

Self-regulated learning of prospective mathematics teachers with different learning styles

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Abstrak: Kemandirian belajar dan gaya belajar merupakan dua dari banyak faktor yang mempengaruhi capaian siswa dalam pembelajaran di setiap level pendidikan termasuk pendidikan guru matematika. Penelitian ini bertujuan menganalisis kemandirian belajar mahasiswa calon guru matematika yang memiliki gaya belajar berbeda (visual, audio dan kinestetik). Penelitian melibatkan 66 mahasiswa pendidikan matematika semester 4 yang sedang mengambil kuliah program linier. Pengumpulan data dilakukan dengan tes kemampuan matematika, angket kemandirian belajar, dan wawancara semi struktur. Tes digunakan untuk memilih calon guru yang memiliki kemampuan matematika tinggi sebagai subjek. Subjek terpilih diberikan angket untuk mengetahui tingkat capaian kognisi, motivasi, perilaku dan konteks dalam empat tahap kemandirian belajar. Wawancara dilakukan untuk mengonfirmasi dan memperdalam pilihan subjek pada angket. Data hasil angket dan wawancara dianalisis secara kualitatif. Hasil penelitian menunjukkan bahwa calon guru matematika dengan gaya belajar berbeda memenuhi empat aspek kemandirian belajar pada tahap (1) perencanaan, pemikiran, dan aktivasi, (2) pengawasan, (3) kontrol, dan (4) reaksi dan refleksi dalam tingkatan, pilihan, dan strategi yang berbeda. Perbedaan tersebut kemungkinan dipengaruhi oleh kecenderungan gaya belajar yang dimiliki calon guru.

Kata kunci: *Kemandirian belajar, Gaya belajar, Calon guru matematika*

Abstract: Self-regulated learning and learning styles are two of the various factors which contribute to students' achievement in learning at each level of education, including mathematics teacher education. This study examined the self-regulated learning of prospective mathematics teachers (PMT) with different learning styles (visual, auditory, kinesthetic). It involved 66 PMTs who enrolled on a linear program course in the 4th semester. Data were collected through a questionnaire, a test, and a semi-structured interview. The test was used to select PMTs who have high mathematics ability as the subjects. They were provided with the questionnaire to examine their fulfilment of cognition, motivation, behaviour, and context in the four stages of self-regulated learning. The interview was administered to confirm and thoroughly explore subjects' responses in the questionnaire. The results of the questionnaire and interview were qualitatively analyzed. This study found that PMT with different learning styles fulfils four aspects of self-regulated learning in the stage of (1) planning, forethought, and activation, (2) monitoring, (3) control, and (4) reaction and reflection in different extent, preference, and strategies. The differences are possibly affected by their different learning styles.

Keywords: *Self-regulated learning, Learning styles, Prospective mathematics teachers*

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A. Introduction

Achievement in learning is affected by many factors. Those can be cognitive, metacognitive, motivational, and emotional aspects (Mih & Mih, 2010). Moreover, someone's academic progress in the educational process is specifically influenced by self-regulated learning and the ability to complete their independent tasks (Hong & O'Neil, 2001; Sungur & Tekkaya, 2006). Self-regulated learning is about how far students could control their learning process which affects their academic success (Boekaerts, 1999; Beishuizen & Steffens, 2011; Lyn et al., 2011; Zimmerman, 2008; Zimmerman & Schunk, 2011). It is the student's ability to manage their learning in relation to the demands of the educational and social environment and a vital component to mediate success in the learning environment (Kalenda & Vavrova, 2016; Hartley & Bendixen, 2001; Lehmann, Hahnlein, & Ifenthaler, 2014; Zimmerman, 2008). Self-regulated learning can lead to achieve learning success and give insight on how to control the learning process and to learn efficiently (Cosnefroy et al., 2018). It is also defined as an active and constructive process where the students can set goals, monitor, and control their cognition, and motivation (Pintrich, 2000; Schunk, 2005).

Pintrich (2004) explains four aspects of self-regulated learning: cognition, motivation, behaviour, and context. In addition, Pintrich (2004) proposes four phases of self-regulated learning: (1) planning, forethought and activation, (2) monitoring, (3) control, and (4) reaction and reflection. Phase 1 includes three aspects, namely the setting of planning and goal, the activation of perceptions and knowledge of the tasks, and the activation of context and the self in relation to the task. Phase 2 deals with varied monitoring process which constitute metacognitive awareness of distinct aspects of the self and context or tasks. Phase 3 is the effort to control and regulate the various aspects of the self and tasks or context. Phase 4 delineates different forms of reactions and reflections of the self or the tasks and context. Pintrich (2004) argues that "The four phases do represent a general time-ordered sequence that individuals would go through as they perform a task, but there is no strong assumption that the phases are hierarchically or linearly structured such that earlier phases must always occur before later phases..."(p.389).

Supporting students' self-regulated learning in the educational context is an attempt to help students understand what they have such as initiative, responsibility, perseverance, and the ability to think in coping difficult tasks (Darmiany, 2009). Barnard-Brak, Lan, and Paton (2010) found that individuals who are able to self-regulate his/her learning appear to have better academic results than those who do not show the aspects of self-regulated learning. Furthermore, Zimmerman (2008) proved that prospective teachers who have self-regulated learning exhibit better time management and self-reaction than those who could not regulate their learning. Cheng (2011) reveals that self-regulated learning relates to the prospective teachers' perception of effective learning in terms of learning motivation, goals setting, the control of action, and learning strategies. These aforementioned studies clearly unravel that students' ability of self-regulation contribute significantly to students' success in teacher education.

The students' learning styles and their self-regulation reflect the personal character or cultural value (Boekaerts, 1998). One aspect of achieving learning goals in self-regulated learning is behavioural control, including behaviour during learning. Behavioural aspect during learning favoured by learners is called as learning styles (Tsingos, Sinthia, & Smith, 2015). It is a preferred individual way to respond (cognitively and behaviorally) the changes in the learning context (Tangen, 2018) or the selection of preferred learning conditions or situations (Brown,

2015). A learning style shows the way someone processes information with the aim of learning and applying it (Cruz, Ballard, & Dacanay, 2017; Kolb & Kolb, 2005; Willingham, Hughes, & Dobolyi, 2015). Insight on learning styles can offer valuable suggestions and instructions to students and teachers to optimize the learning process (Truong, 2016). Learning style is one of the key factors that influence academic performance in learning when planning, implementing and evaluating learning (Simoes, Redondo, & Vilabs, 2013). Learning style is also a broad concept that plays a vital role in educational outcomes in the classroom (Ibrahim & Hussein, 2016). Learning styles based on modality can be classified into three types: visual, audio, and kinesthetic (De Porter & Hernacki, 2004). The three learning styles differ from its sources and means of perceiving and processing information, namely visual, audio, and movement or tactile (Sarasin, 1999). For example, students with visual learning style tend to better process information from seeing pictures than listening to the voices.

