Deployment of Educational Technology: Utilizing Perspectives of Multiple Stakeholders

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Abstract:

This paper explores the utilization of a multiple stakeholder framework in the formative and summative evaluation of an online homework system. The framework considers five project-related outcomes (learning, performance, quality, resource allocation, and inspiration) from the perspective of student users, faculty, affected faculty, departments, institutions, the project team and the funding agency. OWL, an online homework system deployed in numerous disciplines, will be used to provide examples that illustrate the place of multiple stakeholders and outcomes in the evaluation framework.

Key words: Evaluation, Learning technologies, Project deployment, Online homework

Introduction

Most projects associated with innovative deployment of new educational technologies are initiated with the intent of improving learning performance of the students. Project teams are typically led by faculty from a given discipline who partner with experts in a given technology.   A resultant project plan will include development and deployment with some consideration to the existing pedagogy of the potentially impacted courses. Rarely does the typical project plan take a holistic approach that considers the perspectives of the multiple stakeholders present in a college environment.

The value and process for considering these multiple stakeholders is the focus of this paper using experiences gained from deploying an online homework system (OWL) in various academic disciplines and on multiple campuses.

About the Online Web-based Learning (OWL) System

The Online Web-based Learning (OWL) system was developed at the University of Massachusetts at Amherst in 1997 and is used today by over 10,000 students annually in more than a dozen departments on multiple campuses. OWL is used to administer online homework assignments and grades them automatically. Students receive constructive feedback after answering each question, so they learn from their mistakes very quickly. If a student doesn’t answer enough questions correctly to pass, he or she can redo the assignment repeatedly until passing, subject to instructor-generated course rules.. OWL generates a new set of questions for each retry, so students can apply the feedback about their mistakes to successive tries until they pass.

OWL has been used most successfully in large introductory courses taken by students from many majors outside the department offering the course. Examples include Chemistry, Physics, Calculus, Computer Science, Geosciences, Communication, Art History and Accounting. These courses are taught in large lecture sections at UMass and elsewhere, and, before OWL, offered little or no homework for students due to the high cost of grading. Adoption of OWL in these departments has been significant in important ways including: students’ performance is improving as they spend more time on graded homework assignments with immediate feedback; and the cost of homework administration is decreasing dramatically in courses that relied on small, instructor-led recitation sections before OWL. (Rath and Hart, 2001; Dufresne et al., 2002) In Calculus and Accounting, courses that traditionally assigned little homework due to limited grading resources, more graded homework can now be assigned

OWL is more than just an online question-and-answer system. The OWL architecture allows the integration of other, more interactive exercises such as guided discovery activities and intelligent tutors. . In Art History, the use of OWL has been coupled with the use of interactive modules that allow students to explore fundamental aspects of architecture and painting. Information about student performance in these activities is tracked by OWL comparably to the results of question-and-answer assignments.   *Guided discovery modules* allow students to interact with a multimedia simulation or visualization activity (displayed in a separate window), using leading questions to guide them to the "discovery" of basic laws and concepts such as gas laws or electromagnetic radiation (Fermann et al., 2000; Spaziani et al., 1999). *Intelligent tutors* customize their instructional strategies to the needs of the individual student (Woolf, et al., 2000; Hart et al., 1999). They vary the pace of instruction, presenting problems in such a way as to challenge the student at the appropriate level. Students are required by the tutor to interact with the instructional material to demonstrate facility with it.

Identifying the Stakeholders and their values

Effective evaluations recognize the importance of identifying and incorporating the multiple perspectives of a project's stakeholders (Patton, 1997). Stakeholders for OWL, or any other educational technology project include: students; course instructors and teaching assistants; other faculty members of the host academic department; faculty of other departments that receive affected students in subsequent courses; the university or college administration; project developers; and the commissioners or funding agencies. Each of these stakeholder groups, when considered in detail, are usually diverse in their needs and perspectives.

Students, for example, differ in their approach to a given course as a function of their background (e.g., age, gender, class level, subject-matter familiarity, and major), academic aptitude (e.g. learning skills) motivation in taking the particular course (e.g., elective or required for their major or as a pre-requisite for subsequent course.) The perceptions of the new technologies for the students will vary depending on their academic skills, preferred learning styles, and their motivation to learn as opposed to more focused on succeeding in the course on a grade basis.

Ultimately, a project will be more successful if the new technology is fully integrated with the overall course experience. This involves consideration of pedagogy, use of lectures, labs, discussion groups, textbooks, homework, and exams. These same considerations present a challenge in considering the perspective of *instructors* and other *affected faculty*. While instructors have a core commitment to successfully meeting the course objectives strong biases usually exist in regard to pedagogy. The degree to which instructors feel a sense of "ownership" to the new technologies being introduced is a major consideration in their willingness to fully embrace the new technologies.

The other key factor of interest to instructors, *host departments* and *university* is the relationship of the new technology to course management and the utilization of resources. Time and money stand out as key resource concerns associated with developing and deploying new educational technologies.

The *project team* stake, in many cases, isthe most abstract. Their goals in formulating and proposing a given project are usually driven by factors that are associated with the mission of the host institutions but more likely are personal in nature. The origins of many projects are connected to professional aspirations to address outstanding educational issues with novel and innovative approaches. Assessing this more intangible goal is as important as many others as it can sustain the effort and encourage subsequent activities.

Funding agencies or commissioners of the project usually have their own agendas set by their governing bodies. These perspectives need to be carefully considered, as outcomes need to be assessed with an eye towards the commissioner's reporting requirements.

