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Semester Projects on Human-Computer Interaction as Service and Outreach: Undergraduate and Graduate

Frank E. Ritter and Sarah J. Stager

Abstract We present an approach for using class projects in undergraduate and graduate human-computer interaction (HCI) classes to have social and economic impact. Class projects can help teaching by being more motivating to students, help students and instructors in their careers, be more interesting to the instructor, and have more impact to society and academia. We provide two example project descriptions used at Penn State's College of IST since 2000, suggestions for how to teach project-based HCI courses, and example projects that have suggested useful interface changes to the websites of a variety of government, non-profit, university, and small-to-medium-sized businesses, as well as publishable and published graduate projects. These reports fulfill a pedagogical goal by having students demonstrate mastery of the material, particularly evidence- and theory-based changes to improve the usability of websites. The reports provide (in the best cases) strong, correct suggestions for improving the usability of these websites or extend the method, practice, and application of HCI methods. The use of these reports also helps reduce plagiarism because the sites and thus work are unique.

Keywords Project-based learning · Team-based learning · Outreach · Task analysis · Usability reports · Teaching human-computer interaction · Teaching information science and technology

Introduction

In our experience, students in the last 2 years of their undergraduate degree programs in most American, British, and German universities, participating both in residential instruction or fully remote, have enough knowledge and skills to contribute to research and engineering. They cannot do this on their own typically (although

F. E. Ritter (✉) · S. J. Stager
College of IST, Penn State, University Park, PA, USA
e-mail: frank.ritter@psu.edu; sjs230@psu.edu

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there are, of course, exceptions), but they can participate in guided class projects that have impact on outreach and application. Such projects not only enhance the educational experience but also develop a sense of social responsibility and community involvement among students.

In our work, we use decomposition to parse the requirements of a user-centered system. This is done by leveraging the psychology of user-centered design. Lessons on poor design found in the real world as examples of the worst interfaces allow students to develop pattern recognition of poor interfaces through applying heuristics of interface design such as those developed by Nielsen and Molich (1990), Norman (1983, 2013), Stone et al. (2005), and Shneiderman et al. (2016). Task analysis, usability testing, and other methods are also used to develop structures to improve design.

Project-based learning is supported by research showing there is improved retention and transfer of learning when exposure to content and experience is provided through project-based learning (e.g., Blumenfeld et al., 1991; Greeno & Engeström, 2005; Kokotsaki et al., 2011). Our scaffolded approach is designed for continuous and simple improvement through three key ingredients, (a) establishing a shared language, (b) empowering action, and (c) allowing time to practice with feedback. This works well for students participating in residence and fully remote.

Student work on projects is used at other places as part of clubs and, for example, at Purdue as a special projects course (EPICS), but at PSU it is applied in a standing course. Students in our human-computer interaction (HCI) courses at Penn State (IST 331, IST 413, and IST 521) use this approach. These courses are 3 credit hours that meet for 3 hours per week for 15 weeks. A normal load is 12–18 credit hours per semester. At least 2 office hours per week are provided for further consultation.

Successful student reports provide a set of suggestions about how to make systems more usable based on applying the course material. The reports have provided contributions to local companies, the university's systems, non-profits, and other organizations through a focused, real-world group project over a semester examining a website or other system interface. Similar approaches are presented by Cameron (2014) and by Bagby (2014) in the previous volume.

Where we say website, you can read this as meaning any system with an interface because the principles or concepts being used for websites are applicable to any system with a user interface. Student projects have done other HCI-related projects, examined, and, in some cases, created apps for mobile devices and skins for applications. Table 1 provides a set of example organization websites and systems that have been examined or developed in these courses.

What is novel, we believe, is the set of constraints on this approach to adding a project to courses and the scaffolding we provide. The rest of this chapter attempts to describe the approach in enough detail that you can create similar projects in similar courses.

