THE HEWLETT-PACKARD SENSORY HOME PROJECT

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ABSTRACT
In the Brigham Young University (BYU) School of Technology, we have a unique opportunity to combine art and engineering disciplines to explore a variety of industry sponsored projects. Faculty in the school believe that for students to excel in 21st century economies, cross-disciplinary team-based projects need to be performed on a regular basis. The question is how can cross-disciplinary innovation, design, and engineering curricula be integrated to provide project experiences that teach problem definition (strategic thinking), design thinking, as well as problem solving (implementation) to student teams? This research paper reports how teams of Industrial Design (ID) and Information Technology (IT) students collaborated with Hewlett-Packard (HP) on projects to explore ways to design and integrate sensors in homes that enhance the health, fitness, safety, security, and energy use of individuals and families. These HP projects were intensive, six-week learning experiences where cross-disciplinary ID/IT student teams explored and defined problems, exercised multiple design thinking methods, and validated design prototypes with users in future home settings. This paper describes the purpose, curriculum, and activities that were developed for the project. It reports feedback from the participants and shows how the HP project sponsors received the project outcomes. It also analyzes results of the projects, including how the collaboration affected the students and BYU's School of Technology educational programs a year after its implementation.

Keywords: Design thinking, user experience design, collaboration, cross-disciplinary projects

1 INTRODUCTION

Faculty in the BYU School of Technology believe that real-world, cross-disciplinary, team-based experiential learning projects need to be performed on a regular basis for students to excel in 21st century economies [1]. The School of Technology encompasses seven diverse bachelor's degree programs including Industrial Design (ID) and Information Technology (IT). This unique situation allows the opportunity to combine classes and students on cross-disciplinary projects. Specifically, we believe that cross-disciplinary, team-based experiential learning is necessary for ID and IT students' professional success. Given this belief, how can artistic and engineering curricula be integrated to provide project experiences that teach problem definition (including strategic thinking), innovative design thinking, as well as problem-solving (implementation) to cross-disciplinary student teams?

Schaeffer et al. [2] builds on a long history of cross-disciplinary, team-based education literature by arguing that undergraduate education should not be teaching traditional domain-specific and analysis-orientated engineering, and instead, should be focusing on "educating and graduating strategic engineers who can realize complex systems for changing markets in a collaborative, globally distributed environment." Furthermore, they suggest two critical success factors required by engineers in our IT-dependent, flat world are an ability to adapt to changes and to be able to work at the interface of different disciplines. Similarly, it has recently been suggested that traditional ID undergraduate education needs to shift away from educating ID specialists to preparing ID students to assume leadership positions, dealing with contemporary, ill-understood phenomena, and cross-disciplinary challenges [3]. Since as early as 1995, the area of Human-Computer Interaction (HCI) has been a primary gateway that IT engineers employ to help people efficiently, effectively, and affectively use IT to transform data to information and information to knowledge to meet their needs [4]. Today, the original scope of HCI has evolved to design and engineer the entire user experience (UX) due to the ubiquitous nature of IT and information interfaces [5]. In the disciplines of both ID and IT, design competencies – such as qualitative thinking, speculation, ideation, prototyping, and specification – are in high demand for user-centered design and engineering in today's global, cross-disciplinary knowledge economies. Unless the focus of undergraduate ID and IT includes cross-disciplinary educational experiences, these students' lack of preparation will limit the role they can play in their professions and careers.

This paper explains how ID students (with artistic backgrounds in product design) and IT students (with backgrounds in IT system design and engineering) collaborated on real-world projects for Hewlett-Packard. These interdisciplinary teams explored ways to integrate IT and sensors in future homes. The purposes of these projects were to enhance the health, fitness, safety, security, and energy use of individuals and families. The curriculum, and activities developed for the project are presented, as well as feedback from the participants and the project sponsors at HP. An assessment of the outcomes of this cross-disciplinary experiential learning experiment will also be discussed including how BYU's School of Technology programs and students have been affected a year after its implementation.

