Journal of Positive School Psychology http://journalppw.com
2022, Vol. 6, No. 5, 2706-2730

Systemic Thinking Processes Of Preservice Teachers With Systematic Cognitive Style In Solving Complex Problems

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Abstract

Systemic thinking is a simple technique for finding the focus of the system. Systemic thinking is also defined as looking for and seeing that everything has an orderly pattern and works as a system. The objectives of this research are 1) to find the stages of systemic thinking; and 2) analyzing the systemic thinking process of preservice mathematics teachers who have a systematic cognitive style. This research uses qualitative research method. The main instrument of this research is the researcher with using additional instruments such as complex problems, interview guidelines, and cognitive style questionnaires. The subjects of this research are 155 mathematics education students or preservice teachers then 7 preservice teachers who have a systematic cognitive style were chosen as the subjects. The result of this research includes 2 things. First, the stage of systemic thinking consists of 5 stages, namely the identifying stage, the investigation & classifying stage, the clarifying stage evaluating and justify-ing stage, and the reflecting stage. Second, the thinking process of preservice mathematics teachers who have s systematic cognitive style includes 5 stages. At the identifying stage, the preservice mathematics teachers identify information, processes and variables in a garment factory; and understand the objectives to be achieved from solving mathematical problems. At the investigation & classifying stage, the preservice mathematics teachers identify the key information, determine the production capacity of all lines; and determine the total order of t-shirts and jeans from 5 buyers. At the clarifying stage, the preservice mathematics teachers explain the system at the garment factory, and determine the sewing time provided by each buyer. At the evaluating & justifying stage, the preservice mathematics teachers can make various sewing schedules for each buyer, deter-mine the sewing schedule for 5 buyers where the time required to make the orders does not exceed 30 days, and determine the remaining production time so that it can be ensured that nothing is by R. At the reflecting stage, the preservice mathematics teachers review the sewing schedule that has been decided and revise the sewing schedule if there are mistakes. The findings in this research are the stages of systemic thinking and subjects with systematic cognitive style have detailed characteristics by paying attention to every aspect related to the problem as a whole and then breaking down into more specific matters in solving mathematical problems; and subjects with systematic cognitive style are able to produce many detailed and systematic solution options.

Keywords— Systemic thinking, systemic thinking stage, cognitive style, mathematics problem, systematic cognitive style, complex problem

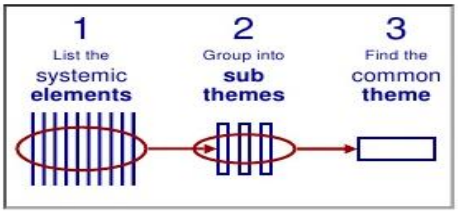
Introduction

In everyday life, we are often faced with non-routine or complex problems. Complex problems are problems that involve many variables in the system and the relationships that occur in these variables (Funke, 2012). Because it involves many variables in a system, there are infinitely possible solutions and strategies to solve for the system itself. To be able to solve non-routine problems or complex problems, systemic thinking skills are needed (Johnny, et al., 2016). Epistemologically, systemic thinking is a combination of analytical thinking and synthetic thinking (Bartlett, 2001; Amer, 2005). Analytical thinking is the base of critical thinking and synthetic thinking is the base of creative thinking. Critical thinking and creative thinking are Higher Order Thinking Skills (HOTS). It is in accordance with the argument from Wang & Wang (2011); King, et al. (1999), and Miri, et al. (2007) stating that HOTS include critical thinking, design thinking, system thinking, logical thinking, reflective thinking, metacognitive, and systemic thinking.

Systemic thinking has an important role in life and is very much needed to solve problems faced in the field of business and economics (Atwater & Pittman, 2006; Atwaterm et al., 2008), psychology (Stanton & Welsh,2012; Campbell, et al. 1992), leadership, mathematics (Zachariades, et al., 2012) and so on. Systemic thinking also plays a role in solving complex problems (Johnny, et al., 2016; Maani, K.E. & Maharaj, V., 2001). In order to study the systemic thinking, two theoretical perspectives can be used, namely through system thinking theory and analytical-synthetic thinking theory (Bartlet, 2001; Amer, 2005). System thinking is thinking about how things interact with others (Bartlett, 2001) and according to Prahasta (2018), it is a process of understanding how a (sub) system affects each other within a larger entity. System thinking is a way of thinking and language used to describe and understand the forces and their relationships which form the behavior of a system. While systemic thinking is a simple technique to find the focus of the system or gain systemic insight in complex situations and problems (Bartlett, 2001; Amer, 2005). The basic idea in systemic thinking is to list as many different elements as possible and then look for similarities. This can be described as follows.

Figure 1. Systemic Thinking Concept

The concept of systemic thinking has its element and abstract origins from the following thinking techniques: 1) Creative Thinking and Lateral Thinking; 2) The Theory of Constraints (TOC); 3) The Theory of Inventive Problem Solving (TRIZ); 4) System Thinking (ST); and 5) Neuro-Linguistic Programming (NLP). The



(Amer, 2005; Bartlett, 2001)

systemic thinking process consists of 3 steps, namely 1) listing as many system elements as possible to ensure that the theme is accurate; 2) classifying similar elements and describing what each group has in common; and 3) finding common themes (running through) from the group description. The systemic thinking process can be described in the following figure.

Figure 2. Systemic Thinking Process (Amer, 2005; Bartlett, 2001)

The systemic thinking process can be broadly categorized into 2 main stages, namely 1) the stage of dividing a situation into elements and 2) the stage of classifying and finding the genera theme that can describe these groups of elements. The first stage in dividing a situation or system into sub-elements or sub-systems is the definition of analytical thinking, such as examining and breaking down information into parts by identifying motives or causes, making conclusions and finding evidence to support generalizations. According to Anderson & Krathwohl (2015), the level of analytical thinking includes the cognitive processes of differentiating, organizing, and attributing. The second stage is classifying and finding general theme that can describe these group of elements using synthetic thinking. Synthesis (creating) is the ability to combine pieces of information so as to form a new design. Based on the Revised Bloom's Taxonomy, the level of synthetic thinking is accommodated in the create level which includes cognitive processes of generating, planning and producing. This process can be described as follows.

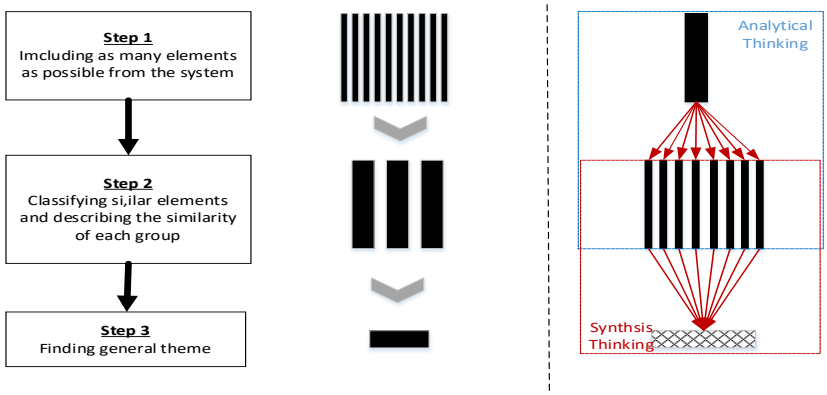


Figure 3. Systemic Thinking Stages

Based on the description, it shows that the systemic thinking process has a high level of problem solving because systemic thinking is a combination of analytical and synthetic thinking and systemic thinking is needed when solving complex problems or non-routine problems. The preservice mathematics teachers are teachers who will later become prospective mentors and student facilitators in the process of learning mathematics. In the 21st century era, educational targets and achievements are increasing and developing compared to the previous era, so that the preservice teachers who have superior competencies are needed to prepare quality students. The ability of preservice teachers in HOTS is an obligation that must be mastered and through systemic thinking skills, it indirectly develops and trains the ability to perform analysis and synthesis. Besides being a role in HOTS, the ability to think synthetically affects the spatial ability of a study by Bochkareva (2014) which examined on how to develop analysis and synthesis in the process of solving opportunity problems; a study by Kalmykova (1954) which examined the process of analysis and synthesis in solving arithmetic problems; a study by Kazachek & Epova (2014) which examined the analytical and synthetic activities when studying algebra; and a study by Koldunova (2015) which examined on how to structure analytical and synthesis problems in teaching algorithm theory. Furthermore, Stenberg, et al., (2011) states that analytical and synthetic thinking are two prerequisites for creative thinking where it requires analytical thinking, synthetic thinking, and practical thinking.

The topic of systemic thinking skills is something that has the urgency to be studied and is the focus of this research. One of the interesting parts to study is the stage of systemic thinking. By identifying the stages of systemic thinking, we can find out the difficulties and obstacles faced

by students when they face non-routine problems or complex problems. The underlying theory in order to find the stages of systemic thinking includes the research of Bartlett (2001), Johnny, et al. (2016), Zachariades, et al. (2012), Jacob (2014), Ponte (2007) and Prahasta (2018).

This research is motivated by students who are accustomed to solving non-routine problems so that when faced with non-routine problems, many students have difficulty in finding solutions. In addition, students are also rarely faced with complex problems while in the real life, we will be faced with complex problems and that we are required to be able to find or solve them. Therefore, educational institutions need to improve their capabilities in growing and developing HOTS and one of them is systemic thinking.

