Quantified Self: An Interdisciplinary Immersive Theater Project Supporting a Collaborative Learning Environment for CS Ethics

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ABSTRACT

This paper presents Quantified Self: Immersive Data and Theater Experience (QSelf) as a case study in collaborative and interdisciplinary learning and toward a project-based education model that promotes technical art projects. 22 students from several departments engaged in a semester-long effort to produce an immersive theater show centered on ethical uses of personal data, a show that drew more than 240 people over 6 performances. The project was housed out of the computer science department and involved multiple computer science undergraduate and graduate students who had the chance to work with students from the department of theater and dance. By analyzing the technical artifacts students created and post-interviews, we found this project created a novel and productive space for computer science students to gain applied experience and learn about the social impacts of their work while the arts students gained a fluency and understanding around the technical issues presented.

CCS CONCEPTS

• **Social and professional topics → Computing education**; • **Applied computing → Performing arts**; **Collaborative learning**;

KEYWORDS

Collaborative Learning, Interdisciplinary Education, Ethics, Pedagogy, Curriculum, Theater, Performance

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1 INTRODUCTION

Education around computing is highly valued and even non-technical students grow strong interests in developing computer literacy throughout college and career. Despite the ubiquitous impact of computing in their lives, without becoming a computer science (CS) major, it is unlikely non-technical students have the opportunity to formally study privacy, data ethics, or socio-technical problems. Within CS departments, on the other hand, we have requirements [1] that our majors leave with an understanding of computing ethics and social impacts. Even with most departments having a course dedicated to social impacts, CS students rarely gain perspective on how outsiders conceptualize their work prior to entering industry. We see this as opportunity in the CS curriculum to connect CS students' study of social impacts while offering non-technical students the chance to develop knowledge and perspective on computing.

As an approach to bridging this gap, we devised a novel, yearlong project around creating a theater piece about data to offer an opportunity for engineers and non-engineers to work together and learn about crucial problems from one another. This performance, titled Quantified Self, was also meant to create space for dialogue among engineers and non-technical users in the audience. However, for this paper, we focus on the educational dimensions for those involved in the production of the show.

Interdisciplinary education is already being discussed as priority for the future of computing education [2]. At the same time, art and design fiction are being heralded by communities in education and human-computer interaction (HCI) as methodologies for collaboration [6], thinking about the future [3], and engagement between engineers and users [5, 14]. Thus, we saw an opportunity in the production of a highly technical art piece to structure a space for educating technical and non-technical students.

In this paper, we present our technical theater piece as a case study toward promoting technical art projects as a promising way to create interdisciplinary educational opportunities. After reviewing the motivating literature, we provide a full description of our project, highlighting the choices our team made to elevate learning opportunities for all involved. We further offer insights from post-project interviews with the students involved in the production. Our findings indicate that technical students were given opportunities for learning technical skills while gaining insights into social impacts of their work. Further, non-technical students developed awareness, subject-matter interest, and formed more complex opinions about computing in society.

2 PRIOR WORK AND MOTIVATION

2.1 Interdisciplinary CS Education

Computing is a pervasive function of any educational or career activity. Whether doing graphic design, making a website, writing an algorithm, or sending photos to a colleague, modern life requires some level of computing skills. Due to this expansion of the field, computing practitioners take multiple forms—from "creative coders" to "designers" to "back-end engineers." In light of these changes, researchers are discussing the need for interdisciplinary learning within CS education [2, 21]. Seeing the future need of integrated, interdisciplinary approaches to world problems, consortia such as

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the National Academy of Sciences are promoting interdisciplinary research and learning more broadly [18].

Adopting interdisciplinary practices in CS higher education has several challenges to address: a) getting CS students to develop skills beyond writing valid code; b) offering non-CS students access to education about computing; and c) structuring opportunities for technical and non-technical students to learn with and from one another. In terms of (a), ABET already has pushed the requirement for CS departments to integrate education in related outside areas such as law, business, and social impacts of technology [1]. Researchers have successfully designed courses with service-learning components [17] or that motivate interest in CS by incorporating current events, media, and arts [4].

Towards (b), it is rare to find engineering departments taking on the responsibility of educating non-technical students. Rather, humanities departments tend to offer technology-focused courses. When engineering departments do create such offerings, however, there are promising results such as courses about privacy meant for non-technical students [7]. There has also been progress in using artistic means, such as dance [15] or creative writing [12], to create opportunity to interest a more diverse body of students in CS.

