods and approaches.The findings of the study indicated that a prototype of the Trig-GO application has been developed. The results of the development of the application prototype were evaluated through qualitative methods. The data was obtained from five experienced teachers and six students via observations, interviews and document analysis. Therefore, the results of the analysis showed that the Trig-GO application prototype developed need improvement. Thus, this also will give impact to the quality and production of the application prototype. It is expected to assist students in solving trigonometry questions at the highest level. The development of this prototype application is intended to assist teachers in providing teaching aids that can be used in the teaching of trigonometry through a digital approach.

Keywords: Development, applications, mathematics, need analysis, trigonometry, students learning

Introduction

Sepeng and Webb (2012) explain that mathematics involves a lot of various concepts of space, number, quantity and order that exist in sports and games which are more relevant to explain to students. Although mathematics is a difficult subject for some students to understand, meaningfully teaching and learning can help students improve their mathematical results (Marshiza 2012). Most students consider the trigonometry to be the most difficult and abstract topic compared to other topics in mathematics (Challenger 2009; Demir 2012; Gür 2009; Jaworski 2010; Moore 2012; İnan 2013; Orhun 2004; Thompson 2008; Weber 2008; Yusha'u 2013; Zengin, Furkan & Kutluca 2012). Students' understanding of mathematics will produce positive results if the teacher is able to convey a mathematical concept in a more effective way other than just being teacher-centered (Mashira et al. 2019). The development of this Trig-GO prototype application is intended to assist teachers in providing teaching aids. It can be used in the teaching of trigonometry through a technology approach. The development of technology and the internet during this crisis has changed the lifestyle and needs of society, including the education system (Soni 2020). The main idea of developing Trig-GO apps is to reduce errors, improve students' understanding and achievement in trigonometry topics. Due to lack in students' understanding regarding the transfer of numerator and denominator in fractions involving trigonometry (Ngu & Phan 2020)mathematics is considered as being "pure theoretical" (Becher, 1987, teachers need to implement teaching and learning session by involving digital materials (Natana et al. 2019). The usage of digital applications are able to increase students' understanding in line with current needs (Che Ghani et al. 2016). Poor mastery of symbols and algorithm processes in the trigonometry component resulted in students failing in solving trigonometry questions. There were some significant mistakes by students when solving trigonometry questions. The main challenge of education today is focused on virtual learning. In circling this current of scientific and technological advancement, every country needs to improve its approach to its education system. The topic of trigonometry is a field found in the subjects of mathematic. Students' understanding in trigonometry can be enhanced by providing several platforms that fit the demands of the 21st century. Sanchal and Sharma (2017) state that sports and games are one of the best approaches to enhance students' understanding and perception of digital learning in mathematics.. Therefore, digital learning platforms need

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to be provided as a method of teaching and learning. This is one of the efforts to increase the level of understanding and level of student achievement in trigonometry. This is because digital learning is able to provide a wide space for students to understand the entire learning topics involved (Soni 2020). As such, with today's economic boom and digital learning has created the need to build Trig-GO apps. The construction of these Trig-GO apps is to support and provide a digital learning platform for teachers and students. This is because digital learning can be applied to all educators not only to students and teachers but also to parents (Heng & Sol 2020). Thus, a study needs to be conducted at the secondary school level to explore the views of teachers and students on the need in developing Trig-GO apps.

Purpose And Objectives of the Study

The purpose of this study was to develop a Trig-GO apps that contains digital components such as notes, exercises, learning guides and games that lead to improved understanding in trigonometry. Specifically, the objectives of the study are as follows:

i. Explore teachers' views on the need in developing Trig-GO appss.
ii. Identify the types of misconceptions of students in the topic of trigonometry learning.
iii. Identify the level of understanding of form four students in the topic of trigonometry learning.
iv. Design and develop Trig-GO apps in trigonometry learning topic.

Methodology

Research Process

There are several learning design models that are often used by researchers in producing a module. Among the well-known learning design models are ADDIE model, ASSURE model, Kemp model and the Dick, Carey and Carey model. A comparison of the criteria or characteristics of the learning model is as in the Table 1.

There are five elements such as analysis, design, developmen, implementation and evaluation which is also an acronym for ADDIE model. The ADDIE model is based on behaviorism, a burst of ideas developed by Reiser dan Dempsey (2012)for designing learning systems. This model is the basic model to the formation of other design models such as the ASSURE model, the Kemp model and the Dick and Carey model. Ahmad Abdullahi (2015) elaborates that there are five basic steps. The steps are analysis, design, development, implementation and evaluation in the ASSURE model, the Kemp model and the Dick and Carey model. Culatta dan Kearsley (2016) explained that the ADDIE model is generic and linear in nature which is less effective in determining the behavioral changes that occur. According to Culatta dan Kearsley (2016), this model was also difficult to obtain critical information throughout the study. Therefore, the researcher will not use this model as the basic model in the construction of the Trig-GO apps.

