Integration of Video Tutorial Screencast Sketchup Make (VTS-SUM) To Enhance Students' Visual Spatial Skills

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Abstract

Problems in learning 3-dimentional Geometry are related to a low level of visual spatial skills. The purpose of this study is to test a learning approach, using video tutorial screencast SketchUp Make, or VTS-SUM. The approach combines screencast video and 3D software for topic Plans and Elevations. SketchUp Make is a free 3D software, which can be downloaded from the internet. Using this software, students were trained to rotate, view, transform and cut objects, using tools provided to enhance their visual spatial skills, before drawing the plan and elevations of the objects. The video tutorials demonstrate steps in using the software. The study involved a total of 54 Form-Three high achievers, 25 of whom were male and 29 female. The study was conducted for six weeks using a quasi-experimental single group design, in the form of pre-posttest. The instruments used for this study were selected from visual spatial mental tests and the data obtained was analyzed, using paired sample t-test. The results showed that, there were significant differences in the mean scores of visual spatial skills, before and after learning via VTS-SUM ($t=26.87$; $p<0.05$). Hence, learning via VTS-SUM proved to be effective to enhance the students' level of visual spatial skills.

Keywords**:** video screencast, SketchUp Make, visual spatial skills, Geometry, VTS-SUM, Plans and Elevations

INTRODUCTION

Problems in learning Geometry among Malaysian students are evident in their poor performance in the subject. Ministry of Education (MOE) participated in Trend in International Mathematics and Science Studies (TIMSS) to measure Malaysian students' knowledge of skills compared to other countries [1]. TIMSS is an international assessment organized by the International Association for the Evaluation of Educational Achievement, the United States of America for mathematics, science, and reading, conducted on 14-year-old students every four years. The report from TIMSS 2019 showed that, the students' level of Geometry is below the standard level [2]. Similarly, another report for TIMSS 2015 also stated that, students were poor in the concepts of Geometry [3]. Therefore, there is a need to find ways to increase students' scores in Geometry. Students' problems in learning Geometry have been associated with their low level of geometrical thinking [4, 5]and visual spatial skills [6, 7]. According to [7], visual spatial skills (VSS) relate to the ability to mentally rotate the object, view the object from any angle, transform the object from 3D to 2D and cut the sides of the object. In practice, teachers prefer to use 3D blocks and draw 2D images of the 3D objects on the whiteboard [6]. This strategy is inefficient to generate students' level of VSS as they fail to visualize the properties of the 3D objects in their minds [8, 9]. Students will learn the concepts by memorizing rather than constructing the concepts on their own [10].

LITERATURE REVIEW

VSS

VSS is a pertinent factor to be considered by educators, because it involves not only low-achieving students [11], but also their high-achieving peers [12]. Problems in learning Geometry at the secondary school level result in a low number of students interested to take up science and technical courses at the university level[13]. This definitely does not support the vision of the MOE to produce more technical experts for the country, as stated in the educational blueprint [1]. Since 3D is also important in their future careers [14], students should be motivated by teachers to gain the mastery of Geometry at the secondary school level. Some researchers had recommended using 3D manipulative software such as SketchUp Make to teach concepts of Mathematics [6]. [11, 15, 16]. This special software can be downloaded from the internet for free. Besides being user friendly, it provides the right tools that are needed for students in learning Geometry. Studies showed that SketchUp Make supported learning Geometry for 2D [[6], [17]and 3D, [11]. In addition, MOE encourages teachers to integrate ICT in teaching and learning via blended learning. However, there are problems encountered when using ICT in teaching and learning, for example, students' difficulties in learning new tools in the new software, as they cannot remember all the steps in using the tools [18]. Teachers too are having difficulties teaching students with different competency levels of ICT [19].

