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The Development Of *Computer Aided Design* Learning Model In Civil Engineering Vocational Education Study Program In Universitas Negeri Semarang

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Abstract

Computer Aided Design (CAD) learning model in the Civil Engineering Vocational Education program in Universitas Negeri Semarang, especially 2-dimensional modeling, continues to be developed so that learning outcomes are accepted by the standards the business / construction services industry. Development of learning outcomes is inseparable from efforts to develop learning model that is used during the learning process. The development of learning models in this study focused on the development of learning methods, learning materials and CAD learning evaluation techniques. This study used the research and development using the Dick and Carrey design. The research sample was 34 students who took Computer Graphic course. The results showed that the three aspects: the development of methods, the development of teaching materials and materials and the development of evaluation techniques were categorized as excellent and very excellent. The CAD learning method was very suitable to be developed through conceptual learning methods, direct practice learning and case study learning. The use of this method was based on the needs faced in the classroom (situational). This means that the use of this method could be used at once, or varied according to the condition in the class. The use of learning equipment is one of the keys for successful learning development. The learning equipment developed in this study included the use of hand-outs, modules and supplements. The use of all three was very successful to support optimal learning outcomes. The use of all three was also aimed to facilitate the diverse learning needs of students. The development of evaluation techniques in learning included three domains: cognitive, psychomotor and affective domain. The cognitive domain was divided into two aspects: construction knowledge and the use of software. The development of evaluation techniques showed that the ability of students in each domain was in the excellent and very excellent category.

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INTRODUCTION

Civil engineering vocational education program of Universitas Negeri Semarang (UNNES) is one of the undergraduate programs in the Civil Engineering Department. The Civil engineering vocational education program aims to produce qualified graduates in the field of vocational education who have solid knowledge, attitudes, skills, competencies and ethics and have an entrepreneurial spirit in facing the era of globalization (Unnes 2015 curriculum).

One of the competencies that must be possessed by every graduate of the Civil engineering vocational education program is competence in the field of drawing and design, both manual drawing/conventional using manual drawing equipment or computer aided design. The courses support competence in the field of manual drawing is Drawing 1 and Drawing Building Construction Building Construction 2. While the subjects that support competence in the field of drawing with a computer *(Computer Aided Design* / CAD) is Computer Graphics 1 and 2.

The problem faced by Civil engineering vocational education program is the ability to innovate the development of CAD learning. This problem is in line with the reference stating that the problem of improving the quality of education basically lies in the willingness of education managers to innovate or renew (Djemari Mardapi, 2005: 72). According to Quisumbing as quoted by Djemari Mardapi, learning innovation is a dynamic innovation. The dynamic process in engineering study programs is caused by the demands of quality education that is always changing in accordance with the demands of society and the development of current science and technology. The dynamic process of education in the field of engineering, changes from being *"what is being taught"* to *"what is being learning"* (Mills and Treagust, 2003: 3).

Teaching method that has been used so far is more teacher-centered. In contrast, the future challenge is learning that emphasizes students' activity in learning *(student centered).* Shrank (2005) states that *"effective learning is supported by carrefully combined media that supports a learner-centered, real-world learning experience "* (Inchaurreguie, 2009: 4). Inchaurreguie (2009) also adds that learning must be able to integrate learning in the classroom with developments in the industry, especially learning to draw with CAD. This opinion is in line with the statement of the Head of the *School of Mechanical, Materials and Civil Engineering Royal Military College of Science Cranfield University* who argues that *"there should be a greater emphasis on computer-aided design"* (Reffold, 1998: 276) . This opinion is also corroborated by Paliokas (2009: 613) who argued that *"the teaching computer aided design (CAD) constitutes a major chalenge today. Designers from various academic disciplines (architect, engineerings, graphics designers, etc) who are more or less familiar with CAD technology seek more creative ways of expression".* The problem of learning to draw with a computer is that it must also involve learning that combines practical skills and technology so that the learning that is designed has an impact on the development of science and technology. Winn and Banks (2012) also argue that *"in design and technology pupils combine practical and technological skills with creative thingking to design and make products and systems that meet human needs. They learn to use current technologies and consider the impact of future technological development. "*

The problems in this study included: 1) analyzing the development of CAD drawing learning and 2) evaluating the results of developing CAD drawing learning model.

