DOCUMENT RESUME

ED 477 039 IR 021 767

AUTHOR	Kazlauskas, E. J.; Boyd, E. F., III; Dessouky, M. M.
TITLE	The Virtual Factory Teaching System (VFTS): Project Review and Results.
SPONS AGENCY	National Science Foundation, Arlington, VA.
PUB DATE	2002-06-00
NOTE	7p.; In: ED-MEDIA 2002 World Conference on Educational Multimedia, Hypermedia & Telecommunications. Proceedings (14th, Denver, Colorado, June 24-29, 2002); see IR 021 687.
CONTRACT	EEC-9872488
AVAILABLE FROM	Association for the Advancement of Computing in Education (AACE), P.O. Box 3728, Norfolk, VA 23514. Tel: 757-623-7588; e-mail: info@aace.org; Web site: http://www.aace.org/DL/.
PUB TYPE	Reports - Evaluative (142) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01/PC01 Plus Postage.
DESCRIPTORS	Cooperative Learning; Distance Education; Higher Education; Information Networks; *Instructional Design; Instructional Innovation; Multimedia Materials; *Program Evaluation; Student Projects; *Teaching Methods; Technical Education; World Wide Web

ABSTRACT

This paper presents a review of the Virtual Factory Teaching (VFTS) project, a Web-based, multimedia collaborative learning network. The system allows students, working alone or in teams, to build factories, forecast demand for products, plan production, establish release rules for new work into the factory, and set scheduling rules for workstations. Included in the paper are a system description and list of project tasks. The evaluation component involving 3 different campuses is described and the results of 3-years of analyses are presented, including demographic descriptions, self-assessment results, performance results, attitudinal responses, and usability. In addition, instructor observations and course project output is also examined as components of the VFTS evaluation effort. It is believed through the analysis that the VFTS is an excellent instructional method to teach students the integration of the different modules in operations planning. (Author)

The Virtual Factory Teaching System (VFTS): Project Review and Results

Kazlauskas, E .J.
Instructional Technology
University of Southern California
United States
kazlausk@usc.edu

Boyd III, E .F.
University of LaVerne
United States
fboyd1@fboyd.com

Dessouky, M M.
Industrial Engineering
University of Southern California
United States
maged@usc.edu

Abstract: This paper presents a review of the Virtual Factory Teaching (VFTS) project, a web-based, multi-media collaborative learning network. The system allows students, working alone or in teams, to build factories, forecast demand for products, plan production, establish release rules for new work into the factory, and set scheduling rules for workstations. Included in the paper are a system description and list of project tasks. The evaluation component involving three different campuses is described and the results of three-years of analyses are presented, including demographic descriptions, self-assessment results, performance results, attitudinal responses, and usability. In addition, instructor observations and course project output is also examined as components of the VFTS evaluation effort. It is believed through the analysis that the VFTS is an excellent instructional method to teach students the integration of the different modules in operations planning.

Background

To address the manufacturing educational needs of new engineers, a web-based, multi-media collaborative learning network, referred to as a Virtual Factory Teaching System (VFTS), was developed under an National Science Foundation (NSF) grant (Dessouky, et. al 1998; Dessouky, et. al. 2001; Kazlauskas, et. al. 2000; Kazlauskas, 2001). This tool is currently being used by engineering students from the University of Southern California, San Jose State University, the University of Virginia, and most recently North Carolina Agricultural and Technical State University. The overall aims of the project are:

- To provide, disseminate, and evaluate a manufacturing education pedagogical tool that promotes student understanding of complex factory dynamics.
- To improve student skills in communication, persuasion, negotiation, and management, as well as in the technical arenas of production planning, forecasting, simulation, scheduling, and integration.
- To provide a forum in which engineering and business school students can participate in virtual teams that cut across universities.

The research plan of the project is aimed at exploring the interface between virtual factories, engineering education, intelligent agents, and the Internet for new ways of teaching modern manufacturing problems, practices, theory, and techniques to engineering and business undergraduate students. In addition, it is aimed at examining its potential for use as an information vehicle on the topic of manufacturing for K-12 students. Various research questions are addressed, such as: how students perform when using new technology-enhanced modes of learning; what are the effects on attitudes; how intelligent agents might assume tutoring and participative roles; and how team performance, hampered by geographical separation, might be enhanced via advanced communication technologies.

