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Investigating TVET Level Three Students' Misconceptions Affecting Performance in Trigonometry: A Case of Kicukiro District, Rwanda

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Abstract: *This study sought out to investigate level three students' misconceptions affecting performance in trigonometry in two selected schools of Kicukiro District. The target population was 386 level three students in selected TVET schools located in Kicukiro District for 2021-2022 academic year. Among these schools, one public and one private school were chosen purposively and a sample of 196 participants was taken using stratified sampling methods so that each trade in the selected schools was represented. This study followed a descriptive survey research design and the data from selected participants were collected using questionnaires and analysed using SPSS. The results indicated that 70% of the students have positive attitudes towards trigonometry and they were interested in this unit, but trigonometric concepts were not explained clearly and they were not familiar with notations. They also have misconceptions in making invalid references and conceptual misunderstanding on trigonometric ratios, trigonometric equations and solving word problems. The study recommends trainers to motivate their trainees in learning trigonometry, to explain trigonometric concepts clearly; provide more exercises, including word problems, and advise trainees to avoid carelessness while doing assignments.*

Keywords*: Attitude, Misconception, Teaching & Learning, Mathematics, Trigonometry*

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1. Introduction

Mathematics is a fundamental part that helps people to understand the word where mathematical concepts are used to solve word problems in various fields. It helps learners to increase their initiative, flexibility and critical thinking (Aboki, Uwimana & Yadav, 2015). Also, a positive attitude toward mathematics helps students to perform well in this subject. It has been found that students acquire more in mathematics if teachers give their students interesting tasks which help them to enjoy the topic, teachers and parents provide accurate feedback to their students and support students to acquire accurate mathematical knowledge and be confident in mathematics. (Hwang & Son, 2021).

Trigonometry is a branch of applied mathematics which studies the relationship between the sides and angles of a triangle. It helps in calculus as well as college level courses relating to architecture, surveying, and engineering (Maknun, Rosjanuardi, & Jupri, 2019). Surveyors sometimes use the method of triangulation to

measure the distance to inaccessible point, or they measure lengths that are impossible to measure directly. Trigonometry helps architecture in calculations of heights, roof slopes, ground surfaces, and light beam angles, compute precision loads and forces. The engineering application of trigonometry is everywhere, such as in automobile engine crankshaft design, in robotic arm movement programming for assembly line operation, and in land survey result calculation (Ni, Jung, & Zhou, 2015).

Mathematics curriculum in high schools includes trigonometric concepts due to its importance at secondary level and its applications in advanced mathematics, sciences and engineering but it remains to be difficult for both teachers and students (Courtney, 2016). Trigonometry has many applications in engineering (Bird, 2010) like in electrical engineering where trigonometric principles are used to create circuits and describe the sinusoidal movement and characteristics of current and voltages in circuits, in electro-mechanical devices such as motors, generators and robotic mechanisms are displayed using trigonometry where rotation is described by sine and cosine functions and phase angles. Application of trigonometry in real life includes navigation, land surveying, global positioning system (GPS) applications, robotics, and the design of structures such as buildings and bridges. Thus, trigonometry as a branch of applied mathematics can be used by students in vocational and technical schools

Rwandan Technical and Vocational Education and Training (TVET) schools are primarily aimed at training citizens with knowledge, skills and attitudes which can help them to create their own jobs and support private sectors, instead of waiting for being public servants (Education, 2008). The government of Rwanda has contributed more in the promotion of TVET education as one of the strategies that can help to reduce unemployment rate and poverty reduction where 60% of all Rwandan secondary students will be enrolled in TVET schools. To have competent graduates in TVET, which can fit a labour market, students must have appropriate theories and practices in order to solve current challenges and adapt to an ever-changing world of work (RTB, 2022). Since mathematics is the basis of engineering and technology, all Rwandan students in TVET schools must study mathematics in order to have sufficient knowledge and skills in their learning process. Trigonometry is taught in level three because it serves as prerequisite for other mathematics topics and is linked to other modules. Although mathematics is important for them, they do not perform well in this subject, particularly in trigonometry (Gur, 2009).

