Isn't it effective if the transformation of product design tests into 3-dimension modelling?

B R Setiadi, J Puspito, Sudiyatno, D Kurniawan and B Kartowagiran

Department of Mechanical Engineering Education, Universitas Negeri Yogyakarta, Indonesia

E-mail: bayursetiadi@uny.ac.id

This study aims to prove whether changing and transforming into 3D modelling is more effective and efficient than presenting product design job questions in the form of 2D multi-view projection. This research study uses a mix-method with a sequential explanatory design—data collection using questionnaires and observations from video recordings of work. The research object was 28 students taking CAD courses in the Mechanical Engineering Education Department. The Covid-19 pandemic resulted in data collection being carried out online. The results showed that students’ speed on drawing problems with 2D and 3D modelling according to three levels (easy, medium, and difficult) had differences. The 3D modelling view makes it easy for respondents to do it in a short time and with the right results. If explored more in-depth, the thinking skills that dominate respondents according to their perceptions emphasize creative thinking processes and the ability to solve problems.

1. Introduction

Drawing is an engineering language to express the intent of an engineering degree [1]. For this reason, passing information is an essential function for both language and images. The technical language is expected to be able to convey information accurately and objectively. It is unnecessary to convey information in the design that cannot be given to reduce bias in reading the draft. A draftsman needs to make the right image by considering the reader [2].

The technical drawing is one of the most important bases on which the industrial sector starts research, development, design, manufacture, quality control, and distribution [3]. The consequences of the technical drawing agreement need to be known by both parties (the designer and the drawing user) to understand well that they must be able to make, read, and correct drawings. Technical drawings also contain art elements and pay attention to specific rules, as described in the established standards [4].

The development of technical drawing science in this decade has shown significant changes, especially in the effectiveness and efficiency of work and the products produced [5]. The existence of software to make it easier to modernize computer-based engineering drawings is also equipped with features and tools that are sophisticated and applicable [6]. These changes can be seen as many software vendors such as Autodesk, Dassault Systems, and others always update their software every year both on Computer-Aided Drafting (CAD), Computer-Aided Engineering (CAE), and Computer-Aided Manufacturing (CAM). User demands and advances in software technology from each vendor are increasingly complementing and supporting each other.

The presence of the 4.0 industrial revolution is a challenge and a threat to the world of education that intersects with learning engineering design [7]. The existence of sophisticated computers and
software in the industry poses a threat to educational institutions that have not massively carried out software-based designs and drawings. Industries with a fast, precise, and efficient orientation emphasize drawing techniques by relying on software and having abandoned conventional engineering drawings [2].

Projection is a way of depicting an object, point, line, plane, and the view of an object on a drawing plane. In case studies in teaching engineering drawings and CAD, many problems related to the parallel projection are implemented in learning. Parallel projection is very dependent on the reader's knowledge in observing images in 3 dimensions [8]. The parallel projection consists of three types, namely oblique, orthographic, and axonometric. Oblique projection is an image projection in which the projection lines are not perpendicular to the projection plane, but form an arbitrary angle (Simmons, Phelps, & Maguire, 2012) and has one object surface is parallel to the projection plane [9]. Orthographic projection or referred to as multiview projection, which divides 3-dimensional images into two dimensions [10]. This projection is known in two kinds, namely projections with a front view in quadrant I (Europe view) and quadrant III (American view). This type of projection is often found in CAD learning, where after students draw 3D, it is continued by presenting it in 2D with multiple views.

Along with orthographic projection, the axonometric projection also has a major contribution to CAD learning. This projection has three kinds, namely isometric, dimetric, and trimetric. However, applying axonometry tends to present the most isometric view in both CAD teaching and industry.

The crucial problem is the industry trend that has begun to shift towards modelling to 3D or known as Model-based Definition. This method is widely used in architecture to be termed as Building Information Management (BIM) [11], [12]. The application of BIM from a business point of view can increase company efficiency, even creating new jobs, namely structural modellers, which simultaneously reduces the workload of engineers. Currently, learning 3D modelling in the Department of Mechanical Engineering Education, Yogyakarta State University still uses the old method of presenting questions in 2D. The critical, creative, and problem-solving approach [13] supports student success in completing the questions on the job sheets distributed by lecturers to students.

Based on the problems presented above, questions will arise. Are there any advances in design and manufacturing still relevant? This question was also continued, whether presenting a 2D model in a CAD learning job sheet would facilitate knowledge or make it difficult for them to understand what was being done? This is a problem that needs to be studied in-depth to determine the advantages and disadvantages of the methods that have been used up to now. How do students respond to using their three thinking skills to solve 2D and 3D questions? Confirmation was also asked students, is presenting the questions on the job sheet in 3D modelling faster and easier to understand?