The ASSURE model is also an abbreviation for analysis; state the teaching objective; select teaching materials; use media and teaching materials; require active student involvement; and evaluate the results of teaching. This model was produced by Heinich et al. (1996) constructed this model with the aim of designing learning modules that are relevant to curriculum standards. This model is linear and only focuses on formative assessment (Ahmad Abdullahi 2015). Therefore, this model is not suitable for use by researchers in an effort to evaluate modules at all levels.

In addition there are nine components in the Morrison, Ross and Kemp models. This model was produced by Morrison, Ross dan Kemp (2004) with an emphasis on the evaluation process in module construction. According to Ahmad Abdullahi (2015), this model has three evaluation processes namely formative evaluation, summative evaluation and validity evaluation. Ahmad Abdullahi (2015) stated that this Kemp model does not have a clear relationship between one step with another step because the model diagram is too dynamic. Thus this model is not suitable for researchers in their efforts to design and evaluate modules more effectively.

In this study, the researcher fully uses the learning model of Dick, Carey and Carey (2001) which was developed through a system approach. There are three domains emphasized in this model namely cognitive domain, behaviorism domain and constructivism domain (Ahmad Abdullahi 2015; Chang 2006) or teaching, has traditionally involved instructors, learners, and textbooks. The content to be learned was contained in the text, and it was the instructor's responsibility to \"teach\" that content to the learners. Teaching could be interpreted as getting content from the text into the heads of learners in such a way that they could retrieve the information for a test. With this model, the way to improve instruction is to improve the instructor (i.e., to require the instructor to acquire more knowledge and to learn more methods for conveying it to learners. According to Ahmad Abdullahi (2015), this model is one-way, but shows a clear sequence and is interdependent between one step with another step. Two important processes in assessment namely formative assessment and summative assessment are present in this model. This model also emphasizes group involvement in producing a complete module (Dick, Carey & Carey 2005).

This Dick, Carey and Carey model is well suited for the construction of Trig-GO appss that use several mutltimedia digital tools (Chang 2006)or teaching, has traditionally involved instructors, learners, and textbooks. The content to be learned was contained in the text, and it was the instructor's

Table 1: Comparison of Learning Model Characteristics

Learning Model	*ADDIE*	*ASSURE*	*KEMP*	*Dick, Carey & Carey*
Pioneer	Reiser and Dempsey (2012)	Smaldino (1996)	Kemp et al. (2006)	Dick,Carey and Carey (2001)
Number of Steps	5 steps	6 steps	9 steps	10 steps
Review Steps	No	No	Yes	Yes
Interrelated Steps	No	No	No	Yes
Assessment Process	One Assessment	One Assessment	Formative Assessment, Summative Assessment and Validity Assessment	Formative Assessment and Summative Assessment
Justification of Model Effectiveness	Generic in nature and less effective in determining behavior change and difficult to obtain critical information throughout the study (Culatta & Kearsley 2016).	It is linear and only focuses on formative assessment (Ahmad Abdullahi 2015).	The shape of the ovule and has no clear relationship between one step and another because the model diagram is too dynamic/ in the circle of the ovule (Ahmad Abdullahi 2015).	The steps are arranged linearly and interrelated with each other and are one of the student-centered models (Obizoba 2015) particularly in the nursing content-laden curriculum. Instructional design model steps and processes enable faculty to determine the scope of the course contents, sequence of instructions, innovative presentation, and evaluation strategies. The generic instructional model of analysis, design, development, implementation, and evaluation (ADDIE.

responsibility to \"teach\" that content to the learners. Teaching could be interpreted as getting content from the text into the heads of learners in such a way that they could retrieve the information for a test. With this model, the way to improve instruction is to improve the instructor (i.e., to require the instructor to acquire more knowledge and to learn more methods for conveying it to learners and e-learning (Utama 2016)recent education using it and universities in particular are trying to apply it. One of the subjects of this research is The Accounting Department of Airlangga University in Surabaya. The idea of this research is to investigate the students about how they know deeply about e-learning system and learning objectives as a first step to conduct e-learning model. After the model completed, the next step is to prepare database learning. Entity Relationship Diagram (ERD. This is because this model is a model that emphasizes every step stated from the problem determination process up to the evaluation process (Dick, Carey & Carey 2001). There are 10 steps explained in Dick, Carey & Carey's learning construction model namely determining teaching goals; make teaching analysis; identify students and context; writing learning objectives; construct criteria reference test items; develop teaching strategies; build and select teaching materials; construct and conduct formative assessments; construct and conduct summative tests; and review the teaching.

