AN INVESTIGATION INTO THE MATHEMATICS PROCESS SKILLS OF THE MIDDLE SCHOOL STUDENTS

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Abstract

The development of mathematics process skills in students is essential in learning and application of mathematics. The purpose of this study is to investigate the mathematics process skills of the students at the middle school level. The design adopted in this study was a descriptive research design. Twelve schools were randomly selected from four townships of four districts from Yangon Region. In order to obtain the require data, (600) students were requested to participate in this study. A mathematics process skills test was used as an instrument. It consists of five main parts: problem solving, reasoning, communication, connection, and representation. Each part consists of (10) multiple choice items. Students' answer sheets were scored manually, each correct answer was scored one mark while a wrong answer was scored zero. Mean, standard deviation, and Pearson product-moment correlation were calculated to analyze the data. The research findings indicated that most of the students possessed moderate level of mathematics process skills. Communication skill was the highest among the students and connection skill was the lowest among the students. Furthermore, there were significant positive relationships among five mathematics process skills.

Keywords: mathematics, mathematics process skills, problem solving, reasoning, communication, connection, representation

Introduction

Today society requires individuals who are able to think critically about complex issues, analyze and adapt to new situations, solve problem of various kinds and communicate effectively. The study of mathematics can equip individuals with knowledge, skills and habits of mind that are essential for successful and rewarding participation in such a society. Mathematical problem solving, reasoning, communication, connection and representation are more important than the ability to answer familiar textbook questions because it comes to developing mathematical skills in everyday life.

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Mathematics today requires the ability to think mathematically, to solve new problems and to learn new mathematics ideas that are beyond the textbook. The aim of mathematics education is to encourage students to apply mathematical knowledge and skills in everyday life situations(MOE, 2009). Learners must have mathematical process skills such as problem solving, reasoning, communication, connection, and representation in order to apply, combine and adapt their mathematical knowledge to new situations in their life and work. Therefore, this study is intended to investigate the mathematics process skills of students at the middle school level in Myanmar.

Statement of the Problem

The current mathematics teaching in schools has traditionally emphasized on repetition, drill, and convergent right answer thinking. Most of the times, teachers do not emphasize on the mathematical understanding and the development of mathematics process skills of the students. Students are rarely asked to construct their own understanding. There is a little work or activity to apply mathematics in students' real life situation. Thus, students' learning is facing with difficulties and poor mathematics performance usually occurs in schools. This is one of the real problems of the mathematics classrooms today.

Purposes of the Study

The main purpose of this study is to investigate the mathematics process skills of students at the middle school level. The specific purposes of the study are:

- to investigate the students' mathematics process skills(problem solving, reasoning, communication, connection, and representation) in mathematics,
- to examine the highest and the lowest process skills among the students, and
- to explore the relationships among mathematics process skills of the students.

Research Questions

The research questions are as follows.

Q_1: To what extent do the students possess mathematics process skills(problem solving, reasoning, communication, connection, and representation)in mathematics?

Q_2: Which process skills are the highest and the lowest among the students?

Q_3: Is there any significant relationship among mathematics process skills of the students?

Scope of the Study

This research has its own particular limitations. The first limitation is related to the participants of the study who came from only Yangon Region. Participants in this study were Grade Eight students from the twelve selected schools in the academic year (2016- 2017). The second limitation is that this study is only concerned with the National Council of Teachers of Mathematics' mathematics process skills (problem solving, reasoning, communication, connection and representation) of the students. The third limitation is the content area of the subject. The content area is limited to eleven chapters from mathematics textbook volume I and three chapters from mathematics textbook volume II to measure students' mathematics process skills.

Definition of Key Terms

Mathematics

Mathematics is a way to settle in the mind of children a habit of reasoning (Lockee, n.d, cited in Mishra, 2009).

Mathematics Process Skills

Mathematics process skills are defined as the skills that can be acquired through the processes of problem solving, reasoning and proof, connection, communication and representation (National Council of Teachers of Mathematics, 2000).

Significance of the Study

Mathematics is a powerful tool for learning other subjects and solving daily life problems. Mathematics equips students with concise and powerful means of communication. Mathematical structures, operations, process and language provide students with a framework and tools for reasoning, justifying conclusion and expressing ideas clearly. Students must have mathematics process skills, if they want to understand mathematics deeply.

Carpenter et al. (1981, cited in Bergeson, 2000) expressed that mathematical problem solving skill was central to mathematics learning. Students need to acquire ways of thinking, habits of persistence and curiosity and confidence to solve unfamiliar problems, problems requiring multi-steps, or problems with extraneous information. Thus, teaching for problem solving and learning problem solving skill become the primary and important concerns of the teacher and the learners.

Lockee (n.d, cited in Mishra, 2009) expressed that mathematics was a way to settle in the mind of learners a habit of reasoning. Complete mathematical understanding includes the engaging process of thinking and reasoning. There is a need for the teachers to help students become more aware of and take more control their own thinking in order to produce more skillful mathematician.

Communication both orally and in writing in mathematics classroom helps students understand mathematical concepts deeply. Hulukati (2005, cited in Alhaddad et al., 2015) stated that if students are not able to communicate properly and interpret mathematical problems and concepts, they cannot solve the problem well. Thus, creating opportunities to develop students' mathematical communication skill is needed in today mathematics classroom.