Many case studies have emerged showcasing fascinating efforts for (c). Work between Carnegie Mellon and Disney Research shows that combining efforts between artists and engineers led to novel projects and technical applications that may have otherwise not been feasible [11]. Hybrid classes between CS and journalism [16] or CS and bioinformatics [9] have been successful at getting computing skills out to other fields and giving breadth to CS students.

A common theme for creating outside engagement in science is to incorporate arts. For practitioners, conferences such as Ars Electronica bring highly-skilled technicians and artists together to push boundaries of the discipline. In the classroom, technical and scientific classes that incorporate art components appear to work at all levels. From K-12 classrooms that get students into math using poetry [10] or computing using digital art [22] all the way to college classes making dancing robots [19] or professional artists and scientists co-creating theater [6]. Throughout these examples we find higher levels of engagements, reflection on socio-technical issues, and refreshing new approaches to computing.

2.2 Design Fiction / Deeper Engagement

Success of arts and science collaboration goes far beyond interdisciplinary classes. Within the realm of HCI, design fiction has blossomed as a promising approach for thinking about the future, discussing ethical implications, and engaging a broader public [20]. Design fictions allow technical work to happen in a space that blends fact and fiction and welcomes modes of critique and social thinking [5].

Long before it was an HCI trend, sci-fi operated as an intersectional space for scientists, hobbyists, creators, and the public to conceptualize the future and what technology means to human enterprises [5, 13]. Many artists and designers who want to pose questions about how technology is impacting people employ "speculative design" as a method for asking questions and generating dialogue between communities and stakeholders [3]. HCI researchers have adopted a framework of "enactments" using speculation and theatrics as a methodology for users to experience possible future [8, 14]. In turn, gaining insights about public perceptions and attitudes toward technological change.

Seeing these successes in both interdisciplinary education through art and design fiction for public engagement, we began considering a creative endeavour that connected these two potentials. Our first project involved obtaining a small internal grant from our engineering school to support making an art installation as the class project for an upper-division data science course. This pilot, involving 30 students working in groups to make 6 art pieces about data, showed us promise of expanding. Not only were students enthusiastic to think through social dimensions of data applications, but the prospect of a public unveiling of their work amplified their desire to take on challenging technical work.

Following this, we began laying the foundations for a more robust project that would bring together students from different departments to create, converse, and ultimately learn from each other. For the remainder of the paper we report on the resulting year-long project, QSelf, which brought together students from seven departments to create an immersive theater performance about data ethics. Our project offers a case study relevant to the literature of interdisciplinary CS education, collaborative learning, and CS ethics education and provides a model appropriate for adoption as a capstone project within a CS curriculum.

3 APPROACH

QSelf was a student-led initiative to create an immersive theater production that brought together a sci-fi drama and interactive art installations to create an explorable world for audiences to think about the future of data in our society. Audience members were able to connect their social media accounts at ticketing to offer their own data to personalize the experience. From the start of the project in autumn 2015, we aimed to make the production a collaborative learning opportunity to bring together students from diverse backgrounds. Students involved in the production were offered multiple modes for engaging with new material and each other. Students were able to take on roles as actors, production staff, technical staff, or scenic designers. Here we detail the full scope of the project.

3.1 Team and Project Structure

The production team was mainly composed of students. The project lead was a third year PhD student in computer science. While a number of university professors and industry experts served as advisors, almost all the decisions and creative outputs were made by the students themselves. Two other PhD students and a professional data scientist served as co-producers. The rest of the team were 19 students - 15 undergraduate, 3 masters and 1 PhD. Students came from 7 different departments crossing technical and non-technical majors: 5 from computer science, 1 from electrical engineering, 9 from theater/dance, 1 in studio art, 1 from music, 1 in neuroscience, 1 in english, and 3 in an interdisciplinary technology department. The production crew was split up into two teams: 1) a technical team that designed scenic elements and engineered the interactive exhibits and 2) a theatrics team dedicated to preparing and producing the performance.

While this project took place outside of a typical class structure, we found ways to incorporate the production into university requirements for students. Theater and dance majors have to spend a certain number of hours supporting theatrical productions which this was able to count toward. Most of the computer science students took independent study credits under the supervision of our project lead. One undergraduate CS student became employed as a research assistant working between the data scientist and project lead. Some students were employed by the project as an intern while others volunteered out of interest.

