Student Research in Web Engineering: An International Perspective on Internal and External Opportunities

Larry Hatch[1] and Thomas J. Heistracher[2]

[1] Visual Communication and Technology Education, Bowling Green State University, College Park room 131, Bowling Green, OH, USA
lhatch@bgsu.edu
[2] Information Technology and Systems Management, Salzburg University of Applied Sciences, Urstein Sued 1, 5412 Puch / Salzburg, Austria
thomas.heistracher@fh-salzburg.ac.at

Abstract. This work is to provide an overview of the potential of internal and external projects for web engineering education as a means to student research. This paper also provides a working process for systematically engaging outside industries in the real world problems. The paper includes insights from both an Austrian and American perspective involved in the process.

Keywords: Student Research, Scholarship of Engagement, Web Engineering Curricula, Evolution of Web Technologies.

1 Introduction

The universal purposes of a university have for decades been teaching, research and service. More recently US universities have added the scholarship of engagement. This new type of scholarship involves engaging students with the community, schools, business, industry or even tackling global issues (poverty, education, clean water) to help in improving the conditions of society or global community. The scholarship of engagement normally involving students in research is easy to understand in theory. It is much less clear as to how to go about this methodology or read about good practice in this area.

Around the world, industries are trying to stay competitive. Web engineering is affecting industries more frequently as corporations move to reach and interact with widening suppliers and markets. The same is true of universities that are trying to find both audiences at a distance and new niche programs. While many of the industries are able to turn their most urgent web-engineering projects directly to their internal web engineering departments or contract them out to external web engineering firms with special expertise, there remain dozens of important but less urgent opportunities that are neglected for lack of time or finances. Seldom do companies have the opportunity to ask the "what if" questions that go beyond an immediate short term timeframe. While web-engineering firms do not want the university to encroach on their business plans, they also realize that universities can have a different role. Universities hold untapped potential to help these industries. They have the ability to integrate the latest technology, often have intellectual networks that are worldwide to solve problems, and have a growing number of students ready to engage the process.

In core classes we often engage students in highly structured problems that have definite and predetermined solutions so that basic principles can be obtained. As students progress in Web Engineering, they need to be able to address more sophisticated problems that are realistic and almost by nature ill-structured problems. As a visiting professor to Salzburg University of Applied Sciences (FHS) in Austria, one of the authors of this paper had the rare opportunity to see first-hand and oversee two undergraduate research teams. What was witnessed was not perfect but it was systematic, well planned, and certainly noteworthy. In ongoing communication with the deputy chair, also one of the authors, the purpose, process, and issues around this effort were elaborated to share with an international audience.

1.1 Changing the undergraduate paradigm

The use of team-based undergraduate research experiences fits into several categories of best practice for undergraduate teaching and learning. It is in alignment with Chickering and Gamson's [1] principles of good practice in undergraduate education in that undergraduate research clearly encourages active learning. Undergraduate research is further supported as a high impact practice by Liberal Education and America's Promise (LEAP) [2]. This is an American initiative that focuses on practices that encourage economic creativity and democratic vitality. They have listed undergraduate research as one of ten high impact practices that increases rates of student retention and student engagement. They also acknowledge that these high impact practices are unsystematic on most campuses in America.

As a movement, this type of research was supported by Boyer's [3] advocacy for a broader view of scholarship that eventually led to a term called the *scholarship of engagement*. By bringing definition to this term, the ability to evaluate, acknowledge and reward faculty for this effort has increased. The National Review Board [3] defines the Scholarship of Engagement as:

> "A term that captures scholarship in the areas of teaching, research, and/or service. *It engages faculty in academically relevant work that simultaneously meets campus mission and goals as well as community needs.* In essence, it is a scholarly agenda that integrates community issues. In this definition, community is broadly defined to include audiences external to the campus that are part of a collaborative process to contribute to the public good."

