An analysis of mathematical connection ability based on student learning style on visualization auditory kinesthetic (VAK) learning model with self-assessment

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Abstract. This research aims to analyze the quality of VAK learning with self-assessment toward the ability of mathematical connection performed by students and to analyze students' mathematical connection ability based on learning styles in VAK learning model with self-assessment. This research applies mixed method type with concurrent embedded design. The subject of this research consists of VIII grade students from State Junior High School 9 Semarang who apply visual learning style, auditory learning style, and kinesthetic learning style. The data of learning style is collected by using questionnaires, the data of mathematical connection ability is collected by performing tests, and the data of self-assessment is collected by using assessment sheets. The quality of learning is qualitatively valued from planning stage, realization stage, and valuation stage. The result of mathematical connection ability test is analyzed quantitatively by mean test, conducting completeness test, mean differentiation test, and mean proportional differentiation test. The result of the research shows that VAK learning model results in well-qualified learning regarded from qualitative and quantitative sides. Students with visual learning style perform the highest mathematical connection ability, students with kinesthetic learning style perform average mathematical connection ability, and students with auditory learning style perform the lowest mathematical connection ability.

1. Introduction
Mathematics is a universal science which underlies the development of modern technology. It has an important role to support other disciplines as well as to enhance human mind. The development of mathematics in the field of number theory, algebra, analysis, probability theory, and discrete mathematics has also underlain the rapid development of information and communication technology. In fact, mathematics learning must be given in any level of education since it is regarded as the mother of science and the servant of knowledge. Mathematics learning must enable skill development, which is: (1) mathematical problem solving; (2) reasoning and verifying mathematics learning; (3) mathematical communication; (4) mathematical connection; (5) mathematical representation [1]. One of the critical abilities that students must have is mathematical connection ability. It helps students to learn how to connect mathematical ideas that will ease them to formulate and verify deductive assumptions amongst topics. The concepts and procedures of modern mathematics can be applied to solve other problems in mathematics as well as other disciplines. Through connections, students can rebuild understanding of previous knowledge [2,3].

The According to [1], the importance of mathematical connection is “When students can connect mathematical ideas, their understanding is deeper and more lasting”. Mathematical connection assists students to memorize skills and concepts and to apply them appropriately when they are put in a
problem solving situation. According to [4], mathematical connection becomes more significant because it supports students to enhance their understanding concerning the connection between mathematical concepts and any concepts of other sciences. Mathematical connection can also help and support students in learning mathematics [5].

The low ability of student’s mathematical connection will influence students’ learning quality which may cause under achievement in mathematics learning. The fact shows that in mathematics learning students still get into trouble when they have to make connections between learned materials and prerequisite materials which they have understood in prior and that the development of mathematical connection in Junior High School students is still under expectation. Research conducted by [6] proves that mathematical connection is significantly required so that students are able to associate connections between mathematics and mathematics itself, mathematics and other subjects, and also mathematics and factual problems are reality. The indicators of mathematical connection ability are (1) Finding and understanding connections amongst any representations of concept and procedure; (2) Comprehending the connection amongst topics in mathematics; (3) Applying mathematics in other subjects or in daily life, (4) Comprehending the representation of concept equivalence or similar procedures, (5) Discovering connections between one procedure to another in an equivalent representation, (6) Applying connections amongst mathematical topics, and amongst mathematical topics and other ones.

The difficulty in understanding mathematical connection experienced by students can be caused by students learning style since it determines how students can engage things through their senses; which sense can develop more than others in learning process. Learning style is a method that is used by an individual to get and focus on new information [7]. [8] states that teachers who teach based on students’ different learning styles will be more oriented on both process enhancement and learning result and they will be more open to change compared to those who do not apply learning style as the foundation of pedagogies.

The quality of learning must also be considered in learning process. One of several factors which influence toward learning process is the proper learning model that is applied. Learning model which can be applied to achieve mathematical connection ability in students is Visual Auditory Kinesthetic (VAK) learning model. VAK is a learning model which points out that learning process must take advantages of all senses owned by students, whereas VAK learning model works by combining auditory, visual, and kinesthetic senses. This type of learning model emphasizes on direct learning experience through visualization, auditory, and kinesthetic ways [9]. VAK learning model considers that learning process will be effective by underlining the three modalities and hence it can be understood that learning process is carried out by training and advancing students’ potentials which they have owned. The steps to conduct learning process applying VAK learning model include preparation stage, delivery stage, training stage, and result presentation stage.