2 CURRICULUM & PROJECT ACTIVITIES

The cross-disciplinary ID/IT HP project was an intensive, six-week learning experience where students explored and defined problems, exercised multiple design thinking methods, in addition to iteratively prototyping and validating design prototypes with users in future home settings. This section describes the curriculum management, team organization, and project activities.

2.1 The Innovation Boot Camp & Human-Computer Interaction curriculum

All ID and IT students in the School of Technology at BYU are required to take a 10-hour course in innovation and design thinking principles and practices [6]. This course has demonstrated the value in having students work on cross-disciplinary efforts. However, a cross-disciplinary collaboration experiment of this magnitude was a first for the School of Technology.

2.2 Interdisciplinary ID/IT teams

Students were randomly assigned to teams by the IT and ID instructors. Most teams consisted of one ID and two IT students. Instructors assigned extra students to groups that contained a student who had historically underperformed or a foreign student with language challenges. Students were organized into smaller teams to encourage a lot of participation and to push students to take initiative in helping their team develop multiple innovative design solutions.

Instructors planned their courses so that there was an hour overlap of the IT students' lab time with the ID students' class time. During this overlap, student teams were provided project feedback, instruction, and time to coordinate their efforts. The project required each team to:

- Practice problem definition (strategic thinking) as well as problem solving (implementation).
- Practice principles of design thinking.
- Experience the benefits and challenges associated with cross-disciplinary teamwork.
- Collaborate with their HP industry sponsors on the design of real-world project solutions.

2.3 Cross-disciplinary HP project activities

The HP project required student teams to iteratively complete the following activities:

1. Explore how sensors can enhance individual and family health, fitness, and well-being.
2. Research and generate ideas on how sensors could change our sense of safety and security for children, parents, and grandparents.
3. Create personas to be used to direct product ideas, concepts, and design proposals that address discovered user needs.
4. Understand and conceptualize how sensors can cause people to rethink, revalue, and effectively conserve energy and other home resources.
5. Envision and ideate how an IT and sensor-embedded home can affect peoples' experiences or cultural norms that individuals, geographic regions, and we as a nation may take for granted.
6. Research and define user values and needs within a home that can be enhanced with the IT and technology in general.
7. Refine, validate, and measure design proposals with users to identify how clear and meaningful they are to users; including, at a minimum, a graph with real data and descriptions about what the

team learned about user errors, failures, and/or surprises. Describe how user testing impact the redesign of user interfaces.

8. Iteratively redesign their team solutions to better meet user needs. Complete two iterations of prototyping.
9. Test all design solutions on users and use their feedback in redesigning team solutions.
10. Present the development of team personas, problem definitions, designs, prototypes, and user testing results to instructors and sponsors in multiple design reviews.
11. Complete evaluations of individual team members' contributions to the team and project.
12. Create and give a final presentation to HP sponsors that demonstrate the results of the project: fleshed out personas, an insightful problem statement, design concept(s) that solve the problem statement, video and audio that tells the story of how team solution(s) integrate into their personas' lives, describe what technology is needed to make the team solution work, answer the question "What's the value to the persona (customer) & to HP?", present user testing processes and results, and demonstrate the team's final prototypes.
13. Make a team poster for the presentation (42" x 48") that presents the key points of each teams' work in a concise visual form. The posters must include at least the following: a design solution title or team name, the team's problem statement, a summary of team persona(s), key solution and project highlights, and their design conclusion.

2.4 Assessments and evaluations of student team solutions

Each team received multiple assessments and evaluations throughout the project. The instructors chose to use real-world feedback rather than grading individual project tasks. Teams gave feedback to one another on a regular basis during weekly lab meetings. Every week one or two different teams were selected to present progress to the class. Following the presentations, the class and the instructors provided immediate feedback on the team's work. However, the HP sponsors gave the most important assessments and evaluations during two different design reviews.

There were many good examples of storytelling in the design reviews, but the HP clients criticized several teams for being too narrow in their solution concepts. For example, one team presented a gesture-based interaction solution for changing the TV channel while cooking needed to either expand the solution to a variety of sensors that aid in various aspects of cooking, or follow the arm and finger interface through "a day in the life of the user" to demonstrate more uses and solutions to the person's household challenges and needs. During these reviews, HP sponsors also coached the students on how to give professional presentations to clients (e.g., "Don't be focused on, or married to, a technology. . . Use the persona to drive problem definition and solution concepts.")