Following the importance of self-regulated learning (e.g., Barnard-Brak et al., 2010; Zimmerman, 2008; Cheng, 2011) and learning styles (Simoes et al., 2013), the present study aimed to examine self-regulated learning of prospective mathematics teachers (PMT) who have different learning styles. Referring to the phases and areas for self-regulated learning by Pintrich (2004), we identified how PMT achieve cognition, motivation, behaviour, and context in the stage of (1) planning, forethought and activation, (2) monitoring, (3) control, and (4) reaction and reflection. We argue that equipping future mathematics teachers with related knowledge such as content knowledge for teaching (Ball, Thames, & Phelps, 2008) is still built on their self-regulation to achieve such knowledge. Thus, teacher education program should not only focus on the aspect of knowledge but also prospective teachers' ability to self-regulation. Mumthas and Suneera (2015) assert that prospective teachers must be aware of factors which affect self-regulation and strategies to develop their self-regulated learning. Moreover, understanding their ability to regulate learning independently enables them to be more reflective (Perry, 2013). In this case, insight into PMTs' self-regulated learning contributes to the effort to support its development in teacher education.

B. Methods

This study followed a qualitative approach which aimed to identify self-regulated learning of prospective mathematics teachers (PMTs) based on visual, audio and kinesthetic learning styles. The subjects of this study were 66 PMTs who enrolled in the linear algebra course. The subjects were given the questionnaire of learning style, which had been developed by the researchers and fulfilled the validity and reliability criteria (Nugroho, Juniati & Siswono, 2017). It resulted in 45 PMTs with a visual learning style, 7 PMTs with an auditory learning style, and 14 PMTs with a kinesthetic learning style. Then, all the subjects were provided with a mathematics test to reduce the subjects into three PMTs who have high mathematics ability (score more than 80 in the test) with respect to each category of learning style. The test comprises two problems on the simplex method in a linear program. Self-regulation is considered contributive to students' ability to solve problems. In this case, students who can solve the test better (get a higher score) are more likely to demonstrate a complete picture of self-regulated learning than those who scored lower. In order to have more data on students' self-regulation in learning, we decided to select that criterion for the subjects.

With the selected subjects, the study was carried out through the following steps: (1) Giving a questionnaire of self-regulated learning that contained four aspects, namely cognition,

motivation/influence, behaviour and context. The questionnaire had been validated and examined for reliability (Nugroho, Juniati, & Siswono, 2018). In each item of the questionnaire, the subjects were asked to choose one of the four options (never, seldom, often, always) which suit their factual condition. (2) Interviewing the subjects to obtain data about cognition, motivation/influence, behaviour, and context. The interview was conducted in a semi-structured manner that might be extended following the subject's answers but remains on the planned content. (3) Analyzing the results of questionnaires (Appendix 1) and interviews descriptively. (4) Triangulating based the results of questionnaires and interviews. (5) Concluding the data. The conclusions were obtained based on the questionnaire and interview data by paying attention to the aspects of self-regulated learning.

In step 3 of data analysis, subjects' responses to the questionnaire were converted to numerical data: never (score 1), seldom (score 2), often (score 3), and always (score 4). Then the average of the score was used to interpret subject's fulfilment of the aspects of self-regulated learning in each stage: $1 \leq x \leq 2$ (could not meet the aspects) and $2 < x \leq 4$ (could meet the aspects). The rationale for this category is the subjects' responses to the questionnaire. We argue that the response 'never' and 'seldom' indicates that the subjects are not consistent in the actions. Meanwhile, 'often' and 'always' denote the actions are their routine. Indeed, the ability of self-regulation in learning is developed from consistent actions or an active and constructive process (Pintrich, 2000; Schunk, 2005). We also coded each aspect of self-regulated learning in the questionnaire in order to be easily referred to in the data analysis. For example, Cog-S1 refers to cognition aspect in stage 1. The results of the questionnaire and interviews were analyzed according to the stages and aspects of self-regulated learning (Pintrich, 2004). We developed a matrix of self-regulated learning to help this analysis (See Appendix 2)

C. Findings and Discussion

In this part, we provide data on PMTs' self-regulated learning relating to their styles of learning and referring to the aspects and the stages of self-regulated learning (Pintrich, 2004). For the transcript of the interview, we coded V (visual subject), A (Auditory subject), K (Kinesthetic subject), and P (Researchers).

Stage 1: Planning, forethought, and activation

Cognition

Subjects' responses to the questionnaire (Appendix 1, Cog-S1) and transcript 1 reveal that they meet the aspect of cognition in stage 1. They could identify the needs of learning (transcript 1, line 2-4; 6-8), set the target of learning (transcript 1, line 10-12), activate prerequisite knowledge (transcript 1, line 14-16), and activate metacognitive knowledge (transcript 1, line 18-20 and 22-24)

Transcript 1

- 1 P₁ : Are you looking for learning resources before attending lectures? If so, how do you look for it?
- 2 V₁ : Yes, I usually search first on youtube and books to know what to learn
- 3 A₁ : Yes, looking for sources from books and the internet before lectures
- 4 K₁ : Yes, I looked for learning resources first by browsing on the internet
- 5 P₂ : Do you always prepare special tools or equipment in learning mathematics?

