Journal of Research and Advances in Mathematics Education
ISSN: 2503-3697 (Print)
Vol. 1, No. 36-48, January 2016
http://journals.ums.ac.id/index.php/jramathedu

The Profile of Students' Thinking in Solving Mathematics Problems Based on Adversity Quotient

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Abstract. *The purpose of this research was to know the thinking processes of climber, camper, and quitter high school students in solving mathematical problems. This research used a qualitative descriptive method. Subjects were determined by purposive sampling. The technique of collecting data was done by task-based interviews. Based on the results of data analysis it can be concluded that: (1) the profiles of climber's thinking processes are: (a) assimilation and abstraction in understanding problems, (b) assimilation, accommodation, and abstraction in planning problem solving (c) assimilation, accommodation, and abstraction in implementing the plan of problem solving, and (d) accommodation in checking the solution; (2) the profiles of camper's thinking processes are: (a) assimilation in understanding mathematical problems, (b) assimilation, accommodation, and abstraction in planning problem solving, (c) abstraction in implementing the plan of problem solving, and (d) assimilation in checking the solution; (3) the profiles of quitter's thinking processes are: (a) assimilation and abstraction in understanding problems, (b) assimilation, accommodation, and abstraction in planning problem solving, (c) assimilation, accommodation, and abstraction in implementing the plan of problem solving, and (d) assimilation in checking the solution.*

Keywords*: assimilation, accommodation, abstraction, adversity quotient, problem solving*

Abstrak. *Tujuan penelitian ini adalah untuk mengetahui proses berpikir siswa climber, camper, dan quitter pada jenjang SMA dalam memecahkan masalah matematika. Penelitian ini menggunakan metode deskriptif kualitatif. Subjek penelitian ditentukan melalui purposive sampling. Teknik pengumpulan data dilakukan dengan wawancara berbasis tugas. Berdasar hasil analisis data diperoleh bahwa: (1) Profil proses berpikir siswa climber: (a) siswa memahami masalah dengan asimilasi dan abstraksi, (b) siswa melakukan asimilasi, akomodasi, dan abstraksi dalam menyusun rencana pemecahan, (c) siswa melaksanakan rencana pemecahan dengan asimilasi, akomodasi dan abstraksi, dan (d) siswa melakukan akomodasi dalam memeriksa jawaban; (2) Profil proses berpikir siswa camper: (a) siswa melakukan asimilasi dalam memahami masalah, (b) siswa melakukan asimilasi, akomodasi, dan abstraksi dalam menyusun rencana pemecahan, (c) siswa melakukan abstraksi dalam melaksanakan rencana pemecahan, dan (d) siswa melakukan asimilasi dalam memeriksa pemecahan masalah; (3) Profil proses berpikir siswa quitter: (a) siswa memahami masalah dengan asimilasi dan abstraksi, (b) siswa melakukan asimilasi, akomodasi dan abstraksi dalam menyusun rencana*

pemecahan, (c) siswa melakukan asimilasi, akomodasi, dan abstraksi dalam melaksanakan rencana pemecahan, dan (d) siswa melakukan asimilasi dalam memeriksa pemecahan masalah.

Kata kunci: *asimilasi, akomodasi, abstraksi, adversity quotient, pemecahan masalah.*

Introduction

Mathematics is a tools to develop the children's logical thinking and cognitive abilities. In fact, the object of mathematics is abstract (Suradi, 2007) which turns out to become an obstacle for children. It leads to an assumption that mathematics is a complicated subject. Dawkins (2006) asserted that mathematic class is definitely not merely a spectator sport. To understand mathematics, the students have to actively involve in the learning processes instead of solely paying attention to the teacher. In accordance to Saad (2010), mathematics is frequently called as a "scary" thing. Furthermore, Dawkins (2006) stated that students need to work harder at math classes than they do with their other classes. However, the students generally find it difficult to learn and solve mathematic problems. Thus, Adversity Quotient (AQ) is considered to have a role in mathematics learning process.

AQ is the intelligence to withstand adversity (Stoltz, 2000). Stoltz classifies three types of people related to AQ, namely: The Quitter (low AQ), The Camper (moderate AQ), and The Climber (high AQ). Quitters are group of people with less eagerness to accept the challenge of life. Campers are type of people having enthusiasm to face the problems and challenges, but they terminate it due to their incapability. While climbers are people who keep surviving to strive against all sorts of things that will keep crashing, regardless it may be the problem, the challenge, and the obstacle, things that continue to occur every day.