In this study, the researcher fully uses the learning model of Dick et al. (2005) which was developed through a system approach. There are three domains emphasized in this model namely cognitive domain, behaviorism domain and constructivism domain (Ahmad Abdullahi 2015; Chang 2006). This Dick, Carey and Carey model is well suited for the construction of Trig-GO appss that use several mutltimedia digital tools (Chang 2006) and e-learning (Mamattah 2016). This is because this model is a model that emphasizes every step stated from the problem determination process to the evaluation process (Dick et al. 2001). There are 10 steps explained in Dick, Carey and Carey's learning construction model namely determining teaching goals; make teaching analysis; identify students and context; writing learning objectives; construct criteria reference test items; develop teaching strategies; build and select teaching materials; construct and conduct formative assessments; construct and conduct summative tests; and review the teaching. Table 2 shows a summary content of the Trig-GO apps based on the Dick, Carey and Carey model. Therefore, the steps found in this Dick, Carey and Carey model are highly interrelated. In addition, the steps mentioned can also clearly to help researchers in developing Trig-GO apps systematically. Components such as teachers, students, materials and tools, learning activities, delivery strategies and assessment of student achievement can be analyzed (D'Angelo, Bunch & Thoron 2018) more specifically so that the components are interconnected in an effort to support student learning more robustly (Dick, Carey & Carey 2005).

a. Teaching Objectives

The first step emphasized before building an apps is to identify the learning goals to be taught. In this study, the researcher has two main goals namely to develop the Trig-GO apps and then evaluate the Trig-GO apps with several tests conducted. In the process of completing these teaching goals, four elements that need to be emphasized are respondents; learning activities; achievements and tools used (Dick, Carey & Carey. 2005). Respondents consisted of Form Four students; activities refer to activities constructed in an effort to define and to reduce misconceptions, increase levels of understanding and levels of achievement. Achievement refers to the results of the Trigonometric Comprehension Test (TCT) and the Trigonometric Achievement Test (TAT). Achievements in this study also refer to learning tools by using Trig-GO appss online or offline.

b. Teaching Analysis

Analyzing learning means determining the skills needed by Form Four students in this study based on a concept map. This concept map will be constructed based on the findings of the needs analysis. There are three areas of learning that students need to master in the process of understanding the components of trigonometry in more depth.

c. Students and Context

Identifying student traits is a domain of behaviorism (Utama 2016)recent education using it and universities in particular are trying to apply it. One of the subjects of this research is The Accounting Department of Airlangga University in Surabaya. The idea of this research is to investigate the students about how they know deeply about e-learning system and learning objectives as a first step to conduct e-learning model. After the model completed, the next step is to prepare database learning. Entity Relationship Diagram (ERD. This domain is particularly important in this study by focusing on the exact target group population (Dick, Carey & Carey 2005). To identify the traits or characteristics of Form Four students related to misconceptions, Newman's Error Analysis was used. Whereas, in identifying the level of understanding of students, Anderson and Krathwohl Taxonomy is applied. At this step the teacher can find out whether the teaching and learning process of students is active or not. In addition through this step, the teacher can see the ability of students in the trigonometry component through the working solutions shown by the students.

d. Learning Objective

Dick, Carey dan Carey (2005) explained that the writing of learning objectives encompasses the ability and capability of students to apply knowledge after learning a topic. In this study, the ability and capability of the students is to understand the learning topic of Triangle Solution. Next the student is able to solve the questions related to the Trigonometry component. When Form Four students successfully solve these questions, they are already able to dispel the misconceptions that often occur in their thinking. Newman's error analysis was selected by adding two types of errors as suggested by Sari and Wutsqa (2019). The seven types of errors that can be seen during the findings analysis process relate to the types of misconceptions. Among them are Type-Reading, Type-Comprehension, Type-Transformation, Type-Process Skills, Type-Justification, Type-Language and Type-Neglect.This provides opportunities and space for Form Four students to improve their performance in the Trigonometry Achievement Test (TAT).

e. Criteria Reference Test Items

The test items are based on the Curriculum and Assessment Standard Document found in the Secondary School Standard Curriculum for Form Four mathematics. Anderson and Krathwohl's taxonomy was used as a guide to construct questions in order from the low-level thinking skills domain to the high-level thinking domain. Each constructed item will undergo a pilot study to obtain reliability. In addition, evaluating content validity and face validity from relevant experts is also required in this study. These assessed items must be based on the language used appropriate for Form Four students (Creswell 2012); the length of time to answer a question (Dick, Carey & Carey 2005); and the probability of students obtaining the correct answer (D'Angelo, Bunch & Thoron 2018).

f. Teaching Strategies

Based on the findings of the needs analysis, the researcher can determine the appropriate teaching strategy to apply the Trig-GO apps in the Triangle Solution learning topic. The module is built to include activities and gamification is guided by constructivism learning theory by using inquiry approach inkuiri (Bahagian Pembangunan Kurikulum 2016; Khairul Hasni, Norazah & Zanaton 2015; Nor Puteh & Fareed Mohamed 2013),has five phases namely engagement, exploration, explanation, elaboration and evaluation. The researcher examines each learning plan including creating activities and decides how each part of the activity is done. For example, when involving collaborative activities, then the researcher needs to determine the material, time and items that cover the activity.

