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Abstract

Several methods have been developed, presented, and discussed at recent ASEE and EDGD conferences on the topic of computer-based multiview drawing instruction. While small-scale and localized testing of these instruments and methods has been undertaken, no larger-scale or multi-location experiments have been attempted. This paper describes an experiment that was carried out at two different university campuses with engineering and non-engineering students in an effort to validate the efficacy of these tools in comparison with more traditional methods of orthographic drawing instruction.

Specifically, participant groups of students at each location were exposed to one of two computer-based instructional tools completely, a mix of a computer-based tool and manual drawing methods, or an entirely manual method of multiview drawing instruction. Through the use of pretest/posttest data and survey information, student scores and perceptions were analyzed for useful quantitative and qualitative results. The implications for such results are potentially significant in the areas of foundational instruction, self-study, and remediation of students in engineering graphics and other spatially-associated fields.

Introduction

As has been described in past studies, a significant challenge that many engineering and technology students struggle with is the ability to "see" virtual images in three-dimensional environments [1, 2]. Future success as a student and as a professional in many areas, both technical and non-technical, can be dependent on this ability to manipulate 3D space and objects within that realm [3, 4, 5]. Research in this field has also shown that spatial capabilities can be strengthened through appropriate instruction [6, 7, 8]. A useful and applicable method of instruction and practice for engineering and technology students' spatial skills has traditionally involved orthographic/multiview drawing.

There are several problems that must be overcome for multiview drawing to be effectively used as an instructional tool. First, it is important for students to comprehend the basic standards of multiview drawing, and master the fundamental concepts of multiview drawing applications. Second, the instructor must be able to deal with a wide variety of visualization abilities in the students, and deal with the logistical issues of providing instruction and feedback to students participating at these various levels of ability and experience.

The use of computer-based tutorials is one method of dealing with the difficulties mentioned above. Tutorials allow for self-paced and varied emphasis instruction, practice, and remediation, providing the instructor much flexibility in such situations [9, 10, 11].

Methodology

Research was carried out at two locations: Pennsylvania State University – Erie and Purdue University. In each setting, four different groups were used in the experiment. One group underwent multiview instruction using a tutorial developed by Sheryl Sorby of Michigan Technological University in Houghton, Michigan. A second group experienced multiview instruction using a tutorial developed by one of the authors and Kellen Maicher at Purdue University, followed by standard paper-and-pencil practice. A third group was exposed to the same Purdue tutorial followed by computer-based practice. The final group at each location was the control or non-treatment group that experienced standard lecture instruction on the multiview topic.

Participants

The Purdue University participants consisted of 16 male and 29 female (n= 45) students enrolled in a Technology in Education class. These students were education majors, and with a few exceptions, had no prior experience in engineering drawing principles.

Instruments

There were four instruments used in this study, including a multiview drawing pretest and posttest, a tutorial on orthographic drawing designed by Sheryl Sorby of Michigan Technological University, a tutorial designed by Patrick Connolly and Kellen Maicher of Purdue University, and a spatial experience questionnaire.

The pretest and posttest consisted of fifteen problems each, wherein the participants were asked to look at an isometric pictorial representation of an object and then select from three options the correct representation of the front, top, or right side view of the object.

The tutorials by the above-mentioned developers covered all basic principles of orthographic construction and its applications. The Sorby product covered other related topics as well, but these were not accessed as part of this study.

Procedures

Due to the different structure of classes and characteristics of the participant sample groups, the procedures varied slightly at the two locations. The Pennsylvania State – Erie procedure was as follows:

> All students were required to complete a pre-class quiz on a 7 page reading assignment covering the basics of isometrics. A short lecture was given followed by 10 practice problems.
>
> The following week all students were required to complete a pre-class quiz on a 6 page reading assignment covering the basics of orthographics.