The mathematics problems given are non-routine or complex problems related to the application of mathematics in which problem solving is governed by cognitive, metacognitive, and affective processes (Mwei, 2017). The aspects that will be reviewed in this research are 1) the stages of systemic thinking; and 2) systemic thinking process observed from the perspective of students' cognitive style. Cognitive style is an aspect of the whole personality and cognitive processes. According to Martin (1998), cognitive styles are categorized into 5 types namely systematic style, intuitive style, integrated style, undifferentiated style and split style. The cognitive style that is the focus of this research is the systematic style which is related to logic, a rational attitude that is used step by step, a sequential approach to thinking, learning, problem solving and making decisions. Systematic cognitive style has a tendency to have a systematic scale that is high and low on an intuitive scale so that someone with a systematic cognitive style is characterized by a sequential, comprehensive, concrete, structured, and divided problem-solving approach in a small scope. Someone with the criteria of Systematic Style (SyS) cognitive style will solve problems in detail and in order.

This research analyzes 1) the stages of systemic thinking and 2) the systemic thinking process of preservice mathematics teachers who have a systematic cognitive style. The results obtained are 1) the discovery of the stages of systemic thinking and 2) the discovery of the characteristics of systematic thinking process of preservice mathematics teachers who have a systematic cognitive style in solving mathematical problems.

Method

Research Design

The research used a qualitative research design namely by finding the stages of systemic thinking and describing the systemic thinking process of preservice teachers in solving mathematical problems. Students' systemic thinking is shown from the students' construction process in solving a given problem. The aims of This research are to 1) find the stages of systemic thinking; and 2) examine and describe the systemic thinking process of preservice mathematics teachers in solving complex problems based on the cognitive style in the Systematic Style (SyS).

Sample and Data Collection

The subjects of this research were mathematics education students/ preservice mathematics teachers from Universitas Kristen Satya Wacana (UKSW). The subjects in this research consists of 155 students who were given a cognitive style questionnaire consisting of a systematic style (SyS), intuitive style (IS), integrated style (InS), undifferentiated style (US), and split style (SpS). The results of the analysis of filling out the cognitive style questionnaire can be seen in Table 1 below.

Table 1. Preservice Mathematics Teachers' Category of Cognitive Style

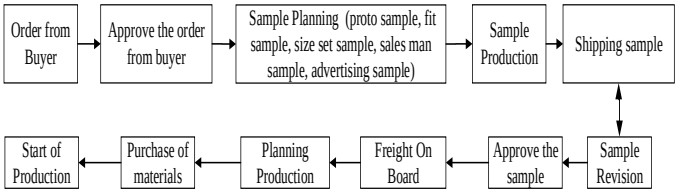
Cognitive Style	Frequency
Systematic Style (SyS)	7
Intuitive Style (IS)	1

Integrated Style (InS)	2
Undifferentiated Style (US)	15
Split Style (SpS)	130
Total	**155**

Based on Table 1, 7 selected research subjects that fall into the systematic style (SyS) category are the preservice mathematics teachers who have a systematic cognitive style. In the next stage, the researcher gave a mathematical problem related to the topic of scheduling in a garment factory. The characteristics of the mathematical problem used in this research is a complex problem because it contains a system that exists in the garment factory and there are relationships between variables, elements, and processes that are in the production stages at the garment factory. In addition, the mathematical problem in this research can also be categorized as a non-routine problem because it has many solving strategies and answers, meaning that the subject can design sewing scheduling in various ways and with various answers. The subjects in this research are the preservice mathematics teachers who have a systematic cognitive style and have good communication skills with the completeness and correctness of their work. This research uses the research instruments consisting of a cognitive style questionnaire, interview guidelines and mathematical problems. Validation of research instruments is carried out by expert judgment/validators in terms of content, language, and point accuracy in the instruments. Validation of mathematical problem instruments is directed at the suitability of the problem with the research objectives, such as discovering the stages of systemic thinking, problem construction, language, and content. The mathematical problem given in this study is:

In a garment factory, there is a process of t-shirts and jeans production scheduling with the following stages.

Stage 1: Pre-Production (development)



Stage 2**:** Production and delivery

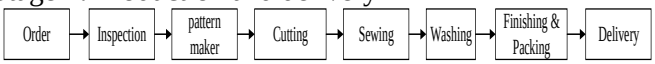


Figure 4. Stages in Garment Factory

To be safe, the production process (sewing section) on average takes about 30 - 35 days, while for the cutting section (including inspection, pattern, and cutting stage), washing, finishing & packing in general takes the average 7 days. The sewing section consists of lines where each line has a number of sewing machine operators as in Image 6. This factory has 10 lines which different number of operators each as in Table 2.

Table 2. The Number and Total of Operators of 10 Lines in Garment Factory

Line	1	2	3	4	5	6	7	8	9	10
Operator	20	40	30	20	40	30	30	40	20	40

In this factory, 1 line with 40 operators can produce 1200 t-shirts per day or 300 jeans per day. In a certain period, this garment factory receives order from 5 buyers as in Table 3.

Table 3. The Order from 5 Buyers

Buyer	Total of T-shirt Order	Total of Jeans Order	Development Period	Delivery Duration	Deadline
A	30000		50 days	2 days	90 days
B	25000	5000	50 days	2 days	100 days
C	50000		50 days	7 days	120 days
D		15000	60 days	7 days	120 days
E		15000	60 days	5 days	120 days

If the factory fails to deliver the goods on time, the factory must pay the loss (by R) to the buyer. Make sewing schedule for this factory!

Analyzing of Data

This research uses qualitative analysis by triangulating data from the results of the questionnaire, the work of the research subjects and the interviews with the research subjects. The data analysis was carried out based on the guidelines in qualitative research such as data collection, data reduction, coding, and data presentation. The results of the analysis had been through the process of data reduction, data triangulation in order to obtain the results of the analysis in accordance with the research objectives. The data analyzed in this study include the results of interviews and the results of the work of preservice mathematics teachers.

Result

The first aim of this research is to examine the systemic thinking stage based on system thinking stage (Prahasta, 2018), and systemic thinking stage (Bartlett, 2001 & Johnny, et.al, 2016). If associated with the origin of the word, systemic thinking is related to system thinking where systemic thinking is a simple technique to find focus system. System thinking is also defined as way of thinking and the language used to describe and understand the style/strength and their relations which form a system behavior (Prahasta, 2018). Furthermore, Prahasta (2018), states that the stages of system thinking include identifying, determining variables and observing their variations; determining its causal relations; looking for causal links; creating closed causal links; and define the system and its internal and external boundaries.

Related to the theory from Mason, et al. (2010), systemic thinking is related to mathematical thinking. Mathematical thinking includes 2 stages specializing and generalizing. Specializing process precedes the generalizing process which starts to be formed in the systemic thinking domain. Generalizing in systemic thinking domain includes clarifying and justifying (Johnny, et al., 2016). The linkages and developments of systemic thinking stages according to Bartlett (2001), Johnny, et al. (2016), and system thinking according to Prahasta (2018) can be seen in Table 4

Table 4. Stages of Systemic Thinking

System Thinking Stage from Prahasta (2018)	Systemic Thinking Stage from Bartlett (2001)	Systemic Thinking Stage from Johnny (2016)	Systemic Thinking Stage in this Study
Identifying and determining variables and observe the variations	Listing as many system elements as possible to ensure that the themes are as accurate as possible	Specializing	Identifying

Determining the causal relations			Classifying and Investigation
Looking for the causal chain/moving as a whole	Classifying similar elements and describing what each group has in common	Clarifying	
Creating a closed causal chain (the relevant loop)			Clarifying
Defining the system and its internal and external boundaries	Determining the general theme of the group description	Justifying	Evaluating & Justifying
			Reflecting

Based on Table 4, in the stage of including as many system elements as possible to ensure that the theme is as accurate as possible, it is necessary to identify information, variables, processes which occur in system elements so that, in this study, the first stage in systemic thinking is the identifying stage. Then, the next stage is to classify the same elements and describe the similarities that each group has where in Johnny (2016), this activity is called clarifying. The purpose of this elements classification is to find the cause-and-effect relationship which exists in the system elements. Investigation is conducted in order to find the relationship between system elements. During this process, one of the efforts is to classify the same elements and this activity is called classifying. Therefore, in this study, the second stage in systemic thinking is classifying and investigation stage. The next stage is to create and explain the linkage between the system elements which in this study is understood as clarifying activity. The final stage is to determine general theme in the group description and in system theory. The last step is to define the system and its internal as well as external boundaries. In the process of determining the theme, justifying activity is needed (Johnny, 2016). On the other hand, in this fourth stage, the thinking stage used is the stage of synthesis thinking so that according to the Revised Bloom's Taxonomy, between the analysis level and the create (synthesis) level, there is evaluating level. Therefore, the fourth stage in systemic thinking is the evaluating and justifying thinking stage. The last stage of systemic thinking is the reflecting stage. Reflecting thinking stage is needed in systemic thinking and this is in accordance with the research from Zachariades, et al. (2012). Reflecting thinking plays a role in minimizing an individual's weakness when he has difficulty to find solution and draw a problem solution (Agustan & Siswono, 2017; Kholid, M., et.al., 2020).