g. Teaching Materials

Materials, tools and resources are necessary in ensuring that students use them as best they can to achieve clear objectives (Dick, Carey & Carey 2005). The Trigonometry Games Online/Offline apps or its acronym Trig-GO apps is built in *apk* format. The requirements of this material can be achieved by students or users can obtain this software for free and securely through the Google Playstore application. This module can be used manually in printed or physical form as well as digitally for users to use it more easily. Various types of gamification are also produced in digital form to attract students. In addition, the digital elements formed should focus on activities to eliminate misconceptions, increase students' level of understanding and level of achievement in learning topics involving this component of trigonometry.

h. Formative Assessment

The formative assessment used in this study is the Trigonometric Comprehension Test (TCT) conducted by interviewing students. This assessment aims to find out the level of understanding of Form Four students in the learning topic of this Triangle Solution. . D'Angelo, Bunch dan Thoron (2018) explain that formative assessment does not necessarily go through formal testing. Formative assessment can be done by various methods namely interviews, short quizzes, observations, discussions and question and answer sessions (D'Angelo, Bunch dan Thoron 2018). Therefore, the researcher in this study also made field notes to record all the information obtained through observation throughout the teaching process.

i. Summative Test

Summative evaluation was performed to see the effectiveness of the modules used as a whole (Dick, Carey & Carey 2005). The Trigonometric Achievement Test (TAT) was adopted in this study as a summative assessment. The UPT constructed should be in line with the objectives of the study to identify the level of student achievement in the learning topic of Triangle Solutions. The findings of this test provide information on the effectiveness of teaching process by using the Trig-GO apps in the experimental group compared to conventional methods in the control group. The results of this evaluation also serve as reference material by researchers for future improvements to the Trig-GO apps.

j. Review the Teaching

The final step in this model is to review the teaching. The researcher conducted a questionnaire on Form Four students who were directly involved with the Trig-GO apps. This questionnaire aims to obtain respondents' perceptions related to digital learning by using the Trig-GO apps in the learning topic of Triangle Solutions. This questionnaire was conducted as feedback and reflection to see the strengths and weaknesses of the Trig-GO apps. This information is important to the researcher for the improvements that need to be made so that this module can have a positive impact on the students.

Table 2: The content of the Trig-GO apps based on the Dick, Carey and Carey Model (2005)

Steps	*Trig-GO apps Contents*
Teaching Objectives	Build a Trig-GO apps Evaluate the Trig-GO apps
Teaching Analysis	Concept maps related to the field of learning under the Trigonometry component Number fields, relevance fields and shape and space fields.
Students and Context	Newman's Error Analysis is used to look at the students' misconceptions. Anderson and Krathwohl's Taxonomy is used to see the pupils level of understanding.
Learning objective	Identify and eliminate common misconceptions in the topic of Triangle Solutions. Increase students' understanding of the topic of Triangle Solutions. Improving student achievement in the topic of Triangle Solutions.
Criteria Reference Test Items	Anderson and Krathwohl's taxonomy Reliability and validity of constructed items.
Teaching Strategies	Modules and Gamification guided by Constructivism Theory
Teaching Materials	Computers, mobile phones, tablets, internet, printed materials, gamification From manuals to digital information.
Formative Assessment	Trigonometry Comprehension Test (TCT) To explore students' level of understanding
Summative Test	Trigonometry Achievement Test (TAT) To identify the level of student achievement.
Review the Teaching	Questionnaire-Perception of Digital Learning Using Trig-GO apps Strengths and weaknesses of the module Improvements at every stage or step

Validity

Four experts were appointed to validate the content of the interviews at the needs analysis phase by looking at the content and adjusting the language used. To determine content validity, the number of expert evaluators is not less than two and not more than six experts (Kong 2011; Strickland et al. 2013). The selection of these experts is in line with the validation process related to the design and development type study for the needs analysis phase. This was also done by some researchers where they have appointed three experts (Lam et al. 2018) and four experts (Faizal Amin Nur 2015; Mohd Nazri 2016) to evaluate the study items in phase one. The four appointed experts are professionals directly involved in the field of mathematics. In addition, the appointed specialist must still be serving in the field of education (Mohd Effendi Ewan et al. 2017).

The validation rubrics of both interview instruments submitted to all experts used four Likert scale points to indicate the content validity index for each content item (I-CVI). According to Kim et al. (2018as well as factors that contribute to instructional technology competencies required to enhance knowledge and delivery skills of university lecturers are examined in this study. A framework model is presented with the aim of revising and further developing curriculum competencies in tertiary education based on reviews on the philosophies and learning theories from past studies. In this regard, particular attention would be directed towards the Analysis, Design, Develop, Implement, Evaluate (ADDIE) the acceptable I-CVI value is 0.80 and above. While a value of 0.90 is indicative of an excellent face validity value (Stewart & Haswell 2013there are few examples of physiotherapists in New Zealand (NZ). Based on Table 3, it is found that the S-CVI values for the protocol of interview with teacher and interview with students are 0.92 and 0.95 respectively. Both of these values indicate that the interview protocol has an excellent facial validity value (Table 3).