The project timetable consisted of the following: a Baseline period to provide an understanding of the Industrial Engineering courses (with scheduling content) using traditional instructional methodologies, i.e. without the VFTS; the use of the VFTS to provide an understanding of the Industrial Engineering courses (with scheduling content) offered at the various institutions; then the use of an expanded version of the VFTS at the same institutions with pedagogical agents and use of virtual teaming included. The following presents an overview of the features of the VFTS; a description of the evaluation approaches; and three-year project results.

System Description

The architecture of the VFTS was kept simple and modular. There are three layers in the design: AweSim Server, VFTS Java Server and Clients. Clients, which are students in our case, use standard WWW browsers like Microsoft Internet Explorer, to connect to the VFTS Java Server using its Web Page. Most of the communication between the clients and the server takes place using Java applets. The Java-Server functions as a mediator between the AweSim factory servers and the clients. The Awesim Server is responsible for factory knowledge and simulation. The layers interface using a message protocol set up to minimize bandwidth requirements. Other components of the VFTS include the use of Ptolemy, a graphing package, and Drasys, an Operations Research (OR) package.

The system allows students, working alone or in teams, to build factories, forecast demand for products, plan production, establish release rules for new work into the factory, and set scheduling rules for workstations. They can run simulations where an animated panel displays jobs progressing through their factory, with queue counts, finished goods counts, graphs, and reporting functions all available. Students access via the VFTS, using computers in university computer labs, or in their dorms or homes, a virtual representation of the factory. The professor posts assignments related to this factory over the Internet, "unfreezing" parameters as necessary so students may experiment without redefining the entire factory. Students observe the effects of their decisions, and student teams assume factory roles to solve problems; if they reach an impasse, intelligent agents provide guidance. Selective information may be given based on student roles; for example, the production supervisor may have equipment information, the engineer new technology information, etc. Students sort out strategies and can discuss options via e-mail and electronic chat rooms. Since this course is a common one found in many universities, collaboration among universities is feasible. Faculty members virtually "team teach" the course. Intelligent agents are incorporated into the VFTS to monitor student progress and provide immediate feedback.

The latest version of the VFTS software includes support for user account management, adding security to allow students within a group to share data while preventing access to it from students outside the group, a more easy to use interface, instrumentation so that the software will gather data on student usage patterns, on-line help, on-line documentation and an on-line tutorial to help for students and faculty learn how to use the VFTS, and an introductory homework exercise to help students learn how to integrate the VFTS into the course. A project that uses the VFTS was developed to complement the students' classroom learning and was integrated into the courses at the participating universities. The latest version also includes a pedagogical agent that monitors students' use of the VFTS and provide guidance. This required integrating the pedagogical agent software (ALI) into the VFTS, adding the ability for ALI to maintain a persistent model of each student's knowledge across sessions, extending ALI to include more sophisticated explanation capabilities, adding VFTS-specific knowledge to allow ALI to understand the instructional objectives of the VFTS and provide appropriate support to students, and instrumenting ALI to maintain a log of interactions with students to aid our evaluation.

The current version VFTS is available at http://vfts.isi.edu.

Project Tasks

The VFTS project included a large set of tasks involving design, development, usage, evaluation, and dissemination. The various tasks associated with the VFTS project are as follows:

- Define instructional objectives and complete evaluation design.
- Develop and/or acquire evaluation instruments.
- Solicit feedback on the instructional objectives, evaluation design, and VFTS use from each university.
- Gather evaluation data for control group (engineering classes without the VFTS).
- Analyze evaluation results for control groups.
- Complete instrumentation of the software to support evaluation
- Teach engineering classes with the VFTS and gather evaluation data.
- Analyze evaluation results for experimental group and compare to control group.
- Use the evaluation results to revise and refine the VFTS and its use in the engineering curricula, its instrumentation, and the pedagogical agents.
- Teach engineering classes with the VFTS, including the use of virtual teams that span multiple universities, and gather evaluation data for this final experimental group.
- Analyze summative evaluation results.
- Make final revisions to the VFTS software based on evaluation results.