Based on the breakdown theory of thinking stages from Prahasta (2018), systemic thinking stages from Bartlett (2001) and Johnny (2016), then systemic thinking stages can be categorized into 5 stages namely the identifying stage, investigation and classifying stage, clarifying stage, evaluating and justifying stage, and reflecting stage in this study. The first stage of systemic thinking in this study is the identifying stage where the activities include identifying, understanding, and including information, variables, elements, and processes as much as possible which occur in system elements, initial condition and final condition. The next step is to investigate the cause-and-effect relationship in the system elements and proceed by classifying them in groups. According to the study of Johnny et al. (2016), Jacob (2014), and Bartlett (2001), a person will investigate the way and cause-and-effect relationship in the variables and system elements. In order to identify this process, it requires the ability to investigate the relationships in the variables and system elements as well as the ability classify information, variables, and elements into groups having similar characteristics.

Therefore, the second stage of systemic thinking is investigation and classifying stage. The third stage is clarifying. In this stage, clarification is performed after identifying the working system from the system elements and variables. The relationship between system elements is explained to form a system model design which applies as a whole in this clarification. When the system model design is formed, various possibilities for alternative solutions to the system are designed in order to determine the completion of the system. In this stage, the research subjects made various alternative solutions in the system and continued by evaluating and selecting the alternative problem solving that was considered the most optimal. Therefore, the fourth stage in this research is the stage of evaluating and justifying. The last stage is the reflecting stage. In this stage, the research subjects reflected on the solution that had been decided, reanalyzed the solution applied in the mathematical problem and improved the solution that had been made.

The mathematical problems given in this study is a problem related to garment factory system. There are 5 systemic thinking stages included in this study namely the identifying, investigation & classifying, clarifying, evaluating and justifying stage, and reflecting stage. The indicators of systemic thinking stages can be seen in Table 5 below.

Table 5. Systemic Thinking Stage Indicator

No	Stage	Indicator
1	Identifying	1. The subject identifies information, variables, processes that occur, initial conditions (prerequisites) and final conditions that exist in mathematical problems; 2. The subject records information, variables, processes that occur, initial conditions (prerequisites) and final conditions in mathematical problems; 3. The subject understands the information, variables, processes that occur, initial conditions (prerequisites) and final conditions that exist in the overall mathematical problems; 4. The subject has an overall picture of the existing system in the mathematical problems; 5. The subject understands the goals to be achieved in math problems.
2	Investigation & Classifying	1. The subject relates the information contained in the mathematical problems with the prior knowledge that is mastered; 2. The subject groups and categorizes variables, information, processes, initial conditions (prerequisites) and final conditions in mathematical problems based on character and similarity of properties; 3. The subject identifies the performance of all parts of the system; 4. The subjects analyze the causal relationship of variables, information, processes, initial conditions (prerequisites) and final conditions that have mathematical problems.
3	Clarifying	1. The subject presents the relationship between variables, information, processes, initial conditions (prerequisites) and final conditions in mathematical problems; 2. The subject explains the causal relationship between variables, information, processes, initial conditions (prerequisites) and final conditions in mathematical problems; 3. The subject describes the performance of each part of the overall system and the core problems in mathematical problems; 4. The subject plans various possible solutions to mathematical problems; 5. The subject creates a system model design.

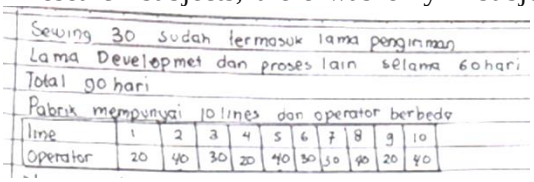
4	Evaluating & Justifying	1. The subject makes various alternative solutions in mathematical problems; 2. The subject predicts the impact of each planned alternative solution in mathematical problems; 3. The subject predicts the possibilities that will occur if the problem-solving plan is implemented in the system; 4. The subject evaluates the various alternative solutions to mathematical problems by analysing the various possibilities and impacts; 5. The subject decides on solving mathematical problems that will be applied in the system based on the analysis of various alternative solutions.
5	Reflecting	1. The subject decides on the solution to the problem that is considered the most optimal; 2. The subject reflects on the solution that has been decided and it is a solution that meets various criteria in mathematical problems; 3. The subject re-analyse the solutions applied to mathematical problems; 4. The subject fixes the settlement if it is considered that the solution decided is not in line with expectations/targets.

The results of research on systematic cognitive style are divided based on five stages such as identifying, investigation and classifying, clarifying, evaluating and justifying, and reflecting. The following is a description of each process in the systemic thinking process in the Systematic cognitive Style (SyS). Based on the results of the initial research, it was obtained that subjects with systematic cognitive style had the characteristics like using a step-by-step approach when solving problems; well-defined; looking for an overall method or program approach; and the create an overall plan to solve the problem. Subjects with systematic cognitive style are convergent thinkers; concrete; highly structured; logical; rational; ordered; and linear. According to the filling out to the cognitive style questionnaire on 155 research subjects, it was obtained 7 preservice teachers who have a systematic cognitive style. In this research, the research subjects are denoted by S1, S2, S3, S4, S5, S6, and S7. The following are description of the results from research subjects.

Identifying Stage

In the identifying stage, several attitudes and answers shown by research subjects were that the subjects repeatedly read the given mathematical problem while some subjects marked the information found in the mathematical problem. The subjects tried to understand the given mathematical problem as a whole and found new key information to determine the solution strategy. Research subjects could explain the system, variables, stages, and important processes that exist in the garment factory. The stages in the garment factory consist of 2 stages such as the pre-production stage (development) and the production & delivery stage. In the development stage, there are sub-stages starting from orders from buyers to factories to purchasing raw materials. After the development stage is complete, it is continued by production and delivery stage. Just like the development stage, in this production and delivery stage, there are sub-stages such as ordering raw materials, inspection, pattern making, material cutting, sewing, washing, finishing & packing, and shipping. The inspection, patterning, and cutting sections are combined into one that is called the cutting section. The steps taken by the subjects are 1) understanding the stages in the garment factory which include the pre-production stage as well as the production & delivery stage; 2) identifying that the time at the stage of inspection, pattern making and cutting takes 7 days; and the time for finishing & packing takes 7 days; 3) the time required for the production process is 30-35 days; 4) there are 10 lines with a total of 310 operators; 5) there are 5 buyers who ordered t-shirts and/or jeans with a certain quantity and a deadline set by the buyer; 6) the development period for buyer A, B and C is 50 days and buyer D and E is 60 days; and 7) the line that has 40 operators can produce 300

jeans/day or 1200 t-shirts/day. The 7 research subjects identified, and explained the system in the garment factory completely, and out of the 7 research subjects, there was only 1 subject who wrote down the information obtained from the given mathematical problem, namely S2 where the result of its work is as follows.


Sewing 30 sudah termasuk lama pengiriman
Lama Developmet dan proses lain selama 60 hari
Total 90 hari
Pabrik mempunyai 10 lines dan operator berbeda

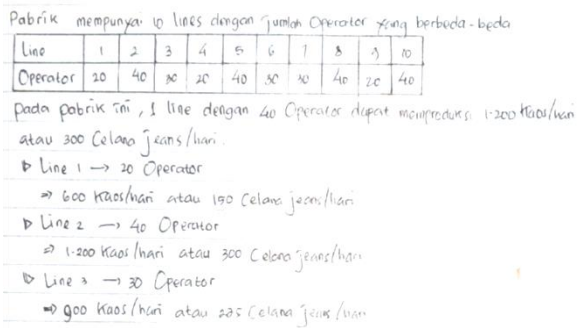
line	1	2	3	4	5	6	7	8	9	10
Operator	20	40	30	20	40	30	30	40	20	40

Figure 5. S2's Work in The Identfying Stage

Some of the interview and work results from the research subjects can be concluded that at this identifying stage: 1) the subject understands the objectives to be achieved such as making production schedule for 5 buyers; 2) the subject understands that the schedule to be made must not exceed the specified sewing deadline so as not to be exposed to the risk of compensation (by R). There are 3 understandings of the sewing deadline for example the sewing time allocation is determined from search for the remaining sewing time from the deadline minus the total time for the stages in the garment factory; sewing time allocation does not exceed 30 – 35 days for each buyer; and sewing time allocation should not exceed 30 -35 days for all orders. Third, all subjects understand the key information on mathematical problems such as the time required for each stage, production capacity, and the number of orders in the garment factory.

Investigation & Classifying Stage

The investigation and classifying stages are the process of the subject conducting an in-depth search of the initial identification results. The initial steps taken by the subject were 1) categorizing 10 lines into 3 categories based on the number of operators for example the line group with 20 operators, 30 operators and 40 operators (S1 and S2) and continued by determining the production capacity of each line group; 2) determining the production capacity for each operator and each line (S3, S4, S5, S6, S7); 3) determining the total production capacity of t-shirts or jeans every day; 4) determining the total number of operators; 5) determining the sewing time allocation by investigating the relationship between time limit, development time, delivery time, cutting time, washing time, and finishing & packing time; 6) determining the key information that the total sewing time to complete all orders of 5 buyers is 30-35 days so that it is not by R and 7) determining the number of orders for t-shirts and/or jeans from 5 buyers. An example of a research subject's work in grouping lines into 3 categories is as follows.