Sampling

This study uses a purposive sampling method involving five teachers and six Form Four students. Palinkas et al. (1968) stated that the number of samples intended for the interview method ranged from 1 to 22 participants. The ideal size of participants for the interview approach is between five to 10 people because large groups are difficult to control and they limit everyone's opportunities to share information (Krueger, R. A. & Casey 2002). This needs analysis in this study involved interviews with five teachers who had a minimum of 16 years of experience in teaching mathematics. Teaching experience taken into account is a minimum of sixteen years (Berliner 2001). In addition, a total of six Form Four students from three different secondary schools also participated as respondents in this study.

Table 3: S-CVI scores for the interview protocol

Interview protocol	*S-CVI*
With experienced teachers	0.92
With Form Four students	0.95

The students involved had poor and moderate levels of proficiency in mathematics. Good achievement level refers to students who consistently obtain marks of 80% to 100%. While weak and moderate students are referring to the achievement level of 0% to 39% and 40% to 79% respectively. Information on this level of achievement is obtained from the summative assessment that has been conducted on students by the school in the last examination. Table 4 shows the demographics of respondents interviewed with experienced teachers in the district of Central Malacca.

The respondents consisted of one male teacher and four female teachers. There are three teachers with between 21 to 30 years of teaching experience and one teacher with over 30 years of teaching experience. All of these teachers teach mathematics in Form Four and Form Five. These respondents who have a minimum of sixteen years of this experience are required to obtain positive results in developing student performance more effectively (Berliner 2001). Therefore, the information provided by these experienced teachers is quite important in developing the Trig-GO apps (Table 4).

Next, Table 5 shows the demographics of respondents interviewed with Form Four students in three different schools in the district of Central Malacca. Respondents for this interview consisted of three male students and three female students. The respondents also each had a moderate level of mastery (n = 3) and a weak level of mastery (n = 3) (Table 5).

Table 4: Demographics of interview respondents with experienced teachers

Teachers	*Gender*	*Teaching Experiences*	*Mathematics Teacher*
GA	Female	25 years	Form Four and Form Five
GB	Male	16 years	Form Four and Form Five
GC	Female	25 years	Form Four and Form Five
GD	Female	22 years	Form Four and Form Five
GE	Female	37 years	Form Four and Form Five

Table 5: Demographics of respondents interviewed with Form Four students

Students	*Gender*	*Level of Mastery*	*School Name*
PA	Male	Poor	A
PB	Female	Moderate	B
PC	Female	Moderate	C
PD	Male	Poor	B
PE	Female	Moderate	A
PF	Male	Poor	A

Result and Discussion

There were four themes derived from interviews with experienced teachers and interviews with Form Four students. Among the themes discussed are poor mastery of basic mathematical concepts in trigonometry, trigonometry teaching strategies, digital applications or software in the teaching of trigonometry and consensus of experienced teachers in the construction of Trig-GO apps.

Theme 1: Poor mastery of basic mathematical concepts in trigonometry

It is undeniable that there are some weak and moderate students who are still unable to master the basic concepts in trigonometry. Interviews conducted with Form Four students found that there were respondents who could not give an accurate interpretation of the hypotenuse.

- *"The length of the side of the longest triangle" (P2).*
- *"Related triangles" (P3).*
- *"Phytogras theore" (P4).*
- *"I don't know what you mean but I know PR is hypotenuse " (P5).*

Four of the six respondents questioned with question item number six could not explain that the hypotenuse is one of the longest sides in a right-angled triangle. Analysis of the findings for question item number seven also showed that all respondents still lacked understanding related to the right -angled triangle.

- *"M because it refers to the form" (P1).*
- *"M because the lengths of all sides are not the same" (P2).*
- *"M, I don't know" (P3).*
- *"M, because the answer is almost 18 for the hypotenuse (P4).*
- *"P and M. 1 angle is always 90 degree" (P5).*
- *"M cikgu. I don't know either, Master" (P6).*

Respondent (P3) and respondent (P6) could not give reasons for their choice of answer. The answers given by all respondents were incorrect. The use of the Pythagorean formula should be used by students to determine whether the triangle is a right -angled triangle or not. Respondent (P4) understands the formula, but the value of the length of the hypotenuse should be exactly 17.2 cm. Respondent (P1), respondent (P2) and respondent (P5) only looked at the triangle without making calculations using the Pythagorean formula. Subsequent analysis of interviews with students also found that there were respondents who still failed to state the coordinates of point B based on question item number 11.

