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AUTHOR Cooper, Peter A.; Hirtle, Jeannine S.
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ABSTRACT

This paper is a report on the findings of a study conducted during an undergraduate computer science class for preservice teacher educators which was restructured using constructivist principles. Qualitative analysis techniques were applied to field notes, transcripts of computer-mediated discourse, project evaluations, an interview with the professor, and student interviews. Quantitative analysis techniques were applied to an attitundinal survey and student self-evaluations of their competency related to problem solving, e-mail, word processing, spreadsheets, presentation software, and the World Wide Web. Findings indicated that students met the technical skills required in an introductory computer science course. (Author/AEF)

A Constructivist Approach To Technology Literacy For Preservice Teachers

Peter A. Cooper Ph.D., Computer Science Department
Sam Houston State University
United States
csc_pac@shsu.edu

Jeannine S. Hirtle Ed.D., Curriculum and Instruction Department.
Sam Houston State University
United States
edu_jsh@shsu.edu

Abstract: This paper is a report on the findings of a study conducted during an undergraduate computer science class for preservice teacher educators which was restructured using constructivist principles. Qualitative analysis techniques were applied to field-notes, transcripts of computer-mediated discourse, project evaluations, and an interview with the professor and student interviews. Quantitative analysis techniques were applied to an attitudinal survey, and student self-evaluations. Findings indicate that students meet the technical skills required in an introductory computer science course.

Introduction and Statement of Problem

As educators prepare students for the much-heralded new millennium, the acquisition of technology skills becomes imperative to make them key players in this new Age of Information. In traditional pedagogical strategies, the professor assumes the role of dispenser of knowledge and students are passive receivers who dutifully record and memorize this information. These strategies are simply inadequate for a generation of learners who can access information, play games, purchase products, and conduct global correspondence through access to the Internet. This new generation of learners will take their place in a society that is increasingly information-driven, and this rapidly evolving society will demand learners who can evolve quickly with it. These learners will have to be prepared to continue their education throughout the span of their working lives. The current shelf life of a technological degree is a mere five years, and it is estimated that 75% of the current work force will require some form of re-training simply to maintain their technological competency (Dolence and Norris, 1997).

Today, with information so readily available for public consumption, educators cannot afford to collect and transmit knowledge as if it were a static entity. Now they must respond to New Learners who live and work in this socioeconomic environment. A new pedagogical orientation will be required to serve the kinds of students who go beyond (simply) having a set of skills and a body of knowledge. A dynamic, student-centered pedagogy will be important for all learners as we enter this new century, and it is doubly important for those preparing to enter the teaching profession because the instructional approach they experience will not only set their attitude toward learning, but predispose those attitudes for the next generation of learners.

How can this new generation of learners function in an active environment which demands flexible problem solving skills and critical thinking? The pedagogical model of constructivism offers an answer to this dilemma. Constructivism is a way of building knowledge about self, school, everyday experience, and society through reflection and meaning making (Shor, 1992). One of the primary goals of constructivism is to provide a democratic and critical learning experience for students. It serves to open boundaries through inquiry and to avoid closing them through unquestioned acceptance of prevailing knowledge. It creates the realization that knowledge is never neutral, that the ways in which knowledge is mediated and created are as dynamic and important as the knowledge itself (Hirtle, 1996)

A constructivist orientation to teacher education is important if teachers are to encourage students in schools to develop problem solving and critical thinking skills and to apply, analyze, synthesize and evaluate knowledge, skills and attitudes. Pre-service teachers should engage in these processes throughout the entire teacher education program if we have any hope for a constructivist approach in the schools (White, 1996). Contrary to the evidence about the importance of constructivist pedagogy in teacher education, many teacher education courses are taught along a transmission model. The computer science course required at many universities is usually taught through a formal, didactic transmission approach causing students to learn rote skills with little working knowledge of how to implement them in other situations. This inert learning causes students to learn just enough to be successful in the context of the course they are studying, but the ability to use the acquired skills quickly diminishes from lack of use and lack of conceptual understanding about how and when to apply them. How can traditional skills-based courses organized along the transmission model be restructured so that students may not only acquire the requisite skills, but also gain an understanding of how to use them to solve real world problems?