In solving complex mathematic problems, quitters tend to be effortless to give a try as they consider themselves to be incapable. Campers will likely to give a try, but they terminate it when it becomes more complicated. Meanwhile, climbers will make an enormous endeavor to solve the problems. In accordance to Sudarman (2007), students with high AQ (climber) seem to have higher motivation and privileged learning achievement as well.

Depdiknas (2006) stated that one of the objectives of mathematics learning process in senior high school is to solve the problems including abilities to understand the problems, to establish mathematics models, to implement the model and to interpret the produced solutions. Shadiq (2009) asserted that the skills and abilities to think obtained at the time the students solve the problem are believed to be transferred or used when the students face every day problems. Mathematics problems are typically in the form of mathematics questions, but not all of these questions are mathematics problems. When a student is encountered mathematics problems, he/she is not necessarily facing a mathematics "problems".

According to Polya (1973), there are four phases to solve the problems, namely: (1) understanding the problems, (2) planning problem solving, (3) implementing the plan of problem solving, and (4) checking the completed solution. In the phase of planning problem solving, students have to notice the correlation between information in the problem, how to reveal the unknown/unidentified correlation with available information thus there will be an idea/method to devise a plan. Subsequently, in the phase of implementing the plan, students have to complete every detail step so as to make it easier in checking the solution.

In solving mathematics problems, there will be a thinking process. Students figure out on how to determine the solution of mathematics problems. Marpaung (1986) affirmed that thinking process is a process started from receiving the information (both external and internal), processing, memorizing, and recalling the information as well as changing the cognitive structures. In thinking process, there is a process of receiving information in accordance to the scheme (cognitive structures) that exists in the human brain. New experience or information will be processed with adaptation through the process of assimilation, accommodation, and abstraction. Assimilation is the cognitive process in which a person integrates new perceptions, concepts or experiences into existing schemes in her/his mind. For instance, when the students are encouraged to find the surface area of a rectangular-shaped pool, then she/he can easily find it as in their schemes, they already have the concept of the area of rectangle is the product of its length and width. In the case a new experience does not match the scheme, there will be the accommodation process.

Accommodation occurs in two ways, namely: (1) establishing a new scheme suited to the new stimulus, or (2) modifying the preceding scheme so it suits the new stimulus (Suparno, 2001). For example, a student newly recognizes that multiplication is repeated addition and is given a question "what is the result of 3x2?", surely she/he can answer it by conceiving that 3x2=2+2+2, but when it comes to the question "what is the result of $\frac{1}{2}\times\frac{1}{3}$?", it will be a confusing problem and the student will modify her/his scheme concerning with multiplication. In the meantime, abstraction is a process of drawing a situation into a thinkable concept, in which this concept will be used in more complicated thinking level (Grey and Tall, 2007). For instance, the students are questioned "Find out two positive numbers which sum is 40 and which product is maximum". In understanding the question, students write *x*: the first number and *y*: the second number.

Based on the above elaboration, to find out the existing assimilation, accommodation, or abstraction process as the part of thinking processes in understanding mathematics problems, indicators are formulated in Table 1 as follows.

Table 1. Indicators of Assimilation, Accommodation, and Abstraction Process in Understanding Mathematics Problems

Transformation of Information	Indicators
Assimilation	Subjects can immediately express the information on the problem in their own languages
Accommodation	Subjects do not immediately express the information on the problem in their own languages
Abstraction	Subjects express information on the problem by using symbols

To understanding the process of assimilation, accommodation and abstraction as the components of thinking processes in planning mathematics problem solving, indicators are formulated in Table 2 below.

Table 2. Indicators of Assimilation, Accommodation, and Abstraction Process in Planning Mathematics Problem Solving

Transformation of Information	Indicators
Assimilation	- Subjects plans problem solving by relating information based on their schemes (in accordance to their preceding knowledge)
Accommodation	- Subjects modify their scheme by devising a more effective plan - Subjects devise the plan by trial and error
Abstraction	Subjects devise a plan by using mathematics symbols

To identify the process of assimilation, accommodation and abstraction as the components of thinking processes in implementing the plan of mathematics problem solving, indicators are formulated in Table 3 below.