Besides learning model, assessment toward students also affects the quality of learning result. Self-assessment involves a comparison between an implemented learning process and several criteria to build students awareness in order to make changes and improvements to achieve better results during learning process in the future. Self-assessment implies judging one’s performance by criteria previously established in a more or less conscious way [10]. This research aims to analyze the quality of VAK learning using self-assessment toward mathematical connection ability and to analyze mathematical connection ability of students based on learning style in VAK learning with self-assessment.

2. Methods
This research applied mixed method concurrent embedded model. The definition of mixed method is research approach which is combining or connecting qualitative and quantitative research methods [11]. This research uses qualitative method as the primary method and quantitative method as secondary method. The quantitative method aims to determine learning quality quantitatively, while qualitative method aims to determine learning quality qualitatively and to analyze mathematical connection of students based on learning style. This research is carried out in State Junior High School 9 Semarang school year of 2016/2017. Sample in this research is VIII A grade students as
experienced class, VIII D grade students as controlled class, and VIII C grade students as trial class. The subject of this research is carried out based on questionnaire results on learning style that have been given to students in prior. The subject is chosen by observing the dominant learning style done by students through the result of questionnaire on students' learning style. This research selects two students based on questionnaire score equivalence for the indicator of other learning styles. Data source in this research is questionnaire on students' learning style, answer sheet on mathematical connection ability test, students' interview result, assessment sheet of self-assessment, and students' response on questionnaire sheets. The obtained data will describe students' mathematical connection ability based on their learning style. The obtained data in this research are collected by applying test technique, questionnaires, assessment, observation, and interview. Questionnaire technique is used to obtain the data of students' learning style and students' response, test technique is used to get the data of students' mathematical connection ability by performing mathematical connection ability test, interview technique is used to discover students' mathematical connection ability more deeply and accurately, while observation is used to find more information to assess students' performance during learning process.

The research instruments include questionnaire sheets on students' learning style adopted from [12] questionnaire sheets on students’ response, mathematical connection ability test, and interview guidance. Research instruments are considered worthy to use only if they fulfill valid criteria. Research instruments which need to be validated include syllabus, RPP, LKS (student worksheet), mathematical connection ability test, interview manual, questionnaire on learning style, self-assessment, questionnaire on students’ response, and learning realization. The result of instrument validation must be at least categorized in good criteria. The analysis of question items on mathematical connection ability which is used in this research covers validity test, reliability test, differentiation capacity, and difficulty level. The analysis result of trial test on mathematical connection ability is including validity of question items, question’s reliability, differentiation capacity, and difficulty level of question items, thus there are only 7 questions out of 8 that will be used, which are question items number 1, 2, 3, 5, 6, 7, and 8. Question item number 4 is not used because it is invalid and its differentiation capacity is less.

The first analysis is taken from the result of students' mathematical connection ability initial test which aims to find out mean similarity of both experiment and control classes using normality test, homogeneity test, and two-mean similarity test. The initial mathematical connection ability of students in both experiment and control classes are normal distributed, homogenous, and similar. Learning quality in this research includes planning (planning and preparation), implementation (Classroom environment and Instruction), assessment (Professional Responsibility). Learning quality can be considered qualified if the result validation of learning devices and implementation is at least good, and the result students' questionnaire with positive responses towards learning is more than 70%. Quantitatively, learning can be considered qualified if VAK learning quality with self-assessment towards students' mathematical connection ability has achieved completeness using mean test and classical completeness test, and experiment class are considered better than control class using proportion differential test and mean differential test. Mathematical connection ability based on learning style is analysed descriptively according to the result of tests and interviews towards the research's subjects.