3.2 Pre-Production

3.2.1 Narrative. The script was written by our project lead prior to the start of the project. It set the basis for 8 characters portrayed by 6 current students and 2 recently graduated students. The characters represented different perspectives on technology: a corporate CEO, a hacker, a journalist, a law enforcement agent, a data scientist, a psychologist, a marketing strategist, and an AI-driven android.

Laden with ethical issues, the script was designed to create an open structure where conversation and technical interaction could occur. We addressed five primary ethical issues within the story line: 1) implications of privacy policies; 2) the psychological effects of data presentation; 3) the use of personal data to infer information about a user; 4) the effects of ubiquitous personalization; and 5) the use of personal data as a commodity. These issues were represented by struggles between characters within the narrative and grounded by the interactive technical exhibits. The play was presented in 4 acts: 2 where scripted performance was being witnessed by the audience and 2 where the audience was freely exploring and the cast was improvising their roles while interacting.

Our goal was two-fold. On the one hand, the arts students would have the chance to understand more complex dimensions of technical issues by having to articulate and embody their roles. On the other hand, the technical students would have to learn how to translate these ideas to the non-technical cast while taking on the technical challenges presented by working with real data in the exhibits.

3.2.2 Exhibits. While fitting the themes of the narrative, the exhibits were finalized in terms of functionality and appearance through a dialogue between the whole team. Everyone on the technical team had an open period to propose the design of an exhibit which would be vetted and revised by the project leadership. Knowing the thematic constraints, technical students were given time to do research and learn the computing tools necessary to build the exhibits.

Our goal was to make the creation of the exhibits be a process where technical students could learn new skills while ensuring a dialogue between the technical and non-technical students occurred in order to make the ultimate adoption of an exhibit into the production as coherent as possible. For most of the students this was the first time they applied their classroom skills to real data for true users. Beyond small prototypes, they were given the chance to learn about public APIs, data processing pipelines, and front-end libraries for presentation. Throughout the process we diligently discussed the reality of privacy expectations from the audience members. Our data scientist designed an encryption protocol that the students had to use to keep data secure once we ran our systems on live data. From conception to implementation each exhibit was discussed at our weekly technical team meetings both in terms of how it represented our thematic issues and its technical specifications. This meant students gained technical and social perspectives in parallel.

One student designed a non-technical exhibit that represented perspectives critical of how technology has affected human relationships. This exhibit was designed in closer collaboration with the theatrical team as it required participation from the audience each night.

3.2.3 Training and Rehearsals. The rehearsal process was led by the theatrical team, though the training of the actors involved collaboration with our technical team. Multiple meetings occurred where the technologists trained the actors on how to work with the exhibits. Certain actors were trained on particular exhibits related to their character. Not only did the actors get trained on how to use the technology, but also they gave feedback on what a non-technical perspective was so that the tech team could tweak the exhibits.

One of the more interesting aspects of the work involved training the actors to be able to speak as technologists. There were 5 (out of 22) rehearsals that were dedicated to working with the actors on their articulation of the tech concepts and testing interactions with the exhibits. Starting with the first reading of the script, we brought the entire team together to hear the full performance. Throughout we paused and explained vocabulary to the actors and offered them auxiliary terminology that could be useful for improvisation. Given that it was an immersive theater piece, the actors had to be prepared to speak impromptu to audience members coherently about technology. During dress rehearsals the actors had the chance to practice their improvisation with our technical team and then afterwards we did feedback sessions. It should also be noted that one actor actually was a CS major and he was crucial for giving continuous feedback to the theatrical team outside of these dedicated sessions.

3.3 During the Runs

Participation during the runs of the show were mandatory for all students involved in the production. Of course, actors were the primary focus while technology students staffed the show as tech support and assistant stage managers while costumed as corporate employees. This further gave the technology students a chance to listen and interact with the audience during the interactive parts of the show.

Within the show, each audience member had a wrist band that unlocked the exhibits and unencrypted their data. Cast members often got to use the exhibits in tandem with the audience and the tech team was able to observe the reactions to their exhibits first hand. After the performance each night, we held talk-back sessions where the production team and actors discussed elements of the show with audience members. Topics ranged from what it was like to play different characters to ethical questions about the script. We further used this as a chance for the audience to talk among themselves about the issues raised in the show.

3.4 Post-Production

After the production, we elicited feedback from all production team members about their experience preparing and producing QSelf. Students were asked to reflect within individual interviews upon their learning, challenges, and recommendations for the future run of the production. This final reflection was individual to allow each person to open up about what worked or did not for them. In the next section, we report the findings regarding educational opportunities the show afforded. However, regarding collaborative process, we found a general interest for more collaboration between the actors and the technologists earlier and more frequently.