Pabrik mempunyai 10 lines dengan jumlah Operator yang berbeda - beda

Line	1	2	3	4	5	6	7	8	9	10
Operator	20	40	30	20	40	30	30	40	20	40

Pada pabrik ini, 1 line dengan 40 Operator dapat memproduksi 1.200 kaos/hari atau 300 Celana Jeans/hari.
- Line 1 → 20 Operator
  - ⇒ 600 kaos/hari atau 150 Celana jeans/hari
- Line 2 → 40 Operator
  - ⇒ 1.200 kaos/hari atau 300 Celana jeans/hari
- Line 3 → 30 Operator
  - ⇒ 900 kaos/hari atau 225 Celana jeans/hari

Figure 6. S1's Work in The Investigation and Classifying Stage

An example of a research subject's work that determines the production capacity for each operator and each line can be seen in Figure 7 below.

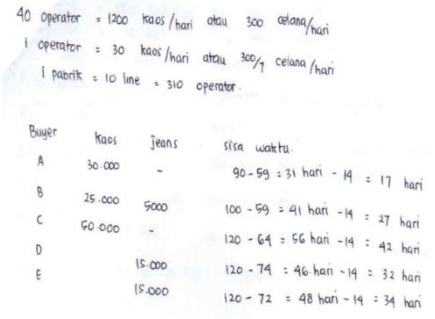


Figure 7. S3's Work in The Investigation and Classifying Stage

Furthermore, determining the number of operators in total is 310 operators with a total production capacity of 9300 t-shirts per day or 2325 jeans per day. The example is in the following.

Figure 8. S5's Work in The Investigation and Classifying Stage

In Figure 8, S5 made an error in calculating the total production capacity of jeans per day where S5 wrote down 2100 jeans/day and it should be 2325 jeans/day. Then the researcher went deep into the process of completion from subject S5 with an interview so that the following description was obtained.

Table 6. Subject S5's Interview Description

P	:	What are you doing in order to solve this problem?
S5	:	Here's the thing mam, the number of t-shirts order can later be produced by several operators, then the division is based on the number of operators in each line. It's known that 40 operators can produce up to 1200 t-shirts per day. Therefore, 1 operator can produce 30 t-shirts in a day. As for jeans, 40 operators can produce up to 300 jeans per day so that 1 operator can produce 7,5 jeans per day. In that factory, there are 10 lines with 310 operators … so the average of per day, the factory can produce 9300 t-shirts or 2325 jeans.

After determining the production capacity of each operator as well as the total production capacity of the whole, the research subjects relate the information obtained to determine the relationship that exists in the garment factory system. The research subjects tried to understand the relationship between the existing processes in the pre-production stage with the production & delivery stage, the relationship between the information obtained such as 10 lines with 310 operators owned by the factory, production capacity of 9300 t-shirts per day or 2325 jeans, operator capacity in producing 30 t-shirts/day or 7.5 jeans/day, 5 buyer orders,

deadline, risk of compensation, and the time of the sub-stages in the production & delivery stage.

Clarifying Stage

At this stage, the research subject explains the stages in the garment factory from the development stage to the production and delivery stage. Furthermore, the research subjects determine and state the relationships that exist in the information obtained from the problems and processes that exist in the garment factory. Then, the research subjects explain the relationship between deadline, development time, delivery time, cutting time, sewing time, washing time, finishing & packing time. The research subjects understand that the deadline is the time given by the buyer to the factory from the time the buyer order the product until the product is received by the buyer. Since the process in a garment factory includes two stages, the relationship between the deadline, the time of the first stage (development), and the time of the second stage, such as the deadline is the time of the first stage plus the time of the second stage.

The time of the first stage is called the development period and it's already known in the given problem. The second stage includes cutting time, sewing time, washing time, finishing & packing time, and delivery time. S5 initially had a mistake in determining the cutting time, sewing time, washing time, finishing & packing time where the subject understood that these three processes took 7 days. In addition, several research subjects (S1, S2, S3, S4) initially misunderstood that the cutting time (inspection, pattern maker, and cutting) takes 7 days. According to their initial understanding, cutting time takes 21 days from the inspection, pattern making, to cutting that each takes 7 days to complete. However, there are also research subjects who correctly understand the information that the cutting section (inspection, pattern making, and cutting), washing section and finishing & packing section each takes 7 days so that the total time required for these three sections is 21 days. After repeatedly understanding the mathematical problems given, finally the research subjects understood that the cutting time, sewing time, washing time, finishing & packing time each takes 7 days so these three parts takes 21 days to complete. In determining the allocation of sewing time, it needs the consideration of the 21 days which is devoted to the cutting, washing, and finishing & packing processes. The length of delivery time has been known from the problem. The time relationship between parts in the second stage is as follows.

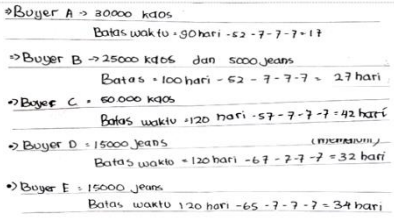


Figure 9. S6's Work in The Clarifying Stage

Sewing time = deadline – development time – delivery – 21 days

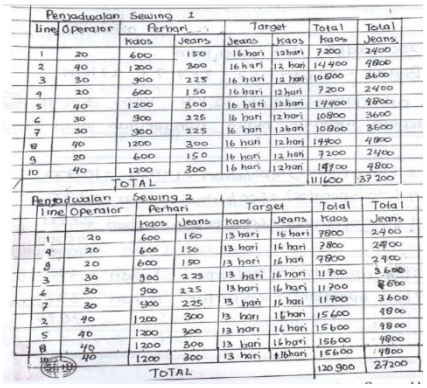
The research subjects can determine the sewing time allocation from each buyer for example, buyer A gives 17 days of sewing time, Buyer B gives 27 days of sewing time, Buyer C gives 42 days of sewing time, Buyer D gives 32 days of sewing time and Buyer E gives 34 days of sewing time.

A total of 21 days is the time for cutting (inspection, pattern making, cutting) that takes 7 days to complete as well as 7 days of washing and 7 days of finishing & packing time. Therefore, the sewing time for buyer A is 17 days, buyer B is 27 days, Buyer C is 42 days, buyer D is 32 days and Buyer E is 34 days. Furthermore, several research subjects (S3, S4, S5, S6, S7) decided to determine the order of processing orders based on the sewing time

allocation starting with the buyer with the least sewing time allocation. There are subjects who put it according to the goods ordering (A-B-C-D-E) and there are subjects who arrange it based on the least sewing time to the most sewing time available (A-B-D-E-C).

Evaluating & Justifying Stage

At this stage, the research subjects make various sewing schedules with various solution strategies. Generally, the solution strategies used b research subjects include 1) making tables; 2) determining the total number of operators needed then determining the line number used to produce the orders; 3) maximizing the allocation of sewing time and comparing it to the production capacity of each line before determining the line number used; and 4) deciding to use the entire line to complete each buyer's order (line blocking system). The work of research subject (S2) who made the target table first such as for the 1st version of schedule, S2 decided to use 16 days to produce jeans and 12 days to produce t-shirts while for the 2nd version of schedule, S2 decided to use 16 days to produce jeans and 13 days to produce t-shirts. The total time needed to produce jeans and t-shirts for both 1st version schedule (16 + 12 = 28 days) or the 2nd version schedule (16 + 13 = 29 days) do not exceed 30-35 days so that S2 understood that all orders will be made on time and nothing is by R. The results of S2's work are as follows.



Penjadwalan Sewing 1

line	Operator	Perhari		Target		Total	Total
		Kaos	Jeans	Jeans	Kaos	Kaos	Jeans
1	20	600	150	16 hari	12hari	7200	2400
2	40	1200	300	16 hari	12 hari	14400	4800
3	30	900	225	16 hari	12 hari	10800	3600
4	20	600	150	16 hari	12hari	7200	2400
5	40	1200	300	16 hari	12hari	14400	4800
6	30	900	225	16 hari	12hari	10800	3600
7	30	900	225	16 hari	12hari	10800	3600
8	40	1200	300	16 hari	12 hari	14400	4800
9	20	600	150	16 hari	12 hari	7200	2400
10	40	1200	300	16 hari	12hari	14400	4800
TOTAL						111600	37200

Penjadwalan Sewing 2

line	Operator	Perhari		Target		Total	Total
		Kaos	Jeans	Kaos	Jeans	Kaos	Jeans
1	20	600	150	13 hari	16 hari	7800	2400
9	20	600	150	13 hari	16 hari	7800	2400
8	20	600	150	13 hari	16 hari	7800	2400
3	30	900	225	13 hari	16 hari	11700	3600
4	30	900	225	13 hari	16 hari	11700	3600
7	30	900	225	13 hari	16 hari	11700	3600
2	40	1200	300	13 hari	16 hari	15600	4800
5	40	1200	300	13 hari	16 hari	15600	4800
8	40	1200	300	13 hari	16 hari	15600	4800
10	40	1200	300	13 hari	16hari	15600	4800
TOTAL						120900	27200