The objectives of the study were 1) as a basis for developing CAD learning model to help improve student learning outcomes and 2) to obtain an effective CAD learning model to be developed in the civil engineering vocational education program.

METHODS

This study employed research and development method. Research and development was directed at the development of learning. The research and development model used in this study was the model of Dick and Carrey. This model was intended to implement of instructional design principles that are adjusted to the steps which must be taken sequentially.

This study involved 34 second semester students who took Graphic Computer courses 1. The percentage of the proportion of students' previous education consisted of two major groups: those from vocational education (SMK) with expertise of building engineering drawing program were 40% and high school (SMA) were 46%. The rest was 9% from vocational education with the expertise that was still in line with building expertise, and 6% from vocational non-building engineering skills programs, such as Engineering Engineering, Audio Engineering, automotive Engineering, and others.

Data collection techniques were related to data sources. The data collection techniques used in this study consisted of test methods, direct observation, interviews and open and closed - ended questionnaires.

Data collection techniques with data sources from students consisted of tests, observations, questionnaires and interviews. The test instruments were in the form of a pretest and a posttest to test students' abilities in cognitive and psychomotor aspects. The instrument used for observation of students is the observation sheet. This observation sheet was used for descriptive data collection, such as assistance sheets. In addition, the questionnaire instrument used for students is a questionnaire sheet. This questionnaire sheet was used to collect data about students' learning styles and student responsiveness to the quality of learning, both in the form of lectures and lecture material. The interview sheet was used as an instrument for collecting data for students used during the implementation of assistance.

There are three techniques for collecting data for lecturers: observation, questionnaire and interview. The observation sheet was used as an instrument for collecting data about the teaching style of the lecturer. The questionnaire sheet was used as an instrument to collect data about lecturer responses during lectures. In addition, the interview sheet was used to obtain supporting data related to research.

The instruments of data collection used for media experts and instructional design experts were questionnaire sheets and interview sheets. The questionnaire sheet was used to express the opinions of experts in assessing the design of learning planned by the researcher. While the interview sheet was used to collect data related to planning or learning design.

The data analysis technique used in this study was differentiated based on the type of data obtained during the study. Most of the data analysis techniques used was descriptive data analysis techniques. Descriptive data analysis technique used is by comparing each item of data collected and compared to the total items collected. Furthermore, the results of comparing these data items were changed using measures of central tendency, such as percentage techniques, mean, standard deviation and others. This descriptive data analysis technique was used for data obtained from observation, questionnaires and interviews, both for students, lecturers and media experts and instructional design experts.

The assessment of the feasibility of learning design by media experts and instructional design experts must be assessed based on the level of feasibility. The level of feasibility of media design and the design of this learning can be seen on table 1.

Table 1. Categories of media design and instructional feasibility

Score	Level of eligibility
90 - 100	Very excellent
80 - 90	excellent
60 - 80	Recommended with repairs
<60	Not feasible and not recommended

RESULTS AND DISCUSSION

The results of the study focused on the development of CAD learning model. The development of CAD learning model in this study included the development of learning method, the development of teaching materials and the development of CAD learning evaluation techniques.

The development of CAD learning method was carried out in this study included three methods: the case study learning method, the learning method of concept mastery and practical learning methods. In general, the implementation of the three methods began with the lecture method which aims to explore the basic abilities of students, both in terms of cognition relating to construction and the use of the software.

The results of the study showed that the three methods used in the category were very excellent. The results of the assessment of a method pembe LAJ ran C AD look like in table 3.