Another major interest was for the technical exhibits to be pinned down earlier to allow the cast to get more comfortable and knowledgeable. Similarly, the technical team appreciated the ability to be inventive, but would have preferred the technical challenges be structured more top-down to allow them to develop skills in a more constrained environment.

4 EVALUATION

As a show, QSelf was a success, selling out all 6 performances and bringing in over 240 people with many more on the wait list. As a collaborative learning experience, which is the emphasis of this paper, we found strong evidence of learning among the students who worked on the production, the type of learning that could not have occurred in traditional classroom settings. Below we present two sources of evidence: the exhibits designed by the students and post interviews.

4.1 Exhibits

Students in our technical team were tasked to design and develop novel interactive exhibits that tied to the performance. In total, 10 exhibits were built. To highlight a few, one exhibit was a 4-player game where the players' Facebook and Twitter posts were shown anonymously and the game was to see if people would own up to what they said. Another exhibit was a magic mirror where a player's private data was used to display personalized greeting messages in a private room on the set. The development of these exhibits presented various degrees of technical as well as creative challenges. Students were able to overcome these challenges, communicate across diverse teams that included designers and non-technical users, adopted strong version management skills using GitHub, and got first-hand experience of the stresses involved in preparing for a software launch. In terms of CS skills, all our front-end systems were built in either ReactJS or P5.js, which are popular JavaScript-based UI frameworks widely used in the industry. The back-end server was built in Python to securely manage the social data provided by the audience members. The students not only had learned and honed their Python and JavaScript programming skills but also had become familiar with data skills such as authenticating users (OAuth), retrieving data from APIs, and visualizing the data. The skills they learned were central to those expected by CS majors. Moreover, they all made this project an experience highlight on their CVs.

However, the pressure of finalizing the exhibits prior to our first show turned out to be a challenge. One student commented that he was interested in the conceptual material, such as privacy, but it got left behind because he spent too much time on debugging.

4.2 Post interviews

After the production, we conducted 15 interviews (5 from the tech team and 10 from the theater team), which represented 79% of the crew. Each interview took about 20 minutes. Our questions focused on self-reported learning, change in opinions, and technical content understanding. Each interview was recorded, transcribed, and coded. We looked for insight language, changed assumption/viewpoint, new information/knowledge, and behavioral changes. Overall, we found that participating in QSelf had impacts on students' technical knowledge, ethical viewpoints, and daily activities, especially related to the interdisciplinary opportunities made available by the project.

Participants expressed having insights through the production. When asked whether the experiences had made them more knowledgeable about the issues, most (13/15) were affirmative. The majority felt strongly so (8/15). "*Yeah. Absolutely! (P5)*". There is evidence that the experience helped students dispel certain previously held misconceptions. "*I didn't think [companies offering free services] would use my data for malicious intent. (P5)*" "*It opened my eyes to the fact that [my data] is being used for things, and that it's being bought and sold, and I had no idea that that was a thing before. (P9)*" This suggests that students did gain new knowledge.

However, there were limitations to the knowledge gained. A number of art students made specific statements that they became more knowledgeable only about the issues of data use but not about the underlying technical skills such as coding (P4) or data analysis (P2), even though that was of interest to them. Certain misconceptions were still held by some students. "*[Texting lets you] communicate with people easily without having to put all your information out there (P8)*", when in fact texting could still expose one's personal information. Two students (2/15) reported gaining no or minimal new knowledge. One explained that "*I already knew a lot (P14)*" prior to joining the crew. The other student explained that "*because I worked more on the front-end of the project, I wasn't doing a lot of the research tasks. (P11)*" But this same subject also reported that "*[the show] made me perhaps a little bit more skeptical (P11)*". This seems to suggest while a student might not gain concrete knowledge, the student nevertheless had a change of attitude.

