Learning Style Preferences and Students’ Ability in Mathematical Investigation on Display Data

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Abstract. A mathematical investigation is an inquiry activity to solve a mathematical problem. Good investigative skills will support mathematical problem-solving and mathematical literacy. The purpose of this study is to explore students’ mathematical investigation based on Kolb's learning styles: diverging, assimilating, converging, and accommodating. Mathematical investigation is measured by four indicators, i.e Specialization, Conjecturing, Justification, and Generalization. This is a qualitative study and the subjects were 7th-grade students of Islamic Secondary School Manahijul Huda Ngagel, Pati, Central Java. The results showed that there are differences students’ ability of mathematical investigation for accommodator and divergent, also for accomodator and convergent. Students with accommodating learning styles have better investigative abilities, demonstrated on indicators specialization, conjecturing, justification and generalization. Students with assimilation learning styles have a good specialization and generalization but are less successful in the process of conjecture and justification. Conversely, students with convergent learning styles are only good at specialization, but not for conjecturing, justification, and generalization. Students with divergent learning styles have the most difficulty when doing divergent less able to do specialization, conjecture, and generalization.

1. Introduction
An investigation is a process of a probe by recording or recording facts through observation, experiments, etc. intending to obtain answers to questions [1]. Investigative ability is the ability to investigate mathematical processes or patterns and regularity in mathematics. Through investigation, students can explore mathematical thinking, examine the regularity of patterns in mathematics and verify the data that has been done [2].

In mathematics learning, the investigation is a method to solve mathematical problems [3]. For the same problem, students might adopt different strategies to find solutions, depending on their preferences. One of the preferences that affect the ability of problem solving is learning style [4]. In this context, learning styles are interpreted by individual systems to concentrate on, process, internalize and maintain new and difficult pieces of information [5]. Another study, carried out by Bosman also showed that high achievements were obtained by students with certain learning styles [6]. She recommended teachers to provide learning in accordance to students’ learning style preferences. This research aims are to examine and explore the role of learning styles in students’ ability of mathematical investigation on Display Data.
2. Theoretical Framework

2.1. Mathematics investigation

Mathematics investigation supports the development of the idea of interesting and complex mathematical knowledge and can evaluate several solutions needed to solve it [7]. This understanding is in line with Yeo's opinion which states that a mathematical investigation is a problem or an open statement that allows a student to explore to get to the desired meeting point [3].

Yeo revealed that problem-solving can be solved by using two methods, the first method using mathematical investigation and the second method using another method. Figure 2.1 explains the relationship between mathematical investigation and problem-solving [3]. Yeo mentioned that as a process, the investigation consists of Specialization, Conjecturing, Justification, and Generalization [3][8]. Meanwhile, according to Stacey, someone has a mathematical investigation ability if he has collected data, classifies the data and represents [9]. Other indicators are presented by Karunia, namely: (a) investigating the adequacy of data, (b) observing mathematical processes, patterns of regularity in mathematics, (c) observing drawings, diagrams, tables, or other forms of mathematical representation, (d) observing mathematical processes or patterns of regularity in mathematics, (e) verifying data or facts in mathematics [2].

In this research, the concept of investigation used is a mathematical investigation according to Yeo, because the study conducted by Yeo uses the subject of secondary school students, the same as this study.

![Figure 1. Relation of Mathematical Investigation and Problem Solving](image)

2.2. Learning styles

Learning style is not an ability but a preferred method to use someone's own ability [10]. Kolb defines learning styles as cognitive characteristics, affective, and psychological behavior of a learner about how he/she understands, interacts and responds something into his learning environment, which is unique and relatively stable [11].

Bobbi DePorter classified learning styles into three kinds: (a) visual, (b) auditory, and (c) kinesthetic [12]. While David Kolb classified learning styles with more complex, through 4 stages of the learning cycle. These stages are CE (concrete experience), RO (reflective observation), AC (abstract conceptualization), and AE (active experimentation) [11]. At the CE stage, students learn through feelings by emphasizing concrete new experiences, more concerned with relationships with others and sensitivity to the feelings of others. At the RO stage, students learn through observation (watching) of new experiences. Students will use their thoughts and feelings to form their opinions. Students observe and reflect on their experiences in various aspects. While at the AC stage, students learn through thinking by bringing up and modifying existing abstract concepts. Students create concepts that integrate their observations into theories. At the AE stage, students learn by doing, applying to their original world to
see results. Students tend to be strong in terms of the ability to carry out tasks, dare to take risks, and influence others through their actions.

Regarding to the four stages of learning, Kolb develops four learning styles:

a. Divergent (feeling and watching)
   People who have this learning style prefer watching imagination to solve problems. They respond to information with general ideas with a group of people's decisions.

b. Assimilator (watching and thinking)
   Students who have this learning style have advantages in understanding and responding to various information offerings and are proficient in building theoretical models. They think ideas and concepts are more important than practical opportunities.

c. Convergent (thinking and doing)
   Students who have this learning style can solve problems and will use their learning to find solutions to practical problems.

d. Accommodation (doing and feeling)
   Students who have this learning style love to apply the subject matter in a variety of new situations to solve various real problems they face. And they are proficient in applying the material and connecting it with everyday life.