The Study

In summer 1998, the computer science department scheduled a 'special' section of its introductory computing course, CS 138 Multimedia and Networking Computing. This special section was to be used to implement the constructivist principles identified above. Enrolment in the class was restricted to preservice undergraduate and in-service graduate students. The class was limited in size (13 students; 4 males and 9 females) and met each day from 8:00 am to 10:00 am for five weeks. The instructor was assigned to the computer science department and held graduate degrees in Higher & Adult Education and Mathematics Statistics and Computing for Education. He collaborated with an education colleague in the conceptualization of this course and some of the initial planning. This colleague acted as data collector for the study and co-author for the study.

The structure of the course was organized around two real-world problems.

- The Coming Millennium
- The Teacher Supply Store

Each problem was presented in the form of a case study to the students and both instructor and students collaborated in a deconstruction and analysis process to code the case study in terms of:

- Event sequence (Knowledge acquisition, Actions, Processing, Reflection, Evaluation)
- Tools (Advanced application, Grand Themes, Technology tools)

In addition, a set of meta questions were used to explore the sufficiency and completeness of the deconstruction process. Handouts illustrating one of the case studies and the deconstruction process will be provided during the presentation.

With the primary intent of the instructional approach being 'skills acquisition driving the need to know', the course structure was designed to apply computer applications to real-world, problem solving, rather than teach the technical skills in isolation. Traditionally, the course content would consist of six areas; using WWW resources, Word Processing, Spreadsheets, Presentation Applications, Databases, and Web Page design. In contrast, the instructor had three considerations in designing the new course

- To be problem centered
- To work within a collaborative framework
- To provide a context in which the requisite skills would naturally emerge.

The instructor performed three distinct roles: director and classroom manager to set the focus of each classroom session, facilitator for the deconstruction and analysis phase, and as technical expert on the use of computer software resources and their application to the case study.

Deconstruction and analysis of case studies were performed in a group setting. Initially the process used a chalkboard. As students became more aware and capable of using applications, notes taken during the analyses were written to a word processor and then e-mailed to the group. After the initial analysis and to facilitate the free flow of ideas, threaded message boards were used to allow continued group discussion free of time and location constraints.

Data were collected from a number of different sources including:

- Field notes taken by the co-investigator
- Interviews with students
- Attitude and skill surveys,
- Instructor-created web sites, and the transcripts of the threaded message boards.

The study was concerned with evaluating the quality of learning and student attitudes. How can traditional skills-based courses organized along the transmission model be restructured so that students may not only acquire the requisite skills, but also gain an understanding of how to use them to solve real world problems?

Findings

This course was organized according to constructivist principles. First of all, the instructor developed two problems to guide student inquiry: the millennium project and the feasibility study for a teacher supply store. The first problem, the millennium projects, was directed toward student personal interest. The teacher supply store project was directed toward students' professional interest.

The instructor designed the millennium project to give students the opportunity to gather, sort, and evaluate web-based information about the significant millennial issues, and to identify those issues which were most important and real to the students. The students used a number of Internet based tools to support the process including the use of web browsers, search engines, email and a forum (threaded message boards). Web page composition software was used to construct and publish a web page that reflected their interest and the issues they felt most important.

The instructor developed the school supply store project to appeal to the students' professional interests. The students were presented with the task of investigating the feasibility of starting a school supply store in a mid-sized town. The students were tasked with examining the market, evaluating prospective locations and deciding on inventory. The students were also given the opportunity to decide on how the store was organized and run. They utilized spreadsheets to develop a financial plan, word processors and web tools to locate and gather information on (real) prospective sites for the store and presentation software to simulate the presentation of the financial plan to a bank for loan purposes. Again the students used email and the forum to communicate ideas and information to each other.