Screencast Video

Screencast technique is an application that can be used to overcome the problems faced by students and teachers in using software [20]. It is a recorded video that captures the movements of the pointer on the computer's screen using a software . Hence, the video consists of steps in doing a task. Screencast videos are widely used in education, including in the teaching and learning of Mathematics [11],[18].[21]. Topic Plan and Elevations was chosen for this study as it has high VSS [11]. The learning objectives for this topic are drawing orthogonal projection and drawing plan

and elevations for the 3D objects. This topic is under Chapter 7 of the form 3 textbook. It was identified that, students were having difficulties in this topic, such as incorrectly drawing the orthogonal projections for the objects and being unable to draw dashed lines for any hidden lines in the 3D objects [22]. Not much study in Malaysia related to geometry has been conducted for high achievers at upper secondary schools regarding VSS using screencast video. The purpose of this study is to investigate the impacts caused by VTS-SUM on the enhancement of visual spatial skills among form 3 high achievers for topic Plans and Elevations.

VTS-SUM

VTS-SUM is a learning approach that integrates video screencast video, SketchUp Make and visual spatial skills. These components are identified to be in the first layer (L1) in the lifecycle of VTS-SUM as shown in Figure 1. In order to produce the screencast video, Camtasia Studio was chosen as it is the best software for screencasting[23]. In addition, it provides special effects, such as callouts and zoom-n-pan to the video. These effects are essential to produce video tutorials that engage students with learning. Besides, four visual tools in SketchUp, namely, orbit, position camera, standard view and section cut, that support visual spatial skills, were selected. These tools, in the same order, correspond to rotating the object, viewing the object from different angle, transforming the object from 3D to 2D and to cutting the surface of the object, respectively. Meanwhile, the second layer (L2) is developed based on five stages of ADDIE model. At the analyze stage, learning objectives and problems in learning Geometry are highlighted. Moreover, learning outcomes, storyboard, special effects for screencast video and visual tools are emphasized at the design stage. At this stage, prototype and draft for the module of VTS-SUM are developed. There are eight activities in the module related to the learning objectives and each of the activities are supported by screencast videos. At the implementation stage, the pre- and post-tests are conducted to test the level of VSS, while the prototypes for the video and module are modified, based on the findings at the evaluation stage.