![Figure 2](image_url)

**Figure 2.** The relation between Kolb's stages of learning and learning styles [11].

3. Method
This is confirmatory research, began with quantitative data and continued by qualitative analysis. descriptive research with a qualitative approach. The study was conducted at the second semester of 2018. The research subjects were 7th at Junior High School MTs Manahijul Huda Pati. Kolb's questionnaire was used to determine student learning styles, while tests and interviews were used to determine the investigative ability of students on Display Data. Data was analyzed by One Way Anova and explored by qualitative analysis.
4. Results

The measure of Kolb’s learning styles showed that 35% of students are divergent, 21% of students are convergent, 26% of students are Assimilator, and 18% of students are Accommodator. Anova single factor was used to measure the effect of these learning styles to students’ ability of mathematical investigation. The effect was measured by Anova single factor, as represented at Table 1 below.

| Source of Variation | SS    | df  | MS   | F      | P-value | F crit |
|---------------------|-------|-----|------|--------|---------|--------|
| Between Groups      | 4661,31 | 1,00 | 4661,31 | 331,63 | 0,00    | 3,99   |
| Within Groups       | 927,68  | 66,00 | 14,06  |        |         |        |
| Total               | 5588,99 | 67,00 |         |        |         |        |

The results showed p-value as 0,00, there are significant difference of students’ investigation based on learning styles. Multiple comparisons is analyzed as further analysis and the result is:

| Learning Styles                  | p-value   | t critical two-tail |
|----------------------------------|-----------|---------------------|
| Divergent - Convergent           | 0,76805259| 2,09302405          |
| Divergent - Assimilator          | 0,97051293| 2,10981558          |
| Divergent - Accommodator         | 0,01757279| 2,20098516          |
| Convergent - Assimilator         | 0,83815084| 2,14478669          |
| Convergent - Accommodator        | 0,03910438| 2,30600414          |
| Assimilator - Accommodator       | 0,12486744| 2,44691185          |

Table 2 showed that under alpha 5%, p values are below than 0,05 for the comparison of the Divergent vs the Accommodator and the Convergent vs the Accommodator. Its mean that the Accommodators’ ability of mathematical investigation is different with the Convergent and the Divergent.

5. Discussion

5.1. Mathematics Investigation of Students with Divergent Learning Styles

Research subjects with divergent learning styles are S-07 and S-32. On the indicators of Specialization students with divergent learning styles are less able to find the frequency of data. Students are also less able to calculate and draw diagrams correctly. For conjecturing and justification students with divergent learning styles are only able to read diagrams but are less able to proceed to the desired proof. For the generalization indicator, students with divergent learning styles are less able to solve the problems well.

5.2. Mathematical Investigation Ability of Students with Convergent Learning Styles

Research subjects with Divergent learning styles are S-03 and S-34. Based on the analysis for specialization indicators, students with convergent learning styles tend to think and then continue working on the problems. Their answer sheet and interview showed that students with convergent learning styles have a good ability to find ideas.
At the indicators of conjecturing and justification, students with convergent learning styles tend to take risks by analysing what will be calculated and concluded later. Unfortunately, subject S-34 did not add conclusions after finishing the calculation. At the indicator of generalization, students with convergent learning styles can answer the whole of the questions given. The student also answered firmly without hesitation when asked during the interview.

5.3. Mathematical Investigation of Students with Assimilator Learning Styles
Research subjects with assimilator learning styles are S-15 and S-20. At the specialization indicator students with learning style assimilator can find the frequency of the data. Subjects with the assimilator learning style also able to calculate and draw diagrams correctly. While the coefficient and pie charts are fairly abstract parables. On indicators of conjecturing and justification students with divergent learning styles can read diagrams and proceed to proof. However, there is a lack of language in the words to conclude on S-20 subjects. Yet when the interview can answer it with one sentence conclusions. At the indicator of generalization of students with learning styles assimilation can solve the problems given well.

5.4. Mathematics Investigation of Students with Accommodator Learning Styles
Research subjects for accommodator learning styles are S-16 and S-30. Both of them able to carry out the four indicators of mathematics investigation, specialization, conjecturing and justification, and generalization. The results of data analysis on specialization indicators showed that students with accommodator learning styles tend to be strong and careful in working on problems. At indicators of conjecturing and justification, students with accommodator learning styles tend to take risks. It means to infer the allegations and believe the allegations are correct by showing the results of the calculation. As well as answering firmly everything asked about the problem. On the generalization indicators, students with accommodation learning styles able to answer the whole of the questions given perfectly. The student without hesitation also answered firmly when asked during the interview.

6. Conclusion
a. Mathematics investigation for the students with the accommodator learning style showed the best performance in problem-solving than others.
b. Students with assimilator and convergent learning styles have almost the same mathematical investigation abilities. This is shown in the data, where students with convergent learning styles mastered one indicator, while the assimilator learning style mastered 2 indicators.
c. Students with divergent learning styles have the lowest mathematical investigation than others. Students with divergent learning styles were unable to finish all of the indicators.

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