HP did not want to stifle innovation by giving specific ideas or criteria for student solutions. (Their only request was that they did not want multimedia or gaming solutions.) The sponsors wanted to prune and facilitate rather than guide or direct team solutions. However, the lack of criteria and direction from the sponsors made the project a little too ambiguous for the time allocated to the project. This ambiguity made it difficult for sponsors to give feedback without biasing students' further designs. Consequently, the instructors had to interpret, clarify, translate, and organize the feedback to help the teams make progress.

At the end of the project, student teams presented their results. Sponsors and instructors gave final evaluations of each team. The top three teams were selected by the HP sponsors and given formal recognition. Team solutions were also graded by instructors using a rubric based on the criteria listed in (12 and 13) above. Individual grades were calculated using a multiplier based on individual team member evaluations of each member's contributions to team project progress and the final solution.

3 EXAMPLES OF STUDENT TEAM OUTCOMES

For most teams, the final solutions from the HP student projects exceeded the sponsors' and instructors' expectations. Although it was a new and difficult learning experience for the students, the vast majority of ID and IT students said it was a very valuable and enjoyable experience. Yet, this cross-disciplinary experiential learning experiment was not without some frustrations. Both students and instructors experienced some frustration with the ambiguous nature of the project. Several students felt there was not enough time to work on the project, and a few teams experienced collaboration and communication issues between the ID and IT students.

3.1 The quality of team solutions

The overall quality of the final deliverables (posters, presentations, videos, and prototypes) was very high. Figure 1 is an example of the poster created by one of the top three teams selected by the HP sponsors. This figure represents the depth of thought, effort, and professionalism demonstrated by almost all teams in their final presentation. Even though the details of the poster cannot be easily read, it is evident that this team communicated their fleshed out persona, problem statement, solution, and the technology and usability of their solution.

Figure 1. Sleep Safe Team Poster

3.2 Examples of student feedback after the experience

For many of the students, one of the most exciting aspects of the project was the opportunity for cross-disciplinary learning and cooperation on an actual real-world project. Most students had positive assessments of the experience:

- "I liked the fact that it was very real-world and more applicable to life outside of college than probably 90% of most things we do."
- "Yes. They [the ID students] have an extremely unique viewpoint on how things are to be done, which often conflicts with ours [the IT students]. Working as a group with them gives us a chance to work with that viewpoint, conflicting sometimes, to achieve a richer whole."
- "It was very beneficial, because these ID students were very open and willing to work with us IT students. I could have seen this going in a very different direction if they would have had a bad attitude. As for the interdisciplinary aspect of it, I thought it was just great. The final product could have been functional, but never so pretty and good looking without the help of the ID students."
- "Because of the scale and rapidness of the project we had to give each other aid, but since neither of us had really ever done proficient work in the other disciplines before, each of us would both under and over estimate how long it would take to do things. But, it stretched us, which is [a] good thing…. The project quickly took on the feel of a senior project, and minus the actual deliverable having 8 weeks of work as opposed to 2 semesters, working with the ID students in

this project rivals the amount I learned on my senior project."

Most teams were able to work together effectively. However, two teams had significant problems with individual personalities. One team had a dominant ID personality that never let the team settle on a solution and created problems with working with IT students. This team stayed together, but the IT students felt alienated. One IT student stopped working with the team altogether and the other participated but felt his opinion wasn't valued. The team's solution was incomplete and, the HP sponsors considered it the "worst" project presentation. Another team reached such a rancorous impasse that the team chose to split up. This team's problem was due to a stubborn, dominant personality of an IT student that did not know how to work well with people who had different opinions than his own and had problems accepting sponsor feedback.

Several students were frustrated with trying to understand the feedback from the HP sponsors. Some teams struggled with criticism or with being asked to come up with a new solution at their design reviews. Other students were defensive of their ideas despite the sponsors' feedback that the teams solution concepts did not meet HP needs. Another reason some feedback was not well received was due to the fact that IT students are accustomed to right-or-wrong answers and numeric grades rather than subjective, experienced-based user and instructor feedback. However, just because some students did not like the feedback, does not mean the real-world, cross-disciplinary experience was not the best learning method for them to develop their professional abilities (as discussed above).