Anthony and Walshaw (2009) pointed out that to make sense of a new concept or skill, students needed to be able to connect it to their existing mathematical understandings, in a variety of ways. Some students see mathematics as an isolated subject and encounter difficulties in making sense of new mathematical concepts and ideas due to the lack of connection skill.

So, there is a need for students to have mathematical connection skill in order to connect and apply mathematics in everyday contexts.

Today, students are facing with difficulties in solving word problems. They cannot represent the problem statement with mathematical language or symbols because of the lack of mathematical representation skill. Lesser and Tchoshanov (2005) stated that students' representation skill effected on the understanding of mathematical concept. Therefore, mathematics teachers need to consider and use the most effective teaching methods to develop students' representation skill.

The lack of mathematics process skills might cause the most difficulties among students while solving unfamiliar problems. Myanmar students are also facing this kind of problems. Thus, teaching of mathematics should be based on process oriented approach. Creating of a classroom atmosphere where students are encouraged to use a variety of tools to reason, make connections, solve problems and communicate ideas should be the goal of every mathematics teachers.

According to the facts mentioned above, it is necessary to study mathematics process skills of the students and to give suggestions for the teachers to foster effective mathematics instruction and to improve mathematics performance of the students.

Theoretical Framework

Mathematics Education

Mathematics education is a critical component of the 21st century literacy because it is used extensively in science and technology. It can be described as a filter in the educational pipe-line, blocking the advancement of many individuals who have an interest in science and engineering but who lack the requisite mathematical skills. Grouws and Cebulla (2000) stated that if students were to compete effectively in a global, technologically oriented society, they must be taught the mathematical skills needed to do so. The prosperity of man and his advancement have depended considerably upon the advancement of mathematics. According to the above perspectives, mathematics education can be regarded as the important aspect in the person life.

Mathematics Reform Movement

Before the twentieth century, mathematics education was mainly textbook-based and dominated by rote recitation of factual information. In drawing of a technological advanced society, there was a call for changes in mathematics education. Basic to the reform movement was a standards-based approach to mathematics teaching. Standards-based instruction in mathematics is an instruction with a clear identification of what students should learn at each level. The driving force behind the standards-based approach to mathematics instruction has been the standards developed by the National Council of Teachers of Mathematics in 2000.Standards provide more than a curriculum framework as they describe the skills, concepts and knowledge that are to be mastered (Education Alliance, 2006).

Mathematics Process Skills/Standards

Mathematics process skills/standards are the basis of the functional skills standards for mathematics and apply at all levels. The National Council of Teachers of Mathematics, (NCTM) (1980, cited in Krawee, 2010) pointed out that in the existing mathematics curriculum, mathematics competence was erroneously tried to foundational computation skills and it called for a shift in focus to problem analysis and interpretation. Members of NCTM recognized the need to link mathematics instruction to the increasing requirements of the society. In 2000, NCTM proposed five process standards that should be incorporated into the mathematics curriculum at every grade level. They are:

- problem solving,
- reasoning and proof,
- communication,
- connections, and
- representation.

The process standards refer to the mathematical process through which students should acquire and use mathematical knowledge. To teach in a way that reflects these process standards is one of the best definitions of what it means to teach according to the standards.

(i) Problem Solving

Problem solving is an integral part of all mathematics learning. Polya (1966, cited in Mishra, 2009) asserted that the central activity of all teaching of mathematics is the development of problem solving skill in students. Effective problem solvers constantly monitor and adjust what they are doing. They make sure to understand the problem and plan frequently, periodically taking stock of their progress to see whether they seem to be on the right track.

(ii) Reasoning

Mathematics is the science of logical reasoning. Reasoning skillis crucial to one's success in the modern world, where making rational decisions is increasingly becoming a part of everyday life. According to Mishra (2009), reasoning mathematically is a habit of mind, and is developed through consistent use in many contexts. Systematic reasoning is a defining feature of mathematics. It is found in all content areas of mathematics with different degrees of rigor at all grade levels.

(iii) Communication

Communication is the process of expressing mathematical ideas and understandings orally, visually, and in writing, using numbers, symbols, pictures, graphs, diagrams, and words. Lomibao et al. (2016) defined the communicating skills as the ability of the students to express their ideas, describe, and discuss mathematical concepts coherently and clearly. Communication process also helps students to develop a language for expressing mathematical ideas and an appreciation for the need for precision in that language.

(v) Connection

Mathematical ideas are interconnected and built on one another to produce a coherent whole. Viewing mathematics as a whole highlights the need for studying and thinking about the connections within the discipline. Singapore Ministry of Education (2012) defined connection as the ability to see and linkages among mathematical ideas, between mathematics and other

subject, and between mathematics and everyday life. This helps students make sense of what they learn in mathematics. Students should learn mathematics with understanding, actively building new knowledge from experience.

(vi) Representation

The term representation refers to the use of symbols, charts, graphs, models, manipulative, and diagrams as powerful methods of expressing mathematical ideas and relationships. Representing applies to externally observable processes and products as well as to those that occur internally in the minds of students as they are doing mathematics. When students have access to mathematical representations and the ideas they represent, they have a set of tools that significantly expand their capacity to think mathematically (Van de Walleet al.,2010).