A misunderstanding of trigonometry will affect greatly the performance in mathematics and other subjects where trigonometry is applied. It was shown that students have misconceptions among trigonometric concepts where students believe that there is a positive correlation between angles and trigonometric functions, for example students have trouble understanding the difference between a radian and pi radians (Williams, 2019). Apart from that, TVET students are trained to use hands on skills rather than using theories. If learning theories is a challenge, learning mathematics is another issue. If trigonometry is generally considered as a difficult topic for students in science combinations, it becomes more difficult for TVET students as they are interested in technical courses rather than in mathematics and sciences. That is why students in TVET schools have many difficulties in learning trigonometry compared to the ones in science combinations. The above views inspired this need to investigate level three students' attitudes and misconceptions affecting performance in trigonometry.

2. Literature Review

Mathematics is a tool which is used in science, technology and engineering (Courtney, 2016). Engineers' feeling about mathematics plays a major role on the choice of engineering as career since mathematics is applied in different subjects of engineering studies. Trigonometry is a part of applied mathematics which has many applications in engineering but most of the students have errors, misconceptions and obstacles in this unit (Gür, 2009). Trigonometry is a significant and integrating topic in high school mathematics curriculum due to its importance in advanced mathematical thinking and it is a pillar not just for advanced mathematics only but also for physics, geometry, and mechanics (Martín-Fernández, Ruiz-Hidalgo, &Rico, 2019). Also, trigonometric functions are used to describe motions where sine and cosine functions are used to describe motion of disturbed water, vibration of plucked string, and passage of sound in the air. Based on the importance of mathematics in technology, Rwanda TVET Board (RTB) decided that students at TVET lower levels (level 3 to level 5) must have mathematics modules in their studies. Students' learning and performance in mathematics is affected by a number of factors, including students' attitude towards the subject, teachers instructional practices, and school environment (Mazana et al., 2018). Students' attitude comprised of their confidence, awareness of mathematics and engagement (Sanchal & Kuiti, 2013).

Students come in class with a number of misconceptions or inaccurate pieces of pre-existing knowledge. c

Concepts reduce the complexity by simplifying the environment that people live. Learning concepts help students to define and explain objects in our environment. Difficulties in learning concepts can be related time, memory, strategies, concentration, culture, development and insufficiency of teachers (Kesan & Kaya, 2007).

"Misconceptions" is a term used to describe deep, intuitive misunderstandings about mathematics. These form when students get an idea in their heads about how something works that makes intuitive sense to them. Misconceptions heavily influence a student's ability to learn and retain mathematics in class and, in many cases, are the cause of great confusion to the student. When a student gives a wrong answer, most of teachers tend to respond him/her in the following two ways: (i) they tell him/her that he/she is wrong, and proceed to "give him/her detailed steps to follow to get the answer right" or (ii) ask the student to "try something else". In the first case, a student is trying to memorize the steps that are in conflict with his/her understanding of mathematics because he/she haven't changed his/her own mind about the misconception first. In the second case, randomly guessing until he/she hits on the correct response and then trying to remember that one. That is why misconception is a problem with understanding, not with memory. Misunderstanding and misrepresenting ideas motivated researchers to investigate implicit misconceptions in prospective mathematics teachers' reasoning about particular trigonometric concepts (Malambo, 2021).

Students often have limited context of knowledge in understanding trigonometry (C. L. L. Il Maknun et al., 2022). The greatest obstacle was that students memorize the sequence or steps. A research entitled "Pre-University students' difficulties in solving trigonometric function problems" indicated that common misconceptions were misinterpreted language, distorted definition and technical mechanical error (Shahrill & Pinamang, 2015). According to Bobby Ojose (2015), 'Misconceptions are misunderstanding and misinterpretations based on incorrect meaning' and teacher is obliged to know them in order to plan and deliver his course effectively. Misconceptions can arise in any subject but in this research we were interested in mathematics, specifically in trigonometry.

2.1 Misconceptions in leaning mathematics

It was found that most of learners fail in mathematics due to misunderstanding of the basic mathematical concepts (Martín-Fernández et al., 2019), misunderstanding of meaning and coherence of meanings (Courtney, 2016). Another research conducted by Rusmar, Tekinologi, &Industri (2018) in Politeknik Teknologi Kimia Industry (PTKI) Medan indicated that students had perceived the difficulties in accepting mathematics knowledge.