- 6 V₂ : *Yes, it's usually been prepared before lecturing like a calculator, eraser, pencil, pencil sharpener, book, ruler*
- 7 A₂ : *Yes, like calculators, erasers, pencils, bows, colour markers, modules and rulers*
- 8 K₂ : *Always preparing such as stationery, books (modules and notes), calculators, rulers, ballpoints, pencils, erasers*
- 9 P₃ : *Did you set a target during the lecture?*
- 10 V₃ : *To get A*
- 11 A₃ : *Yes, the target is to understand lecture material and get an A*
- 12 K₃ : *Always set the target to get the maximum score and a GPA of more than 3.2*
- 13 P₄ : *Did you write the prerequisite materials needed on the book or personal notes?*
- 14 V₄ : *Sometimes*
- 15 A₄ : *Yes, I did*
- 16 K₄ : *Yes*
- 17 P₅ : *Do you understand the purpose of the mathematics lessons you are taking? Explain it!*
- 18 V₅ : *Knowing the learning objectives of the course because they have been explained earlier by the lecturer*
- 19 A₅ : *I understand some parts because there were explained in the lecture contract in the first meeting*
- 20 K₅ : *Yes, mostly I understand*
- 21 P₆ : *Do you know what you will learn? Explain!*
- 22 V₆ : *Yes, because it had been delivered in the first meeting and the lecturers often explain the material to be studied at the next meeting*
- 23 A₆ : *Yes, I know from the study contract and learning plans explained by the lecturer in the first meeting*
- 24 K₆ : *Yes, because at the beginning of the lecture, we were told the learning plans and books to be used.*

Motivation

Subjects' responses to the questionnaire (Appendix 1, Mot-S1) show that they fulfilled the aspect of motivation in stage 1. It is also supported by the results of the interview in which they were oriented to the target of learning (transcript 2, line 2-4; 6-8), understand the importance of tasks which affect the achieved score (transcript 2, line 10-12), seek help if they encounter difficulties in accomplishing tasks (transcript 2, line 14-16). In this aspect and stage of self-regulated learning, auditory subject prefers to understand the given course to get A as motivation.

Transcript 2

- 1 P₁ : *Do you make the target of learning or score as motivation in learning? If so, why?*
- 2 V₁ : *Yes, because if you do not have the target, will be less motivative*
- 3 A₁ : *Yes, because to encourage enthusiasm in learning*
- 4 K₁ : *Yes, in order to understand the material and get the maximum score*
- 5 P₂ : *Do you plan a "celebration" when the target is reached? If so, how will it look like?*
- 6 V₂ : *Yes, usually be grateful by buying food and then eating it with friends*
- 7 A₂ : *Usually, be grateful by inviting friends to eat together*
- 8 K₂ : *No, just be grateful on myself because there is usually a higher score than I got*
- 9 P₃ : *How important are your tasks in the course?*

- 10 V_3 : *Very important, because the task contributes to the final score*
11 A_3 : *Very important, because the task determines the final score. In addition, the task also reflects our ability working on it*
12 K_3 : *Very important because the task can later help the final score*
13 P_4 : *When you encounter problems in the course or doing tasks, what do you do?*
14 V_4 : *Usually, I try to solve it, and if I have difficulty, then I will learn via YouTube or ask a friend who understands and if you haven't gotten the solution, ask the lecturer*
15 A_4 : *Usually, look for solutions in different reference books and ask friends*
16 K_4 : *Ask a friend, and if don't find a solution or solution, I usually contact my high school math teacher*

Behaviour

In this aspect and stage, subjects' responses to the questionnaire (Appendix 1, Beh-S1) indicate that they plan to learn outside the course meeting and make a checklist of learning target during the course. Respectively, the results of the interview (transcript 3, line 2-4 and transcript 3, line 6-8) support subjects' responses. Although the subjects plan the learning, the auditory subject learns at home without making a specific schedule. This shows that they provide time and effort in learning and plan a self-assessment toward the behaviours.

Transcript 3

- 1 P_1 : *How do you manage the time for the course?*
2 V_1 : *I usually learn after sunset by reading the material that has been learned and try the exercises*
3 A_1 : *I do not make a schedule but have learned again after courses*
4 K_1 : *In order to arrange a time during course, I have made a note for the deadline of the tasks and learning schedule during the course*
5 P_2 : *Do you make notes about the deadline of activities or achievement during the course? Explain!*
6 V_2 : *I rarely make it for this semester, but in the previous semester, I made it, a kind of checklist.*
7 A_2 : *Yes, records such as task deadlines and target to be achieved*
8 K_2 : *Yes, make a note for a list of achievements.*

Context

In this aspect of stage 1 of self-regulated learning, subjects' responses to the questionnaire (Appendix 1, Con-S1) and interviews (Transcript 4) unravel that they add notes to the learnt topics in the course (line 2-4), redefine the problem (line 6-8), provide a simple example of the problem even though some found difficult (line 10-12), and understand the meaning of the symbols used in solving the problem. Line 14-16 shows that auditory subject is difficult to understand the symbols. In conclusion, the subjects plan and manage the perception of tasks and context.

Transcript 4

- 1 P_1 : *Did you add notes to the linear program material during the course? If yes, how do you do it?*
2 V_1 : *Sometimes adding by scribbling or adding a small note in a notebook or module as in the completion step because sometimes I forget*

- 3 A₁ : Yes, for example, some additions are not in the module books, then I noted in my book
- 4 K₁ : Yes, if you encounter difficulties or important things will be marked with a red ballpoint or another colour, besides making small notes in the book
- 5 P₂ : Have you ever changed the definition of the problem using your own language during the course?
- 6 V₂ : Yes, suppose the problem is known to the house or bungalow then the price is known after that find out the decision table. I also change the variable with x and y
- 7 A₂ : Yes, for example changing with own sentences when making mathematical models
- 8 K₂ : Often, for example, there is a company producing fabric and then making a mathematical model using x as fabric
- 9 P₃ : Can you make a simple example of the material you have studied?
- 10 V₃ : The simplex material is still difficult because the problem is complicated
- 11 A₃ : Yes, I can but rarely make it
- 12 K₃ : I can but only replace the numbers and the sentences
- 13 P₄ : Do you understand the meaning of each symbol or variable used in the course? Try to explain it!
- 14 V₄ : Yes, I understand. For example, there are symbols M , A , S +, S -
- 15 A₄ : Lack of understanding because there is still something unclear
- 16 K₄ : Yes, for example in the maximum case use the sign "less than or equal to" then variables such as " x " symbolize something.

Referring to students' responses to questionnaire and interview, at the stage of planning, forethought and activation, the PMTs' with different learning styles plan and analyze the needs in mathematics learning, set learning goals, have their own ways to find learning resources, know the prerequisite material needed to learn new concepts, understand the task at hand, and plan to reach the target. In addition, they try to redefine the concept using their own language and try to find out every symbol that appears in the topics.