Research Method

Research Design

A quantitative research method was used in this study. The research design used in this study was a descriptive research design.

Instrument

A mathematics process skills test was constructed for this study. This test consists of five main parts: problem solving skill, reasoning skill, communication skill, connection skill, and representation skill. Each part consists of (10) multiple choice items. It was based on the content areas of Grade Eight mathematics textbook prescribed by the Department of Educational Planning and Training. This test included (14) chapters: (11) chapters from mathematics textbook volume I and (3) chapters from mathematics textbook volume II. The test items were prepared according to NCTM's process standards (National Council of Teachers of Mathematics, 2000) and mainly based on New Jersey Assessment of Skills and Knowledge (New Jersey Department of Education, 2006).

After preparing the instrument, in order to get validation, an expert review was conducted by five experts in the field of teaching of mathematics

from the Department of Methodology, Yangon University of Education. Since, ambiguities were found in the responses, necessary changes were made in the original test after consulting with the experts.

Pilot Testing

A pilot testing was done with a sample of sixty Grade Eight students in No. (1), Basic Education High School in Thingangyun. To measure the reliability of this test, the Cronbach's Alpha was calculated. According to the pilot study, the internal consistency (Cronbach's Alpha) for the students' mathematics process skilltest was (.721).

Population and Sample Size

This study was conducted in Yangon Region. The sample schools for this study were selected by using a stratified random sampling method from Yangon Region. Two high schools and one middle school were selected from each district. Therefore, eight high schools and four middle schools were included in this study. Fifty Grade Eight students from each selected school were selected as the samples. There were (600) participants in this study. Table (1) shows the number of population and sample size of the selected schools.

Table 1: Population and Sample Size

No.	District	Township	School	No. of Student	
				Population	Subject
1	East	South Dagon	BEHS 2	320	50
2			BEHS 6	423	50
3			BEMS 3	157	50
4	West	Hlaing	BEHS 1	163	50
5			BEHS 4	145	50
6			BEMS 8	96	50
7	South	Thanlyin	BEHS 1	435	50
8			BEHS 2	326	50
9			BEMS Bogyoke	75	50
10	North	Mingaladon	BEHS 3	426	50
11			BEHS (Branch) Htaukkyant	125	50
12			BEMS 7	168	50
Total				**2999**	**600**

Note: BEHS= Basic Education High School
BEMS= Basic Education Middle School

Data Collection

The modified instrument was distributed to all participants of the twelve sample schools with the help of the headmaster/headmistress of those schools in January, 2017.

Data Analysis

After four weeks, all the participants' answer sheets were gathered and their answer sheets were scored according to the marking scheme. Each correct answer was scored one mark while a wrong answer was scored zero. The data were analyzed by using descriptive statistics. In order to know the level of students' mathematics process skills, mean, standard deviation, and percentage were calculated. To examine the relationships among mathematics process skills, Pearson product-moment correlation was calculated.

Research Findings

Students' Level of Five Mathematics Process Skills

Based on the mathematics process skill test scores, students' mathematics process skills levels were divided into three groups: low, moderate, and high. Students with scores above the (+1) standard deviation from the sample mean were identified as high group and students with scores below the (-1) standard deviation from the sample mean were considered as low group. Then, the students with the scores between (+1) and (-1) standard deviation from the sample mean were identified as average group. In order to assess the students' levels of five mathematics process skills, the percentage of these three levels were described in Table (2).

Table 2: Students' Level of Five Mathematics Process Skills

Level	Percent (%)					
	Problem Solving Skill	Reasoning Skill	Communication Skill	Connection Skill	Representation skill	Mathematics Process Skills
Low	22.8	11.3	10.0	15.2	11.0	16.7
Moderate	56.9	71.0	77.1	69.0	68.5	64.9
High	20.3	17.7	12.9	15.8	20.5	18.4

According to the above table, it can be interpreted that most students have moderate level of abilities to solve mathematical problems, to reason mathematically, to communicate mathematical thinking, to connect mathematical concepts and ideas, and to represent mathematical ideas with mathematical symbols, graphs, charts or figures.

Comparison of Five Mathematics Process Skills of the Students

Table (3) shows the comparison of the means for the students' problem solving skill, reasoning skill, connection skill, communication skill and representation skill. The mean of communication skill (6.13) was the highest among five process skills. The mean of connection skill (4.57) was the lowest among five process skills. It can be said that communication skill is the highest and connection skill is the lowest among the students.

Table 3: Comparison of the Means of Five Mathematics Process Skills

Type of Mathematics Process Skill	N	Mean	Standard Deviation
Problem Solving Skill	600	5.37	2.24
Reasoning Skill	600	5.08	2.19
Communication Skill	600	**6.13**	2.03
Connection Skill	600	**4.57**	2.03
Representation Skill	600	5.89	1.93

Relationships among the Mathematics Process Skills of the Students

The Pearson product-moment correlation was used to determine the interrelationships among five mathematics process skills (see Table 4). According to Gay and Airasian (2003), the correlation coefficient below plus or minus .35 was interpreted as low or no relation, the correlation coefficient between plus or minus .35 and .65 was interpreted as moderate relation and the correlation coefficient higher than plus or minus .65 was interpreted as high relation.