Table 3. Indicators of Assimilation, Accommodation, and Abstraction Process in Implementing the Plan of Problem Solving

Transformation of Information	Indicators
Assimilation	- Subjects immediately integrate the information with their preceding schemes
Accommodation	- Subjects implement the plan by modifying their preceding schemes - Subjects implement more effective solution than their preceding schemes
Abstraction	- Subjects include algebraic manipulations in implementing the plan - Subjects use symbols in implementing the plan

To identify the process of assimilation, accommodation, and abstraction as the components of thinking processes in checking the solutions, indicators are formulated in Table 4 below.

Table 4. Indicators of Assimilation, Accommodation, and Abstraction Process in Checking the Solutions

Transformation of Information	Indicators
Assimilation	- Subjects check the steps in solving the problems - Subjects can check the suitability of the solution with available information
Accommodation	- Subject is able to check the solution with other method
Abstraction	- Subjects check the solution by using symbols - Subjects check the solution by applying algebraic manipulations

Problem solving is frequently performed when students learn the functional derivative. Mathematics problems related to the application of functional derivative require students to consider problem solving which often get less serious attention from the teachers, thus students have difficulty in solving the problems. However, the fact that each student has diverse abilities to solve the problems will likely to give a different effect on how student overcomes mathematics problems. For example, climbers will exercise themselves to improve their capability by regularly solving mathematics problems. When climbers encounter a mathematics problem, it is not surprising that they will understand the problem right away since they are accustomed to exercise themselves in solving mathematics problems so that they precede assimilation thinking process in understanding mathematics problems. How about students with other AQ categories? Do quitters who tend to be passive and feel "inferior" in mathematics have different thinking processes from climbers? To answer these questions, researchers conducted a study on on the profile of students' thinking in solving mathematics problems based on Adversity Quotients (AQ).

Research Methods

The study was a qualitative research with a descriptive strategy. The subjects of this research were the eleventh grade students of IPA SMA Negeri I Sukoharjo academic year of 2010/2011. Students were classified based on the AQ by using questionnaire. From each AQ category, subjects were selected by purposive sampling to determine the profile of students' thinking processes. The selection of research subjects was performed by considering several criteria, namely: (1) the result of students' writing test on subject selection, (2) the students' communication skills (based on teacher's suggestion and observation in teaching and learning activities), and (3) the students' AQ category.

The primary data in this study was a task-based interviews collected directly by the researcher, so that the researcher was the major instrument. During the interview, subjects were prompted to work on the worksheet and to communicate their thoughts while the researcher inquired some questions related to the subjects' thinking processes. There were two instruments to assist the interview, namely worksheet and interview guidelines. Worksheet was developed in the form of word problems of two mathematics cases followed by the questions according to the problem-solving phases proposed by Polya. The cases are presented as follows.

1. Problem Solving I

   Case 1

   A rectangle has its base on the x-axis and its upper two vertices on the parabola $y = 1 - x^2$, with $y \geq 0$. What is the largest area the rectangle can have?

   Question Number 1:

   a. Write in your own words what kind of information and what is questioned in case 1!
   b. Explain a plan to solve the case!
   c. Implement your plan in question (b)!
   d. Explain the solution to make sure your answer is correct!

   Case 2

   Determine two positive integers (they might be similar number) whose product is 324 and whose sum is the minimum!

Question Number 2:

a. Write in your own words what kind of information and what is questioned in case 1!
b. Explain a plan to solve the case!
c. Carry out your plan in question (b)!
d. Explain the solution to make sure your answer is correct!

2. Problem Solving II

Case 1

A rectangle has its base on the x-axis and its upper two vertices on the parabola $y = x^2 - 1$, with $y \leq 0$. What is the largest area the rectangle can have?

Question Number 1:

a. Write in your own words what kind of information and what is questioned in case 1!
b. Explain a plan to solve the case!
c. Carry out your plan in question (b)!
d. Explain the solution to make sure your answer is correct!

Case 2

Find two positive integers (they might be similar number) whose product is 400 and whose sum is the minimum!