All technical instruction was taught in the context of these two projects. The professor used direct instruction at the beginning of class period to give students information, which help the student decide on what actions needed be taken to move the project forward to resolution and to establish their priorities for that class period.

This scenario illustrates the professor's use of direct instruction in a large group format for the purpose of moving the project forward and teaching the students' necessary technical skills necessary to complete the "school store" project. Cooper is directing the class to plan for inventory purchase as they ascertain the market demands. He asked the class, " How much software and videos do you estimate would be sold in a week?" After some discussion the class estimated 5 pieces of software at $40 a piece for a total of $900 a month. Cooper entered the figures into an Excel chart he was projecting onto a large screen in front of the classroom.

Teacher Supply Store				
Item	Count	Cost	Selling Price	Revenue
Software/Videos	5		$ 40.00	$ 900.00
Workshops	1		$ 150.00	$ 675.00

Then, he asked, "How many workshops will you run a week?"
The students estimated one.
"How much will you charge?" he inquired?
The estimates totaled to $675 a month.
Cooper then prompted with, "School Supplies. How much do you estimate?"

The students estimated $50,000 and Cooper pasted this into the chart reminding the class, "Bear in mind that we haven't talked about teachers buying supplies, middle school etc. Do you think we could sell $50 a day, 6 days a week, times 4.5 weeks representing a month? That would be $1350 of school supplies." He copies it into appropriate EXCEL chart fields.

After the large group instruction, the students had an increased awareness of how to project inventory needs to market demand and they had the rudiments in designing a useful sheet in EXCEL. The professor then provided hands on practice in working in EXCEL as they moved into small groups to continue the project.

Cooper challenged the class, " I'm going to e-mail you this spread sheet. Seriously think about what you could do to increase your profitability." Between now and tomorrow, I want you to think. What could we be selling as a service. Expect this in the mail in the next few minutes and then you can play with it."

This challenge placed responsibility on the students to think about strategies for increasing profit margins and it allowed them to practice the new technological skill they had acquired as they worked on these strategies. He also utilized another of the courses technical objectives, "having the students be fluent in telecommunications technology," to deliver this assignment. Consistent with constructivist principles, the instructor placed responsibility for continuing learning and practice on the students and he stepped back into the role of coach or facilitator as he allowed student interest and choice to guide their inquiry. The instructor asked them to go back to the forum (threaded message board) and make a commitment about what they would research.

Cooper supplied just-in-time information that would extend students' technical abilities when they needed that extension to support the project. The students were unclear as to how to begin accomplishing the tasks before them. In this scenario, Cooper explained to the class the steps involved in small group decision making before sending them off to work in collaborative groups. He talked them through taking the issues of supplies and then presents the steps necessary in brainstorming the tasks involved in determining the store inventory. Then he suggested how students might divide out the necessary tasks

Students asked about alternate means of data collection. Cooper offered possible suggestions, "You could visit stores and write up a field report of your visit. You could interview teachers to assess their needs. I want to emphasize that you must make a commitment about who will be responsible for collecting what resources. You must think about what you are going to sell in their store."

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Cooper supplied just-in-time information that would extend students' technical abilities when they needed that extension to support the project. When students were uncertain how to organize their project activities, Cooper explained to the class the steps involved in small group decision making before sending them off to work in collaborative groups. He talked them through taking the issues of supplies and then presented the steps necessary in brainstorming the tasks involved in determining the store inventory. Then he suggested how students might divide the necessary tasks using technology to record and publish their results Cooper's just-in-time instructions on constructing an action plan provided the students necessary information to move the project forward, and his seamless integration of technology to support the project made the acquisition of technology skills a natural part of the learning process.