Stage 2: Monitoring

Cognition

Subjects' responses to the questionnaire (Appendix 1, Cog-S2) show that they fulfilled the aspect of cognition with different preference regarding group discussion in this stage as it is supported by the results of the interview. They relearn the course material (transcript 5, line 2-4), ask friends if they do not understand the topics learnt in the course (transcript 5, line 6-8), and do exercises (transcript 5, line 14-16). In this aspect, visual and kinesthetic subjects tend to like group discussion than the auditory subject (transcript 5, line 10-12). The data indicates that the subjects use metacognitive and monitor cognition.

Transcript 5

- 1 P₁ : When do you relearn the materials obtained during the course?
- 2 V₁ : I study and reread the material when I want to take an exam and have an assignment
- 3 A₁ : I learn when there is an assignment and if it relates to the next material
- 4 K₁ : Usually when there are assignments, then I study again or when there are mid or final term
- 5 P₂ : What do you do if you don't understand the material you have learned?

- 6 V_2 : *Study and read again and ask friends*
- 7 A_2 : *Reread and work on problems related to the problem and ask friends*
- 8 K_2 : *Browsing first on the internet and asking friends*
- 9 P_3 : *With whom do you usually have discussions outside the classroom?*
- 10 V_3 : *I usually discuss with friends*
- 11 A_3 : *Rarely do discussions, usually follow in group discussions before the final term*
- 12 K_3 : *Usually at specific times for example when there are tasks*
- 13 P_4 : *How do you try to find out the level of understanding of a problem?*
- 14 V_4 : *Try working on the problem by analyzing the problem, then making a mathematical model. For example, in the case of a simplex problem, when the problem looks for the maximum or minimum Z value, I usually experience difficulties and could not finish.*
- 15 A_4 : *Trying to do exercises*
- 16 K_4 : *Trying to do the exercise then I check the solution, the results will show how I score*

Motivation

The interview (transcript 6, line 2-4) shows that the subjects do not feel bothered if any friends ask whether or not they have learnt or done assignments. Along with the subjects' responses to the questionnaire (Appendix 1, Mot-S2), the subjects use their awareness and monitor motivation.

Transcript 6

- 1 P_1 : *How would you feel if a friend asked: "have you learned or have done your work"?*
- 2 V_1 : *Nothing special*
- 3 A_1 : *Never mind*
- 4 K_1 : *So am I*

Behaviour

The results of the interview (transcript 7) and questionnaire (Appendix 1, Beh-S2) indicate that the subjects use their awareness and monitor their efforts and utilize time to support self-observation or assessment toward the behaviours in different extent. In this aspect of stage 2, they make their notes (transcript 7, line 2-4), attempt to come before the class start (transcript 7, line 10-12), focus on learning when they are alone (transcript 7, line 18-20), make their own learning schedule (transcript 7, line 6-8), utilize the available time to learn with different extent (transcript 7, line 22-24), and work on their tasks individually or in the group (transcript 7, line 14-16).

Transcript 7

- 1 P_1 : *How do you take your notes?*
- 2 V_1 : *I write important material in the module then underline with a highlighter as an affirmation so that it is easy to learn*
- 3 A_1 : *I usually mark with a circle or underline then write back*
- 4 K_1 : *I give affirmation by using a coloured ballpoint*
- 5 P_2 : *Do you schedule learning outside course?*
- 6 V_2 : *Yes*
- 7 A_2 : *Yes*

- 8 K_2 : Yes
- 9 P_3 : When do you come to the class?
- 10 V_3 : Usually, 5 to 10 minutes before the class starts but sometimes on time
- 11 A_3 : Usually 5 minutes before
- 12 K_3 : Usually, 5 to 10 minutes before the class begin
- 13 P_4 : When working on assignments, do you do alone or in groups?
- 14 V_4 : If there is a group, I will be in a group. Otherwise, I'd rather try it myself
- 15 A_4 : Working alone
- 16 K_4 : In groups
- 17 P_5 : What kind of learning situations do you like to study mathematics?
- 18 V_5 : In a quiet and alone situation, if I have difficulty, I will open YouTube to help to explain related material
- 19 A_5 : Calm, alone, and in the mood
- 20 K_5 : Quiet and alone but accompanied by music
- 21 P_6 : Do you use your free time to study the course material which you do not understand yet? When do you do it?
- 22 V_6 : Often, but not often as working on assignments
- 23 A_6 : Not often, when I have one class a day, sometimes trying to work on problems that do not understand but tend to chat with friends
- 24 K_6 : If there is free time and the mood is good, I relearn material that I do not understand.

Context

The results of the interview (transcript 7) and questionnaire (Appendix 1, Con-S2) indicate that the subjects have a difference in monitoring the change of tasks and the situation of context. In checking the meaning of symbols, the auditory subject rarely did it (transcript 8, line 2-4; 14-16). Likewise, he did not often write prerequisite material (transcript 8, line 6-8). Auditory and kinesthetic subjects compared their solution on problems with initial conjectures but the visual subject did not (transcript 8, line 10-12).

Transcript 8

- 1 P_1 : Do you check the correctness of meaning on each symbol or variable used when writing formulas or doing exercises?
- 2 V_1 : I check beforehand by rereading variables such as x and y whether or not they are appropriate and the formula is correct or not
- 3 A_1 : Rarely, but I checked the truth of the meaning of symbols or variables
- 4 K_1 : Check the symbols whether it is correct or not and if it is incorrect I try to correct them
- 5 P_2 : Are you writing down the prerequisite information when learning a new concept?
- 6 V_2 : Yes, for example in the linear program, I look for information in books about determining and analyzing the problem, then writing it
- 7 A_2 : Rarely write
- 8 K_2 : Yes, by writing down what information appears first
- 9 P_3 : Do you compare your final answers with the conjecture you made before solving the problem?
- 10 V_3 : Sometimes, it is usually on simplex to read the problem first using the maximum or minimum
- 11 A_3 : Yes
- 12 K_3 : Yes

- 13 P_4 : *What is your effort to monitor the correctness of concepts and steps in solving linear program problems?*
- 14 V_4 : *For example, in the case of simplex, when working on the problem I look back at the answer from the beginning, the first step is to change the variable and take the decision variable, the objective function, the constraints, then move to the table*
- 15 A_4 : *Open the book and reread then compare with a friend's answer to find out if there is a different*
- 16 K_4 : *I usually look in a notebook so that it is appropriate or not.*

At the monitoring stage, the subjects tried to understand and learn the course material again by examining the symbols or variables used, doing exercises to find out the level of understanding, monitoring learning motivation by learning every day especially if there are difficult materials and remembering the learning objectives and preferring working alone on the assignment and quiet atmosphere to learn. In this stage, they have a commonality in cognition and motivation but demonstrate different choices in behaviour and context.

