

The Development and Testing of an Interactive Web-based Tutorial for Orthographic Drawing Instruction and Visualization Enhancement

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Abstract

As has been shown by significant research over the past several decades, there is much that can be done to encourage student development in visualization ability. This capability to visualize, or “see” in three-dimensional space in the mind’s eye, is crucial in many areas of computer graphics, engineering design, and manufacturing technology, and is spreading across traditional boundaries in many industries.

In conventional engineering graphics instruction, having students alternate between pictorial representations and orthographic views of an object or assembly is one method used to exercise and develop 2D/3D visualization skills. The success of this method of instruction is highly dependent on individual student ability, and often requires a significant amount of instructor mentoring. The authors have written several papers on the rationale for, and the development of, a computer-based tutorial that focuses on enhancing student capabilities with multiview orthographic drawing. An important recent enhancement to the tutorial is the incorporation of an interactive Web-based drawing application that provides real-time assessment and performance feedback. Preliminary analysis of early versions of the application has been both encouraging and informative. The authors anticipate that continued testing and development of the application will provide a novel and effective educational aid.

This paper discusses the technology and methodology used to create the tutorial and drawing application, as well as foundational and pedagogical aspects of graphics instruction and computer-based educational technology. The results of on-going quantitative and qualitative assessment are also reviewed, along with plans for future development.

Introduction

One of the major challenges that students in the engineering and technology fields often face is the inability to visualize and function in virtual three-dimensional space. The successful application of 3D principles in the transforming and viewing of graphical images is a required skill in many career areas, including many outside of traditional technological boundaries ^[1, 2, 3]. Although many students struggle with this skill set, there is ample research that shows that the ability to visualize in 3D environments can be developed and enhanced ^[4, 5, 6, 7]. One practical method of visualization skill development comes in the form of multiview drawing and development. Through the application of multiview drawing principles in solving challenging visualization problems, students exercise and improve their spatial acuity and comprehension by

becoming more familiar with manipulating objects using their “mind’s eye”. Orthographic multiview projections are developed to provide two-dimensional representations of an object from various orientations. An adequate number of these 2D representations allows for the target object to be fully described using two-dimensional media. This description can then be used to manufacture the desired object or to effectively communicate it to others ^[8].

However, it is often difficult for students who have no background in traditional engineering drawing to successfully master the concepts of multiview drawing development, including the principles of view manipulation and placement and other foundational elements. This, in turn, often leads to difficulty for the instructor. In many cases, the instructor is faced with a wide variety of visualization capabilities and engineering drawing experience within the same course population. The challenge of providing adequate individualized instruction to all members of the class can be logistically impossible and quite frustrating.

To this end, an instructional web-based tutorial has been developed that provides individualized, self-paced instruction on the principles and applications of multiview drawing. The goal of the tutorial is to allow students to interface with topical material and visualization development exercises in either a stand-alone or course material supportive environment, providing the educator a way to tailor instruction for students at various skill levels.

Educational researchers have defined a tutorial as an individualized instructional tool that “presents content, poses a question or problem, requests student response, analyzes the response, supplies appropriate feedback, and provides practice until learners demonstrate a predetermined level of competency” ^[9]. A significant number of instructional experts feel that computers provide an excellent platform for tutorials due to their allowance for user interactivity, control, and individualized instruction pace ^[10, 11]. The effectiveness of providing of educational material via the computer as medium is a somewhat controversial and regularly debated topic in educational circles, but supporters of this technology feel that computer-based instruction is an efficacious pedagogical tool if properly designed and implemented ^[2, 12].

Tutorial

The tutorial was developed through several iterations using various multimedia programming tools such as HTML, Javascripting, Microsoft Access, XML, and Macromedia products such as Dreamweaver, Flash MX, and Cold Fusion MX. The capabilities provided by these software packages allow the tutorial to utilize dynamic graphics and information retrieved from an integrated database.

The complete program contains three sections: introduction, learning module (tutorial), and mastery test section, in order to provide instructions, content, practice reviews, and assessment on content mastery. Figure 1 shows an example of the tutorial interface.

