AdWiki: Designing and Implementing a Socio-Technical Infrastructure for Advising Freshmen Engineering Students

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Abstract - Recent studies demonstrate that inadequate undergraduate advising often contributes to engineering students switching out of their majors. In this paper we present findings from a project undertaken to design and implement a web-based advising system for first-year engineering students. The advising system, AdWiki, has been accessed over 6425 times by over 1260 students since its full implementation. AdWiki was created to address three major issues in advising: (1) heavy faculty advising responsibility in the department, (2) lack of appropriate faculty rewards for time and effort spent on advising, and (3) inefficient uses of advising resources. We recognized a need for a technology-based solution, one that was useful, usable, and sustainable. To achieve this objective, we turned to theoretical literature on the design and use of technology and approached our project through the socio-technical perspective. This perspective recommends a holistic and humanistic approach to design, where technology is just one element of a larger system. AdWiki has seen tremendous usage since full deployment, which we believe is a result of our approach. In this paper, we discuss our theory-guided approach to system design and present assessment and usage data to support our process and findings.

Index Terms—Advising, Engineering students, Socio-technical infrastructure, Technology design.

INTRODUCTION

In recent years, U.S. global competitiveness has come under increased scrutiny and several studies have issued calls for improving undergraduate engineering education, especially increasing retention of students and graduate rates. [1]-[5]. Despite an increase in the numerous efforts in this direction – such as learning communities, advising, mentoring, and pre-college programs to recruit and retain more engineering students – declines in engineering enrollments continue. According to a recent National Academy of Engineering (NAE) publication, “only 40 to 60 percent of entering engineering students persist to an engineering degree, and women and minorities are at the low end of that range. These retention rates represent an unacceptable systems failure to support student learning in the field….Without refocusing and reshaping the undergraduate engineering learning experience, America’s engineering preeminence could by lost”[3]. Of several factors that play a role in student dissatisfaction, lack of effective advising is a prominent one, particularly for women [6]-[7].

CURRENT PREDICAMENT OF ADVISING

Advising forms a core function within most institutions. Given the decline in resources at most major institutions, however, there is increasing pressure on advising services. One-on-one advising for students is limited, particularly in research institutions that happen to enroll a significant number of students. This problem is coupled with increasing research, teaching, and service responsibilities for faculty members, leaving little time or no time for advising duties. Given the importance of advising, institutions aim to provide extensive advising support, but the resources are not always used effectively. In essence, the problem is a coupled issue of a mismatch in faculty incentives and expectations, and inefficient use of existing resources for advising.

I. Mismatch in Faculty Incentives and Expectations

At our institution the faculty members in our department are responsible for advising all incoming (~1400) freshmen students; each faculty member advises ~100 students. This advising responsibility is added to their teaching, research, and service responsibilities. If faculty members are to advise students successfully, advising represents a significant responsibility and time commitment. However, faculty members receive a very different message on standards for promotion and tenure decisions, which depend primarily on research and grant achievements. Therefore, there is a fundamental misalignment between institutional claims about the importance of spending time on advising, and the requirements for tenure and promotion [8]. From the logical perspective of many faculty members, advising is a service that they must perform, but do not see as central to their scholarship or their teaching. When evaluating a candidate for tenure most institutions consider the number of publications, the amount of grants, and maybe some dimension of teaching evaluations. Even when institutions plan to rate advising efforts they have difficulties because advising is an elusive practice that is hard to depict and to measure. In fact, it usually has no metric other than the number of students served. Thus, when advising is taken into
account, quantity matters but quality does not. There is rarely an established mechanism for representing advising efforts in a substantial manner or for evaluating and rewarding advising activities. For instance, as a first point of contact, a faculty member likely receives an email from a student asking for an appointment. Sometimes the issue at hand is resolved via email, but often the student visits the faculty member in his or her office. Given that both these interactions are private, and that the conversations and times spent vary, there is no metric to make the service visible, and to take the service provided into account. If a faculty does an outstanding job, there is rarely an extra reward, and if s/he does not, there are no repercussions.