Evaluation

In the preceding list of project tasks, it should be noted that considerable emphasis is placed on the design and implementation of an extensive, multi-university evaluation, which is a central component of the VFTS project. The initial evaluation efforts were used a) to check to make sure each project step was implemented according to plan and that milestones are being met; and b) to consider project modification. This evaluation, formative in nature, assisted in modifying the design and development of the evaluation, as well as of the overall design of the web-based VFTS. For example, a Computer Competencies Multiple Domains instrument that was used initially to determine the level of entering competency in such areas as spreadsheets and statistical packages was dropped. It was determine through initial surveys that the learners were homogeneous in terms of a high level of computer competencies. Through the evaluation process, it was decided to gather more data on such issues on the ease of use and operation of the web-based VFTS, and to modify the actual design by changing the opening screen, and by including more tutorial help.

An emphasis of this project is to evaluate learner outcomes, attitudes, and learning. This effort includes the use of various instruments and examination of student work.

The following are the instruments that are presently being used in evaluation:

- Student Pre-course and Post-course Survey instruments which are used to gather data on student demographics and student self-rated assessment of entering/post-course knowledge of operations scheduling, such as the skills, knowledge, and abilities in the use of gantt charts and regression and time series models.
- Operations Scheduling Pre-test/Post-test instruments which are used measure course content before and after instruction and use of the VFTS.
- Affective-Level/Attitudes Instrument (VFTS Participant Opinion Survey) Pre-test/Post-test instrument which are used to measure reactions to the use of the VFTS, such as reactions to use of simulations, working collaboratively, and relevance to future career.
- Usability Evaluation instrument which is used to gather data on such issues on the ease of use and operation of the web-based VFTS.

The VFTS Studies

Various studies were conducted in the VFTS Project. The first of these was the Baseline evaluation conducted at the various universities, to provide an understanding of the Industrial Engineering courses (with scheduling content) using traditional instructional methodologies. The second of these was an investigation of the use of the VFTS at the same universities, to provide an understanding of the Industrial Engineering courses (with scheduling content). A second usage of the VFTS occurred, an enhanced version with teaming and pedagogical agency. The following represents the findings from these investigations (at three universities to-date).

Demographics

For the most part the demographic analyses showed similarities between both the Baseline and VFTS groups at the various universities, and the demographics appear to parallel those that are found in most engineering programs. Most students were in the 21-22 age category, with the age distributions at most universities typical of a 'traditional' undergraduate student. However, students at one institution had an older mean and the age range was quite large. At all institutions, students were mostly seniors. The majority of students at all three campuses were male, as reflects the common engineering enrollment pattern. There was no significant difference on the gender variable between the groups. The primary language was English but many other languages were represented, with 50% or more students at two institutions having a language other than English as their first language.

Self-Assessment

Instruments gathered pre and post data on a student's interest in the course and on their self-assessment of knowledge of course content, such as whether they could apply forecasting methods to new problems.

Students have a moderate interest in the course. One can support the general statement that students know little, if anything, about the content of the course but think that it will help them in a more general way. At two institutions, students indicated that they did see the course assisting in developing industrial engineering fundamentals. Pre and post-test measures of self-assessment indicate significant gains in most areas. In particular, the overall gains in self-assessment in the second year offerings of the VFTS at two universities were significant. The self-report assessment provides evidence that the students feel as if they have learned the subject in the course.

Performance

As a general statement, it seemed desirable to determine if there are significant differences between and among the participant groups. Representative analyses reflect: performance at each institution in both the Baseline and VFTS options; and Baseline to VFTS Comparisons. In examining Baseline and VFTS groups at the various institutions, analysis indicated overall gains in learning in each offering of the course between pre-test and post-test, and in specific content areas of scheduling. There appears to be a significant difference among the schools on the pretest measure, with one institution scoring significantly higher than the others. Comparison between the Baseline and VFTS performance at each institution indicated a difference on selected pre-test items. Correlations were calculated for the pretest instruments, Baseline to VFTS groups. Although there were some correlations between age and certain items and among certain items, it appears that these results were of no significance in this particular study. There were no significant difference between the Baseline and the VFTS groups on the final exam except for a few selected items. As noted, the VFTS groups did not perform as well on the pretest as the Baseline groups, yet scored approximately the same on the final examination. This could imply that the less strong content-knowledge groups, using the VFTS, performed equivalent to the stronger content-knowledge groups. The post-test scores at one institution are significantly higher than at the other universities. We remark that at only this university was the post-test a component of the student's final grade. In fact, it was treated as the final examination so in this case the students took it much more seriously where they most likely studied for the examination. A comparison of the post-test scores between the baseline and VFTS groups at this university show a significant gain for the VFTS group, although for a smaller class size.