Table 4: Correlations among the Mathematics Process Skills of the Students

Correlation					
	MPS1	**MPS2**	**MPS3**	**MPS4**	**MPS5**
Problem Solving Skill (MPS1)	1	.465**	.477**	.284**	.359**
Reasoning Skill (MPS2)		1	.538**	.412**	.477**
Communication Skill (MPS3)			1	.488**	.441**
Connection Skill (MPS4)				1	.414**
Representation Skill (MPS5)					1

Note: **. Correlation is significant at the .01 level (2-tailed).

MPS = Mathematics Process Skill

The correlation between the problem solving skill and the connection skill shows a significance but low correlation (r = .284, p = .01). There were also significant positively moderate relationships among other mathematics process skills. It can be said that there were significant correlations among the mathematics process skills of the students. The direction of the correlations was positive. This means that if one of the mathematics process skills is high, the other process skills are likely to be high or if one of the mathematics process skills is low, the other process skills are likely to be low.

Discussion, Suggestions, and Conclusion

Discussion

Mathematics is an absolutely critical part of everyday life in this technologically advanced society. It equips individuals with knowledge and skills required for successful participation in such a society. The aims of teaching mathematics are to link school to everyday life, to provide skill acquisition, to prepare students for workforce and to foster mathematical thinking. As having mathematics knowledge increasingly becomes a critical component of success in the jobs of the future, everyone needs to have a profound level of mathematical knowledge and skills. Therefore, current mathematics teaching needs to provide students with the development of the understanding of mathematical knowledge together with the acquisition of mathematics process skills.

It was found that 16.70% of the students possessed low level of mathematics process skills, 64.90% of the students possessed moderate level of mathematics process skills, and 18.40% of the students possessed high level of mathematics process skills. It can be concluded that most students had moderate level of mathematics process skills. So, this finding revealed the answer of the first research question: To what extent do the students possess mathematics process skills in mathematics? Moreover, this finding points out that most students have average level of ability to solve mathematical problems, to reason mathematically, to communicate mathematical ideas, to connect mathematical concepts, and to represent mathematical ideas and concepts. Therefore, mathematics teachers need to be conscious of their

students' mathematics process skills and look for the best ways and means to improve these skills.

By comparing the means of students' mathematics process skills, it was found that communication skill was the highest and connection skill was the lowest among the students. Students got moderate level in both problem solving skill and representation skill, and fairly low in reasoning skill. This finding revealed the answer of the second research question: Which process skills are the highest and lowest among the students? Moreover, this finding points out that most students are poor in connecting skill.

It was found that there were significant relationships among mathematics process skills. The direction of correlation was positive. It means that if one of these skills is high, the others will also be high and if one of these skills is low, the others will also be low. Moreover, reasoning and communicating skills had strong links to all the other processes skills. So, these findings revealed the answer of the third research question: Is there any significant relationship among mathematics process skills? Thus, mathematics teachers should be aware of the fact that mathematics process skills are interrelated, and they should emphasize the process rather than the product.

Suggestions

In a technologically advanced society, there is a call for changes in mathematics education. The current mathematics teaching needs to alter from product oriented approach emphasizing convergent right answer thinking to process oriented approach emphasizing problem solving, reasoning, mathematical communication, connection, and representation. According to the above research findings, most students have moderate level of mathematics process skills. But mathematics teachers should not be satisfied with this level, they should always try to improve their students' mathematics process skills. Moreover, mathematics teachers are responsible for creating learning experiences that can foster these mathematical processes and for promoting students' mathematics process skills. Some suggestions for the development of each mathematics process skill are presented as follows.

(1) Problem Solving Skill: For the development of students' problem solving skill, teachers should model how to select and use relevant problem solving strategies and procedures to help students develop and extend a repertoire of strategies so that they can apply when solving various kinds of problems. It is necessary for the students to get ongoing and continuous opportunities to work on interesting and rich mathematical problems. Teachers should give up some of their control over mathematical activity and allow students to initiate their own strategies to solve problems and grapple with contradictions.

(2) Reasoning Skill: For the development of students' reasoning skill, mathematics classroom should be an atmosphere of acceptance for all students' thinking. Teachers should allow students to think freely and should provide opportunities to express their thinking freely in the classroom. Teachers should ask the student to elevate thinking beyond the evidence to make a generalization. Teachers should guide students' reasoning toward the accepted view through carefully guided questions, and engage them in self-evaluation, and reflection. They should let students practice with mental computation and estimation to encourage students to think more deeply.

(3) Communication Skill: To improve their mathematical communication skill, students need to work with mathematical tasks that are worthwhile topics of discussion. Teachers should model proper use of symbols and vocabulary in oral and written form, encourage students to use new mathematical vocabulary, provide feedback to students on their use of terminology, and ask them extended questions and encourage them to ask themselves similar kinds of question. Teachers should arrange mathematics classrooms in such a way that students are able to become part of a community of learners who respect each other's ideas and can work together to reflect, think out difficult problems, and analyze their work.

(4) Connection Skill: For the development of students' connection skill, it is necessary for teachers to make reform in their teaching in which students can make connections between various mathematical concepts or procedures, mathematics concepts and life situations, and relate

mathematics to other subjects. They should use contextual teaching and learning approach as learning occurs within the context that is personally relevant and with which students have had prior experience. They should use assessment strategies that focus on conceptual understanding rather than on right answers.