II. Inefficient Use of Existing Advising Resources

At present, several advising resources exist on the Virginia Tech campus for engineering students. Both the college and the engineering education department maintain websites that offer advising information. Each engineering department with a major employs an undergraduate advisor to help student navigate the idiosyncrasies of each department’s rules and requirements. Frequent informational and reminder emails are sent to students, and notices are posted on the sites. Therefore, a combination of human and technical – socio-technical – resources is available to the students. In addition, each freshman student is assigned an advisor, who is a faculty member of the Engineering Education department. Yet, as with many resources, there is often a mismatch between necessary information, and how that information can best be delivered, accessed, and maintained for accuracy. Requirements often change and online information becomes outdated. Faculty members often travel for research presentations and other research-related activities, and cannot realistically be expected to be on-call to deliver information first-hand at all times. Moreover, faculty members are often asked the same basic factual questions repeatedly, a redundancy that consumes valuable time. Efforts therefore tend to focus on helping students to get basic information about rules and procedures, or prescriptive advising, and neglect developmental advising, which focuses on helping students to identify their goals and to learn to make good decisions for themselves.

Student advising demands our time and attention if we are to retain students, and help them persist with engineering as a major. However, two interrelated problems with advising must be tackled: advising resources are not used efficiently, and there is often a mismatch between faculty rewards and expectations. The AdWiki project described here is designed to address these issues. Although we realize we are talking primarily about our particular institution, and are grounding this work within the context of freshmen engineering at Virginia Tech, the issues we are addressing are common across campuses. In the AdWiki project, we focused the population of first-year students as the first year of college studies is often the hardest to navigate both socially and academically. Also, students who do well when they are starting out and learn how to make the best use of the resources available to them often continue on the path to success.

PROPOSED SOLUTION TO THE PROBLEM: A TECHNOLOGY-DRIVEN ADVISING SYSTEM

I. Pragmatic Foundations for Technology Based Solution

Digital technology is a uniquely valuable advising tool because online resources are available 24x7, and students can use them as and when needed. Furthermore, at Virginia Tech, no centralized online resource yet existed for engineering advising. Current technological solutions have neither kept pace with the habits of the Generation Y, such as the exponential rise and proliferation of digital media among incoming students in an undergraduate program, nor with innovation in the design of online social systems [9]. Students are now habitual in taking control of their mediated experiences and learning. Therefore, we realized that there was a great potential for the use of technology, but only if done right. Our thinking about the use of technology was especially driven by literature on supporting a community of practice of students, advisors, and faculty that we aim to build in our universities [10]-[12]. Technology has been shown to structure the manner in which work is done and the social relationships among people and through a technology-based platform we planned to provide the necessary long term socio-technical infrastructure that will be a first step towards the fundamental redesign of how advising is organized to increase its benefits for students as well as advisors and faculty [13].

II. Theoretical Foundations for Technology Development and Deployment

The theoretical foundation for the development and deployment of AdWiki came from a close reading of the Science and Technology Studies and Organization Studies literature that points to the mutually constitutive nature of the technical and social aspects in system development and deployment. As Reference [14] states, “Technology is never purely technological: it is also social. The social is never purely social: it is technological. This is something easy to say but difficult to work with. So much of our language and so many of our practices reflect a determined, culturally ingrained propensity to treat the two as if they were quite separate from one another.”

Socio-technical design has a 50-year history and its objective has always been “the joint optimization of the social and technological systems” [15]-[16]. From a socio-technical perspective, “technology” includes apparatus, techniques, and work structure, whereas the social consists of individuals in groups and their coordination. The socio-technical design movement gained enormous popularity in the 1970s owing to a greater awareness of the social impacts of technology and the attempt to improve the quality of life and manager-labor relationships through improved social relations by relegating technology to the background. This
perspective has been particularly pertinent to the work place and in this sense it applies to our project as we try to reorganize how faculty work – at least in regard to their advising function – as well as how students best do their work in order to achieve a successful education, of which advising is a critical component.