- *"(0.0) I think teacher" (P1).*
- *"(-6,5)" (P2).*
- *"(4,2)" (P4).*
- *"Quadratic" (P5).*
- *"Do not know" (P6).*

Less clear level of understanding is shown by students in determining the position of point B based on Point A and Point C. If students fail to determine the exact coordinates, of course they also fail to determine the distance between two points using the distance formula. This is because the distance formula requires the student's ability to enter the exact values of the values on the x-axis and y-axis of the two points.

The inability of students to understand the basic concepts of trigonometry causes students to often make mistakes in solving trigonometry related questions. Based on the observations conducted on the teacher teaching sessions through the ZOOM application, there was an error or misconception that occurred during the student calculation process. Figure 1 shows that there are two students who have a misconception of Type-Process that is, students do not do accurate calculations algorithmically (Figure 1).

Table 6 shows the incorrect calculation by the first student and the second student followed by the correct calculation. The first student made a mistake by dividing 15 309 by 3 to obtain the answer 5103. the student should have divided 15 309 by 7. This shows that the first student failed to understand the basic concepts of mathematics involving index numbers. So it is not surprising that this misconception will continue to occur in the next chapter involving index numbers in trigonometry.

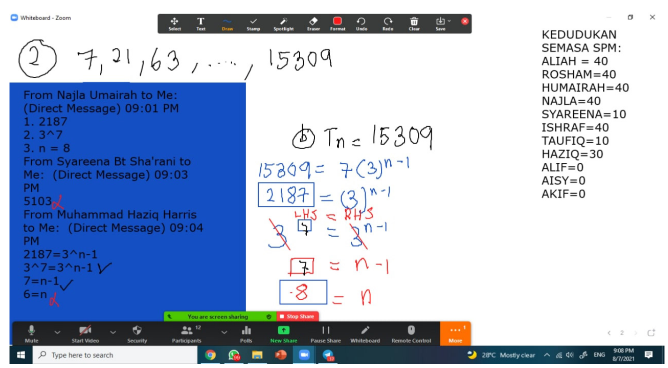


Fig. 1: Observation of online teaching and learning sessions

Table 6. Errors in student calculation

	Wrong Solutions	*Correct Solutions*
First Student	$15\,309 = 7\,(3)^{n-1}$ $\frac{15\,309}{3} = 5103$ $5103 = 7^{n-1}$	$15\,309 = 7\,(3)^{n-1}$ $\frac{15\,309}{7} = (3)^{n-1}$ $2187 = (3)^{n-1}$
Second Student	$7 = n - 1$ $7 - 1 = n$ $6 = n$	$7 = n - 1$ $7 + 1 = n$ $8 = n$

In addition, observations made on student worksheets given by teachers related to trigonometry showed students committing Type-Transformation errors. Type-Transformation refers to a student's error in applying the correct trigonometric formula or the wrong strategy while solving a trigonometric question. Figure 2 shows that students do not understand the correct trigonometric ratio formula that is Students were seen hesitating by writing two calculations, namely and to get the remaining height of the tower. Next, the student is seen writing to find the remaining height of the tower. Finally the student circled the answer as 65.61m while the actual answer was 25.61m.

Type-Process and Type-Transformation errors that frequently occur among students while solving these trigonometry related questions indicate that students do not fully master the basic concepts of trigonometry. The failure of students in applying trigonometric formulas and correct steps also indicates that students are still at a low level of thinking skills. Furthermore, these findings answer the second and third objectives of this study, which is to identify the types of misconceptions and the level of understanding of Form Four students in trigonometry. (Figure 2)

Theme 2: Trigonometry teaching strategies

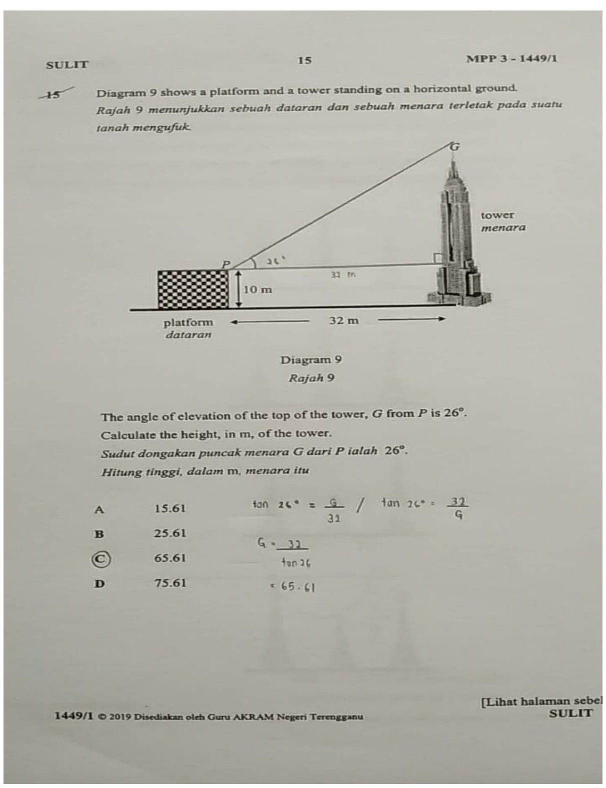
There are several teaching strategies implemented by teachers to enhance students' understanding in the topic of trigonometry. Analysis of interviews with experienced teachers conducted found that the technique of memorizing formulas to be the best option.