When Cooper, was not offering direct instruction, he observed and conferenced with individuals and small groups. In the following scenario, a group asked Cooper about how to collect data? Cooper offered possible suggestions:

"You could visit stores and write up a field report of your visit. You could interview teachers to assess their needs. I want to emphasize that you must make a commitment about who will be responsible for collecting what resources. You must think about what you are going to sell in their store."

He moved from group to group coaching and advising as students sat in front of their computers entering data into their word processing program. "When you talk about merchandising you're going to have to make some decisions. What are people going to buy? What are you going to sell?"

Cooper's continual redirecting students towards the purpose of the project kept students focused and made the technology skills they were learning in the process seem like tools that would help them achieve their project goals.

Data concerned the quality of student learning was gathered during the course and at the end of the course. Students were expected to perform five class demonstrations of the problem solving process using the technology tools as part of their grade evaluation. In the course of the semester the demonstrations utilized all

of the application tools. Grades assigned to the demonstrations ranged from 60% to 100%. The lower grades were generally a result of not applying skills that had been learned, and that were appropriate in the context of the demonstration. In addition students were expected to compete research/short-writing assignments. Again grades ranging from 60% to 100% were assigned. The writing assignments were word processed and e-mailed to the instructor. The lower grades reflected a lack of use of techniques already learned, particularly formatting and organization and structure in the writing. The instructor had a strong sense of the students feeling more comfortable with the research process but not with the reporting process. These results were in line with instructor expectations except that no students failed to complete an assignment and no student dropped the course.

At the end of the course students were asked to perform self-evaluations of their competency in a range of skills associated with six key areas:

- problem solving
- use of email
- word processing
- use of spreadsheets
- use of presentation software
- use of the world wide web

On a 10-point magnitude estimation scale, student self-evaluation scores ranged from 1 to 10. Class averages of the self-evaluation data were in line with instructor-graded presentations. Chart 1 indicates that students perceived they performed better with presentation applications, word processing and web applications than with email, spreadsheets and the problem solving process.