A crucial development in the tutorial program was the creation of an interactive drawing and response capability, which plays a key role in the drill and practice and mastery assessment portions of the tutorial. It is the opinion of the authors that actually creating the 2D representations is more beneficial to the students’ visualization development than merely

selecting the correct 2D representation from three alternatives in a multiple choice format. The interactive drawing and response tool consists of two main sections, as shown in Figure 2.

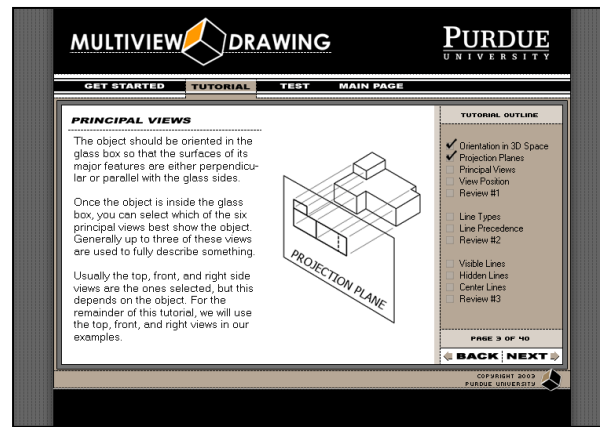


Figure 1. Tutorial Interface.

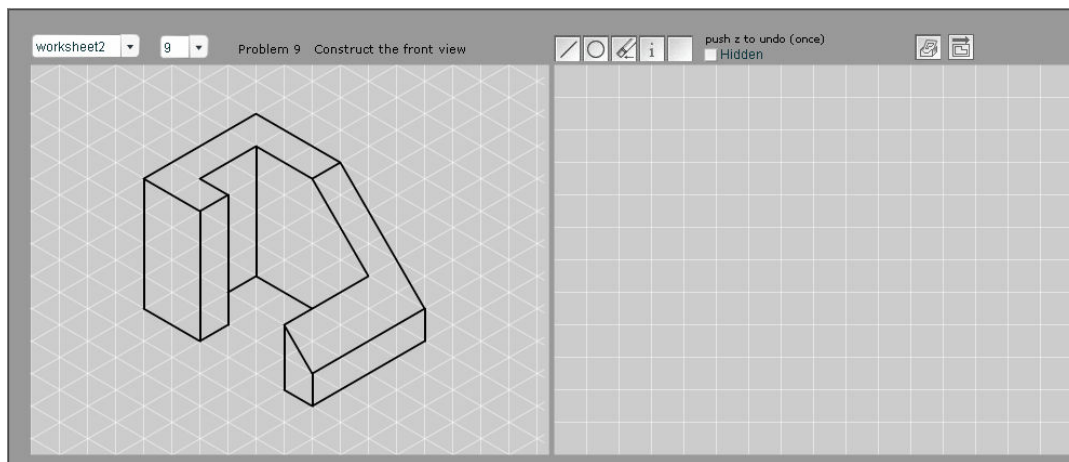


Figure 2. Interactive Drawing and Response Interface.

The left portion is a pictorial representation of a simple part on an isometric grid; the right is a blank square grid for the students to use in creating the requested view with the computer mouse. Across the top of the screen are selection buttons, instructions, and icons that the students utilize to select problems and complete the assignments. Libraries of stored parts and part families can be accessed for multiple problem sets. The program prompts users to create the top, front, or side view of the given 3D representation. By using the line creation, erase, and hidden line toggle options, the user is able to “draw” the requested orthographic view on the grid provided. The “Grade Drawing” icon is located on the far right of the instruction toolbar, and allows the user to check the 2-dimensional view and receive feedback on the correctness of the drawing. Through the use of color-coded text and color-highlighted lines, potential errors are identified for the user. Although still in preliminary development stage, the feedback has been identified as potentially beneficial to students learning multiview drawing techniques. Figures 3 – 5 provide samples of grader responses to the user. There is also a “Get Answer” icon, which displays the solution for the student. This capability can be accessed during the drill and practice portion of the tutorial, but would not be active during the mastery assessment activities.