Table 1 Example websites and systems analyzed showing the range of systems examined

Clinton Township, Wayne County, PA	[State College] Community Help Center
Security Risk Management Association	Penn State Habitat for Humanity
Listserv email list server system at PSU	Oktavamod.com (microphones)
Penn State Office for Disability Services	Your Conversation Connection
DBLP (computer science publication database)	Centre Volunteers in Medicine
PSU Undergraduate Degree Programs Bulletin	The Rowland Movie Theater
Phone app to help with depression (PsySpace)	Centre County United Way
Shakespeare's works as an app for the iPhone	PSU ITS Lab Consulting
CataBus (Centre Area Transportation Authority)	Free Software Directory
MOOC design (Wang et al., 2021)	Deihls' Flowers Inc.
Bibliography tools (Cai et al., 2021)	Northland Bowling
eLion, PSU registrar's website for students dropping classes	Campus Concierge
Southeastern Pennsylvania Transportation Authority (SEPTA)	Becky's Drive In
Walking speed diagnostic tool (Gonzalez-Vargas et al., 2021)	PSU Webmail
Keystroke logger design (Morgan et al., 2013)	Source Forge
One laptop per child usability (Yeh et al., 2010)	work.psu.edu
Banking literacy app (BancAprende.bantrab.com) for youth in Guatemala	AreUHungry
Testing architecture designs in VR (Govindarazan et al., 2023)	CiteSeer

The Class Project

The class project, which is done by a group of 2–4 students, culminates in a 10–20 page report providing 3–5 concrete, supported suggestions for changes to an interface or system. This approach does not have students simply act as HCI consultants for a fictitious interface, but to serve directly as consultants on a real interface. The suggestions may first arise from the student group's opinions of the website, but the groups are strongly told not to just complain that they do not like the website—they are required to support their suggested changes. Support for changes can come from theories, analyses, or empirical studies.

The content of these reports vary based on their project. The appropriate HCI methods to use vary based on the usability risks in each system (Pew & Mavor, 2007). Each group does the same labs, but often the methods do not apply to each system. In these cases, alternative sites or methods are used.

Material Taught and Used

The students are encouraged to use the methods taught in the course, but in some cases, groups have had to find and use additional methods or to develop modified methods. The reports are supposed to have an abstract, an introduction with a picture of the system, several analyses that lead to suggested changes, a summary (preferably with a summary table), and appropriate references to the theories and methods used.

The theories that are taught include the basic psychology of how users will interact with websites (Ritter et al., 2014): the ABCS of anthropometrics, behavioral aspects of the senses, cognition, and social factors. Suggestions to improve the interface can be based on such things as knowing how people read and interact with an interface, how they see colors, how they represent the world (mental models), how they navigate the website to find information, the limitations of memory and problem-solving, and other aspects of cognition and social behavior. They also do labs with a keystroke logger, reading on an interface, and task analysis, both creating an analysis and testing its predictions.

In some iterations of the courses using this method, before the group proposal, students are expected to individually identify an interface and complete the first stage, of proposing an interface to analyze. They are to provide a description of a proposed interface redesign including the purpose of the system (what tasks can be completed), a brief description of the expected users, and a discussion of the issues or problems with the current interface. They are encouraged to include images or screenshots to articulate each of the problems. All problems are to be mapped to or supported by the principles, heuristics, and guidelines in class readings. Each proposal is typically presented to the entire class for deliberation. This exercise allows students to share their process and form groups. The groups then extend the proposal of the selected interfaces and create a report.

Students are taught through course readings and lectures that user research is a necessity for any human-centered system design project. To gain insight into the people who will use the interface and to support student learning of how users are different from designers and developers, the next stage requires students to develop such things as user profiles, personas, and scenarios. The submission at this stage is assembled into a single, cohesive document with a brief introduction section that explains the user groups for this project.