The misunderstanding of mathematics can negatively affect its role in other subjects because it is the language of sciences, engineering and technology and it can reduce its role in society such as critical thinking, logical and abstract thinking. If a student does not get mathematical concepts well, he/she can dislike it. It was also found that students dislike mathematics due to the carelessness of their teachers where teachers do not clarify all concepts, not link them to real-life situation , do not prepare lesson adequately before teaching (Ukobizaba, Ndihokubwayo, Mukuka, & Uwamahoro, 2021) and do not use collaborative method, group discussions which helps students to exchange ideas and get more from their critical thinking.

2.2 Misconceptions in leaning trigonometry

Trigonometry is one of the applied mathematics which is considered as difficult and some students do not like it (Karthikeyan, 2017). Trigonometry is defined as the study of the trigonometric functions of angles and the relationships among them. Those trigonometric functions are used to solve triangles (Clark & Krantz, 2001) but many students make errors in exercises and exams of trigonometry. Trigonometry is difficult because many students are not able to understand how topics are linked to it (Courtney, 2016). The analysis of high school students' errors in learning this topic conducted in Zaria Metropolis in Nigeria indicated that most of students commit errors in solving trigonometric problems and most of errors are related to transformation and process skills (Usman & Hussaini, 2017). It was also indicated that errors do not depend on either the method or cognitive ability but on the process and transformation while solving problems in trigonometry. Another study conducted on derivative of trigonometric functions indicates that some students understand the concepts but fail in algorithm and others interpret concepts wrongly due to the over-generalization of the previous topics (Siyepu, 2015) and a researcher suggests to provide many activities in order to identify and analyses those errors. Another study related to solving trigonometric equations indicates that most of students fail to interpret the value of sine, cosine and tangent of an angle when their values are negative, identify the relevant quadrant, make a valid reference angle(Chigonga, 2016)

Students' attitudes in learning trigonometry

Attitude is defined as a settled way of thinking or feeling about something. If a student has a positive attitude toward mathematics, he/she can perform well in that subject. A research conducted in Singapore (Hwang & Son, 2021) indicate that there is a relationship between attitude toward mathematics and mathematics achievement. This research showed that to have students with positive attitude toward mathematics: teachers could prepare interesting tasks which enable students to enjoy it, school leaders should provide teachers with educational resources, parents and teachers help and supports students to acquire accurate mathematical knowledge and develop confidence in mathematics, and teachers could adjust students' difficulties of mathematical tasks. A study conducted in Indonesia on the determination of mathematical critical thinking and communication skills of high school students in trigonometry materials (Azizi & Herman, 2020) indicated that mathematical critical thinking skills of five students of class X on trigonometry material are still relatively low, Mathematical communication skills of five students of class X on trigonometry are still relatively low, there is a relationship between critical thinking skills and mathematical communication of students, and students' attitudes toward mathematics learning, tests of mathematical critical thinking, and communication skills on trigonometric material are good.

The above literature summaries the role of trigonometry in mathematics, its applications in subjects related to TVET education and how students have difficulties related to their attitudes and misconceptions in learning trigonometry.

2.3 Theoretical framework

In this study, social constructivism theory and theory of reasoned action (TRA) are used. Constructivists believe that knowledge is essentially subjective in nature, constructed from our perceptions and mutually agreed upon conventions. (Idaresit Akpan et al., 2020) According to this view, we construct new knowledge rather than simply acquiring it via memorization or through transmission from those who know to those who don't know. This theory is taken as reference since students may learn correctly or wrongly through their interaction. Students may receive a concept about trigonometry correctly or wrongly through their classmates or other members of the society.

The TRA (Martin Fishbein, 1960) states that the behavioural intent is created or caused by attitudes and our subject norms. This theory indicates that to engage in a particular activity depends on expected outcomes. In this study, TRA was used since if students wrongly get trigonometric concepts, they will not be motivated in learning trigonometry. A student may get a concept correctly or wrongly depending on his/her attitudes or what he/she learnt in society.

2.4 Conceptual framework

Misconceptions in teaching and learning trigonometry depends on how trigonometry is taught and how students absorb it. This study analysed students' attitude and investigated the misconceptions (independent variables) affecting the performance in trigonometry (dependent variable).