3. Result and Discussion
Students are grouped based on learning style questionnaire done before carrying out learning process. Based on grouping, there are 11 students who are learning by visual learning style, 13 students learning by auditory learning style, and 8 students learning by kinesthetic learning style. According to [13] learning quality applying VAK learning model with self-assessment toward mathematical connection ability is based on (1) planning and preparation stage, (2) realization (classroom environment and instruction), and (3) realization or assessment (professional responsibility). Learning quality applying VAK learning model with self-assessment obtained from planning and preparation stage result results in score mean of learning instruments assessment result as much as 4.18 which is categorized as good criteria.
The outcome of learning realization stage is the mean of total assessment towards teachers’ ability in managing the learning as shown in Table 1.

**Table 1. The Result of Learning Realization**

| No | Realization | Mean | Category |
|----|-------------|------|----------|
| 1  | Meeting 1   | 3.97 | Good     |
| 2  | Meeting 2   | 4.03 | Good     |
| 3  | Meeting 3   | 4.13 | Good     |
| 4  | Meeting 4   | 4.30 | Excellent|

Table 1 shows that the mean of learning realization included into good criteria, so it can be concluded that researcher’s ability in planning and managing learning is included into good criteria. Self-assessment amongst students is conducted in meeting 5. The result of self-assessment conducted by students must be used and followed up. Self-assessment result based on 10 competency indicators shows that students are 100% comprehensively understand the given material. Students’ understanding achievement based on 5 competency indicators is 96.9%, whereas 1 student still finds difficulty on the indicators. Students’ understanding achievement based on 14 competency indicators reaches only at number 90.6%, whereas 3 students are in difficulty when facing 14 indicators. The follow-up of self-assessment applies remedial teaching and enrichment.

Learning assessment stage is done by observing students’ response toward learning and its effectiveness. Positive response toward VAK learning with self-assessment gets more than or equal to 70%. It shows that most students agree that the given learning process has been done well. The effectiveness of learning applied prerequisite test in controlled and experimented classes is normal distributed and homogenous. Learning effectiveness regarded from posttest result on students’ mathematical connection ability which is mean test obtained that $t$ calculation = 5.930 and $t$ table = 1.670 with level of significance 5% whereas $t$ calculation > $t$ table, thus it proves that the mean of students’ mathematical connection ability more than KKM (79), regarded from completeness test proves that completeness test result is $t$ calculation = 2.041 and $z$ table = 1.64, whereas $z$ calculation > $t$ table, therefore as much as 75% students of experimented class achieve completeness classically, regarded from proportional differentiation test obtained than $z$ calculation = 3.113 and $z$ table = 1.64, therefore the completeness proportion of students’ mathematical connection in experimented class is better than the one in controlled class, regarded from mean differentiation test obtained that $t$ calculation = 3.486 and $t$ table = 1.670, whereas $t$ calculation > $t$ table, thus it proves that the mean of students’ mathematical connection ability in experimented class is better than in controlled class.

[14] assert that mathematics learning with mathematical connection development provides better results compared to classical learning for students with low ability. [15] research that has been conducted proves that students can learn more effectively if they are able to make connections from one subject to other ones. This report is according to an investigation on how mathematical concepts connect with scientific concepts performed by basic science teachers. Mathematical concepts are connected one another. Thus students must be given chances to understand the connection amongst those concepts in order to make them learn more optimally. Hence, learning activity with VAK model can be considered qualified which is in line with the research which shows that VAK learning model supported by GeoGebra gives better learning achievements compared to expository method application.

Analysis on students' mathematical connection ability in VAK learning with self-assessment is divided into 3 groups based on their learning style, which are visual, auditory, kinaesthetic learning styles. Two students are selected from each learning style to analyse their mathematical connection ability. Two students are selected from each learning style to analyse their mathematical connection ability. Thus there are 6 subjects. When a person understands learning style, she will integrate it into his/her learning process in order to reach an understanding better and easier and to get success [16]. It is then selected two students coded AV16 and AV 25 representing group of students with visual
learning style, AA8 and AA17 representing group of students with auditory learning style, and AK28 and AK31 representing group of students with kinesthetic learning style.

Students with visual learning style have constant characteristics when making a problem solving. They are also able to jot down the steps systematically and clearly. They tend to think by using systematic illustrations so they are used to make illustrations first before solving problems. It is suitable as [17] suggest, whereas the characteristics of visual learner are (1) well-organized, observing any objects, and well-performed, (2) memorizing by illustration, reading better than being read, (3) requiring descriptions and thorough aims and paying attention to details, memorizing what has been observed. It can be concluded that mathematical connection ability of visual learning students is included into fulfilled indicator. It is because visual learning students can complete any problems from all mathematical connection ability test questions. Another characteristic which they have is that they are able to write down steps to solve problem systematically.