(5) Representation Skill: In order to foster students' oral and written representation skills, teachers should use multiple representations in classroom teaching. In mathematical representational teaching, teachers should encourage students to express their own ideas in mathematical language and explain and describe the mathematical problems by reasonable representational models. To improve their representation skill, students should try to select appropriate representation to express their understanding, represent mathematical word problems into simple mathematical language and symbols and use multiple representations as required.

To ensure that students make progress in developing mathematics process skills and can function mathematically, teachers should create classroom environment with the opportunities for students to apply and adapt a variety of appropriate strategies to solve problems, to make and investigate mathematical conjectures, to discuss their thinking as well as evaluate thinking and strategies of other students, to construct mathematical ideas through connecting their previous ideas, and to create and use multiple representation in expressing mathematical ideas. Modern active teaching methods should be applied so as to have effective teaching-learning process. It is also advisable to the teacher to use formative evaluation while teaching mathematics to measure the students' mathematics process skills.

In addition, this research study was conducted to contribute to the development of students' mathematics process skills at the middle school level. However, this study is not entirely perfect, because there were some limitations. In this study mathematics process skills of the students at the middle school level were investigated. Further studies are needed to carry out students' mathematics process skills at other various school levels, and in other regions and states for replication. And, the additional studies are also needed to explore a list of specific behaviors for each of the five process skills

and specific teaching strategies that could be used to teach these process skills in the mathematics classroom.

Conclusion

Today's changing society calls for transferring mathematical knowledge and skills gained in schools to real life situations. However, students do not have the adequate level of mathematical knowledge and skills to function effectively in such a society. When thinking of the basic reasons behind these problems, it is especially the poor mathematic process skills that might cause the most problems among students.

In the light of research findings, it was found that most students have moderate level of mathematics process skills involving problem solving skill, reasoning skill, communication skill, connection skill, and representation skill. This is probably due to the lack of instructional time, the preparation for the examinations, their firmly rooted habits of memorizing, and their mental inertia due to years of mechanical work. In view of the conditions in schools, the entire atmosphere of some schools is so opposed to the true mathematical spirit that true teaching and true learning of the subject are almost impossible.

Learning mathematics with understanding is thought to occur best in situations in which learners are expected to solve problems, reason, communicate their ideas, connect mathematical ideas and represent these ideas. Teachers should emphasize these processes during teaching mathematics in the classroom. They should consider the best teaching techniques to improve students' mathematics process skills and to foster students' better mathematical understanding.

Finally, it is hoped that through this study, mathematics teachers will realize that their students need to improve in mathematics process skills and their instructional approaches need to be changed to improve the students' mathematics process skills. Although this study cannot fulfill all the aims of teaching mathematics in the middle schools, it can be hoped to some extent to foster the quality mathematics education in Myanmar. It is also expected that this research work, in a way, will help mathematics teachers towards a better understanding of the teaching and learning aspects of mathematics education.

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Appendix
Mathematics Process Skills Test
t|rwef; ausmif;om;?olrsm;\ ocFsmbmom&yfqdkif&mpGrf;&nfrsm;ppfaq;vTm

cGifhjyKcsdef (1) em&D nTefMum;csuf/ atmufygar;cGef;rsm;udkzwf&IírSe fuefaomtajzudka&G;cs,fyg/

tydkif; (u)
jyóemajz½Sif;EdkifrIpGrf;&nf (Problem Solving Skill)

1. $\sqrt[3]{\frac{-125}{8\times10^3}}$udk ajz½Sif;aomf -
   A. $-\frac{1}{4}$ B. -4 C. $\frac{1}{4}$ D. 4 &onf/
2. $\frac{x-3y}{x}=7$ jzpfvQif $\frac{x}{y}$ \tajzrSm -
   A. $-\frac{8}{3}$ B. -2 C. $-\frac{1}{2}$ D. 2 jzpfonf/
3. $\frac{x-1}{2}-\frac{x-2}{3}=\frac{1-6x}{6}$jzpfvQif x \wefzdk;rSm -
   A. 0 B. 1 C. 2 D. 3jzpfonf/
4. vkyfom;ESpfa,mufonfvkyftm;caiG126usyfudk4 : 5jzifhcGJa0,lMu&m ¤if;wdkY\ vkyftm;aiGrsm; jcm;em;jcif;rSm - A. 24 usyf B. 34 usyf C. 14 usyf D. 30usyf jzpfonf/

5. $x+y=5$ESifh$x-y=1$nDrQjcif; ESpfckpvHk;udk ajyvnfapaom x ESifh y \

wefzdk;rSm – A. x = 3, y = 2 B. x = 2, y = 3C. x = 1, y = 4 D. x = 2, y = 1 jzpfonf/

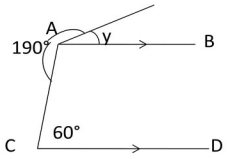
6. P ={x / $x^2 + x - 6 = 0$ESifh$x^2 - 9 = 0$}jzpfvQif PtpkrSm –

A. { -3, 3, -2} B. { 3} C. { 2, -3, 3} D. { -2, 3}jzpfonf/

7. 2011 three – 1201 three \wefzdk;rSm –

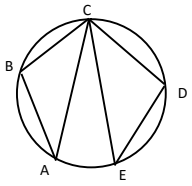
A. 210 three B. 110 three C. 120 three D. 220 three jzpfonf/

