THE ENHANCEMENT OF JUNIOR HIGH SCHOOL STUDENTS MATHEMATICAL SPATIAL SENSE ABILITIES THROUGH COMPUTER-BASED INTERACTIVE MULTIMEDIA INSTRUCTION

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Abstract

Geometry is a basic mathematical concept studied at all education levels. However empirical evidence suggests there are many students who have difficulties learning geometry. One of many factors that enhances the success of students' understanding of geometry is students' sense of spatial ability. Seeking ways to support students' development of spatial sense, researchers studied the impact of Computer-Based Interactive Multimedia Instruction. This study was quasi experimental in nature with Pretest and Post-test Control Group Design. The participants of the study were second grade students of two public junior high schools that were classified as schools of high and middle level ranking, in Bandung. The instruments utilized in this study consisted of prior mathematical skills test (KAM) and spatial sense ability test. The results suggested that: (1a) generally the students' spatial sense ability and learning independency were enhanced using Computer-Based Interactive Multimedia Instruction, compared with conventional learning; (1b) there were no differences in the enhancement achievements between students' spatial sense ability and conventional learning related to school ranking level; (1c) according to KAM, there were significant enhancements of student's spatial sense ability between high, middle, and low KAM; (2) There is no interaction of effect between learning (CBIM and CVL) and school level to the enhancement of ability of students' spatial sense. (3) There is no interaction of effect between learning (CBIM and CVL) and KAM to the enhancement of ability of students' spatial sense.

Keywords: geometry, spatial sense, computer-based interactive multimedia, learning difficulties.

Introduction

The content of the National Curriculum in Indonesia places geometry as an important aspect in mathematic studies because it exists in our daily life and also covers spatial objects. Geometry is not only prominent in deductive method and abstract objects, but also it is an effective technique in solving mathematical problems.

One factor that contributes to the success of students in learning geometry is their *spatial sense*. It was stated by Soedjono (1983) that a student with low understanding of visual and spatial objects would have difficulties in learning geometry. Wheatley (1990) also argued that *spatial sense* was one of the important parts of geometry and also mathematics. Moreover, Del Grande (1990) indicated that the enhancement of *spatial sense* and geometry learning was interelated as a chain reaction, where the enhancement of *spatial sense* could result the enhancement of geometry or vice versa.

However, some research has shown that in mathematics, geometry occupies a wistful position. Many students have difficulties in understanding geometry, especially spatial geometry. To support students efforts to improve student's spatial sense ability in geometry are required. Based on Brunni & Seidenstein (1991) and Leidtke (1993) research, spatial sense can be enhanced through several activities in geometry. One of the efforts made by the researcher to enchance students' spatial sense was by implementing computer-based interactive multimedia instruction. This computer-based interactive multimedia instruction is a learning strategy which uses a computer to deliver the lesson materials with interactive multimedia software. Multimedia resources can provide colorful visual geometry lesson materials with pictures and animations. As stated by Clement (Baist, 2005), learning approaches which utilize computers in to build skills are needed. By using the multimedia computer resources, students motivation to solve geometry problem is increased. Also computer software is capable of presenting abstract mathematical concepts in a more tangible and clearer way.

Theoretical Background

Spatial Sense

Nes & Lange (2007) and Freudenthal (NCTM, 1989) define *spatial sense* as the ability to acquire or understand the outside world. Spatial sense includes visualization, mental imaging and spatial consideration. This ability is the main focus needed in understanding mathematics. Likewise, spatial sense allows students to distinguish and interpret 3-D and 2-D, represent and identify their relationship into mathematical standards.

Wheatley & Reynolds (1999) state that developing spatial sense is as important as developing number sense. It is stated in curriculum documents and in NCTM for Mathematics (1989) that possessing a strong spatial sense allows students to develop image-based solutions for mathematical problems. Ontario's Curriculum for grade 1-8 (Ontario, 2005b) states that spatial sense is one's intuitive awareness towards the environment and objects contained in it. Geometry helps us to represent and picture the objects and their relationship in a room. A strong sense of spatial relationship and competence in utilizing geometrical concepts and language can increase students' understanding of numbers and measurement. Likewise, *New Jersey Mathematics Curriculum Framework* (1996) defines spatial sense as an intuition of shape and space which involves traditional geometry concepts, as well as the ability to recognise, visualize, represent and modify geometrical shapes.