The scholarship of engagement clearly includes, and can be accomplished through, undergraduate research. The National Conferences on Undergraduate Research [4] has developed a statement of principles that also supports this approach. The principles are:

- Combines teaching and research, two historic poles of a professional dichotomy, into one integrated pedagogy and system of performance. In undergraduate

research, scholarship and teaching may not be as separable as conventionally thought or practiced. In undergraduate research, teaching and scholarship become parts of one simultaneous, overlapping, shared process.
- Replaces traditional archetypes of teacher and student with a collaborative investigative model, one using research done with a mentor or done jointly by students and teachers--a new vision portending a major shift in how scholarship in the academy is practiced in a broad range of disciplines.
- Replaces competitive modes of inquiry with ones more focused on collective and collaborative work, offering an enlivening and exciting new heuristic.
- Motivates students to learn by doing. With faculty mentors, students engage directly in practicing the work of their discipline while they avoid passively acquiring knowledge that that discipline has produced.
- Promotes both new research and a student's analytical and communicative skills from the student's first days within the college experience.
- Creates internal networks to support these collaborative learning efforts. Any campus that motivates its students to learn through individual and collaborative research - and can find ways to support these intellectual journeys with the necessary human and material resources - provides its students with a first-rate education.

In summary undergraduate research is supported on almost every front as good practice and a new paradigm for scholarship at a university. This is not to neglect graduate research. Masters and doctorial programs have of course a long history of research practice. Our paper expands generally the idea of using student, graduate and undergraduate in research process through engagement with industry in web engineering. For industry and business there are also benefits to be gained by this activity.

1.2 Web Engineering- New Tools for Supporting Web Engineer Research Projects

Not only is undergraduate research in web engineering being practiced in academia but the tools developed by the field are being used to extend and enhance the process. Tools like the many below will increasingly make it possible to make international collaborative student research possible. Below is a select set of web-engineered products that are, or hold promise, to make a difference with regard to student research in web engineering:

Elluminate [6]: A web conferencing tool that can connect remote groups together with sound and video connections, shared presentations, white boards, and web tours.

Skype [7]: This has helped connect undergraduate researchers and faculty across the globe with affordable and powerful video conferencing software.

CritiqueIt [8]: This is a new collaborative tool for critiquing documents. The tool is especially useful to get input from industry as well as feedback among teams of faculty and students. Critiques can also be done through annotations in video or audio forms.

Wiki's: This easy to use web service is blurring the lines of who is teaching whom. Students help gather and add to these sites as part of a learning community. They work well for student projects to include project management, presentations, links and contact information.

Phidgets (physical widgets) **[9]:** Physical widgets are a USB prototyping I/O system with a main board and dozens of plug and play sensors, webcams, motors, relays, RFID sensors, switches, and displays. The company states that "Applications can be developed quickly by programmers using their favorite language: C/C++, C#, Cocoa, Delphi, Flash AS3, Flex AS3, Java, LabVIEW, MATLAB, Max/MSP, MRS, Python, REALBasic, Visual Basic.NET, Visual Basic 6.0, Visual Basic for Applications, Visual Basic Script, and Visual C/C++/Borland.NET." [9]. We are still in the initial phases of working with this technology at BGSU but it appears promising.

Mobile devices: The smart mobile phones with internet connections are now in the hands of a majority of our students. The Wii, iPhone, iPad, and Nokia Mobile phone with Near Field Communication (NFC) technologies are just some of the new mobile devices that are connecting the web to the physical world in new and unusual ways.

2 Methods

2.1 Intro and Context for the Process

As an American Professor, one of the authors has been a proponent and practitioner of undergraduate research. As an undergraduate himself, he participated in an honors program that allowed him the opportunity to engage in research of own choosing. As a young assistant professor he went on to serve on the university honors committee and a decade later created a Digital Media Research Group (DMRG) for some of the most gifted graduate and undergraduates. Four of these American students came to Austria to continue their work with the American author but also engaged in the team projects taking place at Salzburg University of Applied Sciences (FHS). His duties included not only overseeing the DMRG group but taking on the oversight of two Austrian/American student groups. The projects included Web-Radio and a NFC (Near Field Communication) International Ticketing on mobile devices. This was the first time the American author had witnessed a program that systematically engaged all the students in a major in undergraduate research.

The FHS Information Technology and Systems Management (ITS) program has developed a sound integrated web-engineering research experience that exemplifies best practice in this area and the authors believe this should be shared. At the time this particular research experience occurred the FHS program used a four-year diploma model. Today FHS is using what we are calling the R&D model at the graduate level. The process is the same but the academic structure is somewhat different. In the following, major facets of the course of action are discussed.