8. yHkwGify\wefzdk;rSm –



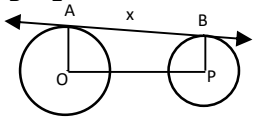
A. 50° B. 100° C. 120° D. 140°jzpfonf/

9. yHkwGif∠ABC = 115°, ∠CDE = 118° jzpfvQif ∠ACE \wefzdk;rSm –



A. 63° B. 53° C. 52° D. 65°jzpfonf/

10. yHkwGif OA – PB = 10cm, OP = 26cmjzpfvQif x \wefzdk;rSm–



A. 16 B. 24 C. 12 D. 15jzpfonf/

tydkif; (c)

pOf;pm;awG;ac:EdkifrIpGrf;&nf (Reasoning Skill)

1. atmufygwdkYteufazmfjycsufftrSefonf –

A. $a^{-3} + a^{-3} = a^{-6}$ B. $a^{4} \div a^{6} = a^{2}$C. $a^{4} \div a^{6} = a^{-2}$D.$a^{3} \times a^{-2} = a^{5}$jzpfonf/

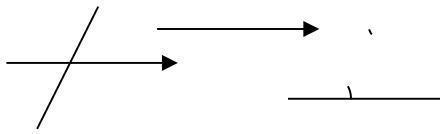
2. nDrQjcif; $y = -x$ *&yfay:wGif ½SdaomtrSwfrSm –
A.(1, 1) B. (-2, -2) C. (3, -3) D. (2, -3)jzpfonf/

3. $P \cup Q = \{x, y, z, u, v\}$, $P \cap Q = \{z, u\}$, $P \setminus Q = \{x, v\}$jzpfvQif Q\P \tajzrSm– A. $\{y, z, u\}$ B. $\{y\}$ C. $\{x, u, u, v\}$ D. $\emptyset$ jzpfonf/

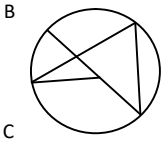
4. udef;pOf 2, 1, 3, 2, 4, …, 5, 4 wGifcsefvSyfxm;aom uGufvyfü jznfh&rnfhudef;rSm– A.3 B. 4 C. 5 D.6jzpfonf/

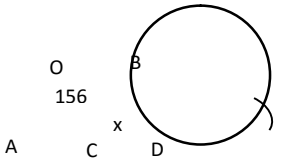
5. udef;pOf1, 9, 25, 49, …\ nMudrfajrmufudef;rSm –
A.$(2n + 1)^2$ B. $(2n - 1)^2$ C. $(2n)^2$ D.$(n)^2$jzpfonf/

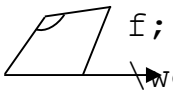
6. yHkwGifx -20\wefzdk;rSm –
A. 70° B. 50° C. 110° D. 90°jzpfonf/



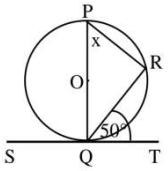
7. yHkwGifOonfpuf0dkif;\ A[dkjzpfonf/ $\angle AOD = 50$ jzpfvQif$\angle CBD$\wefzdk;rSm –
A. 40° B. 130° C. 65° D. 46°jzpfonf/



8. 



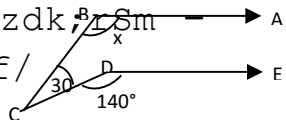
yHkwGifOonfpuf0dkif;\ A[dkjzpfvQif x \wefzdk;rSm – A. 156° B. 24° C. 78° D. 102°jzpfonf/

9. 

yHkwGif O onfpuf0dkif;\A[dk? PQ onf tcsif;rsOf;jzpfvQif

x \wefzdk;rSm –
A. 40° B. 50° C. 80° D. 100°
jzpfonf/

10. yHkwGif BA // DE jzpfvQif x \wefzdk;rSm –
A. 170° B. 120° C. 130° D. 110°jzpfonf/



tydkif; (*)

ajymqdkqufoG,fEdkifrIpGrf;&nf(Communication Skill)

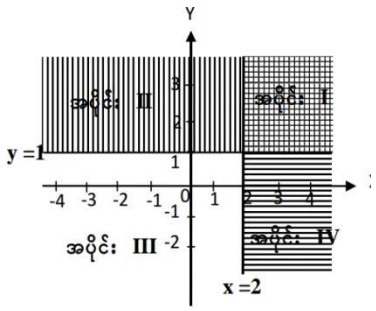
1. 107, 792wGifrsOf;om;xm;aom7\
ae&mvdkufwefzdk;rSm–
   A. rsOf;rom;xm;aom 7 \
   ae&mvdkufwefzdk;atmuf 10 q
   avsmhenf;onf/
   B. rsOf;rom;xm;aom 7 \
   ae&mvdkufwefzdk;atmuf100 q
   avsmhenf;onf/
   C. rsOf;rom;xm;aom 7 \
   ae&mvdkufwefzdk;xuf10 q ydkrsm;onf/
   D. rsOf;rom;xm;aom 7 \
   ae&mvdkufwefzdk;xuf100 q ydkrsm;onf/