Based on the aforementioned definitions, it is concluded that spatial sense is an intuitive awareness about shape and space which requires the understanding of geometric concepts as well as the ability to understand, visualize, describe, see objects from different perspectives and transform geometrical shapes.

Computer-Based Mathematics Instruction

Computer-based mathematics instruction is defined as a learning program that uses computer software (in the form of a CD- Compact Disc) that contains lessons consisting of title, purpose, learning materials and evaluation. The aforementioned explanation is in line with Heinich *et al.*

(Rusman *et al.*, 2012) who states that the computer system is able to deliver the learning materials individually and directly towards the students by interacting with the computer-programmed learning materials which is called computer based mathematics instruction.

Rusman *et al.* (2012) argues that there are four computer-based learning models, which are (1) drilling model, (2) tutorial model, (3) simulation model, (4) instructional game model. Similiarly, Coburn (Herlan, 2006) elaborates that there are five computer-based learning models which include 1) drill and practice, 2) tutorial, 3) demonstration, 4) simulation, and 5) game. Furthermore, Glass (Dahlan, 2009) states that there are several computer-based learning models, such as drill and practice, tutorial, games, simulation, discovery, and problem solving.

Based on this discussion, in this study, the researcher combines the computer-based learning models of drill and practice, tutorial, simulation and discovery.

Computer-Based Interactive Multimedia Instruction

Wijaya (2010) defines Multimedia as a combination of two or more input and output media. The media can be audio (sound, music), animation, video, texts, graphics, and pictures. Munir (2012) has a more comprehensive definition of multimedia that is the combination of several media such as, texts, picture, video and animation in one digital media with interactive capability to send indirect feedback and information. Further, Hofstetter (Munir, 2012) defines that multimedia in computer context is presenting and merging texts, sounds, picture, animation, and video by computer with tool and link, where the user can navigate, interact, work and communicate.

Regarding the above discussion, it can be concluded that multimedia is a combination of several media (file format) form such as texts, pictures, graphics, sounds, animations, videos, and interaction which has been bundled in digital file (computerized).

The definition of interactive is related to two ways or more of communication components. The communication component in interactive multimedia learning (Computer-based) is the interaction between human (as a user) and computer (software/application/ several forms of file format, usually CD). Therefore, the product/CD/application is expected to have capacity for feedback between software/application with the user (Hariyono, 2010).

The learning program using multimedia should be in line with goals and needs. That uniformity criteria of application, said Sadiman, *et.al*. (1993), must connect the aims of the learning program, the student's characteristics, learning stimulus that is used (audio, visual, animation), background or circumstances, neighborhood, and the service range. Thereby Multimedia is able to develop the student's ability in smart thinking (for example, problem solving, spatial sense, making decision, and else) and indirectly enhance skills of computer use (Fryer, 2001).

Based on the explanation above, the definition of Computer-Based Interactive Multimedia Instruction program in this study, is the learning program that uses media such as texts, pictures, sounds, animation, and interaction that is bundled as a computer software (learning CD) containing learning material such as: title, aim of study, learning material, and evaluation.

Based on the aforementioned background, the research questions of this study are as following:

1. Is the enhancement of students' spatial sense ability in computer-based interactive multimedia instruction higher than those learning in conventional instruction, in terms of a) general; b) school levels (high and middle); c) prior mathematical skills (low, middle, high levels) ?
2. Is there any interactional effect between learning (CBIM and CVL) and school

level towards students' spatial sense enhancement?
3. Is there any interactional effect between learning (CBIM and CVL) and prior mathematical skills (low, middle, high) towards students' spatial sense enhancement?