Figure 10. S2's Work in The Evaluating& Justifying Stage

After making the target table, S2 made a sewing schedule for each buyer. In the 1st version schedule, Buyer A's order was completed within 12 days because the order was in the form of 30,000 t-shirts made from using line number 1, 2, and 3. Buyer B's order was in the form of 25,000 t-shirts and 5,000 jeans completed in 27 days with 12 days used to produce t-shirts using line number 6, 4, and 9 and 15 days used to produce jeans using line number 5 and 7. Buyer C's order was in the form of 50,000 t-shirts completed in 12 days using line number 2, 8, 9 and 10. Buyer D's order was in the form of 15,000 jeans completed in 16 days using line number 1, 3, 4, 5, and 7. Buyer E's order was in the form of 15,000 jeans completed in 16 days using line number 6, 7, 9 and 10. In making the 1st version of the sewing schedule, S2 only focused on achieving the set target time, which was 12 days for t-shirts and 16 days for jeans without paying attention to the arrangement of workmanship and the condition of the line, not paying attention to the distribution of line utilization in completing the orders. In the 2nd schedule version, S2 used another strategy where Buyer A's order was completed within 17 days using line number 3 and 6. Buyer B's order in the form of 25,000 t-shirts and 5,000 jeans completed in 27 days with 17 days used to produce t-shirts using line number 4 and 7 and 10 days used to produce jeans using line number 1, 5, and 9. Buyer C's order was in the form of 50,000 t-shirts completed in 17 days using line number 2, 8, and 10. Buyer D's order was 15,000 jeans completed in 15-18 days using line number 1, 3, 4, 6, and 7. Buyer E's order was in the form of 15,000 jeans completed in 10-20 days using line number 2, 5, 8, and 10.

The second strategy is to determine the total operator needed and determine the line number used to produce the orders. Based on the result of calculation from the research subjects, to be able to complete Buyer A's order, 1000 operators are needed with 4 days of processing and 250 operators are needed; Buyer B's order requires 1515 operators with 5 working days using all operators (310 operators); Buyer C's order requires 1680 operators with 6 days of processing and 280 operators are needed; and Buyer E's order requires 2000 operators with 8 days of processing and 250 operators are needed. The subjects who used this strategy are S3, S4, and S5. An example of the Subject's work using this strategy is S3's work.

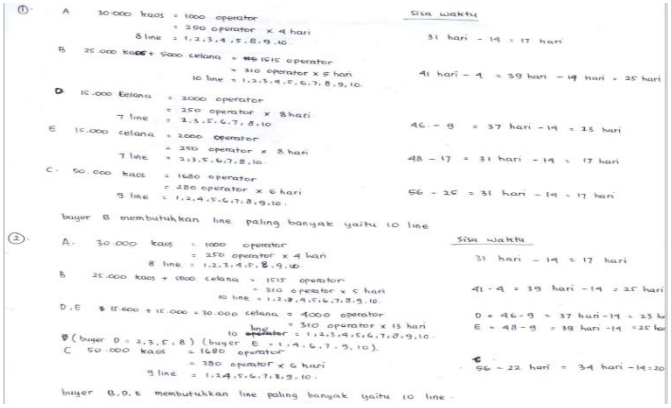


Figure 11. S3's Work in The Evaluating & Justifying Stage

Based on Figure 11. It can be seen that in the 1st version of the schedule, Buyer A's order was produced in line number 1, 2, 3, 4, 5, 8, 9, and 10; Buyer B's order was produced in all line number; Buyer C's order was produced in line number 1, 2, 4, 5, 6, 7, 8, 9, and 10; Buyer D's order was produced in line number 2, 3, 5, 6, 7, 8, and 10; Buyer E's order was produced in line number 2, 3, 5, 6, 7, 8, and 10. It is almost similar to the 1st version of the schedule, S3 decided to reverse the line numbers. The difference with the 1st schedule version is that in the 2nd version, S3 tried to combine the orders from Buyer D and E simultaneously. In this case, S3 did not consider the jeans model ordered by Buyer D and E where S3 assumed that the jeans were in the same model. S3 did not consider if the jeans ordered by Buyer D were different from Buyer E. As for the 2nd version schedule, Buyer A's order was produced in line number 1, 2, 3, 4, 5, 8, 9, and 10; Buyer B's order was produced in all line numbers; Buyer C's order was produced in line number 1, 2, 4, 5, 6, 7, 8, 9, and 10; Buyer D and E's orders were produced in all lines for each buyer. Other than determining the number of operators and line numbers needed to work on each buyer's order, S3 also determined the remaining time for each buyer. If there was time remaining, it was sure that the order is made on time or in less time than the sewing time allocated. Because the sewing time allocated from Buyer C was the longest, S3 decided to complete the order in the arrangement of A – B – D – E – C. S3 had taken into account the time allocation needed to work on orders from Buyer A and B then continued with the orders from D and E and finally C. In addition, S3 had also considered the arrangement of the work and the impacts arising from the selection of the lines and the allocation of the processing time. The impact of choosing this scheduling plan will affect the scheduling of each buyer's order.

The difference between schedule version 1 and version 2 lies in the arrangement of production scheduling from Buyer D and E where the time needed to work on the orders on the 1st version schedule is 16 days while on the 2nd version schedule, the orders are made simultaneously by allocating 4 lines with large capacity to produce order from Buyer D and 6 lines with medium and small capacity to produce the order from Buyer E. These

differences affect the remaining days from the deadline given by Buyer C. Buyer C's order is done in the last arrangement, considering that the sewing time allocation for order C is very long. To work on order from Buyer C that is in the form of 50,000 t-shirts, it requires 1667 operators but S3 came up with 1,680 operators to match the number of operators from each line. In addition, S3 also determines that only 280 operators are used per day so that the number of days is even (in the form of integers). The time it takes to work on order C is 16 days. The 1st and 2nd version schedule for order C is the same, the only difference lies in the remaining time from the allocation of sewing from Buyer C. This can be seen from the results of S3's work as follows.

P : Okay, on the 1st version schedule, what do you think about order C?

S3 : ….. Order C is produced by 1680 operators using 9 lines in 6 days

So, order C will complete in 6 + 10 days (A and B) + 16 days (D & E) = 32 days mam…. So there is a remaining time of 42-32 days = 10 days mam…it's secure right mam…Then, the sewing time for all buyers is 4 + 5 + 8 + 8 + 6 = 31 days…it is included in the deadline of sewing that is between 30-35 days mam …

P : What about the 2nd version of the schedule? Is it secure for order C?

S3 : It's secure mam, …the time is 42 days, …order A 4 days, order B 5 days with a total of 9 days

Because there was a difference in the development, order A and B takes 10 days…Then D and E has a total of 14 days…So, to produce the order A, B, D, E, it takes 24 days. To produce order C, it needs 6 days. Therefore, the remaining day is 42 – 6 – 24 = 12 days.

The third strategy is to maximize the sewing time allocation and compare it with the production capacity of each line and then determine the line number used. The research subject who maximized sewing time allocation is S1 and the 1st and 2nd version schedules can be seen in Figure 12.

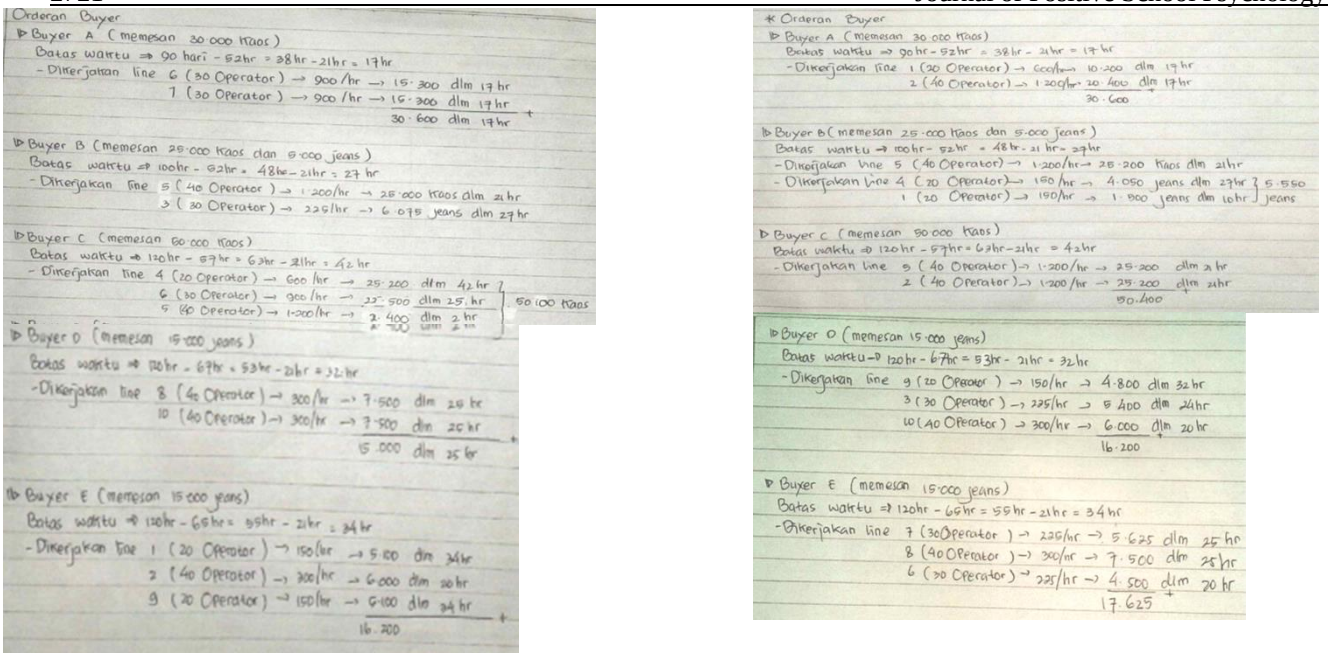


Figure 12. S1's Work in The Evaluating & Justifying Stage for The 1st and 2nd Version

