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An Action Research on The Effect of Using Real Modeled Object in Teaching Orthographic Drawing Concepts on Students' Performance

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Abstract

Computer-Aided Design (CAD) has become a common tool used by educational institutions in teaching engineering drawing. Although more practical, learning that relies too heavily on CAD can lead to a decrease in students' ability to visualize and interpret technical drawing objects. This study will examine the integration of CAD in technical drawing education with the use of real model objects in the orthographic drawing and its impact on students's performance. The study employed a three-step data collection approach, including a pre-test, intervention, and post-test, as well as a questionnaire to determine students' perceptions of the learning process. The study participants were fifteen fourth-grade high school students from SMA Seri Aman, Kota Tinggi. The students had previously been taught orthographic drawing and had prior knowledge of the subject matter. Based on the regression testing results, a p-value of 0.00 <0.05 was obtained, indicating a significant relationship between real modeled object learning and students' learning performance. Additionally, based on the average scores, there was an improvement in each phase, with pre-test scores of 4.46 and post-test scores of 8.40, indicating that the use of real modeled objects significantly improved learning outcomes compared to conventional learning models in orthographic drawing materials.
Keywords: orthographic drawing, real modeled-learning, students' performance

Abstrak

Computer Aided Design (CAD) telah lazim dipakai oleh institusi pendidikan dalam materi pembelajaran gambar tehnik (*engineering drawing*). Walaupun lebih praktis, pembelajaran yang terlalu bergantung pada CAD akan berdampak pada menurunya kemampuan siswa untuk memvisualisasikan serta menginterpretasikan objek objek gambar tehnik. Penelitian ini akan menguji pembelajaran gambar tehnik yang mengintegrasikan CAD dengan pengunaan objek model nyata dalam menggambar ortografi terhadap hasil belajar siswa (*students' performance*). Studi ini menggunakan pendekatan pengumpulan data tiga langkah termasuk pre-test, intervensi, dan post-test, serta kuesioner yang mencoba mengetahui persepsi siswa tentang proses belajar. Responden penelitian terdiri dari lima belas siswa menggambar teknik dari kelas empat di SMA Seri Aman, Kota Tinggi. Siswa telah diajarkan menggambar ortografi sebelumnya dan mereka memiliki pengetahuan dasar sebelumnya tentang materi pembelajaran. Berdasarkan hasil pengujian regresi diperoleh nilai *p-value* sebesar 0.00 <0.05 yang berarti hipotesis yang menyatakan terdapat hubungan antara pembelajaran *real modeled object* terhadap performa belajar siswa. Selain itu, berdasarkan perhitungan nilai rata-rata menunjukkan bahwa terjadi peningkatan pada setiap fase, *pre-test* 4.46 dan *post test* 8.40 mengindikasikan bahwa pembelajaran menggunakan *real modeled object* secara signifikan meningkatkan hasil belajar dibandingkan penggunaan model belajar konvensional pada materi *orthographic drawing*.
Kata kunci: orthographic drawing, real modeled learning, hasil belajar siswa

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INTRODUCTION

The development of models for teaching engineering drawing in schools at both the secondary and tertiary levels has continually evolved over the years (Kosse & Senadeera, 2011). Many such models have been developed, ranging from traditional approaches (such as hand drawing)

to more sophisticated approaches involving technology, such as Computer-Aided Design (CAD) tools (Fakhry et al., 2021). Research literature has revealed some noticeable successes with the use of these models over the years, but it does not suggest that these models are without flaws or limitations (Kosse, 2005). According to Kosse, (2005), these limitations are evident in the output and performances of engineers who were trained using approaches that involved only the use of technology tools, such as CAD software.

Engineering drawing is a means of fostering effective communication between engineers, technicians, and professionals involved in design and production (Martin-Erro et al., 2016). Its language is universal, simple, and clear and can be understood by all professionals involved in the design process. Teachers teach effective engineering drawing in schools by applying some form of existing model or intervention from established theories. However, Kosse (2005) stated that the intervention brought about as a result of the integration of instruction with technology may have caused institutions to overlook developing students' abilities in practical hand drawing. This is because, after all, the ability of the hand is the most important tool in drawing. Pallasmaa, (2009) argues that the hand is a bridge between the mind and the building. He further stated that while the overlying interdependence and emphasis on Computer Aided Design software packages for teaching engineering drawing have had successes and created different opportunities for designers (Guney, 2015); Gracia-Ibáñez & Vergara, 2016), they also have far-reaching consequences.