Research Method

This study is an experimental research in quasi form (quasi experiment). Therefore, the sample subject is not a random choice. The sample subject is the learning group within their assigned classes. The sample is not random as this would be difficult and disrupt teaching activities. This study engages with schools of two ranking levels (high and middle) and student's KAM factor (high, middle, and low). The school level categorization prescribed based on the classification by the local Education Office - Ministry of National Education, based on the national examination ranking, which resulted with two different levels of school ranking - high and middle as the sample subjects of the study. School selection is based on a cluster technique approach.

The study involves two classes, the experiment class and the control class. The experiment class is utilizes Computer-Based Interactive Multimedia Instruction (CBIM), while the control class utilizes conventional learning (CVL).

The conducted research design is *Pretest and Post-test Control Group Design* (Ruseffendi, 2005). Briefly, the conducted research design can be defined as below:

O *X* *O*

O *O*

Explanation:

X : Computer-Based Interactive Multimedia Instruction (CBIM)

O : pretest and post-test of *spatial sense ability*

Result and Discussion

Result of the Study

Analysis of Spatial Sense Ability Enhancement after Learning (CBIM and CVL)

Table 1 shows that the probability value or *Sig*. (*1-tailed*) is smaller than α = 0,05, so H_o is rejected. Thereby, students with CBIM learning have significantly higher than average enhancement of spatial sense rather than CVL's students.

Analysis of Spatial Sense Ability Enhancement after Learning Programs (CBIM and CVL) based on School Level

The result of the Anava pretest based on school level (shown in Table 2) shows that a higher significant value than 0.05 or p (*sig*) > 0.05 was attained. This means that there is no significant difference of the student's spatial sense enhancement average score between high ranking school and the middle ranking school levels. In other words this indicates that the student's spatial sense ability between higher level ranking school and the middle ranking level school is almost equal.

Analysis of Spatial Sense Ability Enhancement after Learning (CBIM and CVL) Based on Student's KAM

The result of two way Anava test based on school ranking level in Table 3 shows that significant value 0,002 is smaller than 0,05 or p (*sig*) > 0,05 which means that there are significant differences in the student's spatial sense enhancement with average scores between high, middle, and low KAM. In order to see which KAM is significant, the after test of ANAVA (post research) is conducted as shown in Table 4.

Table 1
Differentiation Test of the Student's Spatial Sense Enhancement Of Both Learning Groups

Learning Group	n	Mean	t	Sig. (1-tailed)	H_0
CBIM	79	0,6275	8,504	0,00	Rejected
CVL	81	0,4248			

Table 2
Pre-test ANAVA on N-Gain Spatial Sense Based on School Ranking Level

Source	Type III Sum of Squares	df	Mean Square	F	*Sig.*	H_0
Intercept	44.271	1	44.271	1938.171	.000	
Learning	1.647	1	1.647	72.108	0.000	Rejected
School Level	0.002	1	0.002	0.093	0.760	Accepted
School Level Learning*	0.023	1	0.023	1.004	0.318	Accepted
Error	3.563	156	.023			
Total	49.310	160				

Table 3
Two way ANAVA on N-Gain Spatial Sense Based on student's KAM

Source	Type III Sum of Squares	df	Mean Square	F	*Sig.*	H_0
Intercept	30.092	1	30.092	1405.064	.000	
Leraning	1.049	1	1.049	48.966	0.000	Rejected
School Level	0.277	2	0.139	6.473	0.002	Rejected
School Level Learning*	0.023	2	0.011	0.531	0.589	Accepted
Error	3.298	154	.021			
Total	49.310	160				

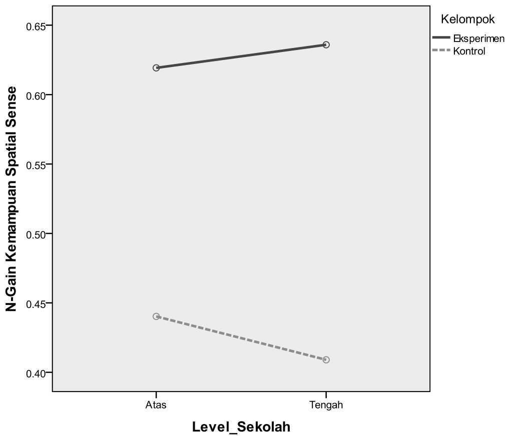
Table 4
Spatial Sense Enhancement Post Research (Tukey) Test Based on KAM and Learning