Based on Figure 12, S1 in making the 1st version of schedule allocated the line number 6 and 7 to work on Buyer A's order; line number 3 and 5 to work on Buyer B's order; line number 4, 5, and 6 to work on buyer C's order; line number 8 and 10 to work on Buyer D's order; and line number 1, 2, and 9 to work on buyer E's order. In the 2nd version schedule, S1 only exchanged the line numbers with the same production capacity for each buyer. S1 allocated line number 1 and 2 to work on buyer A's order, line number 1, 4, and 5 to work on buyer B's order; line number 2 and 5 to work on buyer C's order; line number 3, 9, and 10 to work on Buyer D's order; and line number 6, 7, and 8 to work on buyer E's order.

The fourth strategy is to decide on using the entire lines to complete each buyer's order (line blocking system). This strategy is used by S7 where S7 decides to use the entire line to work on each buyer's order with the arrangement of processing being A-B-C-D-E. At first, S7 also calculated the number of t-shirts produced on the first day until the 11th day in all lines and continued on the 12th day on line number 1, 2, and 3. The on the 12th day in the rest of the lines are used to work on jeans until the 27th day. The results of S7's scheduling are as follows.

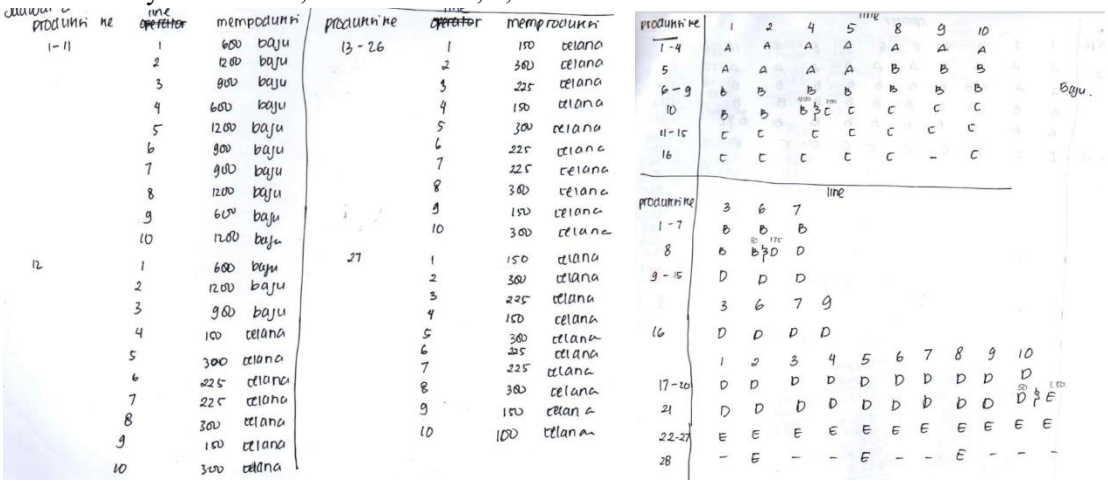


Figure 13. S7's Work in The Evaluating & Justifying Stage

Reflecting Stage

In the reflecting stage, the research subjects rethink the schedule that has been made and decided by reviewing the line number being used, reviewing the production capacity of the selected line, reviewing the required production time, and ensuring that the time for sewing and making orders for each buyer do not exceed the deadline so that no order is by R. In addition, there were several research subjects who revised the schedule that they had made.

Based on the explanation above, in general, the stages of systemic thinking of the preservice teachers in solving math problems can be categorized into 5 stages such as the identifying stage, clarifying & classifying stage, evaluating & justifying stage and reflecting stage. At the identifying stage, the research subjects 1) read and understand mathematical problems repeatedly; 2) have an overview and explain the processes that exist in the garment factory as a whole; 3) understand the stages in the garment factory including 2 stages for example the development stage and the production & delivery stage; 4) understand the objectives to be achieved namely making a sewing schedule for 5 buyer's order; 5) identify and record important information in the mathematical problems; 6) identify the time at the inspection, pattern making and cutting stage takes 7 days; time for the washing takes 7 days; and time for finishing & packing takes 7 days; 7) determine time required for the production process is 30-35 days; 8) understand the information that there are 10 lines with a total of 310 operators; 9) understand the information that there are 5 buyers who order t-shirts and/or jeans with a certain quantity and deadline set by the buyer; 10) understand that the development period for buyer A, B, and C is 50 days and Buyer D and E is 60 days; and 11) understand that the line which has 40 operators can produce 300 jeans/day or 1200 t-shirts/day.

In the investigation and classifying stage, the research subjects 1) relate the information obtained in the previous stage with the knowledge that they have mastered; 2) understand and analyze the relationship between processes, variables and elements in mathematical problems; 3) sort out the information and determine the key information then analyze the causal relationships that exist in the garment factory; and 4) begin to investigate the available resources such as production capacity, number of operators, production capacity of each operator, total daily production capacity, total production capacity of each operator per day, number of orders from 5 Buyers and grouping the lines based on the number of operators. According to the results of understanding and analyzing the information obtained from the mathematical problem, the research subjects began to think about strategies and steps to be taken to solve the mathematical problem. Characteristics of strategies and ways of thinking in solving complex problems for each research subject is to see and analyze the condition as a whole and then break it down into more specific ways. In this case, the research subjects identified the garment factory's production capacity for each line and each operator per day. The production capacity of each operator is 300 t-shirts/day or 7.5 jeans/day. The production capacity of the line with 20 operators is 600 t-shirts/day or 150jeans/day; the production capacity of the line with 30 operators is 900 t-shirts/day or 225 jeans/day; and a line with 40 operators is 1200 t-shirts/day or 300 jeans/day. The total production capacity of the entire line is 9300 t-shirts/day or 2325 jeans per day. The total number of operators is 310 people. Furthermore, the research subjects identified and totaled the number of orders for t-shirts and/or jeans from Buyer A, B, C, D and E.

In the clarifying stage, research subjects 1) present and explain the relationship between variables, information, and processes in the garment factory; 2) explain the stages in a garment factory from the development stage to the production and delivery stage; 3) determine and sate the relationship that exists in the information obtained from the problem and the processes that exist in the garment factory; and 4) explain the relationship between deadlines, development time, delivery time, cutting time, sewing time, washing time, finishing and packing time. The research subjects understand

that the deadline is the time given by the buyer to the factory from the process of production order by the buyer to the process when the product is received by the buyer. Because there are two kinds of stages in the garment factory, the relationship between the deadline, the time of the first stage (development) and the time of the second stage is that the deadline is the time of the first stage plus the time of the second stage. The time of the first stage is called the development period and it is already known in

Deadline = development stage time + production and delivery time

Production & delivery time = cutting time + washing time + finishing & packing time +

The research subjects can determine the sewing time allocation from each buyer, namely Buyer A gives 17 days of sewing time, Buyer B gives 27 days of sewing time, Buyer C gives 42 days of sewing time, Buyer D gives 32 days of sewing time, and Buyer E gives 34 days of dewing time.