Kosse (2005) reported that students taught engineering drawing concepts using only CAD tools lagged the cognitive and psych motive ability to draw and interpret engineering drawing objects orthographically or in perspective views. This he further opined is a result of the absence of hand-drawing instructions. Students or professionals drawing or designing with CAD tools often have everything done for them simply by specifying and giving specific commands to the software. The implication of this is that they cannot visualize for themselves, thus making it difficult for them to interpret the details and specifications of drawing problems presented to them. It is also found that CAD have affect on students' creativity and enthusiasm (Dare-Abel et al., 2016). Thus, Kosse (2005) advocated for an instructional delivery system that integrate hand drawing instruction with the use of technology- where students are first taught to understand the concepts and underlying principles of engineering drawing with hand instructional approaches, and thereafter, the learning is reinforced and made vivid with the use of CAD tools.

in corroborating the views of Kosse (2005) and Kärkkäinen & Stéphan, (2013) stated that one major problem engineering drawing students lack is the ability to visualize objects presented to them when asked to draw in orthographic views. This statement is supported by a lot of empirical research (Ali et al., 2016; Ali et al., 2017). He further elaborated by stating that recent studies have shown a very high level of correlation between successes in engineering drawing and mathematics with visualization abilities and skills. Numerous research literature has revealed that having success in engineering is a function of developing one's visualization skill amongst other factors. Thus

Urdarevik, (2009) stated that developing adequate and relevant engineering drawing skills is dependent on the type of learning environment that students are exposed to. The question now becomes what learning environment and tools can be harnessed to bring about the development of these drawing skills?.

An attempt to provide answers to such questions is the goal of this study. The study attempts to determine the effect of using real modeled objects in teaching students orthographic drawing and projections. Urdarevik (2009) reports that there are known successes in the utilization of models in teaching engineering drawing. in addition, a study that has been conducted by Mohd Salehudin et al., (2019) involving 115 engineering drawing teachers in Malaysia found that the use of real modeled objects is one of the most effective methods in teaching engineering drawing. Therefore, the study would attempt to ascertain the effect of using real modeled objects in the teaching of orthographic drawing on students' performance. The impact would however be measured on the base on how effective the proposed model of teaching is and the results from assessment tests given to students.

METHOD

This study is classroom action research with a quantitative approach. The study utilized a three-step data collection process, which included a pre-assessment, a first post-assessment, and a post-intervention assessment, along with a perception questionnaire. The pre-assessment phase was employed to determine the students' prior knowledge, while the first post-assessment phase evaluated the effectiveness of the instructional delivery process. The post-intervention assessment was conducted two weeks later to compare the pre-test and post-test data. Lastly, a closed-ended perception questionnaire was administered to determine the students' perceptions of the new teaching model. All data collected were recorded for analysis. The participants in this study were fifteen engineering drawing students from Form Four at SMK Seri Aman Kota Tinggi. These students had previously been taught orthographic drawing and had a basic understanding of the subject matter. The study took place in a regular classroom setting, and the participants were assessed using formative evaluation techniques to determine the extent of the skills they had developed. This was done to give the researchers adequate feedback on which teaching model to adopt in teaching the students, to enable them to master the skill of orthographic drawing.

After the data was collected, it was processed using various methods. The data analysis methods used included frequency counts, percentages, means, and related sample t-tests. Frequency counts and percentages were used to analyze the participants' responses to the closed-ended questionnaire, while means and related sample t-tests were used to analyze the data from the pre-test and post-test categories.