Stage 3: Control

Cognition

Students' responses to the questionnaire (Cog-S3) and the results of the interview (Transcript 9) indicate that visual and kinesthetic subject has a distinct preference of strategies in learning and thinking. The auditory subject rarely makes notes on important content and prefer work on the tasks individually (transcript 9, line 3; 7).

Transcript 9

- 1 P_1 : *How do you mark important sentences or formulas in the book?*
- 2 V_1 : *Usually, I mark important things with a highlight or underline and make a small note*
- 3 A_1 : *I rarely do but rather write additional information in a notebook that is not in the module book*
- 4 K_1 : *I mark it with a coloured ballpoint*
- 5 P_2 : *What is the effect of the group discussion and the tasks to the understanding of the concept?*
- 6 V_2 : *Group discussions make it easier to solve problems when I experience difficulties*
- 7 A_2 : *I prefer to do it myself first, but if there are difficulties solving the problem sometimes following group discussions*
- 8 K_2 : *In group discussions, it can convince me that the concept is correct or not, especially when discussing difficult problems.*

Motivation

In this aspect, visual and auditory subjects prefer not to make a group discussion. On the other hand, the kinesthetic subject finds fun learning in a group activity (Appendix 1, Mot-S3). To motivate themselves in learning, they have different strategies (Transcript 10). This shows that the subjects have different strategies to manage motivation.

Transcript 10

- 1 P_1 : *What strategies do you use to stay motivated in learning?*

- 2 V₁ : *The learning target and self-study related material that is considered difficult*
3 A₁ : *Always remember your targets and learning goals and study by yourself in a quiet place*
4 K₁ : *If the learning mood goes down again, do a discussion and refreshing first so that later you can concentrate on learning again.*

Behaviour

The results of the questionnaire (Beh-S3) and interview (Transcript 11) indicate that the subjects show behaviour which supports their effort in learning. They feel challenged when find difficulties (transcript 11, line 2-4), ask their friends when they do not understand the material (transcript 11, line 6-8), and participate in mentorship program held by their friends (transcript 11, line 14-16).

Transcript 11

- 1 P₁ : *Do you feel challenged when you encounter difficulties in learning? Explain!*
2 V₁ : *Yes, for example, there are difficult problems, and the solution has not been met then I am challenged to try the problem*
3 A₁ : *Yes, if there are difficulties working on challenging questions to solve it*
4 K₁ : *I am challenged when a problem could not be solved*
5 P₂ : *What do you do when you don't understand the course material?*
6 V₂ : *When learning in class, I immediately asked the lecturer. Outside the classroom, I usually discuss with friends who have more understanding and looking for books and learning via YouTube*
7 A₂ : *Ask a friend and look for other references*
8 K₂ : *Browsing first on the internet, then asking a friend but I rarely ask the lecturer*
9 P₃ : *What do you do when you are absent?*
10 V₃ : *Usually, I ask my friends whether there is an assignment or not. Besides that, I borrowed a friend's notes*
11 A₃ : *Asking friends about assignments and borrow friends' notes*
12 K₃ : *I ask permission from the lecturer and ask whether there is an assignment or not and then borrow a friend's notebook*
13 P₄ : *Do you often take part in mentorship held by friends?*
14 V₄ : *I often follow learning discussions or mentorship held by friends when there are difficult questions*
15 A₄ : *I do if there are difficulties in learning, especially when I want to have a test*
16 K₄ : *Rarely, but when working on assignments, I follow*

Context

In this aspect, the subjects confirm the change of tasks and contexts (Appendix 1, Con-S3). The results of the interview (Transcript 12) also show that they check the validity of information in the notes they made (transcript 12, line 2-4), check the correctness of mathematics formula they use (transcript 12, line 10-12), and have a difference in checking the correctness of procedures in solving a problem. The auditory subject rarely checks the procedure when solving the problem (transcript 12, line 6-8).

Transcript 12

- 1 P₁ : *How do you check the accuracy of the information that you copied in your notebook or in solving the problem?*
- 2 V₁ : *Usually, before writing important things, I look at modules and lecturers' explanations, so they are not wrong. Besides, I read the questions several times to get information about the questions*
- 3 A₁ : *I usually do by reading on different sources whether or not it is appropriate*
- 4 K₁ : *I do check myself and then match with the answers of friends*
- 5 P₂ : *How do you check the correctness of the steps from the linear program exercise that you are working on?*
- 6 V₂ : *I check it sometimes by looking at the writing of the formula it is correct or not. I usually am wrong on the plus and minus signs then the steps - as in the case of simplex, first determine the maximum or minimum problem then the decision variables are taken and the objective function. Sometimes I am also the wrong in counting, writing, and using the concept*
- 7 A₂ : *I rarely check. Sometimes I check when I have finished working, checking from the first calculation until the last then later checked whether the results if entered into the function are correct or not. Sometimes it is also wrong in counting*
- 8 K₂ : *Check if a linear program has a simplicity problem $c_i - z_j$ then check again one - one comparing the top value and the bottom value is correct or not, but sometimes it is often wrong to write it*
- 9 P₃ : *How do you check the accuracy of the formulas in problem-solving?*
- 10 V₃ : *I read the problem first then determine the problem which is about the company's maximum profit. The first step is to determine the decision variable, for example, x is for house and y is for a bungalow, then determine the objective function and constraints*
- 11 A₃ : *In the case, it is a maximum simplex case, so there is no need to use M and Artificial, but it is enough to use $S1$ and $S2$, then work on it until you find the pivot key*
- 12 K₃ : *Check it by matching the data first after finishing and then checking the final result by entering the formula whether it is correct or not.*

At the control stage, visual and kinesthetic subjects marked sentences, information or important formula in the books but auditory subject rarely did and was more likely to pay attention to explanations from the lecturers. All three subjects followed group discussions when they had difficulty in solving mathematical problems. They also had a strategy that was used to manage motivation while learning. They tried not to give up easily when they had difficulty doing exercises. In addition, they checked the accuracy of information and formulas in the course material and correctness of the procedures when solving a problem. For the latter, the auditory subject was not often doing the check. This uncovers that the subjects choose and adjust the cognitive strategies to learn and think, strategies to manage motivation, increase the effort in learning, and change or confirm the change of tasks or context with different extent.