2.2 Selecting the Projects

To achieve a balanced situation as regards expectations from the educational and the commercial partners, the potential project ideas are systematically collected and subject to an evaluation process. This process ensures that the goals of the suggested projects are aligned with the technical competences of the study program’s faculty and that requirements of the curricula are considered as well. On the other hand it is rather important to inform the industry partners about the fact that there is and cannot be any guarantee with regard to the potential success of the envisaged projects. Thus a communication phase with industry partners needs to precede the selection process, where expectations of both sides are clearly expressed and communicated. For company partners that have a long-time relationship with the study program, this process can be shortened based on the internal experience of the companies regarding project modalities and expectations.

Once all project ideas are collected, an internal review session is triggered with the academic partner to prioritize the candidate projects according to scope, avant-garde in technology, feasibility regarding work load for the students, and general alignment with the study program's research perspectives. This mostly consensual discussion process is also important to bring in new aspects and tasks to the suggested projects from the viewpoints of all technical experts working for the study program. In the end, the number of enrolled students limits the number of eligible projects.

2.3 The Students

Students should be engaged in the projects under consideration of the majors they elected. Specifically for undergraduate students, this helps in aligning the projects with an individual focus of interest. It is not the students who decide which project they want to be engaged in, it is the faculty that assigns individual students to the projects best suited to fit the topics of the major a student selected. With this assignment process, not only individual preferences of the students are considered but also the potential to perform in specific aspects of the projects. In projects with web engineering focus, it makes sense to assign web technology experts amongst the students to a project whereas network-focused projects might benefit from students with background knowledge in that specific field. These alignments optimize the success potential of the project on one side; on the other side they usually lead to a high motivation level of the students engaged.

It is relevant to note here that *all* the students enrolled in the program participate in the projects and not only honors students or students with deep background knowledge in specific fields of technology. This project setting is considered roughly equivalent to a course but it extends over half a year (undergraduate level) or the full year (graduate level) and they must devote about 1/2 day per week to this effort.

2.4 Research Space

The faculty at FHS has an almost new building and the design included planned spaces for student research. This provided the students with a common work area as well as a space for the supervising faculty to oversee progress and monitor informally the time on task that students were contributing. The space is also important if the web-engineering project included physical devices that needed to be integrated into the design (Near Field Communication [NFC] in Nokia mobile device). Each space included at least one computer and enough space for a team of 3-5 students to congregate.

2.5 Faculty Oversight

In the department every project has a lead faculty mentor and at least one secondary faculty assigned. This provides for some flexibility and also assures that the right mix of skills is available for oversight. Faculty meet individually with student researchers and also as a team typically every two weeks. During this first month the meetings were more frequent. In the case of the International Ticketing Project, the American author had two face-to-face meetings with the company and several phone conversations. This particular group of students and faculty also were selected to make a presentation at the Mobile Communication Conference for students in Vienna. Faculty assigned grades at the end of the period.

2.6 Course Integration

The above-mentioned projects are constituent parts of the related curricula, both at the undergraduate and graduate levels. In their third year the students work on their initial *internal project* for about half a year where they face a group-situation of two to three members (see Table 1). The students can achieve their first experiences in project work and project management in a kind of 'protected environment' where no external partner puts pressure on the students. There is a project management course in the same semester that the students need to enroll in, but in contrast to the former diploma program, there is no synchronization with regard to the artifacts of the projects and the project management course. At the end of the internal project, students submit their first bachelor thesis where they systematically work on technical documentation of the work done and the project outcomes of their internal projects.

Pursuing that, the *external phase* of project-oriented working starts in the second half of the third undergraduate year. This phase of industrial placement is also part of the curriculum and requires a minimum of 360 working hours within technology companies to be accounted for by the students. In most cases, students get paid for their work and thus try to extend that phase to four or five months where they can achieve deeper and even more specific knowledge about the problems and challenges of the departments they work for. At the end of this phase, students individually write their second bachelor thesis that theoretically reflects the topics and achievements of their industrial placements.