RESULT AND DISCUSSION

The intervention Procedure

The teaching model utilized for the study was adapted from the general teaching model but was modified to fit the context of the subject matter. The structure of the model is presented below. According to Joyce & Weil, (2013), the general teaching model is a procedural guide for designing, implementing, evaluating, and improving instruction. This model can be applied at all levels of education, for all subject matters, and for any length of an instructional unit. The major proposition of the model is to improve and maximize the efficacy of students' achievement in relation with stated objectives. The general teaching model is based on the integration of technology in instruction and has been influenced by the works of Robert Gagne, Robert Glaser, and James Popham. The general teaching model has a bifunctional role: (1) as a means of guiding instructional designers and teachers through the major steps in designing and carrying out instruction and (2) providing an overall framework and structure with which teachers can view and study the teaching process (Ahmad, 1998; Miles & Robinson, 1971). The general teaching model comprises a linear interactive process that consists of four basic components, which include:

1. instructional objectives (what to teach?)
2. Pre-assessment (who am I Teaching?)
3. instructional procedures (how do I teach?)
4. Evaluation (how do I know I am effective)

The Selection and formulation of instructional objectives is probably the most crucial and essential step in the model. If the instructional objective following the model is utilized, it should be specified in behavioural terms which describes what the students should be able to do at the end of the unit of instruction. The pre-assessment stage is yet another important aspect of the general teaching model. It provides information about the characteristics of your learners in terms of cognitive, psychomotor, and affective domains. It is used when a teacher is about to begin a unit of instruction and is unfamiliar with what the studens already know- that is their skills, knowledge and attitude.the next step is the development of the instructional procedure, these includes a selection of appropriate strategies that allign with the objectives, selection of materials to be used in the delivery and an orderly arrangement of the instructional plan.in doing this, teachers answer the question of how to teach. Lastly, is the evaluation stage that determines how effective the instructional delivery had been and to what extent the stated behavioral objectives was achieved. Below is the adapted model that was utilized for the planning and development of the instructional plan.