2. udef;wpfckESifh ¤if;\
vSefudef;aygif;v'fonf$\frac{29}{10}$jzpfonf/
¤if;udknDrQjcif;jzifh azmfjyaomf – A.
$x+\frac{1}{x}=\frac{29}{10}$ B. $x+\left(\frac{-1}{x}\right)=\frac{29}{10}$
C. $x+(-x)=\frac{29}{10}$ D. $x+\frac{1}{x^2}=\frac{29}{10}$[ka&;Ekdifonf/

3. p \$\frac{1}{4}$onf q \ 3qatmuf 4 avsmhenf;\/ ¤if;udknDrQjcif;jzifhazmfjyaomf -

A. $\frac{1}{4}p = 4 - 3q$ B. $\frac{1}{4}p = 4 + 3q$ C. $\frac{1}{4}p = 3q - 4$ D. $\frac{1}{4}p = 3q + 4$ [ka&;Ekdifonf/

4. yHkwGifx > 2ESifhy > 1udk wpfjydKifeuf ajyvnf apaom tajzonf- A. tydkif; I B. tydkif; II C. tydkif; III D. tydkif; IV wGifusa&mufonf/



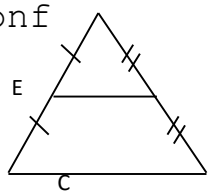
5. ykpäm12+ 3= 21udktajcpepf -

A. ESpf B.av; C.ig; D.wpfq,f jzifhwGufxm;onf/

6. ajymif;vJjcif;y∝ x²udkpmom;jzifhazmfjyygu-

A. y onf x ESifhwdkuf½dkufajymif;vJonf B. y onf x²ESifh wdkuf½dkufajymif;vJ onf C. y onf x ESifh ajymif;jyefajymif;vJonf D. y onf x²ESifh ajymif;jyefajymif;vJ onf [ka&;Edkifonf/

7. yHkwGif AD = DB ESifhh AE = EC[kay;xm;vQif atmufygwdkYteufazmfjycsuftrSeffonf -



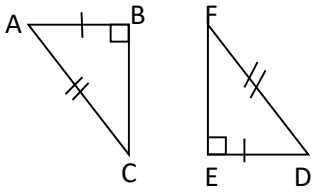
A. DE onf BC \ESpfq B. DE onf BC\wpf0uf C. DE onf BC\oHk;q D. DE onf BC\oHk;yHkwpfyHkjzpfonf/

8. trSwfwpfcküqHkaomaxmifhrsm;\yrmPrsm;tm;

vHk;aygif;onf -

A.axmifhrSef2ckB.axmifhrSef3ckC.axmifhrSef4ckD.axmifhrSef5ckESifhnDonf/

9. ΔABCESifhΔDEFwdkYonf–



A. ESpfem;Mum;axmifhnD

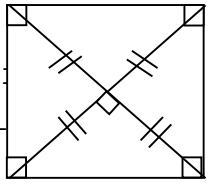
B. ESpfaxmifhESifhvdkufzuftem;wpfem;nD

C. axmifhrSefcHtem;ESifhtjcm;tem;wpfzufnD

D. tem;oHk;em;nD

rSefuefcsuft&xyfwlnDMuonf/

10. yHkwGifaxmifhjzwfrsOf;rsm;onf



A. wpfckudkwpfck xuf0ufydkif;jzwf\/

B. xyfwlnDjyD;wpfckudkwpfckxuf0ufydkif;jzwf\/

C. wpfckudkwpfckaxmifhrSefusvsufxuf0ufydkif;jzwf\/

D. xyfwlnDjyD;wpfckudkwpfckaxmifhrSefusvsufxuf0ufydkif;jzwf\/

tydkif; (C)

csdwfquffEdkifrIpGrf;&nf(Connection Skill)

1. u, v, w wdkYonfudef;ppfoHk;vHk;jzpfjyD; u<v , w < 0jzpfvQif

A. u + w >v + w B. u– w >v - w C. u w >v w D. u w <v w

jzpfonf/

2. axmifhrSefpwk*Hwpfck\ tvsm;onf3 $^{k+2}$ cm ?teHonf$\sqrt{3}$ cmjzpfí{&d,mrSm81 cm^{2}jzpfvQifk \wefzdk;rSm -

A.$\frac{3}{2}$ B.$\frac{5}{2}$ C.$\frac{2}{3}$ D.$\frac{9}{2}$ jzpfonf/

3. ocFsmtpm;ykpämwpfyk'fwGifwnfudef; =D, pm;udef;=d, pm;v'f=Q ESifh tMuGif; R jzpfvQifwnfudef;udk&Sm&efyHkaoenf;rSm -

A. D = dQ - R B. D = dQ + R C. D = dR + Q D. D = RQ + d jzpfonf/

4. axmifhrSefMwd*Hwpfck\ tem;rsm;onfn , n + 1 , n + 2toD;oD; jzpfMuvQifn\wefzdk;rSm -

A.1 B. 2 C. 3 D.4jzpfonf/

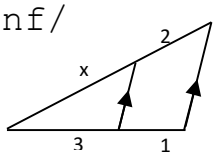
5. udef;wpfckwGif¤if;\20 %udkaygif;aomf42&½Sd\/ ¤if;udef;rSm -