- *"Various strategies. Among them are memorization of formulas and mastery of calculator skills." (GA).*
- *"I will use teaching materials in the form of videos or youtube or power point presentations so that students can follow PdPc with more understanding and clarity" (GC).*
- *"Memorize the formula" (GD).*

Respondents (GA) and respondents (GD) stated that memorizing formulas can improve students' understanding of trigonometry. Mesa and Goldstein (2017) agree in stating that teachers should use mnemonics such as SOH-CAH-TOA aimed at improving students' understanding of trigonometry learning. Analysis of the interview findings of Form Four students also showed that they understood what was meant by Respondent (P1), respondent (P4), respondent (P5) and respondent (P6) were able to state accurately about trigonometric ratios in a right-angled triangle.

- *"Sin equal to opposite over hypotenuse, cos equal adjacent over hypotenuse and tan equal opposite over adjacent" (P1).*
- *"Sin is equal to opposite side divide by hypotenuse, cos is adjacent to the hypotenuse and tan is as opposite to adjacent." (P4).*
- *"Sin x is equal opposite over hypotenuse, cos x is equal adjacent over hypotenuse, tan x is equal opposite over adjacent" (P5).*
- *"To find sin x, use the formula with opposite over adjacent, cos x is also adjacent over hypotenuse and tan x is opposite over adjacent'' (P6).*

Observations made on the students 'exercise books also found that there were notes related to this trigonometric ratio. Students are seen writing SOH CAH TOA in their exercise books before solving the trigonometry questions as in Figure 3.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15 Diagram 9 shows a platform and a tower standing on a horizontal ground.
Rajah 9 menunjukkan sebuah dataran dan sebuah menara terletak pada suatu tanah mengufuk.

Diagram 9
Rajah 9

The angle of elevation of the top of the tower, G from P is 26°.
Calculate the height, in m, of the tower.
Sudut dongakan puncak menara G dari P ialah 26°.
Hitung tinggi, dalam m, menara itu

A 15.61
B 25.61
C 65.61
D 75.61

$\tan 26° = \frac{G}{32}$ / $\tan 26° = \frac{32}{G}$

$G = \frac{32}{\tan 26}$

$= 65.61$

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Fig. 2: Observations on trigonometry related worksheets

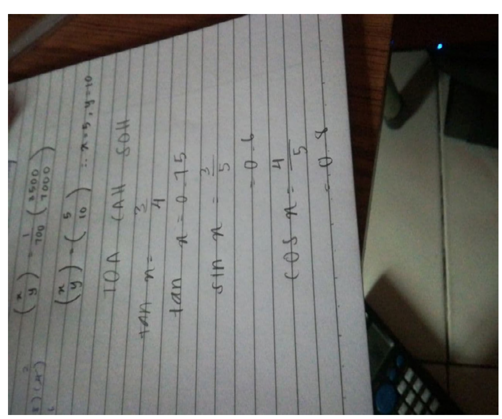

Fig. 3: Writing memorized trigonometric formulas

However, other strategies as stated by the respondents (GC) can also help to improve students' understanding of trigonometry. The use of video, Youtube or Powerpoint can help improve students 'understanding of trigonometry. The results of the study of Asfyra et al. (2020) stated that learning through Youtube can improve students' understanding of concepts where students can find for themselves the broad concept of trigonometric triangles. They also argue that Youtube is also preferred because students can watch learning videos repeatedly at any time and anywhere. Therefore, the strategies used by such experienced teachers can improve students' understanding in trigonometry.

Theme 3: Digital applications or software in the teaching of trigonometry

In addition, experienced teachers also often use digital applications or software in the teaching of trigonometry. These experienced teachers use this application or software to enhance students' understanding in trigonometry. Respondents (GA) stated that the use of Graphmat helps teachers to show trigonometric graphs so that the concepts involved can be explained more easily and effectively to students.

Respondent (GB) stated that graph math is suitable to be used to draw trigonometric graphs. Other software used by experienced teachers is GeoGebra as stated by respondents (GB) and respondents (GE). Desmos was also used by respondents (GD) and respondents (GE) to improve the understanding of Form Four students in trigonometry.