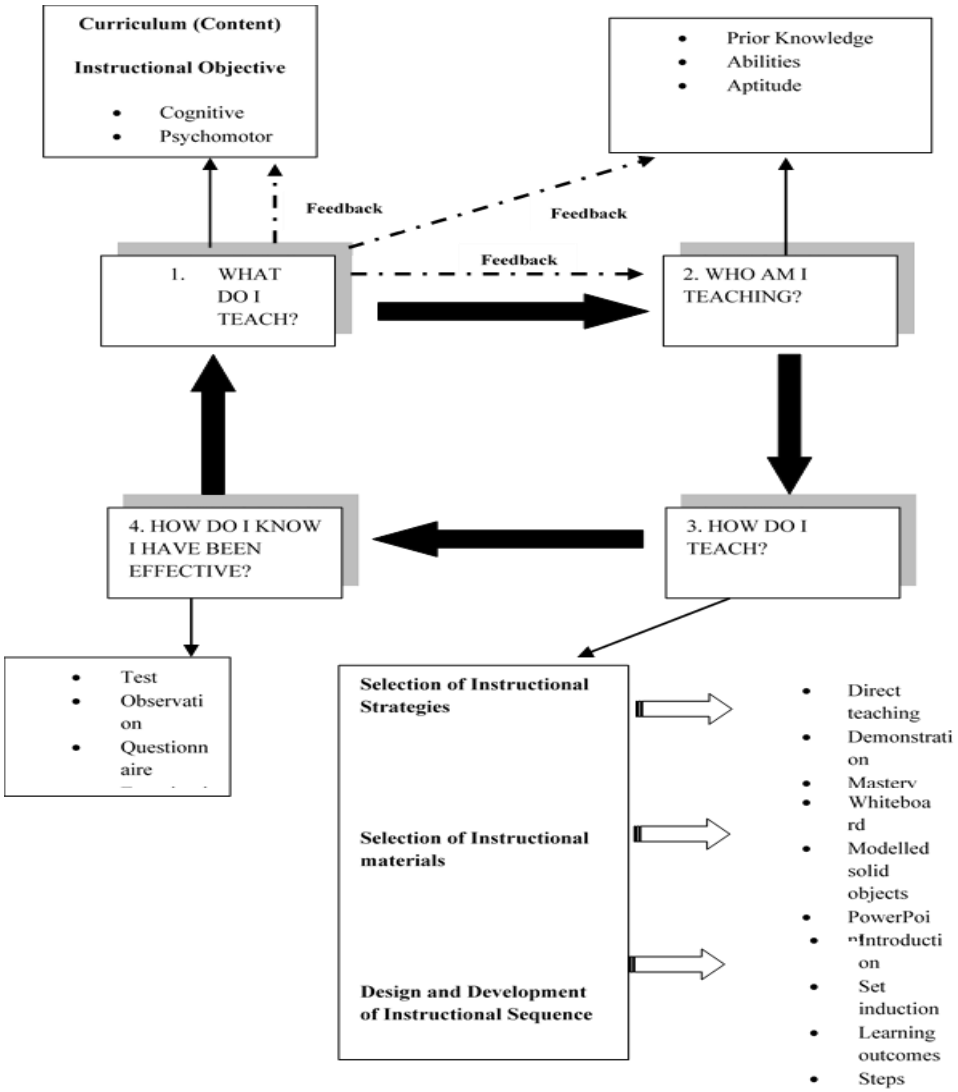

Figure 1. The general teahing Model

The model was adapted and restructured for developing the instruction used in the teaching of orthographic drawing in form four in a secondary school in Johore. The instructional objective focused on the development of cognitive and psychomotor. The cognitive objectives were focused on students' abilty to explain the concept of orthographic drawing as well as describe the importance of orthographic drawing as it relates to engineering applications. The psychomotor objective focused on teaching students how to draw and create orthographic views of solid 3-D objects.

The feedback gotten from the pre-assessment exercise revealed students' prior knowledge and abilities on the subject matter and this helped informed the teacher on how to select appropriate teaching strategies and materials for the instructional delivery process. The instructional strategy utilized for the lessons was direct teaching approach and demonstration, while the instructional materials utilized for the lessons includes, whiteboard, modeled solid shapes, and a powerpoint presentation. Details of the istructional steps and arrangment is provided in the lesson plan at the appendix section. The evaluation methods used to determine how effective the instructional process

was and the extent to which students were able to achieve the stated behavioural outcomes was carried out with assessment tools such as test and observation.

Effect of Real- Modeled Objects in teaching orthographic on Students' Performance

Table 1. Shows the mean distribution for the pre-test, post-test 1, and post-test 2

	N	Minimum	Maximum	Mean	Std. Deviation
Pre-test	15	2.00	9.00	4.6667	2.02367
PostTest1	15	5.00	10.00	8.3333	1.39728
PostTest2	15	7.00	9.00	8.4000	.82808
Valid N (list wise)	15				

Based on the data presented in the table, we can infer that the students' performance improved overall from the two post-tests. This conclusion is drawn from the mean scores obtained for the three different categories of scores. However, the analysis alone does not provide enough evidence to determine whether the difference in mean values between the pre-test and post-test is statistically significant. To address this question, we need to perform a related sample t-test to obtain more conclusive results.

Table 2. paired statistics for pre-test and post-test 1 group

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test	4.6667	15	2.02367	.52251
	PostTest1	8.3333	15	1.39728	.36078

Table 3 Sig (2-tailed) value for a paired sample test

		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Pre-test - PostTest1	-3.66667	2.19306	.56625	-4.88114	-2.45219	-6.475	14	.000

The results from table 2 and 3 shows the statistical analysis of the compared values of scores from the pre-test and post-test 1. Results from the analysis revealed that the mean value for the pre-test scores was 4.67 and the mean value for the post-test1 scores was 8.33. The sig (2-tailed) or the p-value was 0.00 which is less than 0.05 α value, because $p < 0.05$, we reject the H0. Therefore, it indicates that there is a statistically significant difference between the Pre-test and Post-test1 scores of the students. Hence, this implies that the extent of the difference between the pre-test and post-test1 scores for the group can be determined from the mean of both groups. Since the pre-test (μ_1) scores have mean value of 4.67 and the post-test1 has a mean value of 8.33, it indicates that the teaching model using real modeled objects has significant effect on students' performance than the traditional method in learning orthographic drawing.