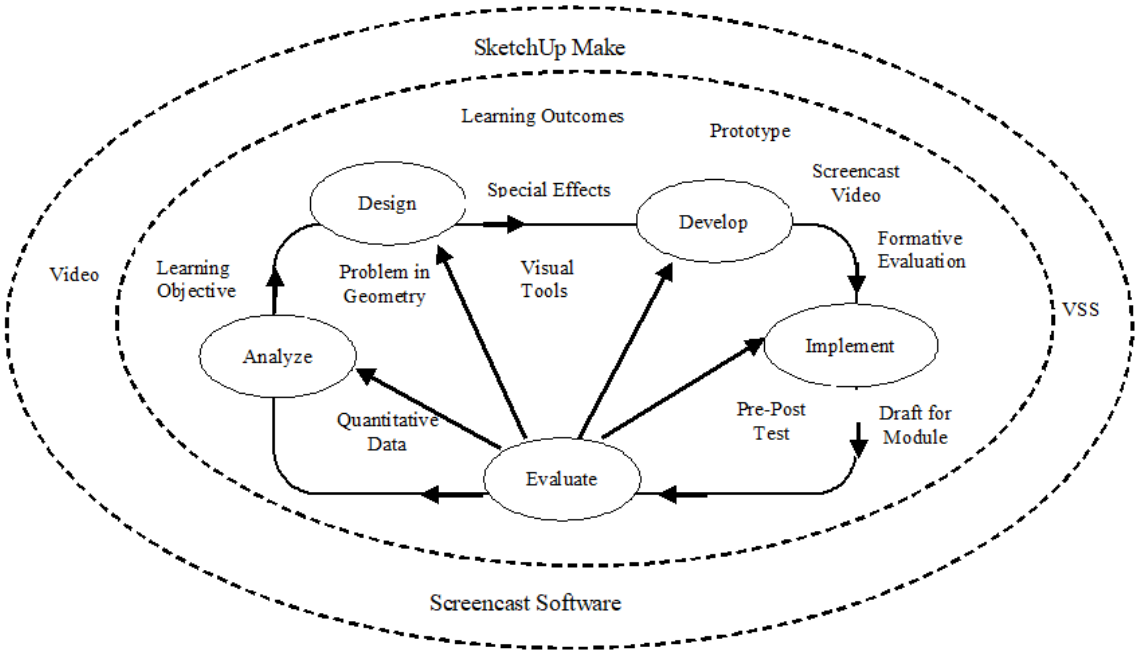

Figure 1. Lifecycle of VTS-SUM

A screencast video is developed for each of the activities in the module. Each video has two parts, namely, Part 1 and Part 2. Part 1 is the beginning of the video that shows steps in using the visual tools in SketchUp Make. This video will help the students to visualize the properties of the 3D objects. Besides, the video also assists them to have a hands-on experience in using the software. They can click 'pause' button at the video player to stop the video. This mode of teaching is in-line with the self-paced learning concept that permits students to construct knowledge on their own [16]. Special effects, such as callouts with text are used to guide students in using the tool. Part 2 focuses on the task that relates to the learning objectives, where students learn to use another set of tools in SketchUp Make to complete a task, for example, drawing a plan for a 3D object. The first tool is 'tape measure' that is used to draw the orthogonal lines. Special effects which are embedded in the video aid students in drawing the line correctly. The second tool that is selected for drawing is 'line tool'. By the end of the lesson, the students are expected to be able to explain why 'dashed lines' are used to represent the hidden object in drawing the plan for the object.

METHODOLOGY

The study involved a total of 54 form three high achievers, 25 male and 29 female. High achievers were selected for this study as majority of them were also having low level of VSS. The study was conducted for six weeks using a quasi-experimental single group design, in the form of pre-posttest. The pre-test was given before the students learnt the topic and the post-test was given after they used VTS-SUM. The average score for each of the four components of VSS discussed earlier was computed and converted into percentage. The students' scores for each component of VSS test were based on the number of correct answers. The instruments used in this study to measure the level of students' VSS have been used widely by other researchers, such as [24-26]. In this study, PSVT:R-Purdue Spatial Visualization Test is used for rotating the object, PSVT:V-Purdue Spatial Visualization Test is used for viewing the object from different angles, MCT-Mental Cutting Test is used for cutting the surface of the object and T3D2DT Transformation for 3D to 2D Test is used for transforming the object from 3D to 2D.

RESULTS AND DISCUSSION

Means for Pre-Post-Test for Each Component of VSS

As shown in Figure 2, for pre-test, the means for rotation and mental cutting test were in the weak category, while the means for view and transformation tests were in the moderate category. After the intervention, the means for all post-test were in the good category and the lowest mean for post-test was mental cutting test. This showed that, the most difficult component in VSS is mental cutting. The findings also indicate that, VTS-SUM successfully increased the mean score for all components of VSS.

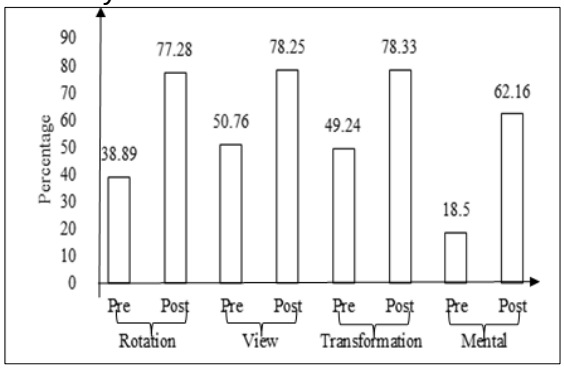

Figure 2. Means for pre-post-test for each component of VSS

Pre-test and Post-test for VSS

The data obtained was distributed into four categories, based on the marks scored: Low (0% -39%), Moderate (40% - 59%), Good (60%-79%) and Excellent (80%-100%). As shown in Table 1, for pre-test, majority of the students (81.4%) were in the low and moderate categories, 18.6% were in the good category and no student achieved the excellent level.

Table 1

Pre-test and post-test for VSS

Level of VSS	Pre				Post			
	N	Score Mean	Minimum % Score	Maximum % Score	N	Mean Score	Minimum % Score	Maximum % Score
Low	21	29.0	12.8	35.9	0	0	0	0
Moderate	19	43.2	34.6	52.6	0	0	0	0
Good	14	70.0	51.3	69.2	34	69.42	61.5	78.2
Excellent	0	0	0	0	20	87.24	80	100
Overall	54	42.3	12.8	69.2	54	76.0	61.5	100

In contrast, for the post-test, majority of the students (63%) were in the good category, 37% achieved the highest level, and none was in the low and moderate categories. Thus, this showed that much improved results were achieved in the post-test. In addition, the study found that, the mean of VSS after learning via VTS-SUM was 76.0, an almost 75% improvement from the prior mean value of 42.3. The mean for the pre-test was at a moderate level but it increased to a good level for the post-test.