Most reports also use a task analyses that can include time predictions. Time prediction is a part of task analysis that involves estimating how long it takes users to complete specific tasks. This metric can be crucial for assessing the efficiency of an interface. For instance, if a task takes longer than expected, it might indicate usability issues. A task analysis of an interface can usually provide suggestions for changes, including making interaction more regular across tasks or supporting important tasks more directly.

Empirical analyses involve recruiting users to test the interface. These are small studies that typically involve three to five users. Creating these studies requires

discussions between the group and the teaching team about how many users to study, representativeness between the users they can recruit and the actual users of the systems, and what tasks should be done in the study. Testing the tasks on the interface, paper or digitally based, the students develop and execute usability testing. Standard usability assessments such as task time and improving the task analyses are often incorporated in this stage. Bagby (2014) notes similar problems and some types of advice for creating war rooms as student projects.

Sometimes, the point of the analysis is to explore and document how usable the interface is (including if it can be learned at all). And sometimes the analyses are used to explore or to show that a particular task is not as easy as might be expected. Discussions about the users to recruit can be very informative when done across projects. The class can see that sometimes the target users are very similar to the users that can be recruited, and sometimes the users and those that can be recruited are quite different. How to find more appropriate users to study is a useful discussion point typically shared with the whole class.

Thus, the report's suggestions are supported by published papers, analyses performed on the website, or empirical studies of the website. This should not only make the resulting suggestions more accurate but also more believable.

Prototyping Used Occasionally

The project does not require going beyond providing suggestions—revising or redesigning the website is often not possible directly, and doing so for an external site within a semester time period is difficult. Revision is difficult not only because of the direct system changes, but more often because of social and administrative processes.

For some projects, however, the group wants to make more concrete suggestions based on their review, and some projects are to create interfaces. In these cases, some groups have gotten the changes implemented on the site, but it seems inappropriate to require students to implement or get implemented changes from an organization neither the teachers nor students control. What is required, though, is being able to submit the report to someone who could make these changes, such as a webmaster, vice-president, or lab manager of the website being analyzed.

When the Adobe Suite and Creative Cloud became available as enterprise software, students gained access to the creation of digital low-fidelity and high-fidelity prototypes through Adobe XD. (Similar tools like Figma could be used.) Student groups using Adobe XD are encouraged to use the user interface (UI) kits to show what their review suggests. This tool provides an opportunity to develop no-code interactive interfaces that demonstrate imagination and iteration. Integrating tools, however, comes with the price of time to learn how to use them. In some cases, the use of paper prototyping persists. In the current volume, Gamrat (this volume) discusses and validates the use of no-tech solutions to engage learning.

If the project includes a suggested redesign, the next stage often requires each member of the design team to sketch out some initial designs on paper. These low-fidelity prototypes allow students to start the design process because they are quick and easy to create, modify, and share. No special tools or software are used, and there is no learning curve of the tool. This format allows students to individually contribute to the design and to go through several iterations quickly. They are encouraged to consult with people who are similar to the users they are designing for to get their feedback. Students then share their sketches with the team; this creates several different designs to consider. Students are then reminded that this is a method known as ideation and that the use of multiple prototypes lead to better design (Dow, 2011). The group submission requires collaboration to sketch a paper prototype that reflects a unified vision for the redesigned interface. Groups embed images of the prototype in a document and provide a brief description of each image. Because these projects vary based on the website being analyzed, the detail and number of prototypes do as well.

The next step in the project is to build a high-fidelity prototype. In the semesters that we integrate digital tools such as proto.io or Adobe XD, students use UI kits and assets to build an interactive digital form of the interface design. Submissions include a document describing the process of creating the interface and the interface including a sharable link to the design if the course integrates Adobe XD.

The Project Process

This approach and these projects follow the risk-driven spiral design model (Pew & Mavor, 2007). Thus, the groups are given feedback at several stages of the process. Groups propose a system with a title typically in Week 5 that includes a contact at the organization and then a paragraph abstract in Week 8. Sometimes they write up an outline and a one-page version around Week 12, get feedback on each analysis, and give an (ungraded) oral presentation 1 or 2 weeks before the final report is due in Week 16 (finals week).