A.22 B. 42 C. 35 D.7jzpfonf/

6. pwk*Hwpfck\axmifh 4 ck\tcsdK;rsm;rSm 1: 2: 3: 4 jzpfvQiftMuD;qHk;axmifhrSm -

A. 30° B. 144° C. 90° D. 108°jzpfonf/

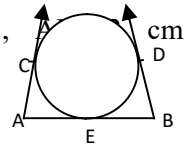
7. yHkygay;xm;csuft&xonf -



A.3 B. 2 C. 4 D. 6jzpfonf/

8. axmifhrSefMwd*HwpfckwGif axmifhusOf;ESpfck\ yrmPudk 4x ESifh 5x [kay;xm;vQif x onf - A. 20° B. 18° C. 14° D. 10°ESifhnDonf/

9. yHkwGif AC, AB ESifh BD wdkYonf 0ef;xdrsOf;rsm;jzpfMujyD;AC=5 cm , cm jzpfvQif BD onf -



A.10 cm B. 7 cm C. 17 cm D. 8cmjzpfonf/

10. tajc 2 ½Sdaom udef;pepfwGif
A. $10_{two} = 2_{ten}$ B. $10_{two} = 3_{ten}$ C. $10_{two} = 4_{ten}$ D. $10_{two} = 5_{ten}$
jzpfonf/

tydkif; (i)
udk,fpm;jyKEdkifrIpGrf;&nf (Representation Skill)

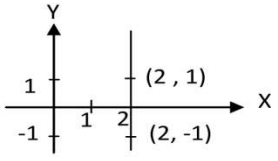
1. pHkudef;wpfckudk –
A. 2n+1 B. 2n-1 C. 2n D. n
jzifhazmfjyEdkifonf/

2. &m*Pef;on fa? q,f*Pef;onf b? ck*Pef;onf c jzpfvQifxdkudef;rSm –
A. 100 a + 10b + c B. 100 a + 10c + b C. 100 c + 10b + a
D. 100 b + 10a + c jzpfonf/

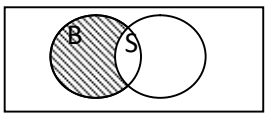
3. A \toufonf x ESpfjzpfjyD; A onf B \toufxuf 4 ESpfMuD;aomf B \ touf udk– A. x + 4 B. x - 4
C. 4x D. $\frac{x}{4}$ jzifh azmfjyEdkif onf/

4. wpfem&Da&pD;EIef;=xrdkif?
wpfem&DavSavSmfEIef; =y
rdkifjzpfvQifa&pkefoGm;EIef;udk –
A. x y B. $\frac{x}{y}$ C. x - y D. x + y jzifhazmfjyEdkifonf/

5. yHkwGifqGJxm;aomrsOf;ajzmifh onf
A. y = 2 B. y = 1 C. x = 1 D. x = 2
*&yfjzpfonf/



6. yHkwGifjc,frIef;xm;aomtydkif;onf
A. A ∩ B B. A ∪ B
C. A \ B D. B \ Ajzpfonf/



7. udef;pOf 2, 5, 8, 11, ...\n Mudrfajrmufudef;rSm

A. 3n+2 B. 2n-1 C. 3n+1 D.3n-1 jzpfonf/

8.

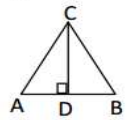
x	1	2	3	4	5
y	120	60	40	30	24

txufygZ,m;t&ajymif;vJjcif; –

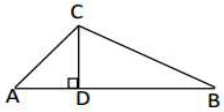
A. $y \propto x$ B. $y \propto \frac{1}{x}$ C. $y \propto x^2$ D. $y \propto \frac{1}{x^2}$ udk&onf/

9. ay;xm;csuf/ / ΔABC onftem;rnDBwd*H, $CD \perp AB$ atmufygyHkrsm;teufay;xm;csufESifhudkufnDao myHkrSm

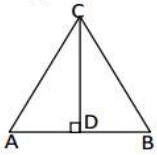
A.



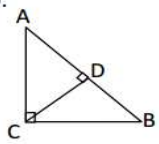
B.



C.

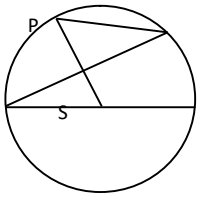


D.



jzpfonf/

10. A[dk O ½Sdaompuf0dkif;wGif atmufygwdkYteufazmfjycsufftrSefonf–



A. $\angle ROQ = \angle RPQ$ **B.** $\angle ROQ = 2\angle RPQ$ **C.** $\angle OQP = \angle PRS$ **D.** $\angle ROQ = 2\angle PRS$ jzpfonf/

Marking Scheme

Problem Solving Skill	Reasoning Skill	Communication Skill	Connection Skill	Representation Skill
1. A	1. C	1. A	1. C	1. C
2. C	2. C	2. A	2. A	2. A
3. A	3. B	3. C	3. B	3. B
4. C	4. A	4. A	4. C	4. D
5. A	5. B	5. B	5. C	5. D
6. C	6. B	6. B	6. B	6. C
7. B	7. C	7. B	7. D	7. D
8. A	8. C	8. C	8. D	8. B

9. B	9. B	9. D	9. B	9. B
10. B	10. D	10. D	10. A	10. B

(One mark for each item)