In the evaluating & justifying stage, the research subjects made various sewing schedules with various solution strategies. Broadly speaking, the solution strategies used by the research subjects include 1) making tables; 2) determining the total number of operators needed and determining the line number used to work on the orders; 3) maximizing the allocation of sewing time and comparing it with the production capacity of each line and then determining the line number used and 4) deciding to use the entire line to complete each buyer's order (line blocking system). Most of the research subjects determine the total number of operators needed

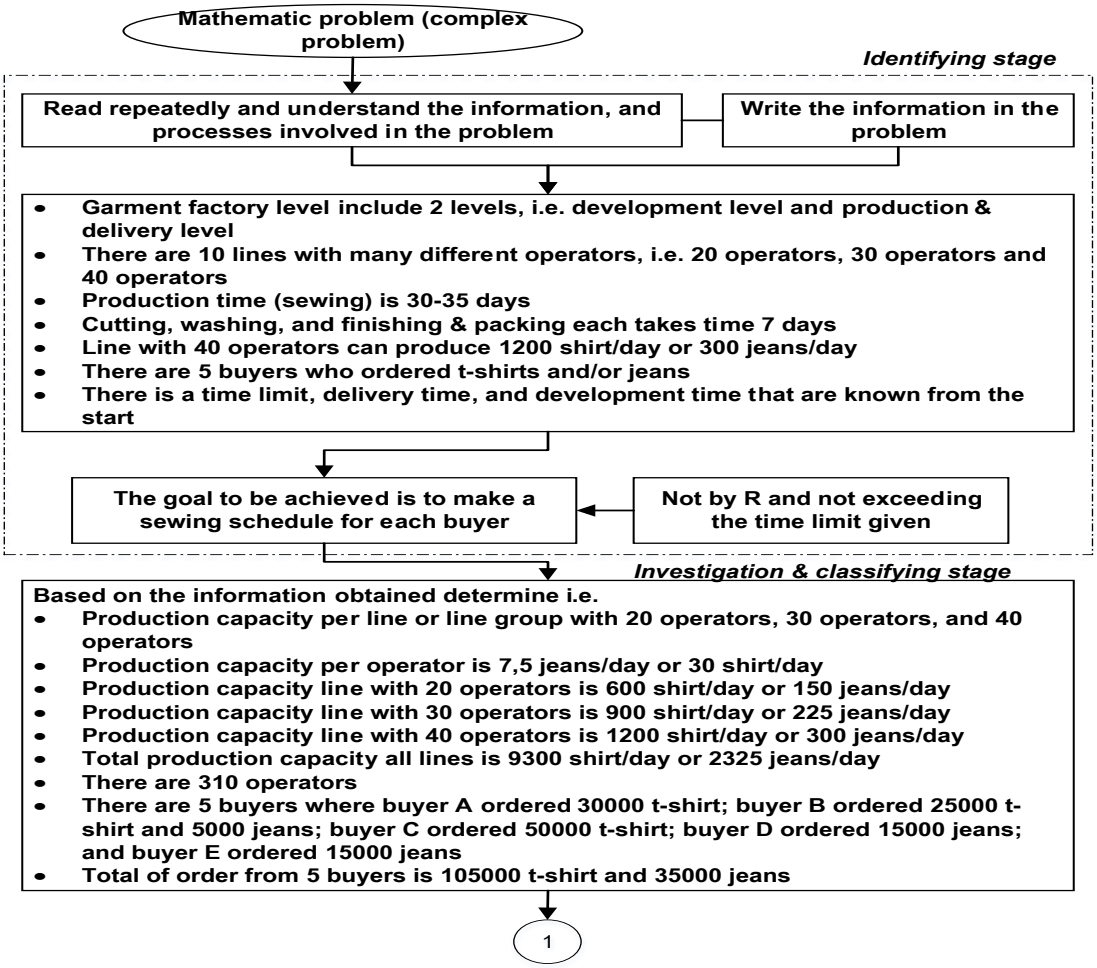
the problem given. The second stage includes cutting time, sewing time, washing time, finishing & packing time, and delivery time. After repeatedly understanding the mathematical problem given, the research subjects understand that the cutting time, sewing time, washing time, finishing & packing time each took 7 days so these three parts took 21 days in total. Therefore, the time relationship between the parts in stage 2 is explained below.

sewing time + delivery time = sewing time + delivery time + 21 days

Sewing time = deadline – development time – delivery time – 21 days

to work on each buyer's then determine the sewing time and the line number used. In presenting the sewing schedule, the research subjects used tables and descriptions based on very detailed calculations. In addition, the research subjects also ensured that the total sewing time of the 5 buyers' orders did not exceed 30 days so that they were not by R. In the reflecting stage, the research subjects reviewed the scheduling that had been made and had been decided by looking back at the line number used, the capacity production from the selected line, the required production time and ensuring that the sewing time and the time for producing the orders for each buyer do not exceed the deadline so that no order is by R. There are several research subjects who revised the schedule they had made as well.

The structure of systemic thinking from research subjects who have a systematic cognitive style in solving mathematical problems is illustrated in Figure 14 belo


Mathematic problem (complex problem)
Identifying stage
Read repeatedly and understand the information, and processes involved in the problem
Write the information in the problem
Garment factory level include 2 levels, i.e. development level and production & delivery level
There are 10 lines with many different operators, i.e. 20 operators, 30 operators and 40 operators
Production time (sewing) is 30-35 days
Cutting, washing, and finishing & packing each takes time 7 days
Line with 40 operators can produce 1200 shirt/day or 300 jeans/day
There are 5 buyers who ordered t-shirts and/or jeans
There is a time limit, delivery time, and development time that are known from the start
The goal to be achieved is to make a sewing schedule for each buyer
Not by R and not exceeding the time limit given
Investigation & classifying stage
Based on the information obtained determine i.e.
Production capacity per line or line group with 20 operators, 30 operators, and 40 operators
Production capacity per operator is 7,5 jeans/day or 30 shirt/day
Production capacity line with 20 operators is 600 shirt/day or 150 jeans/day
Production capacity line with 30 operators is 900 shirt/day or 225 jeans/day
Production capacity line with 40 operators is 1200 shirt/day or 300 jeans/day
Total production capacity all lines is 9300 shirt/day or 2325 jeans/day
There are 310 operators
There are 5 buyers where buyer A ordered 30000 t-shirt; buyer B ordered 25000 t-shirt and 5000 jeans; buyer C ordered 50000 t-shirt; buyer D ordered 15000 jeans; and buyer E ordered 15000 jeans
Total of order from 5 buyers is 105000 t-shirt and 35000 jeans
1

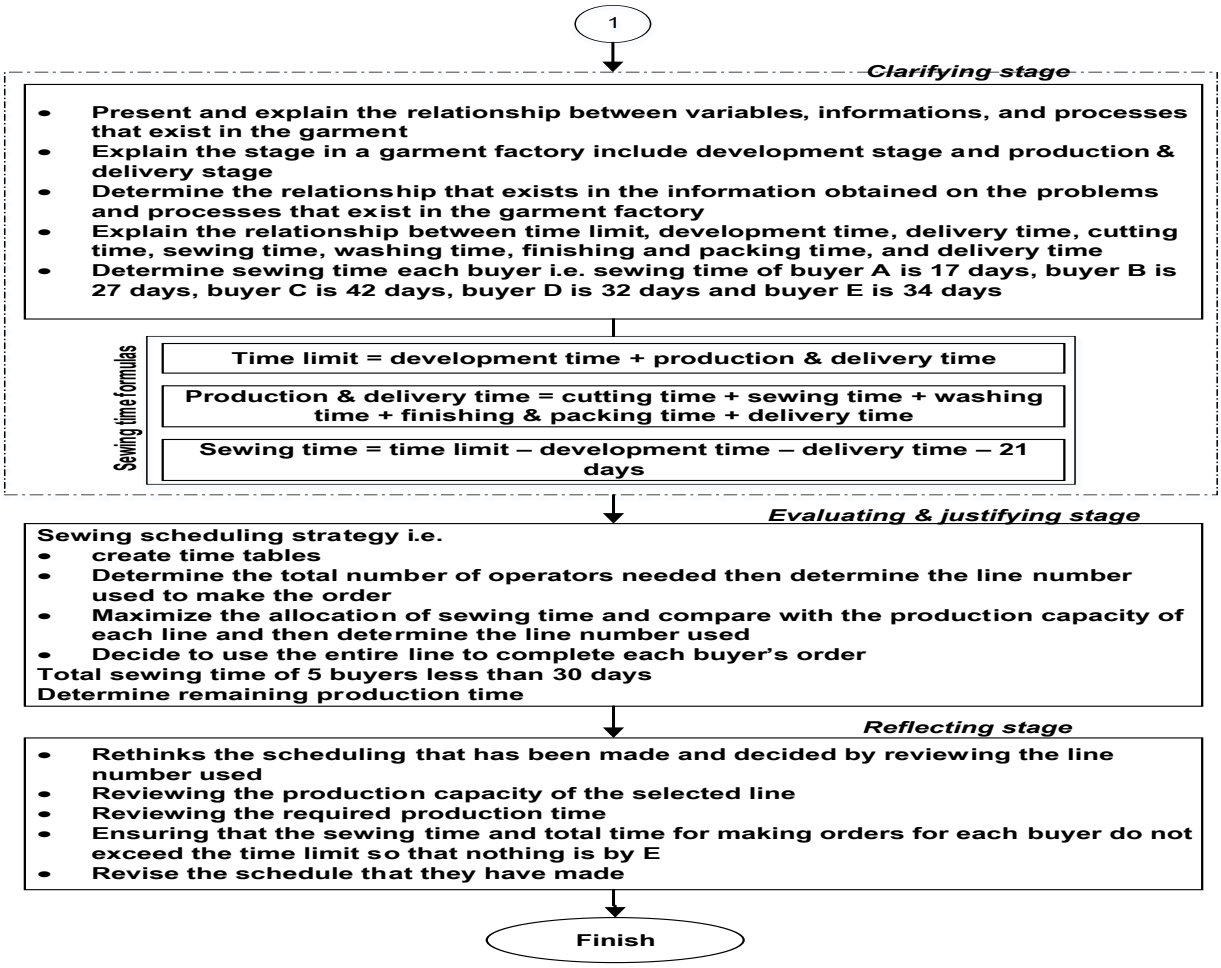


Figure 14. The structure of systemic thinking from research subjects who have systematic cognitive style

Discussion

Systemic thinking processes in individuals who are identified as having a systemic style have high scores on the systematic scale and low scores on the intuitive scale. These individuals usually use a step-by-step approach when solving problems; are well-defined; look for an overall method or program approach; and then create an overall plan to solve the problem. The characteristics are convergent thinkers; concrete; highly structured; logical; rational; ordered; linear; step-by-step approach; concrete on the facts, figures, and data; product centered; reducing the problem to workable segments; deductive; very aware of the approach; using well-defined methods or plans to solve problems; using a sequential process; and dealing with problems by dividing them into smaller group (Martin, 1998; Sagiv et al., 2014). A person with a systematic cognitive style tends to analyze situations to the problems they have (Sagiv et al., 2014).