Attitudes

Instruments gathered pre and post data on a student's opinions, on such scales as usefulness, interest, importance, difficulty, and confidence, for example whether students thought learning to use computer simulations to work on class assignments would be useful to their future career. Results of the analysis indicated that there was no significant change in the attitudes of the students, even with the use of the VFTS.

Usability

In regard to the use of the VFTS, most students seem to be using Internet Explorer on a Windows 98 platform. Student comments on the usability of the software isolated several problems that were resolved in the updated version of the VFTS. The various modules well-received; for the most part the online documentation and tutorials not used or students commented that they were of limited value; students were not positive towards the use of the VFTS teaming aspect of the course. However, effort is being made to modify the teaming aspect of the course with the assertion that this may impact usability findings on this topic.

Other Results

Input was solicited from the instructors of the courses at the various universities. Their comments regarding the use of the VFTS were positive. They noted, in particular, that students using the VFTS had a more realistic course project than their counterparts in the Baseline classes.

The NSF funding for this project has supported five graduate students at the University of Southern California. These students have gained valuable experience in Web-based software development, user interface principles, pedagogical agent technology, educational materials development, and educational evaluation. Perhaps the most valuable training for all the students is the close multidisciplinary collaboration between computer scientists, engineering educators, and educational researchers and educators. These students will have a much broader perspective on research than typical graduate students that work closely with others only in their own field.

Conclusion

The VFTS was instrumental in facilitating students' understanding of the integration between the models for forecasting, production planning, material planning, inventory planning, and scheduling.

It was demonstrated through an analysis of project reports that students had a better understanding of the integration between the different modules. This was illustrated by the fact that students clearly spent a good part of their time, with the VFTS, in testing many different scenarios, and students were able to see the impact of changing a parameter on the output. It is suggested that another major benefit of the VFTS is that a more complex system can be modeled than otherwise. Thus, it was seen that students had a more realistic project than their counterparts in the Baseline groups. To summarize, it is believed through the analysis that the VFTS is an excellent instructional method to teach students the integration of the different modules in operations planning.

References

Desouky, M. Bailey, D., Verma, S, Adiga, S. Beckey, G and Kazlauskas, E. (1998) A virtual factory teaching system in support of manufacturing education. *Journal of Engineering Education. 459-467.*

Dessouky, M., Verma, S., Bailey, D.E., Rickel, J. (2001). Methodology for Developing a Web-based Factory Simulator for Manufacturing Education. *IIE Transactions,* 33(3), 167-180.

Kazlauskas, E.J., Desoukky, M., Rickel, J & Johnson, L. (2000) A Web-based Factory Teaching System: Design and Development. *Proceedings of WebNet2000: World Conference of the WWW and Internet.* San Antonio TX. October 30- November 4, 2000.

Kazlauskas, E.J. (2001). Integrating University-based Technology Projects into Education Programs. In Lee, C. (Ed.) Enhancement of Quality Learning through Information and Communication Technology. The 9th Annual International Conference on Computers in Education. Seoul, Korea: ICCE, 269-275.

Acknowledgement

This research is funded by the National Science Foundation EEC-9872488.

NOTICE

Reproduction Basis

- [X] This document is covered by a signed "Reproduction Release (Blanket)" form (on file within the ERIC system), encompassing all or classes of documents from its source organization and, therefore, does not require a "Specific Document" Release form.

- [ ] This document is Federally-funded, or carries its own permission to reproduce, or is otherwise in the public domain and, therefore, may be reproduced by ERIC without a signed Reproduction Release form (either "Specific Document" or "Blanket").