In recent years, socio-technical design has started to encompass the users themselves in the design of a system and the overall activity has started to take the form of action research [17]. This notion captures our approach to a certain extent as both the principal investigator and co-principal investigators are faculty in the department where this system was being deployed. The approach has also begun to encompass the range of stakeholders that use any designed system; socio-technical interaction network (STIN) has emerged as new way to conceptualize this approach towards system design and use [18]. In a socio-technical approach the actors and artifacts are mutually constitutive in nature and their relationship is synergistic [19].

**Preliminary Research to Guide System Design**

This understanding – that our technology is intertwined with social aspects of stakeholders and the overall institution – guided most of our actions during the project. In order to avoid just another technology that was developed and deployed without any regard to its users, we focused on understanding the stakeholders and their problems. We identified the following communities that would be affected by AdWiki: students, faculty, advisors, and administrators. In order to understand the concerns of each of these communities we used surveys, informal conversations, and participation in meetings. For instance, advising was a topic of a faculty meeting in the department that shed light on several issues pertinent to the design of our system. We had access to results of student surveys on questions around advising that provided us with an idea of the issues students were grappling with. Furthermore, we had access to an extensive collection of emails from students writing about advising issues. We took over a 100 emails from advisees and coded them to identify frequently asked questions, and to understand the ways that students asked their questions. The coding produced 25 categories; each email message was coded with around 2 labels. The results showed that there was a wide variety of messages, and that each email represented more than one category. As a next step these codes were categorized into broader groups to help us in the design of AdWiki. The analysis of email messages also showed at which time during the year the requests are higher and what are those request. Just this rough analysis was demonstrated the advantages of being able to categorize requests and reduce redundancy (Figure 1). We also had access to paper-based advising resources that were used for advising by faculty and staff earlier (a system that was dismantled a few years ago). A preliminary survey with students indicated that students used a variety of resources for advising. In addition to faculty advisors, their peers were a significant source of advice, as were online resources such as departmental webpages.

**System Design and Development**

During the summer of 2009, the implementation of AdWiki started in earnest and the team evaluated online Wikis sites as potential platforms for AdWiki. Initially, we investigated several Wiki platforms that are available as open source such MediaWiki, PBWiki, TWiki and XWiki and analyzed and compared their characteristics. Of these, MediaWiki emerged to be the most robust platform with a wide array of options but immensely easy to use. An undergraduate research member of our team configured a MediaWiki server using Apache, PHP, and MySQL. He further researched and installed extensions that improved the capabilities of AdWiki including enabling a thread-based discussion system to encourage student participation, upgrading the system from using a wiki markup language editor to a WYSIWYG (What You See Is What You Get, much like Microsoft Word) editor for ease of use, and adding social rewards for discussions and advice that students find helpful. In September 2009, we ran into a technical challenge not with the software platform but with its deployment and maintenance. Ackerman [22] has cautioned against such dangers which he terms the socio-technical gap and defines as the “divide between what we know we must support socially and what we can support.

![Figure 1: Coding of Student Emails to Identify Advising Categories](image_url)
technically.” One way to avoid this issue is to look for already existing technical solutions and identify their affordances for the problem at hand. It was clear to us that Scholar, Virginia Tech’s online course management system, would provide the best secure and accessible environment and help us overcome our implementation issues. Scholar also had the advantage of allowing faculty and administrators to enroll students. AdWiki could then appear as a course tab on the Scholar sites of all enrolled students. Once it became clear that a standalone MediaWiki site would not be the best way to reach freshman engineers, our team decided to move the wiki to the Scholar environment. We then had to transition to Scholar by determining its capabilities and limitations, meeting team members in person to discuss how the new environment would affect our existing vision of AdWiki. One of our team members even wrote documentation to explain step-by-step how to utilize its strengths. Several design principles emerge from the literature on design of online communities also guided the use of Scholar as the deployment platform [11], [23]-[24]. Using Scholar made AdWiki inherently people focused and participation friendly. Since participants are provided access only through Virginia Tech’s user-id system, this makes the system private and safe. An additional benefit is that a readymade member profile is available to users, and by disallowing anonymous postings participants are accountable for what they write, thus reducing clutter, noise, and offensive content.