Overall findings for each component of VSS

The overall findings for each component of VSS is shown in Table 2. The overall findings showed that, there were significant differences in mean scores of VSS, before and after learning via VTS-SUM for rotation test, view test, transformation test and mental cutting test at ($t=21.11$; $p<0.05$), ($t=15.26$; $p<0.05$), ($t=10.52.11$; $p<0.05$) and ($t=21.72$; $p<0.05$), respectively. Thus, VTS-SUM was successfully proven to enhance VSS among the students.

Table 2

Overall findings for each component of VSS

Instruments for VSS	Mean	SD*	t	Sig. (2-tailed)	Cohen (d)	r
RT*	38.39	13.36	21.11	0.00	2.83	0.78
VT*	27.48	13.24	15.26	0.00	1.59	0.62
TT*	29.07	20.31	10.52	0.00	1.17	0.65
MCT*	43.66	14.78	21.72	0.00	3.71	0.88

RT* = Rotation Test, VT* = View Test, TT* = Transformation Test, MCT*= Mental Cutting Test, SD* = Standard Deviation

Paired t-test for VSS

Paired t-test was performed in this study to verify that significant differences were found before and after learning via VTS-SUM, as shown in Table 3. Prior to that, normality tests were carried out to confirm the normal distribution of the pre-post data for VSS.

The findings showed that, there were significant differences in mean scores of VSS, before and after learning via VTS-SUM (t=26.87; p<0.05). Thus, the application of VTS-SUM was successfully proven to enhance VSS among the students.

Table 3

Paired t-test for VSS

	Paired Differences					t	Degree of freedom	Sig (2-tailed)
	Mean	Standard Deviation	Standard Error Mean	95% Confidence Interval of the Difference Lower	Mean Upper			
Post-Pre	33.73	9.23	1.26	31.22	36.25	26.87	53	0.00

The outcome of this finding was consistent with those of other studies which showed that, technology-based-learning had positive effects to students in secondary schools[10, 27-29]. Another factor that affects the students is the usage of the screencast video that provides solution for them in learning new software [25]. Besides that, by doing hands on activities using the tools in SketchUp Make, can affect the students too. They will be able to construct the concepts of Plans and Elevations on their own. Furthermore, they can view the process of transforming from the 3D solid object to 2D image using the transform tool. They also can see the hidden lines in the object by using the cut tool. Hence, this finding is supported with other studies that showed that SketchUp Make could enhance the level of VSS[22, 24, 30, 31]. Similar findings about the integration of screencast video with SketchUp Make which increased the level of VSS had been conducted by and [3, 11, 32] but both studies were done for low achievers. Thus, this proves that, the learning approach using VTS-SUM is appropriate for both low and high achievers.

CONCLUSION

VTS-SUM is a learning approach which combined screencast video, SketchUp Make and visual spatial skills. It trains the students to mentally rotate the objects, view the objects from different angles, transform the object from 3D to 2D and cut the sides of the object. By doing so, they will be able to visualize an object before drawing its plans and elevations. Furthermore, they will be able to construct the geometrical concepts on their own.

It was proven in this study that, learning via VTS-SUM successfully elevated the students' level of visual spatial skills for topic Plans and Elevations, taught in Form 3 Mathematics. Based on remarkable results achieved, it can be concluded that VTS-SUM is highly potential to be implemented in the Geometry teaching and learning process and its usage can be further investigated for other related purposes. This research is conducted for high achievers' students in a secondary school in Malaysia, to test their level of visual spatial skills for a topic of 3D Geometry in Mathematics, which is called Plans and Elevations. In future, the group of researchers would like to expand this learning strategy to other topics in Geometry, not only for mathematics, but also for other subjects that are related to Geometry.

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