Question Number 2:

a. Write in your own words what kind of information and what is questioned in case 1!
b. Explain a plan to solve the case!
c. Carry out your plan in question (b)!
d. Explain the solution to make sure your answer is correct!

The worksheet had been validated by two lecturers of Mathematics Education and a mathematics teacher before assigned to the students. The secondary data in this study was observation results. Observation was conducted by scrutinizing the learning process with the aim to examine the materials given to the students and the solutions presented by the teacher, which eventually would be referenced as data analysis of interview. In addition, observation was conducted as consideration in selecting the subject. It was performed based on observation guidelines devised previously in accordance to the objective of observation. The observation guidelines had been validated by the experts who are lecturers at Mathematics Education Universitas Sebelas Maret Surakarta, Indonesia.

The data collection was examined by using non-statistical data analysis with the phases: 1) examining the entire available data from various sources, 2) reducing the data, 3) compiling the data in units, 4) classifying the units by coding, and 5) checking the validity of data. Validation was done through triangulation of time, with the method of checking the interview, observation, or other techniques in different time or situation. Triangulation was done by checking the data from the first interview to the results of second interview for each subject of study.

Results and Discussion

Result of analysis on AQ questionnaire on 69 students obtained 20 students classified as climbers, 32 students as campers, and 17 students as quitters. Subsequently, a student was selected from each category as the subject of the study.

Climber student was assigned to explain information in case 1 in which climber immediately wrote down the answer as presented in Figure 1 and concluded that "we are assigned to find out the largest area the rectangle can have".

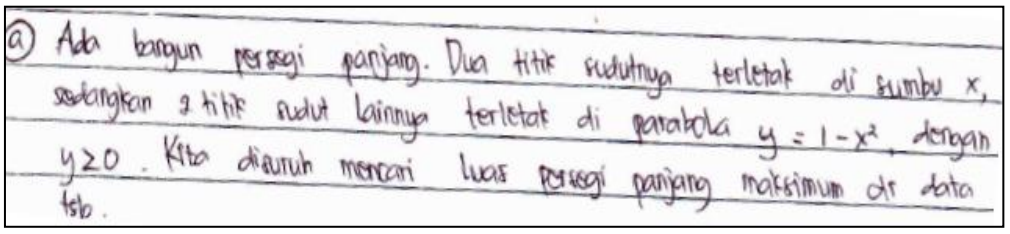

Figure 1. Climber's answer sheet in explaining information in case 1

Similarly in case 2, climber student immediately wrote down the answer as presented in Figure 2.

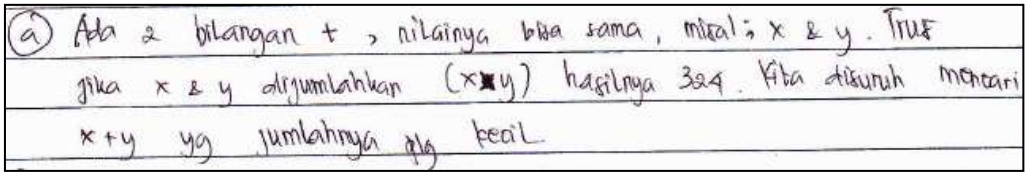

Figure 2. Climber's answer sheet in explaining information in case 2

It appears that climber could describe the information in the question at once by using climber's own words. It indicated the assimilation process was carried out by the student in both case 1 and 2. One of climber's characteristics is the passion to try new things. Climbers tend to train themselves to work on a variety of mathematics problems. As a consequence, climbers are accustomed in solving mathematics problems in which they incline to involve assimilation in understanding the problems. In addition, Figure 2 demonstrates the abstraction performed by the student by symbolizing the two inquired numbers with *x* and *y*. Hence, in understanding mathematics problems, climber performed both assimilation and abstraction.

In the phase of devising a plan of problem solving, the question of how to solve the problems was replied by the answer: drawing out and finding out the point of intersection to determine x and y.

Figure 3. Climber's worksheet in planning problem solving

Furthermore, the student pointed at Figure 3 and stated the inquiry of stationer point was significant to determine the lengths of *x* and *y*. Even though the steps explicated by the student was not exactly similar to student's preceding knowledge (by stating what would be maximized and minimized in a function then analyzing the stationer), it seems that the student devised a plan in accordance to student's preceding knowledge. In this case, the student had related information in case 1 to be adjusted with student's scheme.