Stage 4: Reaction and reflection

Cognition

The results of the questionnaire (Appendix 1, Cog-S4) indicate that the subjects are able to examine their cognition and attribution. It is also shown in their explanation about their ability

to solve mathematics problems (transcript 13, line 2-4). In addition, they also demonstrate the ability to explain the material they had learnt (transcript 13, line 6-8).

Transcript 13

- 1 P₁ : Do you have good problem-solving skills?
2 V₁ : Not good, if I understand the material then I can solve the problem
3 A₁ : Less good
4 K₁ : Sometimes I can quickly solve problems
5 P₂ : Are you able to explain the material that you have learnt?
6 V₂ : Yes, for example, in numerical methods, one-third, eighth, and trapezoidal materials
7 A₂ : Yes, for example, the simplex method is one way to complete a linear program and is related to the maximum and minimum objective functions.
8 K₂ : I can, so if you use the graph method in the solution you will find key points, for example, $x = 0$, then y is the same as the specified value then if you have found the intersection then it will be put in z , whether it is maximum or minimum and it is sourced.

Motivation

In this aspect, students' responses to the questionnaire (Appendix 1, Mot-S4) show that they do not only learn for a test and set time for learning outside the course meeting (Transcript 14). This reveals that they use attribution for the time selection to learn.

Transcript 14

- 1 P₁ : When do you study outside the course meeting?
2 V₁ : Usually, I study after sunset or when I'm in the mood to go to the library to look for books
3 A₁ : Usually at night or after dawn
4 K₁ : Night because usually come home from college immediately go to sleep

Behaviour

In this aspect, the subjects demonstrate specific behaviour in learning such as choosing the seat (transcript 15, line 2-4), not following their way of learning (transcript 15, line 6-8), and knowing conditions which support the optimal learning (transcript 15, line 10-12). This unravels that they are able to determine behaviour in learning.

Transcript 15

- 1 P₁ : Do you always choose where to sit in class? Explain!
2 V₁ : Yes, I chose a seat in the class in the first or second row because it is more focused on learning
3 A₁ : Yes, if I often take notes, it is usually in front of the first line
4 K₁ : No, I sit in a place according to my needs
5 P₂ : Do you follow other friends' method or strategy in learning? Explain!
6 V₂ : No, because in my opinion learning has its own way and convenient learning is a self-study
7 A₂ : No, because I study in my own way
8 K₂ : No, because in my opinion, everyone has a different way of learning
9 P₃ : What kinds of situations make you comfortable to learn?

- 10 V₃ : *The situation is quiet and comfortable*
11 A₃ : *In a calm situation*
12 K₃ : *The atmosphere was quiet and accompanied by music*

Context

Subjects' responses to the questionnaire (Appendix 1, Con-S4) show that they evaluated tasks by checking the accuracy of formulas used in the course or problem-solving. It is also identified in the interview (transcript 16, line 2-4). In evaluating contexts, the only auditory and kinesthetic subject could make similar problems to the problems given by the lecturer (transcript 16, line 6-8).

Transcript 16

- 1 P₁ : *How do you evaluate the accuracy of the formulas in the course and in solving the problem when getting the wrong answer?*
2 V₁ : *I reread, when I get an answer, then I matched with a friend's answer. If my answer is wrong, I will check the formula again*
3 A₁ : *I check back from the beginning by looking at the notebook*
4 K₁ : *I correct based on a book by first opening the formula then checking again whether it is different or remains the same*
5 P₂ : *Can you make similar problems to the example problems given by the lecturer?*
6 V₂ : *I can't because haven't tried it yet*
7 A₂ : *Yes, I can but still follow the example*
8 K₂ : *I can but only replace the numbers.*

At the reaction and reflection stage, the subjects examine their cognitive and provide attribution, use attribution for the time selection to learn, and determine behaviour in learning, such as knowing the best conditions to learn. For evaluating tasks, they check the accuracy of formulas used in the course or problem-solving. However, the visual subject cannot evaluate the context.

PMTs' self-regulated learning

Referring to our interpretation of PMTs' responses to the questionnaire and interview, the present study reveals that prospective mathematics teachers with different learning styles and high mathematics ability fulfil the aspect of cognition, motivation, behaviour, and context with different extent, preference, and strategies in each stage of self-regulated learning. Different extent means one PMT could not fully meet some aspects. For example, visual PMT could not create similar mathematics problem since he had not tried and auditory PMT found difficult to understand symbols. A different preference in the aspects of self-regulated learning is found, for instance, PMTs' with visual and kinesthetic learning styles prefer group discussion to learn individually. The example of a different strategy is when they decide whether or not to make notes on important content on the coursebook or write prerequisite material before learning a new concept. We identified the difference in PMTs' fulfilment of self-regulated learning, as shown in [Table 1](#).

Table 1. The difference in PMTs' fulfilment of self-regulated learning

Stage	Aspect	Learning styles		
		Visual	Auditory	Kinesthetic
Planning, forethought and activation	Cognition	N/A*	N/A	N/A
	Motivation	N/A	N/A	N/A
	Behaviour	Has a schedule to learn outside the course	Learn without schedule outside the course	Has a schedule to learn outside the course
	Context	Understand the symbol	Difficult to understand the symbol	Understand the symbol
Monitoring	Cognition	Group discussion	Learn individually	Group discussion
	Motivation	N/A	N/A	N/A
	Behaviour	Often utilize leisure time to learn; working on tasks alone	Rarely utilize leisure time to learn; working on tasks alone	Often utilize leisure time to learn; working on tasks in a group
	Context	Check the meaning of symbol; write prerequisite material; Sometimes compare the solution to an initial conjecture	Rarely check the meaning of symbol; rarely write prerequisite material; compare the solution to an initial conjecture	Check the meaning of symbol; write prerequisite material; compare the solution to an initial conjecture
Control	Cognition	Making notes; group discussion	Rarely making notes on important content; work on the task individually	Making notes; group discussion
	Motivation	Remembering targets in learning	Remembering targets in learning	Discussion and refreshing
	Behaviour	N/A	N/A	N/A
	Context	Check the procedure when solving problems	Rarely check the procedure when solving problems	Check the procedure when solving problems
Reaction and reflection	Cognition	N/A	N/A	N/A
	Motivation	N/A	N/A	N/A
	Behaviour	N/A	N/A	N/A
	Context	Have never tried to make examples of similar problems	Able to make examples of similar problems	Able to make examples of similar problems

