Teamwork Using an Authentic Product Development Environment

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Abstract

The effectiveness of an authentic product development environment to enhance teamwork skills of rising 9th -12th grade students was studied as part of a 3-week summer program. Teams of students were provided scenarios of 'customer' requirements. The teams translated customer requirements into technical requirements, researched content and developed websites. Usability studies were conducted including heat maps of the websites using eyetracking equipment to provide feedback for closing the loop in the product development cycle. Student reactions to teamwork were documented using survey instruments and interviews. Results indicate participants recognized teamwork as an important element of real world work. The product development environment simulated an authentic real world scenario and played a positive role in emphasizing the need for teamwork.

Keywords

Teamwork, product development cycle, project based learning, web design, eyetracking

Introduction

The importance of teamwork skills is well recognized in the corporate world. The ability to function effectively on multidisciplinary teams therefore has been institutionalized in engineering education in the form ABET Student Outcome (d). The requirement to respond to the accreditation requirement, research on techniques to develop various teamwork skills, and to measure the effectiveness of these techniques continues[1-4]. In addition to teamwork being an essential 21st century skills, team-based learning improves student achievement by increasing student reasoning, problem-solving and critical thinking skills, encouraging more scientific thinking, and developing a deeper understanding of course content[5-12].

The Next Generation Science Standards (NGSS) now includes engineering design, thereby requiring teamwork to being emphasized at the K-12 level. A number of investigations[13-18] have looked at the challenges and opportunities of implementing engineering design in schools. A team environment for project-based learning that promotes interdependence of the team members has been shown to impact student learning outcomes[19].

This paper is based on an NSF funded project (Grant # 1312285) for 9th -12th grade students to learn science concepts. A self-learning approach grounded in the learn-to-write, write-to-learn construct[20-23] using a digitally mediated environment. The paper focuses on authentic learning of teamwork skills using an active-learning project based on the product development cycle and follows the eight essential science and engineering practices of the Science Framework of the NGSS[24].

Participants

Students (n=55, 27 male, 28 female) who were rising 9th-12th graders were recruited from two school districts in Alabama, one rural, and the other urban. All participants self-identified as African-American.

Method and Materials

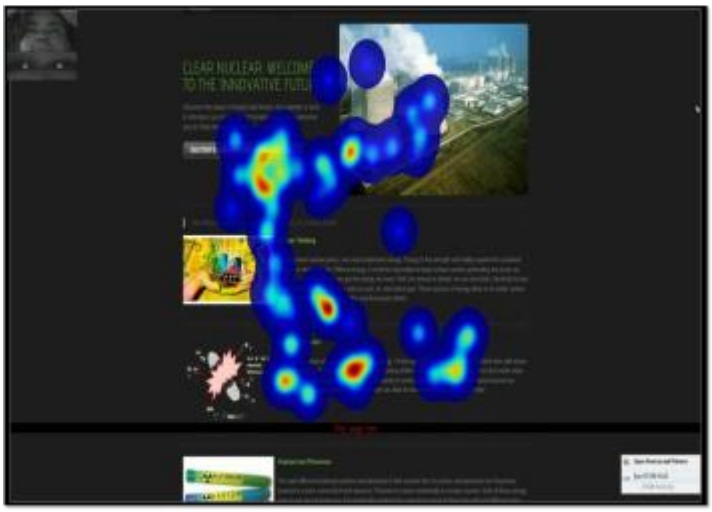
The project team conducted 3-week long sister summer camps simultaneously at an urban location and at a rural location. Both the summer camps had identical components. The overarching context was an authentic product development task, i.e., developing a website in response to customer requirements; embedded in the task was the primary objective of learning science concepts through research and writing. The participants were assigned to five teams at each site based on their choice of a science concept that they wanted to learn. These five science concepts were aligned with the Alabama Course of Study. Each of the science concepts was included in a scenario that was worded as a requirement from a customer (see Appendix A) requiring the development of a website. Each scenario was supported by a webquest that including guiding questions to scaffold the process of researching appropriate content for the website. Some other aspects of the summer camp included oral communication skills, eyetracking, and distance learning with one site experiencing the learning materials face-to-face and the other site learning through an interactive audio/video link. The participants used the Product Development Cycle (Fig. 1) as they progressed through the eight essential science and engineering practices of the engineering design standard of the NGSS.

Figure 1. Product Development Cycle

The participants were provided instruction on the website design software, best practices of website design and oral presentations. The teams presented their products (websites) at the end of the summer camp explaining the process of the development. The teams also participated in a number of team building design-type exercises such as the "marshmallow-spaghetti tower", and "egg drop." Various attitudinal instruments were used to assess and evaluate the effectiveness of the approach. These included pre-post science attitude surveys, team work surveys, web usability rubrics and interviews. The participants also used eyetracking hardware and software to assess

website usability through the use of heatmaps (Fig. 2), thus learning the importance of the verification, validation and improvement aspects of the product development cycle.