There were impacts on attitude and ethical standing. 12 out of 15 suggested changed assumption or view point. "*It's definitely made a change for me...paying attention to the fact that there's some kind of massive control here that I wasn't aware of. (P9)*" ; "*My opinions on how people view data sharing changed a bit, because people seem to be terrified, when people ask for their data, but have no problem putting all of their [data] on Facebook. (P15)*"; "*[Companies] are more monetarily motivated than I originally believed. (P5)*"

One noticeable difference between the technical and non-technical groups was that six art students made speculations about the future and how that could align with their ethical perspective; yet all of the tech students refrained from making speculations. "*I would love for us to take back our data, to understand, or to force some kind of understanding, that what we share still belongs to us and so it can't be bought and sold, and*

that shouldn't be a thing. (P9)"; "*Eventually, I feel like legislation will get passed and at least reign it in. (P15)*"

Beyond knowledge and attitudes, many reported behavior modification in their daily life. 12 out of 15 made explicit comments on behavioral changes. Seven reported having changed certain behaviors as a result of the show: "*I'm more conscious of what's happening to my identity online. (P2)*"; "*I actually noticed that after Quantified Self, I just stopped posting on Facebook. (P13)*"; "*It did make me a little more aware of my presence on different sites and just being aware that everything is accessible. (P12)*" Those who reported no change were predominantly from the technical team.

11 of 15 provided personal anecdotes showing that they applied understanding from QSelf to their daily life. "*I thought it was just a happy coincidence that the shoes I was looking at...being advertised for me on this completely different website...[I felt] this is really creepy. (P9)*" ; "*I decided to Google myself...these links from this blog popped up, these photos [of my bags]...I have no idea where this came from. And that just made me a little more aware of (P12)*".

Several students expressed being more keen and equipped to have conversations about data sharing issues after the QSelf production experience. "*I had discussions with my friends and my roommates, ever since the show, about these topics and I think that they shared very similar views to what I had before the show. (P5)*" Moreover, the new gained knowledge allows this student to bring the discussions to a deeper level. "*And now afterwards, we can have realistic discussions about big data being a commodity. And how that shapes our society and how that shapes our perception and our interactions with everyone else in it. (P5)*"; "*It's something that I bring up more in conversations... people will randomly make a comment, like an advertisement being eerily close, and I can plug in and talk about Quantified Self, and people are always kind of surprised about how much they're sharing, without even realizing it. (P2)*" This suggests students have become teachers.

There was an appreciation among many interviewees of how the interdisciplinary nature of QSelf influenced their learning. There was evidence of mutual learning between groups. "*What came out of doing the project was knowing more about how tech people or computer scientists actually go about doing this. (P14)*" Learning also occurred during team meetings. "*It came up in one of our meetings, is that I only ever had to sign away my data rights once, for that to apply to all of the companies. (P5)*" Several members commented on the edifying experiences of playing a character interacting with the audience. "*[I] become more a little more articulate, especially 'cause I had to talk to the audience about it...and try to draw, elicit responses from other people so that makes you kind of think through it a little more. (P6)*"

5 DISCUSSION

This project availed a lot of potential for the collaboration of technical and non-technical students for the creation of art, thereby learning critical technical issues related to big data. All students walked away with a better ability to articulate technical issues, many of them having changed their viewpoints or behaviors following the production. For technical students, there was a general takeaway that they learned about how the lay public perceives data technology. They were shocked at how little the public understands of technology including how much data is really available through online services and how gullible they were to believe results from even simple algorithms. Having incorporated technical challenges into the project, this gained perspective came without skimping on technical work core to their major.

On the other hand, we learned that both dimensions could be improved. For technical students, going into the project with more structured technical work may have allowed for a better honing of skills. Further, offering even more chances for them to talk to non-technical cast may have allowed for deeper perspectives to emerge. For non-technical students, nearly all of them reported better awareness of technical issues and developed more informed and articulate opinions. For some it catalyzed an interest to learn more since few actually felt they understood the inner-workings of the technical systems. Despite these successes, holding short coding workshops would have improved the experience as many non-technical students stated regret for not learning more technical details. They too wished for more conversation with the technical team earlier in the process.

We believe with some minor improvements and coordination between departments, a project like this would make for a valuable interdisciplinary capstone project. The project was so attractive to students we were unable to meet the demand and bring in everyone who showed interest. It is very clear that on both ends students were eager to work with other departments. In the end students walked away with more than skills for their respective disciplines, but perspective and collaboration skills that will impact them in their careers and personal lives.

6 CONCLUSION

In this paper we presented an overview of an interdisciplinary theater project that structured a collaborative learning experience for computer engineers and artists/designers. The project was successful at building tech skills and gaining understanding of social impacts of technology for the CS students. The non-technical students became more aware and articulate of technical issues. Adopting a similar model, universities could make opportunities like this for interdisciplinary capstone or course-long projects and give students a chance to interact with the public regarding their field.

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