(I) KAM	(J) KAM	Mean Diference (I-J)	Sig.	H_0
High	Middle	0.1235	0.001	Rejected
	Low	0.1153	0.015	Rejected
Middle	High	-0.1235	0.001	Rejected
	Low	-0.0081	0.962	Accepted
Low	High	-0.1153	0.015	Rejected
	Middle	0.0081	0.962	Accepted

In Table 4, the results show significant difference of spatial sense enhancement occurs between high KAM and middle KAM, and also high KAM and low KAM.

Analysis of Interaction Effect between Learning (CBIM and CVL) and School Level to Spatial Sense Enhancement

The interaction between learning and school ranking level to student's spatial sense can be found by analyzing the data of school level (high and middle) in learning (CBIM and CVL) through ANAVA's two way test (pre and post tests). According to table 2, the data shows that the interaction between learning and school ranking level in F is 1,004 with significant value by 0,318. This significant value is bigger than prescribed significant level by 0,05. It means that there are no interactions between the school ranking level and the learning program to student's spatial sense enhancement. This result indicated that in a simultaneous way, school ranking level and learning program have no significant effect to student's spatial sense enhancement. The interactions between KAM and learning program to student's spatial sense can be seen on Figure 1.



Analysis of Interaction Effect between Learning and KAM toJ Spatial Sense Enhancement

The interaction between learning and student's KAM (high, middle, low) to student's spatial sense can be found by analyzing the KAM data (high, middle, low) in learning (CBIM and CVL) through ANAVA's pre and post testing. According to Table 3, the data shows that the interaction between learning and KAM in F is 0,531 with significant value of 0,539. This significant value is bigger than prescript significant level by 0,05. It means that there are no interactions between KAM and learning to student's spatial sense enhancement. This result indicates that in simultaneous way, KAM and learning activities have no significant effect to student's spatial sense enhancement. In graphic, the interactions between KAM and learning activities to student's spatial sense can be seen on Figure 2.

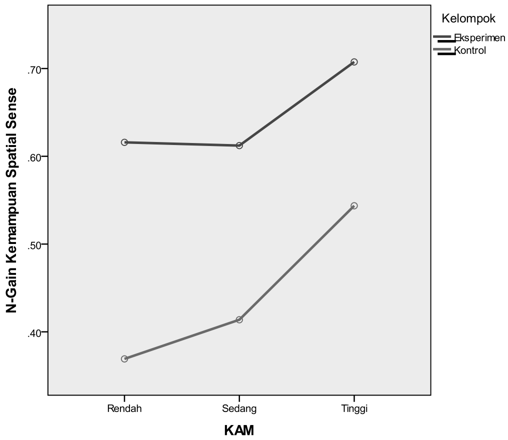


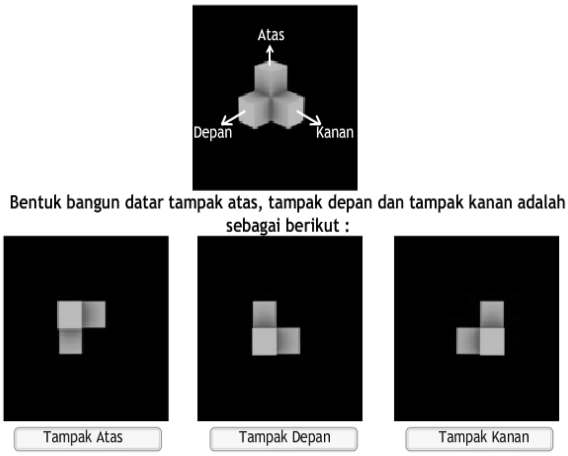
Figure 2: Interaction between Learning and KAM to student's Spatial Sense Enhancement

Figure 2 shows that all students in KAM (low, middle, high) with CBIM learning (experiment group) have higher enhancement of spatial sense rather than CVL's students (control group). If it is arranged orderly, from the smallest to the biggest, based on the average of the student's enhancement of spatial sense with CBIM learning, the composition are Low KAM, middle KAM, and high KAM. The data also equal for the CVL's students that composed of low KAM, middle KAM, and high KAM.