When enrolling in the consecutive master's program, graduate students start to work on the so-called *research and development projects* (R&D projects) in a group situation of four to five members (see Table 2). These R&D projects are small-scale projects defined in part by the information students have acquainted during their industrial placements and in part by the research lines of the study program. Based on the criteria such as innovation potential, correlation with research lines of the study program, envisaged work load and success potential, the R&D projects are again decided upon by technology faculty of the study program in a decision process that in most cases works consensually. Thus on the one hand, individual experience of senior researchers can enrich the list of requirements for a suggested R&D project proposal to better align it with the state-of-the-art in technology; on the other hand - and equally important - the team view on the project proposals reveals which parts of the projects have low research implications and therefore can be dropped from the list of requirements. The dominant benefit of this somewhat substantial process is that external partners (and also students) tend to respect team decisions more readily and therefore more time-consuming discussions are avoided.

Table 1. Undergraduate level with regard to project engagement

Foundation	1st year
Team application integration projects	2nd year
Individual internal projects including external phase	3rd year

Table 2. Graduate level with regard to project engagement

R&D small-scale projects	1st year
Masters' seminar and Masters' theses	2nd year

2.7 Progress Seminar

It is helpful for several reasons to have scheduled progress presentations from the students given to faculty and also company partners. First, this raises the level of commitment of the students to perform well in the project setting as they face potential employers in this presentation. In addition, the motivation to produce standard project artefacts such as progress reports, project flyers or project posters is higher in a scenario close to a real-world situation when compared to a teacher-created problem set.

Second, the general public gets informed about the ongoing activities of the study program in conjunction with industry. There is also the option of inviting journalists to these events who can transport add-value aspects of the study program to the public. This is politically relevant for programs that are (co-)funded by public bodies.

Third, companies get an impression of students they do not directly see in the other projects they are not involved in and thus have the option of a soft form of talent screening. In return, students get deep insight into other projects they are not directly engaged in and thus ‘see’ what topics of interest are active with several companies. So both potential employers and potential employees can indirectly exchange information that helps application planning and engagement decisions in the long run.

3 Web Engineering Case Studies

3.1 Workbench and Potential Issues

All the active stakeholders in the process have different and sometimes divergent interests in the high impact teaching practice discussed in this paper. Industry partners that are used to a lot of contracting with other companies may see the student teams as a kind of cheap external resource at their disposal. This causes two problems if left unaddressed. One the students do not get the rich experience that might otherwise be provided. Secondly, other companies or employees may feel that the university is taking away their jobs. It is the responsibility of the faculty to explicitly protect the project teams from situations like this.

Here the term 'workbench' comes into consideration. This is where a company partner tries to 'outsource' everyday or routine work (i.e. workbench tasks) to the student projects (any project is subject to changes the sooner or later), this triggers an escalation process that can result in a project exit scenario at its worst. Company partners need to know that workbench situations are unacceptable before the projects start. In most cases, the companies with a bit of explanation can understand the educational opportunities that this creates for students. This actually frees the company to think more openly about innovations that they did not have the time or expertise to pursue. It creates a low-risk, high-potential scenario for innovation from their viewpoint and thus increases intrinsically the level of research challenge in the projects. The absence of workbench situations is a key aspect in alignment of the projects with the educational goals set out in the curriculum.

Another benefit of avoiding workbench scenarios is that the expectations of companies regarding long-term support of student project outcomes are clearly communicated to be out of scope for the study program. As a side effect, company partners usually evolve their expectations to a more research-oriented approach in the projects. This of course is in alignment with the goals of the related curricula. Finally companies accept that it is more important to enable students for research (they are potential innovators when engaged as employees after graduation) than to have quick project success, which is in alignment with general sustainability of tertiary education.

3.2 Selection of Case Studies

In the following, two project examples of undergraduate and graduate projects are described and discussed in their context with the conceptual framework explained above:

Web-Radio: This was an internal project for FHS. A web-radio studio had been built into the architectural space of FHS. What was initially mainly an audio radio service had become increasingly a broadcast TV station on the web. For legal purposes every minute of programming needed to be logged and recorded. Another purpose of the project was to create a database system and user interface to reuse the audio and video segments for education. Four students worked on this project each with a mix of skills. In this case the faculty assigned to web-radio served as the industry contact and two of us acted as faculty mentors to the students. A student leader was selected by the team and assignments made in accord with the strengths of each student. One student had to drop out of the program for personal reasons but the rest of the team pulled together and came up with a solution. The student team accomplished their task and the new system was integrated into the web radio service. The students benefited and even learned to present to a relatively large group at the final seminar. The leader of this group went on and was honored with a research scholarship to Bowling Green State University (BGSU) for two semesters to complete another research project.