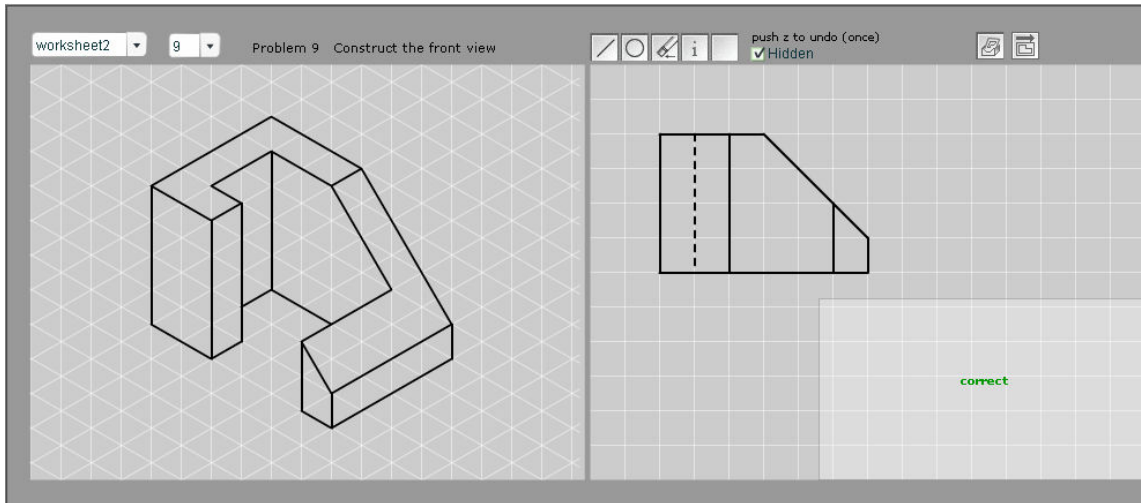


Figure 3. Correct Answer.

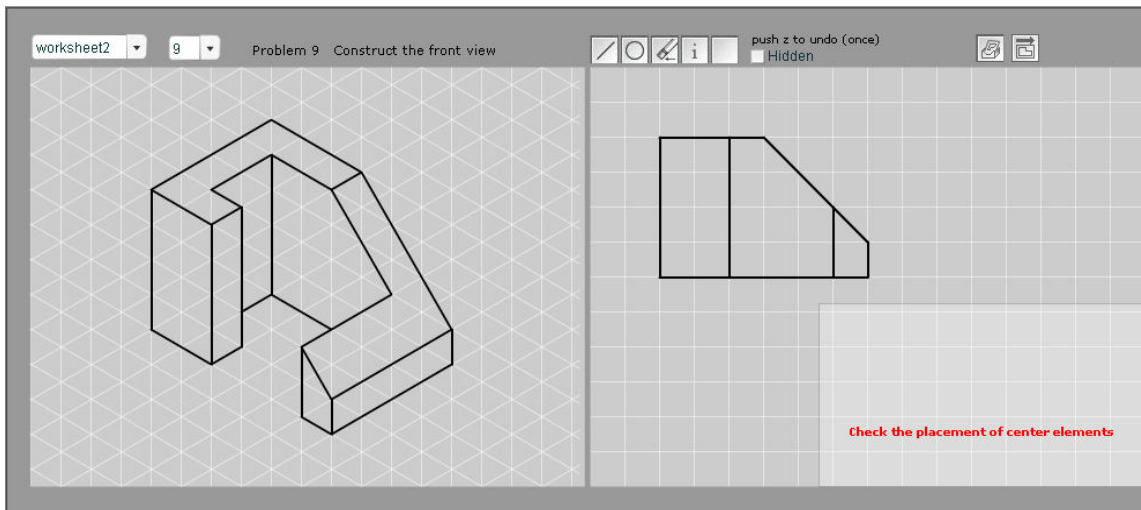


Figure 4. Element Missing.