Similar to case 2, climber was assigned to explain the steps of solution in which climber immediately wrote down the answer as presented in Figure 4.

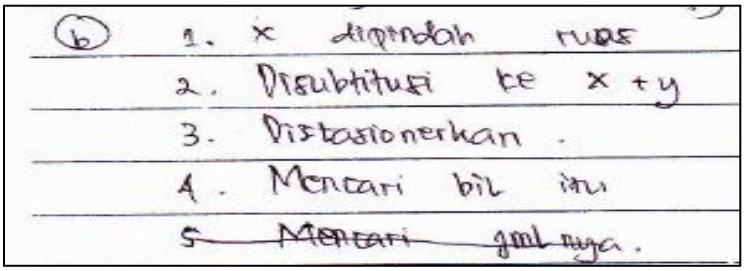

Figure 4. Climber's worksheet in carrying out the plan

In solving mathematics problems, climbers used to have a variety of mathematics problems as an exercise, thus, they are able to plan problem solving by integrating available information in the question immediately with their preceding knowledge. It is called the assimilation process. In this study, the student perceived the length of rectangle as the difference in *x,* so that the student seemed to lead the problem solving steps by assuming the rectangle as a whole (quadrant I and II were regarded as an intact rectangle instead of assuming them as two rectangles). It can be concluded that the student planned a more effective solution, so that the students seemed to make accommodations to devise plan to solve case 1. A variety of experiences in solving mathematics problems ultimately allowed the student to be skillful in sorting out effective solutions which was the process of accommodation. In addition, the student also utilized the symbols *x* and *y* to declare the length of rectangle, which was called abstraction in planning problem solving.

In the phase of implementing the plan of problem solving, the student included algebra manipulation as demonstrated in Figure 5 which indicated the abstraction thinking process.

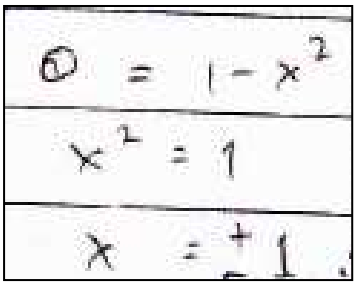

Figure 5. Climber's answer sheet in implementing the plan of problem solving

In the answer sheet, the question on how to find out maximum area was answered by analyzing the graph $y = 1 - x^2$. Within student's scheme, the maximum area can be determined by analyzing the stationer of a function, hence, when the function in the question was $y = 1 - x^2$ the stationer in the equation was analyzed despite further inquiry whether it was the function of area or not. However, it was followed up by the question of what stationer was analyzed to find out the maximum value of function $P(x) = x^2 + 3$, the student answered function *P(x)*. Finally, the student noticed that the analysis of area function stationer was used to determine the possible maximum area. In this case, the student had modified the scheme to be adjusted to case 1, hence, the student carried out

accommodation in implementing the plan. In addition, the student also included assimilation and abstraction in case 2.

Subsequently, student was questioned on how to check the solution of case 2 and the answer was by factoring the solution as illustrated in Figure 6.

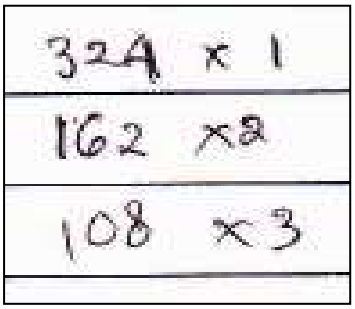

Figure 6. Climber's answer sheet in checking the solution

It appears that the student was able to apply other methods in checking whether the answer was correct, in which student performed accommodation in checking the solutions. The phase of checking the solution is a phase in determining whether the answer is correct or incorrect. It is the phase when climber can seek for other methods to solve the problems compared to the plan already taken. Climbers who always keen on new things will also tend to have sufficient experiences in solving mathematics problems so that they can use other methods to check the answer. In the end, climbers will perform accommodation in checking the solution.

Thus, climbers' thinking process in solving mathematics problems can be summarized as presented in Table 5 below.