Table 2. Results of assessment of CAD learning methods

	Components of the learning method			
	Competency standards	Method formulation	Use of media	Development of evaluation techniques
Media expert	95	93	96	91
Instructional design expert	92	90	89	92

The development of teaching materials was focused in the form of structured and customized CAD material presentation according to development needs. Furthermore, this study also developed teaching materials: handouts, modules and supplementary material. The handout was intended to be a basic reference for the master of CAD learning competency standards. In addition, modules were arranged for learning purposes in the classroom. Modules were arranged systematically according to the needs and flow of learning in the classroom. Supplementary materials were prepared aimed at enrichment material. This supplement material was used to facilitate students who have high learning abilities or those who want to explore the broader functions of the software compared to the modules. Table 3 shows the results of the assessment of the response of students and media experts to the quality of teaching media.

Table 3. Results of assessment of teaching material

	Teaching material		
	Hand-out	Module	Supplement
Student response	91	95	90
Media expert response	90	92	90

Evaluation techniques developed in this study included three domains: cognitive, psychomotor and affective domains. The domain of cognition included 2 components: 1) the domain of cognition related to the ability of construction analysis and 2) the domain of cognition related to software analysis capabilities. The results of the study on the evaluation of the three domains are shown in Table 4 .

Table 4. Learning evaluation results

	Score		
	71-80 (%)	80-90 (%)	91-100 (%)
CAD cognition	7	74	19
Construction Cognition	5	56	39
Psychomotor	12	53	35
Affective	5	81	14

Computer – assisted drawing has become a demand in the industrial world. Becker (1991: 38) argues that *"computer-aided drafting (CAD) is widely used in industry and its future use will no doubt increase. However, the question arises whether students in vocational, technical and engineering education are receiving the training they will need to be prepared for future development."* Pedras and Hoggard confirmed that *"technology educators can not continue teaching without adjusting the curriculum to encompass new development, and they regard CAD as a medium to bring new technology into the classroom".* This opinion also implies that teaching programs and computer – aided drawing is a challenge (Becker, 1991).

The learning process must involve two things, cognitive aspects (brain) and affective aspects (heart) (Jogiyanto, 2007: 20). Cognitive aspects relate to thinking using the brain (Anderson & Krathwohl ,2001). The targets of cognitive learning can be grouped as follows:

a. Knowledge is to identify, retrieve, collect facts and information.
b. Comprehension is to choose and use facts or ideas to understand, interpret or compare.
c. Application is to use facts, information, knowledge, rules, theories or principles in certain situations.
d. Analysis is to separate the whole into parts to see the relationships and find the structure of ideas or concepts, identify parts, relationships and principles.
e. Evaluation is to develop the opinions or make decisions on informational materials, or situational problems based on the value, the logic of usability and usefulness.
f. Creation is related to creation, both products, ideas and concepts.

Greiner argues that *"complex engineering design demand complex models and rely on accurate, coordinated drawing"* (Inchaurrehui, 2009: 5). Hohne & Henkel argues that *" one current trend of instructional multimedia in engineering design education is attempting to develop understanding of systems and their designs"* (Inchaurrehui, 2009: 5) . In the field of civil engineering and architecture, both of these are needed in the design process, especially CAD learning. *Architecture and Engineering increasingly depend on technology both innovate and communicate design. Challenge call for thinking outside the conventional box of knowledge and providing creative and integrated strategies, thus requiring a great deal of coordinated, collaborated effort among various individuals of different disciplines. The role of CAD technologies in this respect is to serve as the bridge and platform on which to develop simple to complex designs* (Inchaurrehui, 2009: 4) .

Learning CAD requires understanding of the basic concepts related to the related scientific knowledge field. Students must understand the relationship between the subject matter that they are studying and the material related to the material (Cheng: 1997). In this case, Cheng said that "*in order to use computers concepts, students must understand how they can relate to the subject matter in architectural design".* This opinion was also reinforced by Clayton, Warden and Parker that *students are using CAD to understand the relationship between design and construction of buildings. As a visualization tool, CAD can help students develop a practical understanding of how the designs translate into the construction process* (Inchaurrehui, 2009: 6).