- Section 1: Students completed the pretest, the Background portion of the Orthographic Drawing section of Sheryl Sorby's 3D Visualization software, the Exercises portion of the 3D Visualization software (which automatically checked their answers), followed by the posttest.
- Section 2: Students completed the pretest, the Purdue Multiview Drawing tutorial and test, completed problems using paper and pencil, checked their answers with an answer key, followed by a posttest.
- Section 3 received instruction using traditional methods. The students were given the pretest, a short traditional lecture on orthographics, followed by the posttest.
- Section 4: Students completed the pretest, the Purdue Multiview Drawing tutorial and test, completed the Purdue Interactive Multiview Drawing software containing the same problems Section 2 completed by paper and pencil (software checked their answers), followed by a posttest.

The Purdue procedure was:

Volunteers were recruited out of a technology class for education majors. Several participants had previous experience with multiview drawing, but no experience was predicted or controlled for. The participants were divided into four groups, with treatments identical to those described in the Penn State procedure.

There were no pre-class readings or introductory lectures given in the Purdue portion of the study. The Purdue control group did hand-sketch problems for practice.

Results

The results of the data for Purdue are shown in Table1.

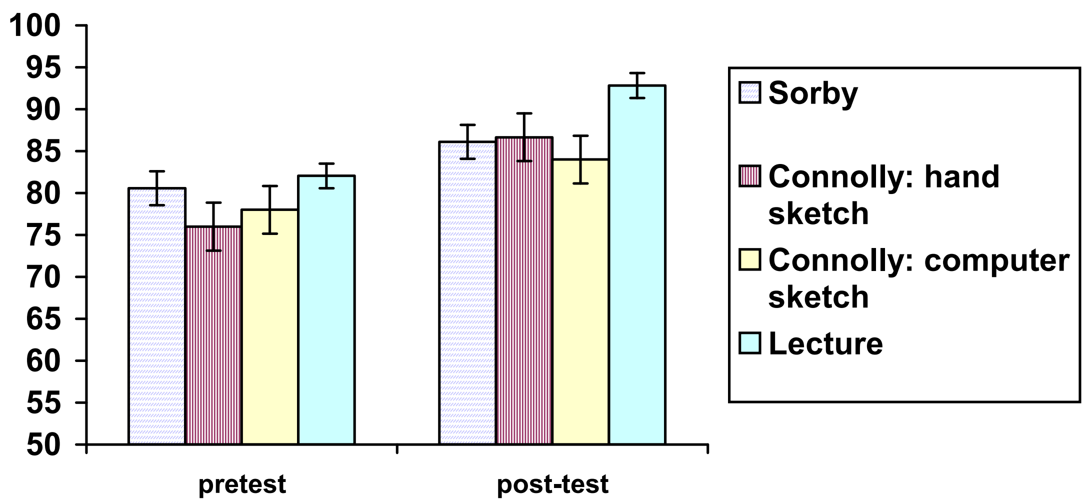
Table 1
Purdue University Results

Group	Treatment	Total # problems for all students (based on number of participants)	Pretest # wrong	Posttest # wrong	% correct pretest	% correct posttest	**Change**
1	Sorby	180	35	25	80.56%	86.11%	**5.50%**
2	Connolly-hand-sketch	150	36	20	76.00%	86.67%	**10.67%**
3	lecture/practice	195	35	14	82.05%	92.82%	**10.77%**
4	Connolly-computer-sketch	150	33	24	78.00%	84.00%	**6.00%**

In this study, a total of 45 participants (18 males, 27 female) completed a pre and post-test on orthographics. The participants completed a pre-test, then received a form of training on orthographics (Sorby N=12, Connolly Hand-Sketch N=10, Connolly Computer-Sketch N=10, and Lecture N= 13), and finally the participants received a post-test.

Figure 1 shows the means and standard errors of percent correct for each type of training in the pretest and post test. These scores (percent correct) were analyzed using a 2(time: pre-test, posttest) X 4 (Training: Sorby, Connolly Hand-Sketch, Connolly Computer-Sketch, Lecture) mixed ANOVA. The results showed a significant main effect of Time with post test scores significantly higher than pre-test scores, $F(1,41) = 16.01$, $p < .0001$. The main effect of training type did not reach significance $F(3,41) = .67$, $p = .58$, nor did the interaction between time and training $F(3,41) = .49$, $p = .69$.
The results showed that on average, participants improved from pretest to posttest, however follow-up up t-tests comparing each groups pre-and post test scores showed that only the lecture group improved significantly $t(12) = 3.51$, $p = .004$, whereas the Connolly sketch group showed a marginal effect that approached significance $t(9) = 2.06$, $p = .07$. It should be noted that the small number of participants limits the power of the current analysis and precluded an analysis by gender. However an examination of mean scores suggested that women tended to show more improvement pre-to post them men. The larger numbers afforded by the inclusion of the Penn State data may help to explore than possibility.