International Ticketing: This was an example of an external project for FHS. A local company is a world leader in ticketing services and RFID (radio frequency identification) tagging. They proposed that the students explore a new RFID technology going into mobile phones called Near Field Communication (NFC). The company wanted a prototype web system built so that anyone around the world could purchase a ticket to an event with their mobile device. The NFC device would interact with *smart posters* as well as enable payment through the phone and finally act as a smart ticket when a person arrived at the event. A strong team of students from FHS worked in conjunction with the American students on this project. The Americans had another project so acted more as consultants/collaborators to the Austrian team. One of the team building experiences that grew out of the research was a chance for the students to present and compete at the mobile communication conference in Vienna. While they did not win, they were bold enough to do the entire presentation in English. As faculty we also were allowed to attend the International NFC conference held in Austria that year. The faculty from the US amongst the authors of this paper found this to be exciting and a very successful experience for all of the people involved.

4 Discussion

BGSU was recently ranked among the top 11 institutions in the US for undergraduate education. Even so, students at US institutions including BGSU often find students that believe aspects of the undergraduate experience are disconnected. In response, BGSU is now involved in a project called Connecting the Undergraduate Experience (CUE) for the 18,000 students (a midsized US university). Some of the concepts gaining consensus among the committee are a radical departure from a system that allowed students to pick from a wide variety of introductory courses within categories to a system that by-design integrates courses in inquiry, problem solving and high impact experiences for all students. While the American author thinks we have done a wonderful job for the most promising students in our system, we have a lot to learn from our Austrian friends. International exchanges are also among the high impact practice we hope to encourage along with a rapidly growing undergraduate research agendas and increasing numbers of our student body.

The FHS model may not work in all contexts, however, the elements that went into the process may be adapted to one's own situation. It appears to have been a win/win/win for the university, industry and most of all the students. The industry has a low-risk low-cost product developed. The university gained prestige for their help to the community. The students got valuable experience in team work, project management, increased their technical depth, and honed their presentations skills.

4.1 International Flavor

FHS is doing a great job in developing students who have an international awareness. The programs in Austria all seem to have international exchanges on a regular basis. Having our DMRG team from BGSU provided a new dimension for both student groups at FHS. The observation is that the exchange has been very positive between students. The American students gained academically but developed a widening world-view and a greater appreciation for Austria as well as technology. Since the American author's stay in Austria, we have had an increasing number of student exchanges often involving research.

5 Summary and Outlook

Both the US and Austria understand the importance of undergraduate research. FHS, and in particular the information technology department, has achieved a system that involves all students in undergraduate research. The general experience is that the US universities have done this very well for many of the top students but it has not been an opportunity for the majority of students. These high impact practices are quickly being adopted in the US for a widening group of students. Since the return of the American author two years ago, a new course in undergraduate research is available to Visual Communication Technology majors at BGSU.

References

1. Chickering A.W. and Gamson Z.F. Seven Principles for Good Practice in Undergraduate Education (March, 1987)
2. Association of American Colleges and Universities, High Impact Practices, http://www.aacu.org/leap/hip.cfm
3. Boyer, Ernest L. Scholarship Reconsidered: Priorities of the Professoriate. [Princeton, N.J.]: Carnegie Foundation for the Advancement of Teaching, 1997. http://honolulu.hawaii.edu/intranet/committees/FacDevCom/guidebk/teachtip/7princip.htm
4. National Review Board http://www.scholarshipofengagement.org/about/FAQs.html
5. National Conference on Undergraduate Education http://www.ncur.org/ugresearch.htm
6. Elluminate, http://www.elluminate.com/
7. Skype, http://www.skype.com/intl/en-us/home
8. Critiqueit, http://critiqueit.com/
9. Phidgets, http://www.phidgets.com/