**SYSTEM DEPLOYMENT AND USE**

Once the wiki platform was decided upon, we focused on identifying the learning goals for student AdWiki users, and on identifying the needs and goals for faculty and advisor users. On the most basic level, we wanted to create a convenient resource that provided up-to-date information about key advising deadlines and procedures, which are complex and change frequently. Therefore, AdWiki could not only keep students informed, but reduce the time spent by faculty and advisors on redundant questions about simple facts. More importantly, we wanted AdWiki to promote not only prescriptive advising, but developmental advising as well. Therefore, we were committed to creating a resource that not only told students what needed to be done, but how they might think about decisions at key moments in their academic careers.

In order to provide this “just in time” advising, we decided to organize AdWiki resources according to the rhythms of the semester. Such topics include Planning Your Course Schedule, Course Drop and Withdrawal: Policies and Considerations, Handling Academic Difficulties: Probation, and Illness and Absences: Policies and Strategies. We also created a form bank with essential documents for convenient access. We also included frequently asked questions that align with current academic issues (Figure 2). These FAQ’s share information, and, more importantly, they offer students ways to think about the challenges and choices that they face. Organizing, writing, collecting forms, and posting to the wiki was our major activity for the fall semester.

As students prepared for Spring 2010 course request, a student sample was enrolled and polled (Figure 3) about their AdWiki experience. Following course request, faculty reported fewer redundant questions. At the end of the semester, we shared the AdWiki with the full Engineering Education faculty.

Figure 2: Current AdWiki Interface – Simplicity and Usable and Useful Knowledge
FIGURE 3: Survey Response to Initial Use of AdWiki

I. Technology as an Impetus for Re-organizing Advising

In addition to the technological solution provided by AdWiki, the process of system design and development also provided the impetus for several changes in the advising system overall. First, a person in the department with most experience of advising started to send a weekly email to all faculty and staff about relevant advising issues for the week. These emails often led to online discussion which increased the knowledge about many issues for everyone. Second, the department implemented a policy of hiring part-time advising support during times of heavy advising requirement. This support has eased the burden of advising for faculty and has made it simpler for the students to gain access to timely help (and signatures). These small steps highlight the organizing aspect of the use of technology. AdWiki is not just a technology deployed for advising but also a source of reorganizing how advising works in the department. It has changed the overall advising system. It is in this context that we believe that developing AdWiki was an example of contributing to the infrastructure of the institution. We use infrastructure here in the sense of a social and technical resource; the social and technical here are mutually constitutive. As we discuss later, the affects of this technical intervention are still continuing through social implications for other advising efforts.

II. Use of AdWiki

Participation is assessed through online logins. In the last 5 months, since the statistics for the site are available, there have been 6162 visits by students (total visits including all participants such as faculty and advisors is 6425), of which 1275 are unique visits (i.e. different users). There are a total of 1598 students enrolled in the site of which 1262 (79%) have visited the site. These data are current as of May 21, 2010. In January 2010, there were 1124 visits (203 unique visitors). In February 2010, there were 1657 visits (891 unique visitors), March 2010 had 1761 visits (750 unique), April 2010 had 911 visits (477 unique) and till May 21, 2010 there were 709 visits (412 unique). Of course, visits alone do not tell us about time spent by users and actual use of the Wiki in depth, and these are statistics that we hope to get access to in the future. Overall, our online observations indicate that students log in for significant time periods to read the information available to them (once a person logs in, they can see the list of all other users logged in simultaneously). We believe that the usage of the system is also due to its accessibility through Scholar which assures single sign-on for students and makes it more convenient to use the resource. Furthermore, in contrast to a webpage on the department website, a site on Scholar gets their attention as they visit Scholar for other courses as well. Therefore, they do not have to make the extra effort to an outside webpage. Plus, as mentioned earlier, the ease of posting announcements makes AdWiki salient as the announcements show up on their Scholar site once they log in. Figure 4 depicts the kind of data and visual information available.