**There is no difference*

Discussion

In the stage of planning, forethought and activation, PMTs' with different learning styles specifically plan and analyze learning needs such as preparing special equipment and sources of reference in learning mathematics. This activity helps to use their cognitive strategies and activate cognition that is relevant to prior knowledge. This is in accordance with Thorndike's readiness law which explains that planning in learning is linearly related to what learners perceive during the learning process (Slavin, 2006). They use the target learning goals that have been set as learning goal orientation and assessment of success in learning so as to motivate and

influence the selection of learning strategies to be prepared. Understanding of the tasks to be faced results in having sufficient information to be able to choose tasks that support the achievement of learning goals. This shows that the process that has an orientation towards achieving goals will actively acquire constructive knowledge and the use of goal orientation by learners will have an impact on the academic achievement of learners (Baumert et al., 1999; Mattern, 2005). In addition, to achieve a goal, it is necessary to bring up and monitor thoughts, feelings, and behaviours (Santrock, 2007). They also listed the achievement of the learning target at each stage of learning during the course. It shows that behavioural achievement in goal orientation is positively correlated with learners' efforts to manage their own time and effort (Pintrich & Garcia, 1991). The PMTs also try to define a problem with their own language based on the knowledge they gained. This is appropriate in the context of learning which has shown that the independent learning process influences motivation and academic achievement (Boekaerts & Niemivirta, 2000; Zimmerman & Schunk, 2011).

At the monitoring stage, PMTs' with different learning styles try to understand and relearn the material that has been obtained. If they have difficulty, they will find information to overcome their difficulties. In addition, they try to do the exercises and check the answers again to find out the level of understanding as a form of monitoring cognition so that they know the learning strategies when experiencing difficulties in working the problems. This is in accordance with specific learning strategies that function to record and conclude important learning materials, where a person is able to adjust themselves to their own academic learning (Zimmerman, 2002). It also shows that the PMTs' has metacognitive awareness which suits the context of learning. They monitor learning motivation so that it remains stable during the course, referring to the target of learning. This shows that self-regulation involves learners who proactively direct their behaviour or strategies to achieve their goals (Cleary & Zimmerman, 2004). Furthermore, they made notes of their version, attempt to attend the course meeting in time, and utilize leisure time to learn the material which they did understand. This shows that the application of self-regulation and metacognitive strategies will facilitate learners' thinking and improve students' skills (Vula et al., 2017).

At the control stage, PMTs' with visual and kinesthetic learning style mark important sentences or formulas in the books, whereas PMTs' with auditory learning style subject rarely do since individuals who have auditory learning styles tend to have difficulty writing something and prefer to listen or read (De Porter & Hernacki, 2000). When encountering difficulties in solving mathematical problems, they often follow group discussions and control motivation by remembering their learning goals. This shows that they have been able to understand all the needs that can support learning. The implemented strategy must be monitored and evaluated, which lead to the development and improvement of certain strategies (Schneider, 2008). They also try not to give up easily when they have difficulty doing the exercises and check the accuracy of the formulas used. This shows that self-regulation of cognition and behaviour is an important aspect of learning and the extent to which students can self-regulate their learning in influencing their academic success (Beishuizen & Steffens, 2011; Lyn et al., 2011; Zimmerman, 2008; Zimmerman & Schunk, 2011).

In the reaction and reflection stage, the PMTs' with different learning styles provide cognitive assessments of themselves in which they realize the ability to solve problems. This shows the importance of understanding their knowledge to know their abilities in problem-solving so that learners who can manage themselves are more successful in learning, problem-solving and academic achievement in general (Nota, Soresi, & Zimmerman, 2004; Sundre &

Kitsantas, 2004). They understand their own behaviour, so they are able to choose strategies that can overcome obstacles faced with regard to learning motivation such as choosing a seat in college and knowing the learning situation that can optimize learning. This shows that a person's behaviour depends on thoughts and feelings towards what happened before (Weiner, 2012; Weiner, 2000). In addition, learners who have self-regulated learning manage time consistently to a current understanding with a series of events in the learning context (Greene & Azevedo, 2010).

D. Conclusion

This study found that prospective mathematics teachers with high mathematics ability and different learning styles (visual, auditory, kinesthetic) fulfil the five aspects; cognition, motivation, behaviour, and context in each stage of self-regulated learning; (1) planning, forethought and activation, (2) monitoring, (3) control, and (4) reaction and reflection with different extent, preference, and strategies. For example, PMTs' with auditory learning style prefer to learn individually to group discussion, learn without specified schedule outside the course meeting, rarely write prerequisite material and make notes on important content, and infrequently check the procedure when solving problems. These profiles differ from PMTs' with visual and kinesthetic learning style. The difference in PMTs' self-regulated learning possibly relates to their distinct learning styles. The findings in this study provide insightful knowledge of PMTs' self-regulated learning. However, it is limited to specific criteria, i.e., high mathematics ability. Further study is required to identify PMTs' who, for example, have low mathematics ability which might affect their fulfilment of aspects and stages in self-regulated learning.

Acknowledgment

The authors would like to thank the Ministry of Research, Technology, and Higher education for funding this research. We are also grateful for the support of our colleagues in Universitas PGRI Semarang and Universitas Negeri Surabaya during the research. The errors or inconsistencies found in this article remain our own.