Figure 2. Sample Student Heat Map



The attitudes towards teamwork were assessed using instruments that measured several dimensions and provided opportunities to respond to open-ended questions. These teamwork instruments were originally developed to assess and evaluate teamwork skills of undergraduate engineering students working on capstone design projects[25]. A Team Citizenship survey was given to the participants a week after the teams were formed and the participants had some experience of teamwork while working on the project. This survey introduced the participants to the four main dimensions and 12 sub-dimensions of teamwork. A Teamwork Achieved survey was given at the end of the project. This survey had a number of components including changes in perception of importance of the various dimensions (Fig. 3), identifying the most effective teamwork dimension and how it impacted their project, and teamwork lessons learned as a result of the product development cycle. This paper provides an analysis of the responses to the Teamwork Achieved instrument for one year of the program as other data are still being analyzed.

Results and Discussion

Responses of those who completed (n=45) Part A of the Teamwork Achieved instrument were analyzed. A majority of the participants reported an increase in the importance of the four main and 12 sub-dimensions of Teamwork Achieved. The changes in perceptions of the participants of the importance of these dimensions of teamwork are summarized in Fig. 3. The process of Member Contributions received the highest increased recognition of its importance. For instance, 76% of the participants recognized that competent performance of team members was more important than they originally had thought. Similarly, 74% of the participants recognized the importance of delegation and completion of tasks as more important than their original perceptions. Finally, 69% of participants reported an increased understanding of the importance of self and team-mates' growth.

D = Decreased; NC= No change; I = Increased		% Respondents Perceptions of Importance		
Process	**Contributions of Team Members**	***D***	***NC***	***I***
Team Relationships	Members engage other members with respect	2	29	69
	Members demonstrate commitment			69
	Members resolve conflicts constructively		40	60
Joint Achievements	Members help establish shared goals		42	58
	Members follow plans to achieve team goals		32	68
	Members work synergistically with others	9	24	67
Member Contributions	Members delegate and complete tasks, as needed	2	24	74
	Members perform competently to team standards		24	76
	Members enable self and others to grow	2	29	69
Team Information	Members strive for fully-informed members		40	60
	Members communicate well with stakeholders	7	40	53
	Members document achievements well		29	71

Figure 3: Change in Perception of Importance of Teamwork Dimensions

Engaging team members with respect and demonstration of commitment were also registered as increased importance by 69% of the respondents. The increased importance of following of plans was reported by 68% of the respondents.

Not only were we interested in changes in participants' views of teamwork, but participants also were asked to identify the most effective process that resulted in their team's successful performance over the 3 weeks of their work on the product development. Of the 37 who responded, 43% considered Team Relations as the most effective process, while for 30% Joint Achievements was the most effective process. Member Contributions were considered important by 14% and the remaining 14% considered Team Information as the most effective process.

Participants were asked the following three open-ended questions on their chosen Effective Team Process:
(a) What actions occurred when this "effective" team process was working well?
(b) How this "effective" team process contributed real value to your team and/or project?
(c) How developing this "effective" process has equipped you for future team projects?

The responses to these questions indicated that the participants had developed a vocabulary to articulate their understanding of teamwork. Typical responses included buy-in, communication, compromise, delegation, team goals, etc. Some examples are given below.

"It made things a lot easier when we talked and respected every one opinion"; "contributed real value when each team member was assigned a role to play when working on the project"; "It showed me to respect everyone's opinions and include them in what we were doing."; "The team leader assigned equal amounts of work or amounts of work she thought some members could handle. Some students received more; others received the amount that they could complete. Most of the team was willing to do work so we were able to divide the work up between ourselves and get it done."

The participants also responded to the following three open-ended questions on Teamwork Learning.

(a) What new understanding of teamwork have you gained over the duration of this experience?
(b) What was the (learning) process that led to this new understanding?
(c) How will this new understanding affect your approach to teamwork in the future?

Some responses of the participants are given below:
"I have learned to be open minded and considerate of others because when you work with a team, you have to work together to win or to come out on top."; "This has equipped me for future team projects in the future because it has shown me that even if you have a team that doesn't mean that you have one, you have to build a team, not just receive one. You have to build trusts and relationships with each other in order to understand what you're working with to understand what you got."; "We have to get to know what a leader is and what type of leader am I in order to gain success."

Conclusions and Future Work

High school participants of the summer program were provided an authentic project-based learning environment. Understanding teamwork was an important component of the summer program. Participants developed vocabulary associated with teamwork and recognized the utility and importance of the dimensions of teamwork. An analysis of responses to open-ended questions on effective team processes and teamwork lessons learned found that a number of the participants exhibited sophisticated understanding of the different aspects of teamwork. Others' exhibited different degrees of understanding of teamwork. Future work will include providing coaching to the participants based on the perceptions and observations of their team-mates to support them in enhancing their teamwork skills.

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