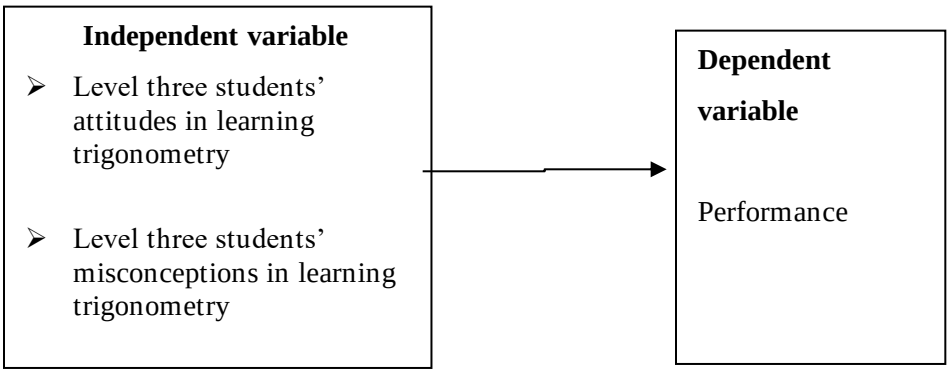

Figure 1: Conceptual framework

3. Methodology

3.1Research design

This study used descriptive survey design to get important data for level three students' attitudes and misconceptions in learning trigonometry within TVET schools located in Kicukiro district, Rwanda. Descriptive survey design used surveys to gather data about varying subjects.

3.2 Population and sample

Population refers to the set or group of all the units on which the findings of the research are to be applied and a part of population that represents it completely is known as sample (Shukla, 2020). In this study, the target population was 386 level three students in the two selected TVET schools located in Kicukiro District for 2021-2022 academic year. Researchers used Slovin's formula.

$n = \frac{N}{1+N(e)^2}$ to obtain a sample of 196 learners. Participants were chosen using stratified sampling method so that each trade from the selected schools would be represented in the sample.

Table 1- Number of participants per trades and schools

School TYPE	Trade	Population size	Sample size
PUBLIC	Automative engine technology	14	7
	Computer system technology	21	11
	Domestic electricity	30	15
	Masonry	34	17
	Production technology	26	13
	Road construction technology	29	15
	Telecommunication	35	18
	Total	**189**	**96**
PRIVATE	Electronic services	31	16
	Computer application	26	13
	Computer system	28	14
	Masonry	28	14
	Accounting	39	20
	Tourism	45	23
	Total	**197**	**100**
Grand Total		**386**	**196**

3.3 Data collection and research instruments

After developing the instruments for data collection, it is very crucial to note that the designed instrument is easy to understand and to complete (Kabir, 2016) and these instruments are giving information those responding the research questions. In this regard, questionnaires were distributed to the respondents who participated in this research. The questionnaires were distributed to the respondents and they filled freely.

The questionnaire shows information related to demographic data such as gender, age and level of study. In addition to this, the questionnaire enclosed the questions related to this study in relation with the objective of this study. Questionnaires were designed based on the information needed, the target respondents, the text within the questions, the sequence of questions, and the questionnaire's size.

Since the data were collected from students at schools, school managers and deputy school managers helped to access students. Questionnaires were distributed to the participants then returned them to the researchers after filling them freely. The information of respondents was kept confidentiality as codes used for privacy.

3.4 Data analysis

In this study, quantitative data were collected from respondents using questionnaires with closed-ended questions. According to Dixon & Woolner (2016), SPSS is helpful in data analysis collected as numeric. In this regard, the collected data were coded and analysed using SPSS Statistics 25 and the results obtained were interpreted in relation with the collected data inserted in SPSS. The answers from respondents were based on the level of agreement and multiple-choice questions. Therefore, the data collected were inserted in SPSS according to the level of agreement, multiple choice. The respondents chose the correct answers after

showing the calculations then after, interpretation based on the correct answers. This helps us to check the errors and misconceptions related to trigonometry.

3.5 Validity and reliability

Validity refers to the appropriateness of the instrument. It is the ability to produce accurate results and measure what it is supposed to measure. Researchers discussed the instruments with other experts in Mathematics Education to ensure validity. In this study, reliability of instruments was ensured through pilot testing with pre-test. The pre-test was implemented by ten students who were not included in the sample. Through pilot testing, a reliability coefficient was calculated using SPSS and found to be 0.772 and a research instrument is acceptable when a reliability coefficient is greater than 0.7. In this study, the research instrument was adequate since the obtained reliability coefficient was 0.772 which is above 0.7.