Figure 1. Average Pre and post test percent correct based on training



The Penn State Erie data was collected for classroom use and is awaiting IRB approval for use as research.** Results from the classroom evaluations suggest that their may have been a ceiling effect with students making very few errors. Therefore there were very few differences between the groups. It should be noted that the Penn State Erie students were all engineering majors and they had received more information about engineering drawing principles prior to the exposure to the class.

** The data will be presented at the conference. Anyone desiring an electronic copy of the final data is invited to email the authors.

Discussion

The results from Penn State Erie are expected to be considerably different due to some participants having prior exposure to the material in class instruction. There may have also been an influence of prior experience in engineering drawing principles. It is also possible that the results were impacted by a ceiling effect in scoring between pretest and posttest. The pretest scores of the non-engineering students, where no prior exposure to orthographic drawing principles was anticipated, were relatively high. Engineering students generally have stronger visualization skills than non-engineering students which should result in the engineering students scoring highly on the pretest in all four groups. Caution is noted in drawing certain conclusions from the results based on sample size limitations with the Purdue results. However, one suggestion for the largest apparent improvements of the non-engineering students (Purdue) may involve the use of freehand drawing (sketching), either with or without tutorial instruction, as a means of increasing spatial comprehension. Group 2 (10.67% improvement) and Group 3 (10.77% improvement) were exposed to sketching practice problems as part of the treatment, while groups 1 and 4 (Sorby tutorial and Connolly tutorial with computer practice, respectively) were not. Furthermore, limited generalizations can be drawn from these data due to the brief nature of instruction and tutorial exposure. It is probable that longer duration exposure to the instructional content and media may have a greater impact on the measurable results of the study.

Referencess

1. Connolly, P. E., & Maicher, K. R.. (2003). Instructional design of a web-based engineering graphics tutorial. *Proceedings of the 58th Annual Engineering Design Graphics Midyear Meeting, Scottsdale, Az.,* 89 - 97.
2. Maicher, K. R., & Connolly, P. E. (2003). Using web authoring applications in tutorial development. *Proceedings of the 58th Annual Engineering Design Graphics Midyear Meeting, Scottsdale, Az.,* 166 - 174.
3. Deno, J. A. (1995). The relationship of previous experiences to spatial visualization ability. *The Engineering Design Graphics Journal, 59*(3), 5-16**.**
4. Holliday-Darr, K., Blasko, D. G., & Dwyer, C. (2000). Improving cognitive visualization with a web based interactive assessment and training program. *The Engineering Design Graphics Journal, 64*(1), 4-9.
5. Study, N. E. (2004). Assessing Visualization Abilities in Minority Engineering Students. *Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition.*
6. Miller, C. L. (1996). A historical review of applied and theoretical spatial visualization publications in engineering graphics. *The Engineering Design Graphics Journal, 60*(4), 12-33.
7. Sorby, S. A. (1999). Developing 3-D spatial visualization skills. *The Engineering Design Graphics Journal, 63*(2), 21-32.

8. Sorby, S. A. (2001). Improving the spatial skills of engineering students: Impact on graphics performance and retention. *The Engineering Design Graphics Journal, 65*(3), 31-36.
9. Newby, T. J., Stepich, D. A., Lehman, J. D., & Russell, J. D. (2000). *Instructional technology for teaching and learning.* (2nd ed.). New Jersey: Prentice-Hall, p. 96.
10. Alessi, S. M., & Trollip, S. R. (2001). *Multimedia for learning: Methods and development* (3rd ed.). Boston : Allyn and Bacon.
11. Eom, W., & Reiser, R. A. (2000). The effects of self-regulation and instructional control on performance and motivation in computer-based instruction. *International Journal of Instructional Media, 27*(3), 247-260**.**