Table 5. Climber's thinking Process in Solving Mathematics Problems

Phases of Problem Solving	Student's thinking processes based on AQ
Understanding the problems	Student implemented assimilation and abstraction
Planning problem solving	Student implemented assimilation, accommodation, and abstraction in case 1; and assimilation and abstraction in case 2
Implementing the plan of problem solving	Student implemented accommodation and abstraction in case 1; and assimilation and abstraction in case 2
Checking the solution	Student implemented accommodation

Additionally, camper's thinking process in solve mathematics problems was obtained through analysis and discussion based on climber's analysis and discussion model. Figure 7 demonstrates an example of camper's answer sheet in explaining information in case 1.

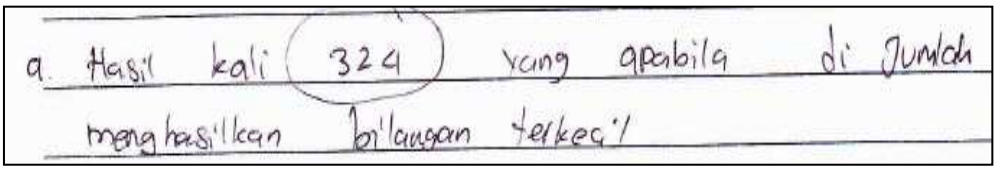

Figure 7. Camper's answer sheet in explaining information

Thinking process of camper students in solving mathematics problems can be summarized as presented in Table 6.

Table 6. Camper's Thinking Process in Solving Mathematics Problems

Phases of Problem Solving	Student's thinking process based on AQ
Understanding the problems	Student implemented assimilation in case 1 and 2
Planning problem solving	Student implemented assimilation, accommodation, and abstraction in case 1; and accommodation in case 2
Implementing the plan of problem solving	Student implemented abstraction in case 1
Checking the solution	Student implemented assimilation in case 1 and 2

Based on Table 6, camper performed assimilation thinking process in understanding mathematics problems. Although campers are less persistent in overcoming new things compared to climbers, yet they also possess willingness to try new things including to solve mathematics problems. Their experiences in solving mathematics problems make it easier for them to analyze information of a problem so that they will tend to engage assimilation in understanding mathematics problems.

Camper involved the thinking process of assimilation, accommodation, and abstraction in planning problem solving in case 1, and accomodation in case 2. Campers' personality that tends to make an attempt even though at any given moment they give up also encourages campers to rehearse themselves to improve their ability to solve mathematics problems. In the case campers encounter a problem that can be solved in accordance to their knowledge, they will integrate available information to their schemes with ease so that camper will tend to assimilate in planning problem solving.

The result of this study indicated that camper proceeded assimilation in devising a plan of problem solving for case 1. In addition, camper also included accommodation in planning problem solving for case 2. The student might be lacked of exercises in solving problems related to minimum value as the result of learning process and the fact that most of textual books incline to raise the issue related to maximum value. Problems regarding with minimum value might not relate to the student's scheme, thus, student devised another plan to solve the problems. This was a thinking process of accomodation.

Camper involved abstraction thinking process in planning problem solving for case 1. As was revealed in the discussion of climber in implementing the plan of problem solving, it is almost certainly that abstraction occurred at this phase. Similarly, the results showed that camper also involved abstraction in planning problem solving.

Camper included assimilation thinking process in checking the solution. It is possible that the student had insufficient knowledge or simply because the student was not used to check the answers. In elaborating mathematics problems, the teachers used to overlook the importance of checking the answers, so that when students are prompted to check the answer, they plainly review the previous method or check the suitability of answers to questions.

Subsequently, quitter's thinking process in solving mathematics problems was obtained through analysis and discussion similar to climber's analysis and discussion. Figure 8 shows an example of quitter's answer sheet in explaining the information in case 2.

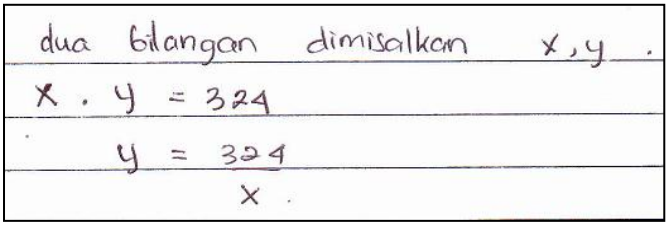

Figure 8. Quitter's answer sheet in explaining the information

Quitter's thinking process in solving mathematics problems can be summarized as presented in Table 7.