The oral presentation allows feedback from the teaching team and joint lessons to be learned across groups. Sometimes it allows groups to collaborate or cross-cite. Many groups can use their system as the topic in a lab applying a particular method (lab homeworks are used to teach several of the methods), and groups get feedback on these lab write-ups that they can use to improve that aspect of their final report. (One early group figured this out before the first lab and made every lab a part of their final report, using feedback from each lab grade to improve the final report.) After they turn in their final report, we provide suggestions on what they should do before sharing the report with the organization and whether we encourage them. For some reports we also ask permission to add them to the website as useful examples (see Appendix), and students can point back to these reports as an accomplishment.

We are lavish with our feedback, treating the reports as early drafts that we would like to co-author, in that the reports have to have author, dates, and page numbers;

the writing has to be organized by headings; and it must look like a paper that can go outside the class because it often does. MacKenzie's (2013, Chapter 8) chapter on writing HCI reports can be useful here. Aspects of word processing that are helpful with this are also taught (Doozandeh & Ritter, 2019a, b). These aspects include how to outline a report, spell, and use paragraph styles.

To illustrate what the reports are like, we will cover a few in detail. Additional reports are available online at http://acs.ist.psu.edu/ist331/example-projects. Some are password protected because Ritter has permission to share them with the class but not further, but some have given permission to share more widely (a form granting or denying permission is now included as part of the final project submission). An example plain text form is included as an Appendix. As a group, these projects show the diversity and strength of projects.

Example 1

As an example, a group looked at the phone application, Penn State-Go, a combined graphical user interface that provides multiple online resources at Penn State/University Park. This application was chosen because one of the group members worked for the University IT service desk and as part of their job routinely responded to calls from students who needed information. Group members were interested because of the incorporation of dining menu and transportation services. Other groups have done university-based interfaces; for similar reasons, they include email list servers and work.psu.edu.

The students' report made concrete suggestions for improving the interface. The group used Adobe XD to develop assets to illustrate these changes. Some suggestions were based on task and needs analysis, including considering what information users were looking for and conducting a user study by running a preliminary survey of classmates and then modifying the high-fidelity prototype to make information easier to find by location and size.

Example 2

In IST 413, Usability Engineering, students developed an interface to respond to a need they identified from the local Society for the Prevention of Cruelty to Animals (SPCA). This group used Adobe XD, including UI kits, to create an application to responsibly dog-sit pets who are available to adopt. Their goal was twofold, to give students the opportunity to interact with pets on a short-term basis and to alleviate the pressure of caring for animals were held at SPCA waiting for adoption. The interface included images of pets available, the responsibilities required, and background checks of users. While this was a hypothetical application, the group went through steps needed to develop the resource including needs assessment,

user profile, persona, scenario, prototyping and usability testing, and creating an implementable and solid high-fidelity app design.

Conclusions

This approach of applying HCI evaluation techniques to a live, real-world interfaces seems to provide motivation and a useful learning environment. Students have generally found it motivating, and the class is more fun and encouraging to teach, and there are plenty of examples from the group projects each semester to ground the topics discussed in class. They also learn how to write useful reports. These reports are useful to organizations and have also led to publications (Stark & Kokini, 2010, and projects in Table 1). The contributions of this approach have been recognized by three press releases, a university and a college, and a conference best paper.

Common takeaways reported by students participating in these course projects include:

- Improved clarity in connecting user research and testing to the design process
- The role/importance of user feedback
- The value of group collaboration in time-constrained deliverables

Basing these reports on real-world systems also helps reduce plagiarism because the sites and thus work are unique and current. We have had two groups examine the same site, but even then collaboration remained academically safe. Most sites are large enough and the study results different enough that collaboration is both worthwhile and yields distinct reports.