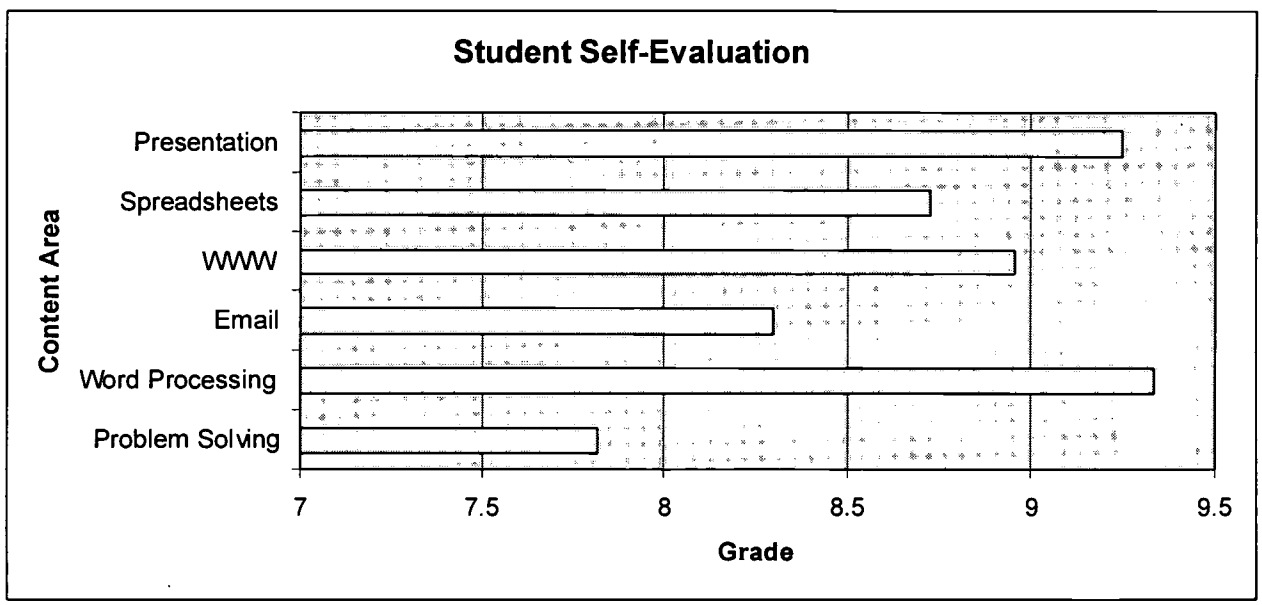

Chart 1: Average student evaluation scores

Threaded message boards were used to provide communication between the groups. The Millennium project forum, the first one used, recorded 46 message in a one-week period with most of the messages referring to new millennium locations. The teacher supply store forum recorded 125 messages in a similar time frame. The messages fell into two groups: brainstorming messages, where students tried to define the boundaries of their solutions to the case study and organization messages, where the groups divided the tasks among themselves and then reported back on their efforts. The students appeared to become more comfortable with the forums and used them more extensively and for more structured purposes in the second case study.

The students responded positively to the process and to the skills they were learning. They reported positive feelings about their technical expertise. One student reported, "I learn how graphics and sound add to a presentation. I also learned to save often. I really enjoyed this class. I never knew all these neat things happened on a PC. "Another student reported, "I also never knew all the things you could use a spreadsheet for.

I enjoyed learning about the formulas to use on a spreadsheet (you don't have to be good at math to use a spreadsheet). I enjoyed learning how to use Adobe Photoshop. You can do a lot of neat things to pictures."

Students reported feeling comfortable with both the content and the instructional process. Students reported :

> "I learned that the computer can read the written text out loud in an array of voices. I also became much more comfortable with PowerPoint, Excell(sic) and the web page composer."
>
> "I learned a lot about doing group work on a project. Group work is my least favorite thing but our group really worked together very well."
>
> "I know computers could be used for many things but I never knew it was this easy to learn to use them. I did not now you could create PowerPoint presentations and put them on the World Wide Web".

Conclusions and Implications

Students in CS 138 were expected to learn how use a number of software applications including office applications (word processor, spreadsheet, presentation) and communication applications (web browsers, page development applications and email). The constructivist approach used in this project provided the students with the time, motivation and resources to develop appropriate skill levels. In many cases, the students discovered and used additional features of the application (such as voice synthesis, threaded message boards) that would not normally have been examined in a traditional course. In addition, some students explored other applications (e.g. Adobe Photoshop) and hardware (scanners, digital cameras) to extend their capability.

The high interest projects in a collaborative setting established strong motivation. The inquiry-driven environment helped develop collaborative skills such as brainstorming, prioritization, checking for understanding, conflict resolution and establishment of consensus. Because interest was keen and motivation was high, students acquired skills any a way that seemed a natural part of the development. In some cases, students reported that not only were they surprised at their degree of technical competency once the course was completed, but they were surprised at how easy it was to acquire it. The investigators believe that the motivation increased the facility of skill acquisition.

The professor's role as well as the students role were restructured in this course. The professor took the lead in problem construction, encouraging self assessment and providing assessment, and in teaching technical skills lessons, as well as group management techniques. He took on the role of coach and encourager and became and adjunct to the teams as they worked their projects. He maintained his stance his professor and provided the necessary motivational and management strategies to organize multiple groups and class projects, but he was accessible and a valuable resource for the community as well.

The constructivist principles of encourage students to think critically as they solve problems, and learn the necessary skills to achieve their problem resolution in a natural way were successfully implemented in this pilot study

Implications

1. Students can learn technical skills collaterally in a constructivist, inquiry-driven curriculum.
2. Interest and motivation, by products of an inquiry driven curriculum enhance and accelerate technical skill acquisition.
3. Introductory computer science courses can be taught successfully in the context of students' professional content areas.

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