3.3 HP feedback on team solutions

After the final presentations, the instructors received feedback from HP on the project experience. Mark Solomon, the lead designer of the HP sponsors, stated that the "combination of the IT and ID students had a great 'real world' effect on the project." He also stated that "it is always refreshing to see student work and see the variety of thinking and solutions that come from this generation's perspective on technology" [7]. Paul Martin, the lead engineer of the sponsors from HP, said, "We were a bit concerned initially that we gave the students too broad of a subject area – thinking we were possibly creating too great a challenge for the students to identify an area to focus on. But the results the students produced would seem to indicate that the broad topic area proved to be a great opportunity for the students to expand their minds and their skills." He also said, "it was also clear that working with each other [ID and IT] broadened their thinking and compelled them to stretch their abilities, both in their own discipline and their understanding of the other discipline" [8].

4 THE EDUCATIONAL IMPACTS GOING FORWARD

There are four topics that the instructors would readdress or change for future projects. First, the project itself was too loose and undefined for the given six-week timeframe. In typical courses that include student projects, the users and problems are known and the challenge is to design and engineer a solution. In this HP project, the student teams needed to define potential users, the problems needing an IT solution, the IT and user interface technology to solve the problem, and identify the value of the solution to both HP and the user – in addition to designing, engineering, and testing a solution. Although the project's scope and ambiguity were appropriate and realistic for IT and ID professionals, for students the magnitude of the project combined with its ambiguity was perhaps a little too much given the time constraint.

Second, according to the students, the HP project sponsors had difficulty in providing student teams with constructive and consistent feedback at the design reviews. This is partly because students don't typically receive feedback from users except in Capstone courses and partly because clients do not always know what they want until they see the ideas presented to them.

Third, the interdisciplinary project teams only had one hour of overlap in their class schedules to coordinate in person and work together on their team projects. They had to set aside time outside of class to work together. Given the intensive, collaborative nature of the project and other course and work constraints between the ID and IT students, this scheduling problem made it hard for student teams to make the consistent, weekly progress the instructors expected.

Lastly, this project pushed the IT and ID students in several ways that were uncomfortable to them because of their different educational backgrounds, professional experiences, and learning styles. It took some time for them to learn to work together, to get used to the ambiguous nature of the project, and to learn to trust the design process. For example, the IT and ID students had never worked together on cross-disciplinary projects so they did not easily know or understand each other and their differing perspectives on the project. Students had not been taught cross-disciplinary skills, and therefore they had to learn in real time how to work with team members with different mental models, perspectives, and experiences. The IT students in particular had to learn and use design thinking skills to generate several iterative (not incremental) design prototypes.

These ID/IT student teams had to learn all this plus complete an ambiguous project in six weeks. This project would have been more appropriate to accomplish over an entire semester.

5 CONCLUSION

The HP Home Sensor project gave BYU ID and IT students a unique opportunity to combine art and engineering disciplines to create real-world solutions through experiential learning methods. Regarding collaborative student teamwork, Glenn Wong (one of the project sponsors from HP) wrote "the collaborative interdisciplinary structure of tackling problems is not taught in most institutions and I believe it is a huge loss for students. From my 13 years of design experience it has been about collaboration whether in consultancy or corporation" [9]. Our cross-disciplinary experiential learning experiment sought to address this deficit in contemporary higher education. The largest challenges emanated from the ambiguous project scope, understanding HP sponsor feedback, and the logistics allowing students enough time to collaboratively complete the project. Going forward, the instructors intend to do another cross-disciplinary project and adapt their experiential learning instructional design to address the challenges described in this paper. Despite the challenges, this experience was—by and large— considered highly successful and valuable. The feedback from students, instructors, and HP sponsors concerning this cross-disciplinary ID/IT project experience establishes it as a valuable tool to prepare students for the challenges they will face in their future professions.

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