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Appendix 1

Subjects' responses to the questionnaire

Stage 1: Planning, forethought and activation

Aspects of self-regulated learning	Coding	Items of questionnaire	Subjects' responses		
			V	A	K
Cognition	Cog-S1	1. I find learning resources before the mathematics course begin	3	3	2
		2. I prepare learning equipment such as notebook, ruler, calculator, etc., to support learn mathematics	4	3	3
		3. I set the score to be achieved at the beginning of the course	4	4	3
		4. I write prerequisite material in a notebook or personal notes which is needed in learning	3	3	3
		5. I know what I will learn in the course	4	3	3
		6. I know the learning objectives of the course I attend	3	3	3
		Average score	3,5	3,1	2,8
Motivation	Mot-S1	1. I make the score target as motivation for learning	4	2	3
		2. I plan a celebration when learning target accomplished.	3	3	2
		3. I consider tasks are very important so that I must welly prepare to work on it	3	3	3
		4. If I find difficult when working on the tasks, then I will ask friends who understand	2	3	3
		Average score	3	2,75	2,75
Behaviour	Beh-S1	1. I learn at home using my planned schedule	3	2	3
		2. I schedule a learning minimal two hours a part of the course meeting	2	2	2
		3. I make notes about the deadline of tasks	4	3	3
		4. I make a checklist for the accomplishment of activities	3	3	3
		Average score	3	2,5	2,75
Context	Con-S1	1. I add notes about the course material related to the learnt topic in the book	2	3	3
		2. I am able to make definition with my own language	3	3	3
		3. I am able to give a simple example of a problem or concept in learning	2	2	3
		4. I am able to understand the symbols used in the course material/content	3	2	3
		Average score	2,5	2,5	3

Stage 2: Monitoring

Aspects of self-regulated learning	Coding	Items of questionnaire	Subjects' responses		
			V	A	K
Cognition	Cog-S2	1. I reread the material I learnt in the course	3	2	3
		2. I ask the friends or lectures about the material that I cannot understand	3	3	3
		3. I discuss in the group about the course material	3	2	3
		4. I do the tasks given in the course/book	3	3	3

Aspects of self-regulated learning	Coding	Items of questionnaire	Subjects' responses		
			V	A	K
		Average score	3	2,5	3
Motivation	Mot-S2	I am not happy if a friend asks me whether or not I have learnt or done a task	3	3	3
		Average score	3	3	3
Behaviour	Beh-S2	1. I make notes in my own ways	3	3	3
		2. I come to the course before 15 minutes it begins	2	2	3
		3. I can be more concentrated when I am alone	4	3	3
		4. I make a learning schedule and attempt to learn accordingly	3	3	3
		5. I utilize leisure time to learn the course material that I have not understood	3	2	3
		6. In my opinion, learning in a group is more fun because I can meet friends	2	2	3
		Average score	2,8	2,5	3
Context	Con-S2	1. I check my understanding of the symbols used in the course material	3	2	3
		2. I write prerequisite information/knowledge before learning a new concept	3	2	3
		3. I compare the solution of a working problem with my initial conjecture	2	3	3
		Average score	2,6	2,3	3

Stage 3: Control

Aspects of self-regulated learning	Coding	Items of questionnaire	Subjects' responses		
			V	A	K
Cognition	Cog-S3	1. I mark important sentences/content in the reference books	4	2	3
		2. I discuss the course tasks with friends	3	2	3
		Average score	3,5	2	3
Motivation	Mot-S3	I make a group discussion so that the learning is more fun	2	2	3
		Average score	2	2	3
Behaviour	Beh-S3	1. I feel challenged when encountering difficulties	3	3	3
		2. I ask friends about a schedule or the course material that I have not known	3	3	3
		3. I borrow friends' notes when I am absent in the course	4	3	3
		4. I join learning mentorship held by my friend	3	3	2
		Average score	3,25	3	2,75
Context	Con-S3	1. I check the accuracy of the information which I write in the notebook	4	3	3
		2. I check the correctness of procedures when solving problems	4	2	3
		3. I check the correctness or accuracy of the formula used in the course material or problem-solving	4	3	3
		Average score	4	2,6	3

Stage 4: **Reaction and reflection**

Aspects of self-regulated learning	Coding	Items of questionnaire	Subjects' responses		
			V	A	K
Cognition	Cog-S4	1. I have a decent problem-solving ability	2	2	3
		2. I am able to explain what I have learnt	3	2	3
		Average score	2,5	2	3
Motivation	Mot-S4	I learn the course material not only in the period of exams	2	3	3
		Average score	2	3	3
Behaviour	Beh-S4	1. I chose a representative seat in the class	4	3	3
		2. I imitate a high-achieved friend's method of learning	4	3	3
		3. I know the situation which makes me more optimal in learning	4	3	3
		Average score	4	3	3
Context	Con-S4	1. I examine the correctness of formula used in the course content or when solving problems with the wrong answer	3	3	3
		2. I am able to make a similar problem to the exemplary problem given by lecturer in the course	1	3	3
		Average context	2	3	3

Appendix 2

Matrix to analyze PMTs' self-regulated learning

Phases of self-regulated learning	Aspects of self-regulated learning			
	Cognition	Motivation	Behaviour	Context
Planning, forethought and activation	<ol style="list-style-type: none"> Analyze the needs of learning mathematics (sources and equipment for learning) Determine the target of learning Activate prerequisite knowledge Activate metacognitive knowledge 	<ol style="list-style-type: none"> Oriente to the learning target Examine the learning success Understand the difficulty of tasks Activate interest/attention in learning 	<ol style="list-style-type: none"> Plan time and effort for learning Plan self-observation on behaviour 	<ol style="list-style-type: none"> Understand problems with their own language Define important information as additional notes Understand the meaning of variables/symbols used in learning Make a simple example of a problem or concept
Monitoring	Use metacognitive awareness and monitor cognition	Use awareness and monitor motivation	Use awareness and monitor effort, time, and the necessity to support self-observation on behaviour	<ol style="list-style-type: none"> Monitor symbols in the concepts or tasks Monitor the use of prerequisite information on the tasks/new concepts learnt Compare the solution of a problem with initial conjectures
Control	Chose and adjust cognitive strategies for learning and thinking	Chose and adjust strategies to manage motivation	<ol style="list-style-type: none"> Increase/decrease efforts in learning Seek help 	<ol style="list-style-type: none"> Check the validity of information in the course material/content Check the correctness of procedure when solving problems Check the correctness or accuracy of formula in the course and problem-solving
Reaction and reflection	<ol style="list-style-type: none"> Do cognitive assessment Do attribution (the understanding of self-actions) 	Use attribution to chose the representative time	Be aware of behaviour selection in learning	<ol style="list-style-type: none"> Examine the accuracy or correctness of formula used in problem-solving Make similar problems to exemplary problems given in the course