Learning CAD requires cognitive understandings. The importance of this cognitive aspect is corroborated by Johnson, Ozturk and Yalvac et al (2012) that *"cognitive skills are critical for effective use of modern CAD programs".* This implies that in CAD learning, there is not one standard and rigid way to solve a technical problem. Bhavnani, John and Flemming (1999: 184) argue that *"complex computer applications such as CAD systems typically offer more than one way to perform a given task".* According to Gagne, Briggs & Wager (1992: 70), *"a cognitive strategy is a cognitive skill that selects and guides internal processes involved in learning and thinking".*

The most important thing in CAD learning is about its learning strategies, not in the knowledge or skills which is classical or traditional learning. Bhavnani, John and Flemming (1999: 183) asserted that *" strategic knowledge holds the key to efficient usage and that this knowledge must be explicitly taught ".* Furthermore, the opinion of Gardner as quoted by Cheng (1997: 7) explains that, *"... CAD learning allows us to take advantage of learner-centered teaching methods. Most important is the idea that we need to teach learning strategies and attitudes rather than just pragmatic skills or knowledge. Giving the students the skills to learn* *on their own is important not only because of the reality of large class sizes, but also each person eventually needs to finds his or her own way".*

A metacognitive aspect also plays an important role in CAD learning in addition to the cognitive aspects. Flavell argues that *metacognitive is the internal processing that makes use of cognitive strategies to monitor and control other learning and memory processes ".* In addition, Johnson, Ozturk and Yalvac et al (2012) argue on the importance of developing CAD learning by focusing on the metacognitive aspect (Gagne, Briggs and Wager, 1992: 71) .

The concept of drawing CAD consists of understanding points, lines, fields and spaces. A field image that looks similar in autoCAD can be meaning something different or has multiple meanings. Images created in autoCAD do not mean the real condition and accuracy of objects as images that are only seen visually. The meaning of a field image in autoCAD is based on the use of drawing commands used by students.

A simple example begins with creating a simple object image. The simple object chosen is a window frame image as shown in Figure 1.

Figure 1. The concept of drawing simple objects in CAD

Figure (a) is the image described by the lecturer. In autoCAD, the process of making images (a) can be made with constructions such as figure (b) or picture (c). The process of drawing objects with drawing techniques (b) is made with more than an entity. The example in the image above consists of a combination of lines and polylines. This drawing concept uses more than one command in autoCAD. In addition, image (c) is created using an entity, namely an object created with a polyline command. Although the final images look similar as in image (a), the image of the drawing process (c) is more meaningful than the process of drawing (b). The accuracy of the method on image (c) has an impact on file size. The ease of editing and more practical.

Explanation of object construction is also followed by an explanation of the construction of more complex objects. The example given is the complete construction of a window frame. An object of a window frame is displayed in its entirety. Furthermore, each component of the window frame is described based on the names of the window frame. The presentation of this material is illustrated in Figure 4.2.

Cheng (1997: 15) has formulated two aspects of observation in CAD learning, namely metacognitive aspects and practical cognitive aspects. Cheng argues in detail that *" metacognitive aspect is arranging the learning process and cognitive aspect is direct ways to learn".* The components of metacognitive aspects in CAD learning consist of "*planning, directing attention, monitoring, identifying problems, evaluating compensating".* In addition, the components of cognitive aspects in CAD learning consist of *"recognizing, repeating, creating mental links, analyzing, structuring, elaborating, summarizing, translating".*