Table 4. Paired statistics for pre-test and post-test 2 groups.

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test	4.6667	15	2.02367	.52251
	PostTest2	8.4000	15	.82808	.21381

Table 4 shows the mean analysis of both the pre-test scores and the Post-test 2 scores. From the overall mean scores in the distribution, it is shown that post-test 2 has a mean value that is greater than that of the pre-test scores. Hence indicating or predicting a significant difference. A further look at Table 3.b reveals the paired sample analysis using SPSS, since the sig (2-tailed) value is less than 0.05 α level, we reject the H0. This implies that there is a statistically significant difference between the pre-test scores and the post-test2 scores at the intervention phase. Hence, we conclude by stating that post-test 2 has a more significant impact on students' performance in learning orthographic drawing using real modeled object judging from the higher value of the mean for the post-test group. This result is consistent with several previous studies that also examined the image learning model using real modelled objects. For example, in a study titled "Effectiveness of 3D Solid Model on Improving Spatial Visualization Ability for Technical Drafting Students" by Valera et al. (2021), the use of actual three-dimensional objects was found to enhance students' spatial visualization ability.

Students' Perception about utilized model in Teaching orthographic

Table 5 Frequency and Percentage distribution of students' response to the perception questionnaire

NO	ITEMS	YES	NO
1.	Do you like engineering drawing?	14 (93.3%)	1 (3.7%)
2.	Do you find the teaching method used interesting?	15 (100%)	0
3.	Were you bored during the usual class activities?	15 (100%)	0
4.	Does the model use help you to remember orthographic concepts?	15 (100%)	0
5.	Was visualizing easy using the model?	15 (100%)	0
6.	Do you think the knowledge of orthographic drawing would be relevant for you in the workplace?	15 (100%)	0
7.	The teaching method used is clear and can help you solve orthographic drawing questions?	15 (100%)	0

The table above gives a summary of students' perception of the utilized model. Hundred (100%) percent of Students agreed to all the items in the perception questionnaire except for the first item with the score of 93.3%.

The Potential of Computer-Aided Design in Mathematics Learning

There are various studies showing that improving visualization skills using CAD can be beneficial in the context of learning mathematics. A study by J. Muminovic et al., (2023) revealed

that CAD can be used as a learning method in mathematics classes, especially in geometry. Various mathematical equations in geometry lessons can be converted into real objects using CAD, thus making students' understanding more profound. in addition, Tang & Yu, (2018) also proved that learning with CAD can improve students' achievement in mathematics. in their research, it was found that students with or without basic mathematics skills can use CAD, but students with basic mathematics skills tend to be able to maximize the use of CAD.

in the study entitled "Design Thinking in Mathematics Education for Primary School," Man et al., (2022) also assessed that in mathematics learning, the learning model should be designed to train students' analytical and critical thinking skills. According to their findings, this can be done, among other things, through geometry learning using 2D and 3D modeling.

Furthermore, a study conducted by Zhao & Chen, (2021) also found similar results. in their research, Zhao & Chen (2021) integrated CAD with mathematics learning, called "MathCAD." The result of this integration made mathematics learning in the classroom more meaningful. Students were able to develop a multi-perspective, multi-level, and multi-faceted understanding of concepts, deeply grasp the essence of concepts, and improve their mathematical thinking skills at the same time.

CONCLUSION

Based on the data obtained and analyzed, findings from the study revealed that students' overall performance in orthographic drawing improved significantly when compared to their previous performances using the traditional method of teaching. This implies that students can achieve more in engineering drawing subjects if they are taught using real modeled objects. The method utilized in the study enhanced their understanding of orthographic drawing concepts and they can adequately draw, interpret and communicate graphic information presented in orthographic projections. Also, based on the obtained data from the perception questionnaire, data analyzed revealed the following about students' perception concerning the model, include

1. The teaching method used was interesting
2. The teaching model was engaging and thus prevented them from being bored.
3. The model helped them to remember orthographic concepts more.
4. Visualization was made easy using the real-modeled objects.
5. The teaching model used was simple and clear and helps them solve orthographic drawing questions easily.

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