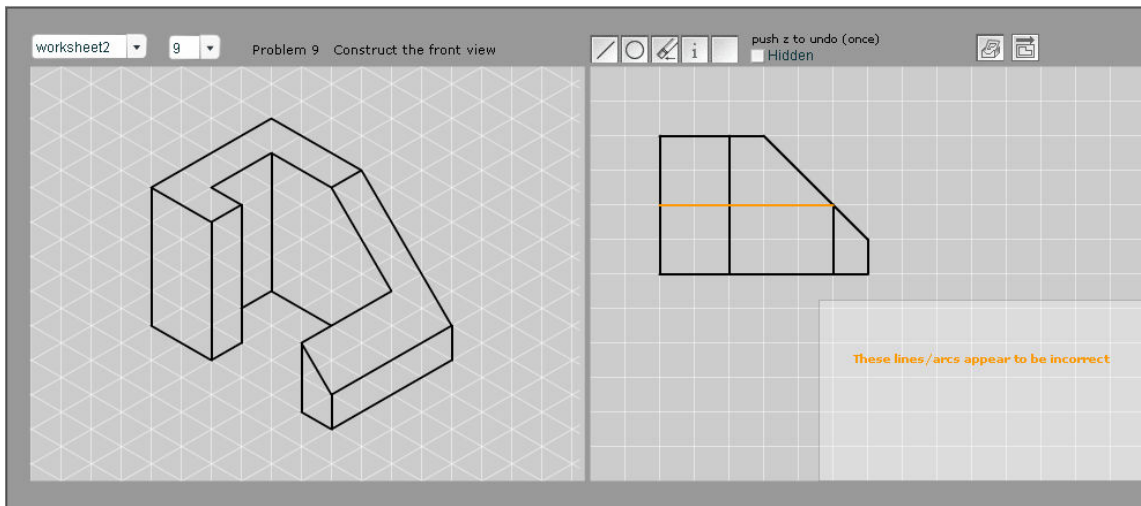


Figure 5. Incorrect Element.

Initial Testing and Feedback

An early version of the basic tutorial (without the interactive drawing and response component) was presented to various groups for review and feedback. These tests included a content expert/design review for accurate content and methodology, a small group alpha test for product usability and completeness, and a small group beta test for content effectiveness. The feedback from these reviews resulted in tutorial modification and usability redesign that have culminated in the current user interface and navigation components.

The interactive drawing and response tool portion of the tutorial was presented separately to approximately eighty students in an introductory engineering graphics course at Purdue University. These students had some basic experience with multiview drawing and had completed several simple problems of this nature in course laboratory exercises. The students were asked to complete ten problems in the interactive drawing and response module and were asked to complete a short survey regarding the interactive tool. From these responses, the following overall opinions were noted:

- The students consistently found the tool to be easy to use.
- The error messages were not clear or were somewhat misleading.
- The product was beneficial in helping them understand multiview drawing applications.
- The aesthetics of the drawing module need to be improved to enhance visibility.
- The instant feedback provided by the responsive grader was beneficial.

Validation Testing

The authors have established a schedule of program revision and testing that will allow for more robust qualitative and quantitative assessment of the tutorial and interactive drawing product effectiveness. This testing will commence in early 2005 and will provide data for analysis and discussion for presentation at the ASEE Annual Conference in June, 2005.

The initial validation of this multiview tutorial will involve the administration of the Kolb Learning Style Inventory to the students. These results will be analyzed later along with the posttest results to identify any recognizable patterns. Three laboratory sections of approximately twenty students each will receive a paper-based pretest to evaluate existing knowledge of multiview principles. Each of the laboratory sections will then be exposed to the web-based instructional tutorial. Following the instruction, one laboratory section will use the interactive drawing and grading tool to complete a multiview creation assignment. The second laboratory section will complete the same problems using traditional pencil and paper methods. The third laboratory section will complete half of the assignment using traditional methods and half with the interactive tools. Upon completion of the assignment, each section will receive an identical paper-based posttest. It is estimated that the testing period will have a one laboratory period (2 hour) duration, after which the results will be reviewed and statistically analyzed.

It is hoped that comprehensive testing of the tutorial will further validate the usefulness and effectiveness of the tutorial as an instructional tool for multiview drawing skill development.

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Biographical Information

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