2. Method

This research was conducted with a mix-method approach (combination). The quantitative approach is the main priority of research, while the qualitative approach is used as a supplement in strengthening quantitative research data. The combined research design used was a sequential explanatory design. This design is characterized by data collection and quantitative data analysis in the first stage and is followed by collecting and analysing qualitative data in the second stage to strengthen the results of quantitative research conducted in the first stage [14], [15]. In a quantitative approach, the survey method is used to see students' thinking responses when facing types of questions. While the qualitative research method used is the observation of online CAD learning records and the time for the test. The choice of this type aims to strengthen the survey results and observe the patterns of students drawing and thinking related to the strengths and weaknesses of each type of question given. Also, the researcher wants to explore and study the transformation of image presentation with new modelling.

The research population is students of the Department of Mechanical Engineering Education who are taking 2D and 3D Computer-Aided Design courses. The research sample used purposive sampling by designating the sampling class taken per class from each study program covering 25% of the total active students from undergraduate students of Mechanical Engineering Education, Diploma III of Mechanical Engineering, Diploma IV-Mechanical Engineering, and S1-Manufacturing Engineering. The research subjects that were used as experimental video recordings were students who were the
fastest and late in working on converting images to isometric projection. The purpose of using these subjects is to explore the difficulties and ease with which students interpret working drawings in 2D and 3D forms.

Data collection techniques using skills tests in drawing parallel projections, observation, and document study. In the practical performance test, students will be given three problems related to the presentation of random isometric drawings to see their ability to think critically, creatively, and solve problems. The measure of assessment is the student's perception of choosing his thinking skills in drawing parallel projections. The observation instrument is used to see the student's thought process. Intent observations were made with visual aids and screen recorder software recording aids. This research's data analysis is descriptive statistics as the primary research, secondary analysis through triangulation of data on practicum video recordings.

3. Results and Discussions

3.1. Research descriptive

This study will reveal the extent to which students' ability to think to interpret the questions presented in 3D and 2D. A total of 28 students contributed both online and offline. CAD research using Autodesk Inventor software. Each participant practices the three jobs provided by the researcher. This CAD learning research in the Department of Mechanical Engineering Education involves 4 study programs and 28 students with details, namely 18 students from the S1-Mechanical Engineering Education Study Program, six students from the D-IV Mechanical Engineering Study Program, two students from the D-IV Study Program, III Mechanical Engineering, and two students from the S1-Manufacturing Engineering Study Program. Based on the identification of data collection techniques, it was found that 60.7% agreed that CAD testing was carried out offline, and the rest (39.3%) was carried out online.

3.2. Speed of completing the test

The respondents' test consists of three levels, namely easy for level 1, medium for level 2, and difficult for level 3 (see Figure 1). The three levels are seen from the differences between students working on the level in minutes. Based on the analysis results, the difference in serving 2D working images and 3D modeling is presented in the following figure.

![Figure 1](image)

**Figure 1.** The speed of doing the test in 2D and 3D drawing and the level of difficulty

Figure 1 shows that there is a time difference when presenting jobs in 3D modeling compared to the questions presented in multiview drawing. This difference is due to the drawn object model's embodiment is more important than geometry in particular for interpreting the image. More work errors in problems presented in 2D were found. In contrast to the presentation of 3D modeling, which produces the same design product with the questions given. Figure 1 shows a decrease in speed on 2D job execution at the easy level to the medium. This problem is caused by a fundamental question that becomes a trap for respondents to misinterpret the product design.
3.3. Ability to think about the interpretation of the questions being tested

The complexity level is an agreement between the researcher and the validator containing the strengthening of basic, intermediate, and advanced skills, including design complexity, shape, multi-tool combination opportunities, and duration of work. At the three levels tested, the percentage was compared to the three thinking abilities: creative thinking, problem-solving, and critical thinking. These three abilities result from respondents' perceptions of their experience after working on the questions at all three levels. The following is presented in Figure 2, which confirms the study results based on the respondents' self-perceptions of several testing levels.

![Figure 2. Students' thinking ability in solving problems at each level](image)

Based on the tabulation above, it can be explained that the imagination of a CAD drafter is influenced by the biggest factor, namely creative thinking, with the percentage of both dominating over half of the total. In planning, the combination of creative and critical thinking can improve problem-solving skills by a percentage of 65%. Job evaluation, both in selecting tools and checking work, is a general procedure applied by respondents by emphasizing critical and systematic thinking [16]. In implementing depiction through CAD, problem-solving thinking dominates 60% compared to other thinking skills [17]. On the presentation side, problem-solving skills outperform both creative and critical thinking skills. Viewed in a visual graph, respondents consistently strengthen problem-solving skills and combine both critical and creative thinking skills to complete the assigned work. This shows that the difficulty level can influence the respondent's thinking pattern in designing a predetermined product.

4. Conclusion

Based on the research results described, it provides several conclusions that are synthesized according to the research question. The researcher provides conclusions based on existing data, explaining that the presentation of test questions in 3D is more effective in drawing accuracy and efficiency when viewed from the resulting processing time. In thinking skills, the difficulty level provides a variant in the level of understanding based on the aspects of imagination, planning, method, evaluation, and display. The use of a combination of critical and creative thinking skills, which results in problem-solving thinking, is used by most of the respondents. Suggestions that can be followed up from the research results are to change the transformation of the presentation of working images in the form of 3D modeling.

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