Subjects with systematic cognitive style at the identifying stage are able to show indications related to information, variables, processes, and initial conditions that are prerequisites for the problems they have. Research subjects show indicators of 1) identifying and understanding the information, variables, and processes that exist in the garment factory; 2) having an overall picture of the existing processes in the garment factory; 3) understanding and recording key information from a given mathematical problem; and 4) understanding that the goal to be achieved is to make a sewing schedule for orders of 5 buyers. Based on the results of this identification, the research subjects can describe the processes that exist in the garment factory and analyze the problem-solving steps that will be taken. This

stage is an early stage that has an important role because it is the initial stage in system thinking (Prahasta, 2018) and in solving mathematical problems (Widjajanti & Wahyudin, 2011; Novita, et al., 2012; Surya, et al., 2017). The process of systemic thinking is closely related to the initial analysis of problems that arise from the information obtained (Hrin et al., 2017). The collection of information obtained becomes material in the subject to carry out further analysis such as the investigation & classifying stage.

In the investigation and classifying stage, the research subjects 1) relate the information obtained from the previous stage with the knowledge that they have mastered; 2) understand and analyze the relationship between processes, variables, and elements in mathematical problems; 3) sort out the information and determine the key information and analyze the causal relationships that exist in the garment factory; and 4) begin to investigate the available resources such as production capacity, number of operators, production capacity of each operator, total daily production capacity, total production capacity of each operator per day, number of orders from 5 buyers and grouping lines based on the number of operators. This shows that the research subjects have met the indicators at the investigation and classifying stage which includes that 1) the subject can relate the information contained in math problems with the initial knowledge they have mastered; 2) the subject classify the information, variables, processes that occur, initial conditions (prerequisites) and final condition in mathematical problems based on character and similarity of behavior; 3) the subject identifies the performance of all parts of the system; and 4) the subject analyzes the causal relationship of information, variables, processes occurring, initial conditions (prerequisites) and final conditions that exist in mathematical problems.

When a person is faced with a complex problem/situation (non-routine problem), they will think like a mathematician who thinks beyond the solution procedure that has been understood by conducting exploration, investigation, and investigative activities (Ponte, 2007). Therefore, at this stage, the subject analyzes the relationship or causal relationship that exists in the elements of the garment factory. Before identifying this cause-and-effect relationship, activities can be carried out to group the elements that are similar and describe the similarities possessed by each group. This activity is referred to as a classifying activity. In addition to classifying activities, there are other activities namely investigations, which include formulating questions, making and testing allegations and proving them. The second stage of systemic thinking is the investigation & classifying stage and this is in accordance with the opinions from Bartlett (2001), Jacob (2014), Prahasta (2018), Johnny, et al. (2016), and Ponte (2007). Furthermore, in determining the causal relationship that exists in the system, classifying, categorizing, and investigation activities are carried out. Categorizing activity according to Jacob (2014) is the process of dividing the entire entity into groups of entities whose members have similarities with one another. If it is associated with the opinion from Ponte (2007), then categorizing activities are part of mathematical investigation activities. Therefore, the second stage of systemic thinking is the investigation & classifying stage.

The clarifying stage is the process of finding the relationship between the system elements explained to form a system model design that applies as a whole. In the clarifying stage, the research subjects 1) present and explain the relationship between variables, information and processes that exist in the garment factory; 2) explain the stages in a garment factory from the development stage to the production and delivery stage; 3) determine and state the relationship that exists in the information obtained on the problems and processes that are in the garment factory; and 4) explain the relationship between deadline, development time, cutting time, sewing time, washing time, finishing and packing time, and delivery time. This shows that the indications of the subjects include the fact that 1) the subject presents the relationship between information, variables, processes occurring, initial condition (prerequisite) and final condition in mathematical problems; 2) the subject explains the causal relationship between information, variables, processes occurring, initial condition (prerequisite) and final condition in

mathematical problems 3) the subject describes the performance of each part of the overall system and the core problems in mathematical problems; 4) the subject plans various possible solutions to mathematical problems; and 5) the subject makes the system model design. In the mathematical problem given in this research, the system model design is in the form of stages at the garment factory which include the development stage and the production & delivery stage where each stage includes several sub-stages. This mathematical problem is limited to tome management at the production & delivery stage. By understanding the garment system design model, the research subjects can analyze the time relationship between the sub-stages in the garment system, in this case, the relationship between time limit, development time, delivery time, washing time, cutting time, sewing time, and finishing & packing time. Because it describes and explains the causal relationship between information, variables, and elements in the system, the third stage is called the clarifying stage and this is in accordance with the opinion from Johnny, et al. (2016).

The evaluating & justifying stage is a step in making alternative solutions from the information obtained. Subjects with systematic cognitive style perform detailed and thorough analysis and calculations regarding all the possibilities that can be generated from various interrelated variations of the solution with previous information and provisions. The subjects prepare in advance the calculation of the variables that affect the scheduling design such as the production capacity of each line, the production capacity per operator, the total production capacity of all lines, as well as the number of orders from 5 buyers. Generally, the solution strategies used by research subjects include 1) making tables; 2) determining the total number of operators needed and the line number used to work on the orders; 3) maximizing the allocation of sewing time and comparing it with the production capacity of each line and then determining the line number used; and 4) deciding to use the entire line to complete each buyer's order (line blocking system). After making various sewing schedules with various completion strategies, the research subjects analyzed the advantages and disadvantages of each alternative scheduling that had been made and then decided on the sewing schedule that was considered the most optimal. This shows that the research subjects meet the following indicators 1) creating various alternative solutions to mathematical problems; 2) predicting the impact of each alternative solution plan from the mathematical problem; 3) predicting the possibilities that will occur if the problem solving plan is implemented in the system; 4) Evaluating various alternative solutions to mathematical problems by analyzing various possibilities and impacts; and 5) deciding on mathematical problem solutions that will be applied in the system based on the analysis of various alternative solutions.

In the reflecting stage, the subjects determine the most optimal solution and perform a more detailed follow-up analysis so as to produce a detailed and accurate final conclusion. The subjects with a systematic cognitive style tend to perform the most optimal repetition and experiment in the solution process. These subjects also have high standards in analyzing all the information obtained. In this stage, the subjects re-check the identifying process so that the initial identification, the relationship between variables, and the relationship between variables and information produces the most optimal and appropriate solution in solving the problem.

The findings in this research are 1) the stages of systemic thinking include 5 stages such as the identifying stage, the investigation & classifying stage, the clarifying stage, the evaluating & justifying stage, as well as the reflecting stage; 2) subjects with systematic cognitive style have detailed characteristics by paying attention to every aspect related to the problem as a while; 3) the stages of systemic thinking for preservice teachers who have a systematic cognitive style include 5 stages of systemic thinking; and 4) at each stage of systemic thinking, preservice teachers who have a systematic cognitive style think as a whole (holistic) the break down into details and base them on systematic and detailed calculations. The data and information obtained are then elaborated by revealing the relationship

between variables with every detail of information which is the special attention by the subject. Subjects with a systematic cognitive style are able to produce many detailed and systematic solution options.

Conclusion

The conclusion in this research indicates that the stages of systemic thinking consist of 5 stages namely the identifying stage, the investigation & classifying stage, the clarifying stage, the evaluating & justifying stage and the reflecting stage. In addition, the thinking process for preservice mathematics teachers who have a systematic cognitive style includes 5 stages for example the identifying stage, the investigation & classifying stage, the clarifying stage, the evaluating & justifying stage and the reflecting stage. At the identifying stage, the preservice mathematics teachers identify information, processes, and variables in a garment factory; and understand the objectives to be achieved from solving mathematical problems. In the investigation & classifying stage, the preservice mathematics teachers identify key information, determine the production capacity of each line and each operator, determine the total production capacity of the entire line; and determine the total order of t-shirts and jeans from 5 buyers. In the clarifying stage, the preservice teachers explain the system at the garment factory and determine the sewing time provided by each buyer. In the evaluating & justifying stage, the preservice mathematics teachers can make various sewing schedules for each buyer, determine the sewing schedule for 5 buyers where the time required to produce the orders does not exceed 30 days and determine the remaining production time so that it can be ensured that nothing is by R. At the reflecting stage, the preservice mathematics teachers review the sewing schedule that has been decided and revise the sewing schedule if there are mistakes. Systemic thinking processes of individuals with systematic cognitive style show that they have systematic and detailed characteristics in each process of completion. Individuals with systematic cognitive style see non-routine mathematical problems as a whole, then divide and classify them so that integration/similarities can be found from each classification made to assist in the problem-solving process.

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