The similarity of composition order of the average of student's spatial sense enhancement in KAM category (low, middle, high) between CBIM and CVL learning indicated that there are no interaction between learning (CBIM and CVL) and KAM (low, middle, high) to student's spatial sense enhancement. Another indication that can be seen that the average differentiation of student's spatial sense enhancement with

CBIM learning program and CVL's student in low KAM category is almost equal with middle and high KAM students.

The result suggests that students with CBIM learning activities have significantly have higher spatial sense enhancement on average compared with CVL students. This is because CBIM is able to facilitate the students to improve their spatial sense better through its presented features. One of the CBIM's features that can help to improve spatial sense ability is the interactive animation and 3D video about *Bangun Ruang Sisi Datar* - Building a Room with Flat Sides. Below are the pictures of one of the video in CBIM about object point of view from the top, front and right sides if the spatial model is identified.



Based on CBIM learning, it is possible for the students to improve their spatial sense ability, because they are given the activities which can develop their spatial senses. This is in line with Van den Heuvel & Buys's (2005) conception that geometry activities would stimulate children abilities in sharpening and developing their perceptions that, as a result, would help to improve children's spatial sense and the way of thinking. CBIM learning, based on school level, shows no significant differences in the enhancement of ability of students' spatial sense. One of the findings in this study is that the school ranking level factor shows no significant differences in varying the enhancement of ability of students' spatial sense. The spatial sense average enhancement of high ranking level school students is almost equal with middle ranking level school students. This means that the student's spatial sense enhancement is not affected by school ranking level factors. Therefore it can be concluded that any student in any school level would get same advantages from the learning program. The effect of CBIM learning activities to enhance student's spatial sense also occurred in every KAM (high, middle, low). The spatial sense average enhancement for every KAM category (high, middle, low) with CBIM learning is higher rather than CVL students. Another finding of this study suggests that in KAM has a significant effect on student's spatial sense enhancement. This is implying that besides the learning factors, KAM also delivers significant effect to the differences of student's spatial sense enhancement. To find in which KAM the differences of spatial sense enhancement is occur, the Post (Tukey) test is conducted. The result suggests that the differences of student's spatial sense enhancement are significant, occuring between high KAM and middle KAM, and also high KAM and low KAM. This means that the enhancement of student's spatial sense with high KAM is better than middle or low KAM, while middle and low KAM is equal. This finding suggests that there are other factors that also influential, that is student's KAM. Therefore, in order to optimize the student's spatial sense, the teacher is suggested to observe student's KAM before the teaching session started. The statistic test shows that there are no interactions between (CBIM and CVL) learning and school level (high and Middle) to student's spatial sense enhancement. In general, the learning (CBIM and CVL) and school level have no significant enhancements of spatial sense ability. The differentiation only carried by the learning program. In other words, the learning factor is not depending on the student's school level. So, the teacher does not have to observe student's school level. The study also shows that there are no interactions between (CBIM and CVL) learning and KAM (high, middle, low) to student's spatial sense enhancement. It means that simultaneously, the learning (CBIM and CVL) and KAM has no significant effect for the differentiation of student's spatial sense enhancement. The differentiation only carried by the learning factor. Therefore, the learning factor is not depending on student's KAM factor.

Conclusion

The results of the study suggest that: (1a) in general, the student's spatial sense is enhanced with Computer-Based Interactive Multimedia Instruction, rather with conventional learning. (1b) in school level (high and middle), there are no significant differences in the enhancement of ability of students' spatial sense between high and middle level students. (1c) According to KAM (high, middle, and low) there are significant average enhancements of spatial sense ability between high, middle, and low KAM. The differences occur between high KAM and middle KAM, and also between high KAM and low KAM. (2) There is no interaction of effect between learning (CBIM and CVL) and school level to the enhancement of ability of students' spatial sense. (3) There is no interaction of effect between learning (CBIM and CVL) and KAM to the enhancement of ability of students' spatial sense.

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