Most projects (about 60%) end up good enough to encourage the students to share with the organizations. About half of the other projects (20%) are good projects pedagogically, but the results are either not clear or not well presented enough to act upon. These are graded and given feedback but are not sent by us to the organizations. Some students do share them.

Discussions about all of the projects in class can lead to additional learning across groups. An exercise that we particularly recommend is asking each group to describe one good thing to do and one bad thing that they have learned from their project so far. This is usefully done about 1/2 and 7/8's of the way through the semester. If the students listen to their peers describe these lessons, they can learn not just from one project but from a room full of projects' lessons learned.

Why We Think It Works

Table 2 summarizes anecdotal beliefs about why this approach has worked. Some of these features are probably not necessary, and most are not sufficient when alone.

Table 2 Some of the features that may help this process work

1.	Group-based
2.	Lots of low-hanging fruit to improve interfaces
3.	Contact information for the system analyzed
4.	Teaching assistants helped coach the groups
5.	Reuse and revision of class exercises into the final report
6.	Motivated by their interests and sometimes support from their parents, colleagues, family, or work associates
7.	Individual sections note authors

It is probably the case that you would not need all of them to have this work in your course.

The first item is that the projects are group-based. This approach provides mini-sections for students to discuss and learn from each other and to practice their knowledge (Gergen, 1985). Groups also provide more "horsepower" to get the projects completed. Two-people groups appear to get less done than four-person groups. Also, four-person groups provide some buffer if a student is having difficulty in the class.

While the project work and groups require more support from the teacher than traditional lecture only courses, the groups can also help reduce teacher workload because they can provide some help to students in their group with a problem, including help with other class-related problems such as what was assigned, what was covered in lecture, or what will be on the test. However, groups larger than four seem to have more trouble meeting and end up with more free riding. Joint authorship but with named sections help reduce loafing.

The second item is that there is still a lot of low-hanging fruit in website and interface design. Students and faculty have no difficulty identifying systems that violate good design. The project can then document how, why, and how much they do so. There may be a relatively large disparity in this area between the ability to implement and design and basic knowledge about the material. In designing civil engineering structures, for example, the designer has to know about bridges and their environments, and students will have to know nearly as much to critique a design. In interfaces, it seems that anyone can (and does!) create a site, but many creators lack basic knowledge about users and their tasks to provide principled criticism.

The third item that helps it work is requiring contact information for the project. Some early projects looked at car manufacture's websites (e.g., Chevy and Ford). These are large, complex sites that are justifiably hard to develop, and a lot of work goes into them. There is less low-hanging fruit, and the reports would almost certainly be ignored if they are turned in without an initial contact. So, requiring a contact helps reduced the size of the site examined because the developers of the larger sites are not as available. Having a contact also means that the teacher has some help in focusing the students because the designers/contacts often have some idea of what could be improved and can help coach the students. Having a contact provides an additional and slightly unusual upside in that someone can thank

them and implement the changes, which is more satisfying than just suggesting changes. Non-profits appreciate this more; universities sites do thank the students but seem to act on the supported changes less often. (These may have hidden users and uses, institutional inertia, or special security challenges, also see Ritter, 2024, and Ginsberg, 2013.) Having a contact does not mean that the contact provides a grade or has to be available at the end of the semester because grading has to be done by someone at the university and because we do not have control over the other organization.

The fourth item is the teaching assistant (TA) or assistants. There is a lot of coaching required to make these projects work. In addition to providing more resources and time periods, teaching assistants also provide a different level, perhaps a more approachable level, of support. That is, students sometimes have concerns that they would rather discuss with a TA. And, a good TA, which we have generally had, knows when to escalate concerns and when not to. That is not to say that you have to have a TA to do this type of teaching, but we attribute some success to the TAs that we have had.