4. Results and Discussion

The purpose of this study was to analyse level three students' attitudes and investigate their misconceptions affecting performance in trigonometry with TVET schools in Kicukiro District. The findings of this study were organized in tables.

4.1 Analysis of students' attitudes in learning trigonometry

The first question was about knowing if the students like trigonometry or not and knowing what stimulate them to like trigonometry or why they don't like it.

Table 2- like trigonometry

	Responses		
Do you like trigonometry?	Frequency	Percent	Cumulative Percent
Yes	135	68.9	68.9
No	61	31.1	100.0
Total	**196**	**100.0**	

The result from the above table indicated that 68.9% like trigonometry while 31.1% did not like it. Even though the proportion of the ones who like trigonometry is high, it is not enough because all students are expected to like it. If 31.1% of the students do not like this topic, their performance in that unit will be low. A student in TVET School will be promoted to the next level if he/she scored at least 70% in each learning outcome, at least 70% in each module. If they do not like it, they can't perform well in this unit while a good performance leads to the promotion in the next level. According to Karthikeyan (2017) trigonometry is one of the applied mathematics which is considered as difficult for some students and some students do not like it. Yet, the ones who like trigonometry indicated that trigonometry is understandable, applied to their specific/core modules and other topics in mathematics, and required high reasoning which opened their mind in thinking. The ones who do not like trigonometry have different view where they indicated that this unit is hard to understand, complicated, have many calculations and formulae, lack of prerequisite in mathematics and did not know the role of it in their real life except stressing students only. It is in this regards that trigonometry become difficult because most of students are not able to understand how topics are linked to it (Courtney, 2016). Generally, TVET students must like trigonometry as a subject which is important in their core subjects (Bird, 2007) and applied in their daily life (Williams, 2019).

4.2 Students' appreciation of trigonometry compared to other topics in Mathematics

The second question contained 3 statements helping researchers to analyse the extent to which students appreciates trigonometry compared to other topics Where 0= Strong agree, 1= Agree, 2=Disagree, 3=Strongly Disagree and 4=Not Sure. The results for question two are represented in table 3 and a student agreed on a statement if his/her answer is 0 or 1

Table 3: Appreciation of trigonometry

	Response				
Level of appreciation of trigonometry	**0**	**1**	**2**	**3**	**4**
I am interested in learning mathematics, particularly in trigonometry	27	42.3	15.8	6.6	8.2
I like mathematics but trigonometry is a difficult topic for me	11.7	33.2	29.6	15.8	9.7
From my previous studies, I never liked mathematics	7.7	15.8	28.1	38.8	9.2

Results from table 3 indicates that the ones who were interested learning trigonometry covered 69.3%, while 22.4% were not interested and 8.2% are not sure. The proportion of the students who like trigonometry is close to that of those who were interested in learning trigonometry. Also 44.9% confirms that trigonometry is a difficult unit while 45.4% did not agree with their classmates. And then only 23.6% dislike mathematics in their previous studies while 67.2% like mathematics in their previous studies

Table 4: Descriptive Statistics of students' appreciation on trigonometry

	Responses				
Students' appreciation on trigonometry	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
I am interested in learning mathematics, particularly in trigonometry	196	0	4	1.27	1.168
I like mathematics but trigonometry is a difficult topic for me	196	0	4	1.79	1.144
From my previous studies, I never like mathematics	195	0	4	2.26	1.079

The mean of the responses on how they are interested in learning trigonometry is 1.27 which is close to 1 (agree), the mean of the responses on how they consider trigonometry as a difficult topic in mathematics is 1.78. Which is closed to 2 (Disagree) and the mean on the question asking if they never like mathematics in their previous studies is 2.26 (Disagree). This indicated that many students were interested in trigonometry, it is not difficult for them and they like mathematics in their previous studies. The standard deviations on these three statements are 1.168, 1.144 and 1.079 respectively, which indicates that participants had heterogeneous ideas about these statements.

TVET students' understanding of trigonometry

The third question contains seven statements which help researchers to test the level at which TVET students understand trigonometry where 0= Strong agree, 1= Agree, 2= Disagree, 3=strongly Disagree and 4=Not Sure. Results from these questions are presented in table 5.