Table 7. Quitter's Thinking Process in Solving Mathematics Problems

Phases of Problem Solving	Student's thinking process based on AQ
Understanding the problems	Student implemented assimilation in case 1; and assimilation and abstraction in case 2
Planning problem solving	Student implemented assimilation and accommodation in case 1; and assimilation and abstraction in case 2
Implementing the plan of problem solving	Student implemented abstraction and assimilation in case 1; and abstraction and accommodation in case 2
Checking the solution	Student implemented assimilation in case 1; and assimilation without accommodation in case 2

Based on Table 7, quitter involved assimilation thinking process in understanding case 1 and assimilation as well as abstraction in understanding case 2. Quitters have a propensity to have no keenness in new things, which make it possible that they are also less interested in solving mathematics problems. Quitters are commonly "inferior" in facing mathematics problems particularly due to the assumption that it is a complicated subject.

Quitter indicated the use of assimilation and accommodation in devising a plan to solve case 1. While in case 2, quitter involved assimilation and abstraction. The main step taken by quitter to solve the problem was to state what would be maximized or minimized in a function and then to analyze its stationer. The step was the reflection of quitter's preceding knowledge or the assimilation process. Additionally, accommodation was done as quitter looked at the rectangle, quitter would likely to search its maximum wide in the form of an intact rectangular instead of dividing it into two rectangles.

Briefly, the question will be quickly completed by perceiving the rectangle as an intact one, thus, quitter eventually performed accommodations in planning solution to solve case 1.

Quitter was evidenced to include assimilation and abstraction in understanding case 1, while in case 2, quitter opted accommodation and abstraction. Abstraction was definitely used by quitter in implementing the plan. Analysis also showed quitter involved abstraction in planning problem solving. Assimilation and accommodation were also included in this phase. Quitter appeared to carry out accommodation in case 2, particularly to calculate the functional derivative of $\frac{u(x)}{v(x)}$, student preferred to alter the function into simple derivative of square root. This method was chosen by quitter as it was highly to be easier or indeed due to the student was incapable to perform the calculation of the functional derivative in the form $\frac{u(x)}{v(x)}$. Quitters seemed to be engaged in assimilation thinking process in this phase. Checking the solution is the phase where the students will determine the final decision in solving the problem. Quitters tend to give up easily by un-checking the answer with other methods. In this phase, it can be confirmed that quitters perform only assimilation thinking process.

The result of thinking processes of climber, camper, and quitter in this study mostly confirmed the result of previous studies carried out by Sudarman (2010) and Widyastuti (2013). Both of them have studied the thinking processes of those three categories in junior high school (SMP) grade in solving mathematics problem based on Polya's phases of problem solving.

Conclusions

Several conclusion can be derived from the study on the profile of senior high school students' thinking processes based on AQ as follows: 1) in understanding mathematics problems, climber involved assimilation thinking process to recognize the problem. In addition, climber also entailed abstraction to understand case 2. In devising a plan of problem solving, climber included the entire thinking process of assimilation, accommodation, and abstraction in case 1, while in case 2, climber merely involved assimilation and abstraction. In implementing the plan, climber carried out abstraction thinking process. In addition, climber indicated the use of accommodation in case 1 and assimilation in case 2. In checking the solution, climber used accommodation thinking process. 2) In understanding mathematics problems, camper involved assimilation thinking process. In planning problem solving, camper performed all thinking process of assimilation, accommodation, and abstraction in case 1, while camper merely used accommodation in case 2. In implementing the plan of problem solving, camper preferred abstraction thinking process and assimilation thinking process in checking the solution. 3) In understanding mathematics problems, quitter involved assimilation thinking process. In addition, quitter also included abstraction in case 2. In planning problem solving, quitter would likely to engage assimilation and accommodation in case 1. Meanwhile in case 2, quitter carried out assimilation and abstraction. In implementing the plan of problem solving, quitter opted abstraction. Quitter also performed assimilation in case 1 and accommodation in case 2. In checking the solution, quitter carried out assimilation thinking process.

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