Improvement of Problem Solving Skills in Engineering Drawing Using Blender Based Mental Rotation Training

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Abstract— **First year undergraduate students in engineering often face difficulties in solving engineering drawing (ED) problems. The potential reasons for this could be either the students' deficiency in visualizing spatial relationships or the instructional method used. We have developed a three-hour MR training using Blender 3D, an open source 3D animation software. In this paper, we present experimental evidence of the effect of our training on the improvement of problem solving skills in ED. We analyzed the results and found them to be significant. Also, the qualitative analysis of students' responses to the open ended questions revealed that, they found training useful in resolving their difficulties in solving ED problems.**

Keywords-engineering drawing; mental rotation; spatial ability; Blender; orthographic; isometric

I. INTRODUCTION

That freshman engineering students face various difficulties in learning engineering drawing (ED) course, is a well known fact [7], [13], [18]. One of the major difficulties they face is transformations between 2 dimensional (2D) projections and 3 dimensional (3D) views of objects [1], [9], [11].

Conventional instruction methods require students to practice sketching and drawing for longer durations; and does not guarantee the elimination of these difficulties entirely [1], [11]. In modern instruction methods instructors make use of software tools such as computer aided design (CAD), multimedia tutors and web based instructions as a supplementary visual aid in learning [4], [5], [8], but these techniques are spread over weeks. Though these techniques are useful in improving ED skills, certain difficulties such as interpretation of engineering drawings required for 2D and 3D transformations are still remain [12].

The possible reasons for this are students poor spatial ability or the instruction method. Spatial abilities are found to be important for engineering drawing [3], [15], [17], [19].

This suggests the need for the improvement of students' spatial abilities and also to examine its impact on learning ED skills. Mental rotation ability is a major component of spatial abilities and found to be important in learning and solving problems of engineering drawing [14], [16], especially in orthographic projections [14]. Research study [16] shows that eight weeks of MR training improves MR ability and students with high scores in MR perform better than students with low MR scores in a multi-view orthographic drawing task. In a previous work we established that 3-hour MR training using Blender improves MR skills of first year undergraduate engineering students [10]. We then continued to investigate the effectiveness of the MR training on improvement of ED problem solving skills. In this paper, we present the findings of our study on the impact of a 3-hour Blender-MR training on students' problem solving skills in ED.

The focus of our current study is specific to the improvement of ED problem solving skills using 3-hour Blender-MR training given to first year undergraduate engineering students (N=54). We address the following research question, 'Does a 3-hour Blender-MR training improve ED problem solving skills of the first year undergraduate engineering students?'

We first administered a pre-test based on spatial visualization ability test (SVATI) [2]; we selected only engineering drawing tasks from the set of test items. Students were asked to write the difficulties faced while solving the pretest. Then students were trained to perform various rotation tasks in Blender such as, rotation of views, rotation of an object along different axes, use of 3D rotation manipulator, and rotation with enabling multiple views. We then administered post-test and surveyed students regarding the usefulness of the training for solving the posttest.

We found our training effective as the paired-sample t-test was significant with moderate effect size (Cohen) [6]. Qualitative analysis of the students' responses to an open ended survey question after pretest revealed that students face difficulties in converting 3D views to orthographic views and vice versa, visualizing in 3D, and identifying the hidden surfaces. Analysis of the student's responses after posttest revealed that the Blender-MR training helped them in resolving these difficulties.

II. BLENDER-MR TRAINING

We adapted the existing training module [10] so as to fit in the purpose of the study presented in this paper. We replaced training items with engineering drawing items. The modified Blender-MR training activities were designed in such a manner that the Blender commands were focused to the relevant MR strategies required for solving ED problems. This resulted in dividing the training into four parts: (1) Introduction to Blender User Interface, (2) Observing objects in multiple views including 3D space, (3) Rotation of views and rotation of 3D objects, (4) Rotation of engineering

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drawing items from the pretest by applying techniques learnt in previous parts.

Our training method is based on instructional strategy demo-drill-practice (DDP): (i) Demo: students watch a demonstration being given by the instructor, (ii) Drill: students carry out the step-by-step actions specified by instructor for a given object, (iii) Practice: students (a) practice the tasks on their own for the same object, and (b) practice the tasks with pretest items and verify their answers.

III. RESULTS

1) Means and Average gain: We first calculated the means of pre-test and post-test performance scores for all 54 students.

TABLE I. MEANS, AVERAGE GAIN

Achievement level - Pretest	N	Mean of pretest	Mean of post-test	Avg. gain
Total	54	4.07	4.85	0.1076

2) Paired-sample t-test analysis and effect size: Result of paired sample t-test analysis shows that our treatment is statistically significant ($p < 0.05$) with moderate effect size (Cohen) [6]. This shows that our treatment was indeed effective.

TABLE II. PAIRED SAMPLE T-TEST ANALYSIS

Pair	N	T	df	p	Effect size
Pretest – posttest	54	-2.03	53	0.047	0.07

IV. DISCUSSION

Results revealed that our treatment for improving ED problem solving skills through three-hour Blender-MR training was effective. The qualitative analysis revealed that training has helped alleviate the difficulties that students typically face while solving ED problems.

In our previous work we found that our training improved MR ability of students where training activities were originally oriented towards acquiring MR skills. Results of the current study showed that students' ED problem solving skills have been improved after the training. This confirms that the mental rotation training improves ED problem solving skills. Our findings suggest that MR is a foundation for many ED skills such as, orthographic and isometric projections. This suggests that doing MR before learning ED reduces the complexity in learning ED skills.

The training with shorter duration of three-hour can be easily included as a tutorial within Engineering Drawing course. This may be of immense benefit to not only low achievers but also to all the students of ED course. Also in order to improve ED skills it is not enough to simply use a tool such as Blender or CAD, it is important to address the underlying spatial skills which form the basis of multiple ED abilities.

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