Table 5: TVET Students' understanding of trigonometry

	Responses				
Level Of Understanding Trigonometry	0	1	2	3	4
Trigonometric concepts are explained clearly	20.4	41.3	18.9	5.6	13.8
I am familiar with notations used in trigonometry	14.4	37.6	22.2	11.9	13.9
My trainer well demonstrated trigonometric formulae	27.3	44.3	13.9	5.2	9.3
My trainer allowed me to participate in class activities related to this unit	33.8	45.1	8.2	7.7	5.1
My trainer gave enough exercises to me for better use of formulae	37.6	41.8	10.3	3.1	7.2
Doing many exercises help me to improve my performance in trigonometry	37.6	41.8	6.2	9.8	4.6
I scored high marks in trigonometry	16.8	34.2	16.3	15.3	17.3

From the above table, the level of understanding trigonometry within TVET Schools located in Kicukiro district, we have seen that trigonometric concepts were clearly explained at the rate of 61.5%, only 52% of the participants are familiar with notation, 71.6% got well the demonstration of formulae, 78.9% were allowed to participates in class activities, 79.4% were given many exercises for better use of formulae, 79.4% did many exercises to improve their performance and 51% scored high marks. According to Clark & Krantz (2001) many students make errors in exercises and exams of trigonometry which can reduce their performance while Sanchal & Kuiti (2013) added that students' attitude comprised of their confidence, awareness of mathematics and engagement.

Table 5: Understanding trigonometry

	Responses		
Level of understanding trigonometry	N	Percent	Percent of Cases
Strong agree	366	26.9%	186.7%
Agree	557	40.9%	284.2%
Disagree	187	13.7%	95.4%
Strongly Disagree	114	8.4%	58.2%
Not Sure	139	10.2%	70.9%
Total	**1363**	**100.0%**	**695.4%**

The results in the above table indicated that 40.9% is the highest proportion which shows that students agreed about the statements on level of understanding trigonometry. Based on these percentages and the means presented in table 6, we see that trigonometric concepts were not explained clearly, students were not familiar with notations and they do not score high marks. Previous researches indicated students' motivation includes practical exercises, being interested in learning mathematics (Fuqoha et al., 2018). That is why trainers must provide enough exercises to the students for better use of formulas and students have to do many exercises to improve their performance in trigonometry. Learning and teaching mathematics should be based on students' needs and interest in order to improve their performance (Bimenyimana & Uworwabayeho, 2022). If a teacher does not explain the content clearly, students do not perform well, that is why attention is needed on explaining clearly trigonometric concepts and use familiar notations in trigonometry.

4.2Students' misconceptions

The fourth question contained six multiple choice questions where a student was asked to work out and then after he/she choose a correct answer. Responses for this

question are presented in table 7 and the bold number correspond to a correct answer. N is the total number of students who attempted each item

Table 6: Students' performance in trigonometry

Students' performance in trigonometry	Responses				
	N	A	B	C	D
1. The value of π is approximately equal to A. 180 B. 200 **C. 3.14** D. all are correct	195	38.8	1.0	**56.1**	3.6
2. $\sin 2a = 2\sin a$ is true when a is equal to A. $\mathbf{0^0}$ B. 30^0 C. 60^0 D. 90^0	186	**57.5**	10.2	11.3	21.0
3. If $3\sec\theta - 5 = 0$, then $\cot\theta =$ A. 5/3 B. 4/5 **C. 3/4** D. 3/5	185	36.8	5.4	**14.1**	43.8
4. If x and y are complementary angles, then A. $\sin x = \sin y$ C. $\cos x = \cos y$ B. $\tan x = \tan y$ D. $\mathbf{\sec x = \csc y}$	179	55.9	11.7	26.8	**5.6**
5. If $\cos 3x = -1\ where\ 0^0 \leq x < 360^0$, then x is equal to A. $\mathbf{60^0, 180^0, 300^0}$ C. 180^0 B. $60^0, 180^0$ D. $180^0, 300^0$	175	**34.3**	33.1	28.0	4.6
6. The length of the shadow of the man is equal to the height of the man. Then the angle of elevation is A.30^0 B. 60^0 **C. 45^0** D. 90^0	188	5.3	11.2	**12.8**	70.7