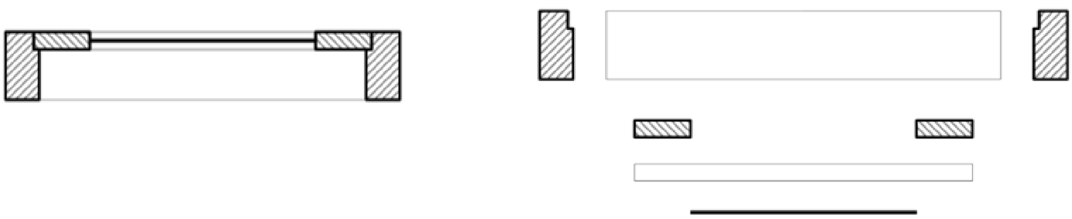

Figure 2. The concept of drawing more complex objects in CAD

Inchaurregui (2009) conducted research on beginner CAD users. His research focused on CAD learning method using the video tutorial. The comprehensive use of multimedia was used in his research. The field of study which was studied in his research are images in the field of architecture. The aspect which was studied in his research was the operational basics of CAD used by beginner CAD users. Inchaurregui also stated in his research there were seven aspects included in the operational basics of CAD. The seven aspects are as follows drawing type, unit, drawing limits: scale, scale factor and sheet size, drawing image information (*styles: text, dimensions and multileaders),* drafting settings, annotation scale and CAD basic operations using image reference patterns (*save, edit templates and new drawings form templates).* The results of his research showed that the level of understanding of the operational basics of CAD was 88.79.

Paliokas (2009) also conducted a research in CAD software learning. The research was conducted by doing several variations of teaching to find the suitable method in CAD learning. The purpose of this study is to improve students' metacognition skills in operating CAD. The metacognition skills in his researcu were 12 items consisting of *"description of what they are designing, description of their goals and an assessment of the final product, identifying strong and weak areas, deficiensies and abilities, analizying their choices, identifying their current level through comparison with ither students, reflecting on alternative ways of achieving their goal, assessing their individual designing style, reviewing their progress, making effective use of new knowledge, recognizing a change in attitude, controlling the intesity of their effort and presence and mental application".*

The results of the study showed that students became more concerned about mistakes during learning with CAD. This research showed that in general the students could be more behaving and reacting positively to mistakes made during the process of drawing with CAD. In line with the research conducted by Paliokas, Johnson, Yalvac & Peng (2012) reported on the level of adaptive expertise of students in running CAD software. The three also developed assessment instruments in the use of CAD software. The report focuses on four components related to the operationalization of CAD, namely *multiple perspectives* , *self-assessment* within the scope of meta-cognitive *(meta-cognitive self-assessment),* goals and beliefs of students *(goals and beliefs)* and epistimologi *(epistemology).*Furthermore, Menary and Robinson (2008) also report the results of their research in terms of teaching and evaluating CAD learning. Both focus on assessing students' ability to operate CAD optimally.

Students are the subject of learning. As a learning subject, students are required to have high motivation and be active in the learning they are taking. The student activity starts from the pre-lecture, the learning process to the learning evaluation stage. In addition to being active in learning, students are also required to be responsible during the learning process. Student motivation is identified through learning styles formed as daily behavior during the learning process. Students must also be active during learning process. The effort taken to measure students' activity is to provide drawing tasks by lecturers that must be completed by students using autoCAD.

AutoCAD is a computer software used during learning. The relatively fast development of autoCAD has an impact on the increasing hardware requirements. In addition, there is also a difference in the version of AutoCAD installed in a computer laboratory with the version of AutoCAD installed and used on the personal computers of students and lecturers. Therefore, optimizing the use of autoCAD software becomes important, without having to use one software version.

CONCLUSION

Conclusions from this study are 1) the development of CAD drawing learning model using practical learning method reinforced with technical assistance and concept master helped to improve students' learning outcomes, especially in the domain of cognition and psychomotor, and 2) the results of evaluation on CAD drawing learning model as a model suitable for students to show their effectiveness in good categories.

This study has several limitations, both in terms of time, cost, availability of resources and some other limitations. Therefore, other studies similar to this study can still be developed to develop several other research variables. In this regard, suggestions that can be given related to similar research are as follows:

1. This study focuses only on computer-assisted drawing learning materials for drawing 2-dimensional objects. Therefore, this study can still be developed for computer-assisted drawing learning material, especially drawing and modeling of 3-dimensional objects,
2. This research was conducted by involving students as the subject of study, especially students of the Civil Engineering Vocational Education program. Therefore, this study study can still be developed with research subjects in vocational schools, considering that many vocational expertise programs use autoCAD software,
3. In determining the variables, this study had not involved parties in in the industries. Therefore, the results of students' products cannot yet be confirmed as acceptable and applicable by the standard of industries.

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