Since the deployment of the system, we have learned a few lessons around how to make the use more effective and increase participation. We now make frequent announcements to students (at least once every two weeks) to remind them about upcoming deadlines. These announcements not only go through emails, but through the announcement function available in Scholar. Through online usage data we see a spike in the use of the system, suggesting that these announcements are effective in attracting students’ attention and encouraging them to visit AdWiki.

Figure 4: AdWiki Usage Statistics from Feb. 1 to March 19, 2010
DISCUSSION AND CONCLUSION

Recently, O'Reilly Media President Tim O'Reilly in his talk at the O'Reilly Web 2.0 Expo (ACM News) asserted that the advent of the Internet represents an "amazing revolution in human augmentation" and compared it to the emergence of literacy. "The real heart of Web 2.0," he noted, "is collective intelligence, which I have defined as harnessing the network effect to build applications that get better the more people use them" and "applications that are built on open, decentralized networks actually lead to new concentrations of power." With this mind, we believe that AdWiki provides a lens into this future of technology-integrated education. At present most of our resources and assessment are tailored towards the physical and locational aspects of interaction. The university campus and faculty focus efforts on office hours and face-to-face meetings. This strategy is proving to be inadequate, given the prevalence of digital media in the lives of our students. The solution is not virtual office hours but an in-depth understanding of the technological in particular digital technology aspects of interaction with students and interaction among students. Physical communities have been successful, but the potential of online resources remains untapped. Therefore, we need to examine in-depth the digital extant of student life to be able to optimize digital resources [25]. One of the outcomes of this project is that it will help us move in that direction by understanding technology use as a means to re-organize the status quo [26].

AdWiki has taught us many important lessons regarding the development and use of technology for advising. First of all, our experience with AdWiki provides a solid argument for a theory-based approach to the design of technological solutions. As we show through our case study, a socio-technical perspective was critical to our design process, the nature of the product, and its means of deployment and use. This approach guided us when our initial attempt at developing the system was limited in its application given the technical constraints of support for the technology. In our case even though the actual software supported our goals, the larger technical infrastructure of deployment failed us. AdWiki also provides many pragmatic lessons. We have learned that the dynamicity of information is a critical problem. The institution, as well as individual departments, change policies constantly which makes it hard to provide up-to-date information consistently. Often, many of the procedures are ad-hoc or contain certain leeway to accommodate student concerns but all this is informal and hard to capture in recorded data. Finally, more effective use of technology leaves more time for face-to-face interaction among students and faculty that go beyond administrative and logistical issues and tackle serious problems about career choices, making interpersonal interaction more effective [27]. We recently presented preliminary findings from our case study at a conference and the audience responded quite positively to the overall aims of our project and to our design and implementation strategy [28]. They also suggested ways to improve the effectiveness of the solution.

Sustainability of Solution: Our efforts have provided a unique advantage to our department in integrating its efforts to improve the first year experience for Virginia Tech students. There is an institution wide effort to enhance the first year experience (http://www.fye.vt.edu/) of all incoming students, and our department is leading the effort for the College of Engineering. A synergistic partnership has evolved between AdWiki and the Quality Enhancement Plan (QEP) that is driving the improvement in first year experiences. AdWiki has provided a foundation for the effort at the departmental and college level and at the same time has benefitted from this partnership in terms of sustainability. The sustainable use of technology is a critical issue as most projects are only able to garner use for their initial period and then wither away. The sustainability of this platform is also being built through incentives for constant participation of faculty and advising staff by reducing their time commitment and redundancy of effort, and by introducing metrics to measure their contribution.

Future Work: The future implementations of AdWiki will include an online question and answer forum, which will allow students to ask questions online. More importantly, we can learn about students' issues and concerns by browsing the questions and their replies. We have also started a Facebook group. Getting the attention of students is challenging, and multiple channels are best used for this purpose; a Facebook group will allow us to reach students' news feed. In this manner, critical announcements can be posted directly to their news feed, if they opt-in. We envision that once the forums become a legitimate way to discuss advising issues and gain advising information we will slowly be able to engage more student participation around AdWiki. Moreover, Reference [29] found that enhancement of personal reputation and sharing of experiences are critical motivations for people to contribute to electronic communities and these ideas will be applicable for AdWiki as well.

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