Students with auditory learning style have slight to similar characteristics in solving problems. They are able to write down the solving steps systematically. However, they do not write them completely and tend to think fast and whisper during learning. It is in line with [17] as they explain that one of the characteristics of auditory learner is getting much information which is delivered by loudly reading and they may not understand written information thoroughly. Students with kinesthetic learning style tend to think while doing something. They usually point out to what they are reading while trying to understand the given problems. This is in accordance with the explanation of [17] regarding characteristics of kinesthetic learners which is to collect information from reading while doing something, to point out to the text while reading, and to give physical responses.

Based on the above analysis, it can be understood that the ability of mathematical connection performed by students with auditory learning style is lower than visual learning students. Auditory learning students are less careful in completing mathematical connection ability test questions since they tend to think fast. Another characteristic of these students is that they are able to write down steps to solve problems systematically, but they do it incompletely. Mathematical connection ability of students with kinesthetic learning style is still under the ability of students with visual and auditory learning styles. They tend to think while doing something so they cannot solve given problems carefully. Therefore, students with visual learning style have the highest mathematical connection ability followed by students with auditory and kinaesthetic visual learning styles.

Students who apply different learning style have different level of mathematical connection ability. However, it does not mean that one learning style can be considered better than other ones. Learning style is a combination of how students absorb, manage, and process information [16]. Therefore, learning style is an important element in learning. Several types of research prove that when teachers know their students’ learning style, they will know the best teaching method. At last, the students can accomplish high learning achievements [18].

4. Conclusion
According to the result of the research, the quality of VAK learning with self-assessment toward the ability of mathematical connection performed by VIII grade students can be found out. Mathematical connection questions given to students can be completed qualitatively in well criteria, as can be seen from (1) the mean of syllabus and worksheet (LKS) scores are considered well-criteria, while the mean of RPP and mathematical connection ability test scores are considered excellent-criteria, (2) the mean of learning realization from first meeting to last one is considered minimally well-criteria, (3) the number of students who give positive response reaching at 70% which means that most students regard fine value toward the learning.

VAK learning model that is applied to discover mathematical connection ability of VIII grade students by completing mathematical connection questions quantitatively can be considered high-grade as can be proved from (1) the mean of students’ mathematical connection in VAK learning more than KKM, (2) the proportion of students from experimented class who achieve completeness score as much as 79 more than 75%, (3) the completeness proportion of students’ mathematical connection in VAK learning with self-assessment is more than the completeness proportion of mathematical
connection in expository learning, (4) the mean of students’ mathematical connection in VAK learning is higher those in expository learning.

The characteristics of mathematical connection ability are different from one student to others based on their applied learning style. Those differences can be seen from students with visual learning style who are able to write down steps to solve problems systematically and completely. The characteristic of students with auditory learning style is that they are able to write down steps on solving problems systematically, but they do not write the solving quite completely. Meanwhile, the characteristics of students with kinesthetic learning style are that they are less careful in answering questions, they prefer to thinking while doing something, and they are able to write down the solving problems systematically but incompletely.

According to the acquired conclusions, there are several suggestions that are given, they are (1) The use of VAK learning model is considered well-qualified, and it can enhance students’ mathematical connection ability. Furthermore, VAK learning model can be benefitted as an option to conduct learning in order to develop mathematical connection ability; teachers can apply self-assessment as an alternative assessment as an attempt to know students' understanding; (2) Teachers should observe and give different method to each student based on their learning style. Students with visual learning style prefer to think fast so that teachers can deliver learning materials through discussion and question-answer session. Students with auditory learning style prefer to think fast so that teachers can deliver learning materials through discussion and question-answer session. Students with kinesthetic learning style tend to think while doing something, so teachers can give learning materials involving pictures, illustrations, tables, or graphs. Students with auditory learning style prefer to think fast so that teachers can deliver learning materials through discussion and question-answer session. Students with kinesthetic learning style tend to think while doing something, so teachers can give learning materials through some activities, such as using properties.

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