The fifth item that has led to success is the reuse of class exercises in the final report. The class typically includes about four class exercises to apply an evaluation method to an interface that the group selects, not necessarily the final project interface. Allowing another interface to be used allows for groups to test other interfaces or to allow work to proceed before the class project interface is selected or to allow a method to be applied when the class project interface does not readily support that method.

These methods have included analyses of search logs, examining a learning curve in an interface, doing a task analysis, and looking at reading speed in an interface. The students do not have to use their class exercise's interface on these projects, but many groups learn that these smaller exercises are useful precursors to the final report. Not requiring use of the class project allows groups some flexibility to choose their project and to change interfaces if required due to unforeseen circumstances and if the interface does not adapt well to the class project. The groups then reuse the previous smaller projects.

Better groups also revise and sometimes extend the analyses from the labs when writing up the class project, either running a few more subjects or doing more or better analyses. In all cases they seem to improve the presentation of the work. Efforts are underway to develop a sustainable community of students who participated in these exercises. The goal of this practice is to enhance the community of people who have shared experiences and develop skills of current, future, and former students.

This reuse provides the additional teaching benefit of providing students a chance to revise their writing and work, each time for a grade. We fear that too often in current undergraduate education students do not see the writing revision process that is taught in graduate school and used in business, government, and academia. Providing formative evaluation and providing feedback are both ranked as "High" influences on learning by Hattie's (2008) meta-analysis of learning.

The sixth item, the context of the interface provides additional motivation to do well at least for one of the students in the group, but often several. If a site is chosen based on a student's avocation or family business, then at least one student is very motivated, and the others can see the impact. If the students jointly agree on a university or local site, they are all motivated in additional ways to contribute to improving that site. Having a social tie to the interface provides additional motivation beyond doing an "evaluation task" for a fictional XYZ Corp.

The seventh and final item is that individual sections of the lab and final report note authorship. This attribution helps the groups work. A common problem in group work is social loafing, and authorship of individual sections is useful when differential grading is required.

Limitations

There are limitations to this teaching approach. In contrast to a course with multiple-choice exams, this approach requires more work from the teaching team than a non-project-based course. The project aspects have to be coached at each level. This coaching is often group-specific as the method has to be applied to a novel situation, but the associated pleasure is that the teacher and student can both learn something.

There is a small risk of having students go out into the wild and run studies and interact with people outside the university. Some students lack the social skills, knowledge, interest, or time to do well on this task. Monitoring the materials and checking in with groups appears to ameliorate these risks. Also, the students can be referred to professional etiquette classes, coached directly, and referred to books on the practicalities of how to run studies (e.g., Ritter et al., 2011, 2013; Ritter & Ricupero, 2023). Also, in team projects, conflicts within teams are common and can arise from various sources, and managing these conflicts effectively could be challenging. The use of authored sections and a group contract help ameliorate but not remove these potential problems.

Finally, this approach is limited to courses that have methods that can be applied easily to real-world problems. Areas like industrial engineering may find that this approach can be applied in many courses. Courses with more theoretical material will have a harder time finding problems and applying methods.

Final Thought

This approach of using student projects is not completely innovative; the idea of doing guided professional work has been done for years by apprentices who work under supervision to perform useful activities. It is just a new kind of apprenticeship in a classroom setting with a focus on real-world application of what is taught in class.

And, at the end of the semester, rather than just turning in grades, the teaching team has the satisfaction of having helped the students do something more with their learning than just classroom exercises—the teaching team and their students end up helping their neighbors, their current and future employers, their universities, and local non-profits.

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Appendix

This is the form that groups are required to return by email with their final report. It helps understand how to distribute the final report.

Name, group name, and date: _____

Contact at the organization:

What did the contact do during the semester, how did it work?

Have you shared the report with the contact? Yes / No

Do you grant permission to Ritter to share the final report with the contact with a cover letter? Yes / No

Do you grant permission to Ritter to share the final report on the course web site? Yes / No

How likely are you to revise the report before sharing based on feedback?

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