About the first multiple choice question (MCQ), we see that only 56.4% of the students get correct answer while 43.6% of them get wrong answer. This is a challenge of confusing the value of π and units of angles. Students must know the value of π and the units of angles since trigonometry is based on angles and sides of a triangle. Failing in this question is due to having an error of "making logically invalid references" where a student make an error originating from the misconceptions of the previous learned material (Schnepper & McCoy, 2013). The second MCQ was thereto indicates the students' capacity in solving trigonometric equations involving double angle formulae and results indicated that 57.5% of them get correct answer while 42.5 failed. This was a simple question because it requires respondents to know that $\sin 0 = 0$ and $0k = 0$ for any real number k. Failing in this question depends on ignorance of trigonometric equation and fail to memorize trigonometric ratios of remarkable angles. According to Schnepper & McCoy (2013) students fail to perform well in trigonometry due to that students lack skills on ratios and angles.

Results of the third MCQ indicate that only 14.1% were correct while 85.9% were wrong on this question or have misconceptions. The ones who got A had an error of using incomplete data (did not carefully read the question where they solve $\sec\theta$ instead of $tan\,\theta$). The ones who got B gave a value of $\sin\theta$ and the ones who got D confuse $cot\theta$ and $\frac{1}{\sec\theta} = \cos\theta$. This is an error related to knowledge of trigonometric ratios. Most of the students have errors, misconceptions and obstacles in trigonometry (Gür, 2009).The one who failed in this question has "a technical error" related to processes and skills related to trigonometric ratios and Pythagorean identities. Results of the fourth MCQ indicate that only 5.6% of the students got correct answer while 94.4% were wrong on it. This indicated that students have misconceptions on trigonometric ratios of angles and their associated angles (complement, supplement, and opposite of angles).Some students understand the concepts but fail in algorithm and others interpret concepts wrongly due to the over-generalization of the previous topics (Siyepu, 2015), this is can create a misconception on trigonometric ratios.

Results of the fifth MCQ indicated that only 34.3% were correct on it while 65.7% were not. The students who got B and D failed because they think that solving trigonometric equations of the form $\cos kx = a$ always gives 2 roots since they learnt that $\cos x = a\ where - 1 \leq a \leq 1$ has two roots in the region $0^0 \leq x \leq 360^0$ and this an incomplete answer. The ones who got C took $\cos 3x = -1$ as $\cos x = -1$. This is due to lack of conceptual knowledge about solving trigonometric equations. Results of the sixth MCQ indicated that only 12.8% got correct answer. This

indicated that most of the participants have an error of misunderstanding of elevation angles and were not able to apply the basic trigonometric formulae in their daily life.

These misconceptions are classified as "making an invalid reference" and "conceptual misunderstanding on trigonometric ratios, trigonometric equations, and solving word problems" The misconception of "*making an invalid reference"* were found in the determination of the value of π. This is due to the previously learnt material where they knew a relationship between units of angles: "$\pi\ radians = 180\ degrees = 200\ grades$". (Schnepper & McCoy, 2013) and *"conceptual misunderstanding on trigonometric ratios and trigonometric equations*" were found in solving trigonometric equations containing trigonometric ratios. The last misconception is *conceptual misunderstanding on solving word problems"* where students failed to get correct answers on the question related to elevation angle using right angled triangle. This misconception came from the lack of conceptual knowledge about applications of trigonometry (Shahrill & Pinamang, 2015).

5. Conclusions and Recommendations

5.1 Conclusion

Level three students in TVET schools located in Kicukiro districts have positive, but not sufficient, attitudes in learning trigonometry where about 70% of them like it, trigonometric concepts were not explained clearly, students were not familiar with notations and they do not score high marks. They also have misconceptions in learning trigonometry related to making invalid references and conceptual misunderstanding about trigonometric ratios, trigonometric equations and solving word problems.

5.2 Recommendations

Based on conclusion and the findings of this study,

1. Trainers are recommended to clarify all concepts related to trigonometry,
2. Trainers should motivate trainees in trigonometry by providing many exercises,
3. Trainers are recommended to prepare exercises that link the course to the real life.
4. Trainees are advised to avoid carelessness and do many exercises in order to be familiar with the use of formulae.

Our research is limited to analyzing students' attitudes and investigating students' misconceptions that cause poor performance in TVET schools located in Kicukiro district and the obtained information cannot be generalized in the whole country, further research is needed in the other districts.

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