- *"Graphmat to more easily show a wheat graph." (GA).*
- *"Geogebra teacher." (GB).*
- *"Graph math to draw trigonometric graphs." (GC).*
- *"Desmos is suitable" (GD).*
- *"Graphmatica..excell..and web browsers, In addition, I use desmos and geogebra software to teach this topic." (GE).*

Figure 4 shows a mind map that can be generated related to digital applications or software in the teaching of trigonometry. This mind map was generated from the theme after analyzing interview data with experienced teachers using Nvivo 12 software. *12.*

Theme 4: Consensus of experienced teachers in the construction of Trig-GO apps

The findings of the analysis of interviews with experienced teachers related to the construction of the Trig-GO apps are divided into four sub-themes as shown in Table 7. Experienced teachers were asked to provide a level of agreement for each theme from a value of 0 (strongly disagree) to a value of 10 (strongly agree).

Respondent (G1), respondent (G2), respondent (G3), respondent (G4) and respondent (G5) stated 95%, 80%, 75%, 95%and 78% respectively on the need for Trig-GO apps construction. An average percentage with a value of 85% indicates to the agreement of experienced teachers in the construction of this Trig-GO apps is very agreeable and necessary.

In addition, Table 4 also shows that the percentage of module construction requirements is high at 90%. Experienced teachers also agreed by 82% that the built-in Trig-GO apps meets the current needs of students who love digital games. Experienced teachers also agreed with the construction of the Trig-GO apps which was built taking into account the content of mathematics syllabus appropriate to the intervention implemented. Moreover, 86% agreement was expressed by experienced teachers that the

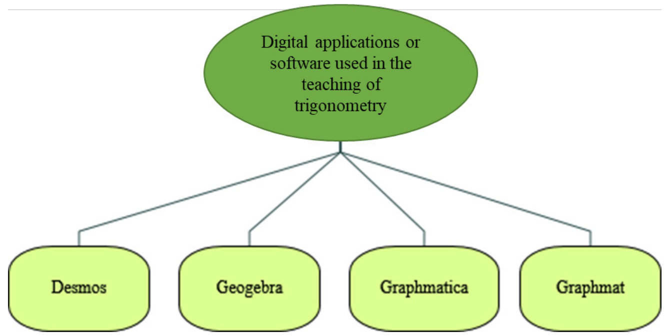

Fig. 4: Digital applications or software in teaching **trigonometry**

Table 7: Percentage of experienced teachers in the construction of Trig-GO appss

	G1	*G2*	*G3*	*G4*	*G5*	*Percent*
Trig-GO apps construction requirements	9	9	10	9	8	90%
Build digital games	9	7	8	9	8	82%
Meet the contents of DSKP/KSSM	10	8	6	10	6	80%
Guided by Anderson and Krathwohl's taxonomic theory	10	8	6	10	9	86%
Average	0.95	0.80	0.75	0.95	0.78	Average Percentage
Percent	95%	80%	75%	95%	78%	85%
Level of Consent	Agree / Need	Agree / Need	Agree / Need	Agree / Need	Agree / Need	

Trig-GO apps be constructed based on the standard Taxonomy theory of Anderson and Krathwohl (Krathwohl 2002; Leslie 2016). Thus, these findings indicate that experienced teachers who teach mathematics agreed for the Trig-GO apps to be constructed. This statement further answers the first objective of this study which is to explore teachers' views on the need in developing the Trig-GO apps.

Conclusion

This study describes in depth the analysis of needs in the construction of the Trig-GO application. In particular, there is a high level of agreement reached for the need for the construction of the Trig-GO application among teachers. The findings of the study from the content aspect of the Trig-GO application prototype showed a high level of agreement by mathematics teachers with an overall mean value percentage of 85%. The percentage range of mean values for each item is also high, between 80% and 85%. The high level of agreement from this aspect of content is due to several references to textbooks as well as the mathematics syllabus were analyzed before the prototype of this application was developed. This is to ensure that the content of the prototype application complies with the guidelines that have been set in the syllabus of mathematics. Thus, the construction of the Trig-GO application is indispensable in improving students' understanding and achievement in trigonometry.

This study can also help teachers in preparing themselves with the needs of various digital applications to build students' understanding of trigonometry while improving the quality of teaching within teachers. The study also provides clear information to policy makers and implementing groups on the importance of needs analysis before making any reforms in the education system. Contributions to the literature on needs analysis with a qualitative approach are important in Malaysia. The contribution to the committee teachers in the school is that they need to be prepared and sensitive to technological developments so that students can enjoy learning more openly and widely. Appropriate action should be taken to improve students' understanding in learning trigonometry especially by using digital applications. This action can create a conducive environment to support students' interest in learning mathematics to reach a high level.

The development of this prototype application is intended to assist teachers in providing teaching aids that can be used in the teaching of trigonometry through a technology approach. Indirectly, it can overcome the problem of lack of teaching aids based on multimedia technology. As the use of this application is more in line with technology, such an approach has shown a positive perception from mathematics teachers. It is hoped that the production of this prototype application can also be used as a reference for ministries, departments or agencies and individuals involved in the process of learning mathematics. The positive perception from the respondents towards the Trig-Go application as one of the teaching aids has illustrated the positive direction in the improvement and enhancement of the application in the future.

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