Framing the stakeholder perspectives

A framework for considering the value proposition for each of these stakeholders provides a technique for considering and incorporating the project's outcome. (Table 1) These outcomes are commonly interrelated. Often, success of a given project will be best assessed through a triangulation of multiple outcomes. The purpose of the table is to deliniate the differing perspectives in the context of the five outcomes discussed below.

Table 1. Evaluation outcomes from the perspectives of different project stakeholders

STAKEHOLDER	Learning Outcomes	Performance Outcomes	Quality-related outcomes	Resource Allocation	Inspiration
Students	• Skill, knowledge, proficiency • Learning strategies	• Course/Major completion • Grades • Placement	• Ease of use/interaction • Self-confidence in discipline	• Value of time • Access	• Curiosity • Expanded interest in subject
Instructors (Faculty/TA's)	• Skill, knowledge, proficiency.	• Course management effectiveness • Support of pedagogy • Opportunities for innovation in use of time and scope of material	• Experience of participation • Engagement • Ease of adaptability	• Time (preparation, teaching, grading) • Training costs • Content creation and integration	• Joy of teaching
Academic Dept	• Ability to apply learning to subsequent courses	• Retention • Appeal of class/enrollment	• Maintainability • Flexibility and currency	• Net changes to personnel and equipment costs • Sustainability	• Reputation among students, university and professional discipline
Receiving faculty	• Capability to apply learning to subsequent courses	• Ability to incorporate enhanced student capabilities	• General student attitude • Relevance	• Minimizing remedial work	• Course enrichment
University	• Demonstrated proficiency	• Student progression	• Acceptance • Ease of support	• Space • Personnel and equipment costs • Access	• Reputation
Developers/ Project Team	• Targeted skill, knowledge, or proficiency	• Milestones • Products • Technology gains • Dissemination	• Product quality (e.g. accuracy, ease speed, utility)	• Maintenance	• Reputation • Application of creativity and innovation • Fulfillment of vision
Commissioners (Funding agency)	• Board proficiency • Development of learning strategies • Appreciation of subject application	• Meet specific program goals and objectives • Milestones • Products • Dissemination	• Professional acceptance	• Technology development costs • Budget performance	• Success in context of broad program goals • Innovation • Exemplary products

Learning outcomes are discipline specific and related to the nature of the course and accepted pedagogy. Evaluation of learning outcomes is problematic for many reasons (IHEP, 1999: McNabb et.al., 1999). One of the hardest challenges occur when the expected change is associated with a paradigm shift, such as focus on inquiry-based learning. These changes are rarely incremental in that new, previously unemphasized skills are being addressed, driving distinct and often different outcomes. Nonetheless, they are at the core of most summative evaluation processes. Evaluations of learning outcomes are typically test-based or measured by application of knowledge in subsequent courses at the time of the test. The stakeholders' perspectives of these outcomes are relatively uniform.

Assessing these outcomes has traditionally proven to be the most difficult because of the multiple, uncontrollable conditions associated with student learning over the course of a semester or curriculum. Isolating the impact of a new technology requires either the creation of a control group or controlled assessments that isolated the learning specific to the new technologies.

The taxonomy of learning outcomes has their own complexity, which is beyond the scope of this paper (see Bloom, 1956 and others). For this framework, knowledge, skills and proficiencies are considered as the core outcomes. Knowledge is being familiar with the facts and principles associated with the subject matter. Skills typically consider competencies associated with procedures and techniques. Proficiency is the application of knowledge and skill to problem solving and reasoning.

Evaluation is further complicated when the objectives are associated with longer-term proficiencies or expertise or developing learning strategies such as those associated with inquiry-based learning. Longitudinal studies of student learning subsequent to the exposure to the new technologies, are both logistically difficult and challenging to demonstrate as directly related to the specific intervention. Immediate feedback tends to focus on the experience rather than a more profound sense of impact.

Performance outcomes vary tremendously by stakeholder. Course completion, obtaining a specific grade, student retention in a curriculum, effective course management, ability to meet student enrollment with specific resources, meeting milestones, and project dissemination are among the outcomes that have varying values depending on which stakeholder is considered.

A core performance outcome, especially important to the project team and funding agency, should be the completion of the development and deployment activities. Numerous project management tools offer the means to track milestones and communicate project status among the various stakeholders.

Quality-related outcomes are associated with the experience of using the technology (e.g., ease of use, accuracy and reliability of the technology, flexibility, adaptability and speed). A student's perspective and consideration of value will often differ significantly from that of the instructor or developers.

These qualities are most readily assessed through surveys, focus groups, and interviews. The challenge in an assessment is to assure feedback allows for the unexpected.

Institutional and funding agency perspectives on quality relate to the ease of supporting and disseminating the new technologies. Acceptance across academic disciplines and within a professional communities become key indicators.

Resource allocation considers time, dollars, equipment, space, maintenance, and other resources necessary to assure sustainability. A student's perspective of cost and time differs widely from that of the instructor or the institution. Students are most commonly looking for performance efficiencies, i.e., the ability to maximize a grade with the minimum of time commitment. Instructors will consider the consequence of preparation and course management.

Introduction of new technologies will often increase workload as supporting the new technologies is additive. Over time, the testable assumption is that the work is amortized in subsequent semesters. However, new users of the technology usually repeat to some degree the cost associated with integrating the technology into their own course.

Institutional concerns include the total cost management of a course (e.g. the use teaching assistants as graders, tutors, or leaders of discussion sections, administrative support, requirements for dedicated or centralized computer centers, and the personnel and hardware costs associated with maintaining the systems.) Ultimately, a project needs to be able to define a resource-model for sustaining the project after the period of external funding.

Finally, there is an outcome associated with *inspiration*. The educational process is at its best when there is consideration of what inspires and motivates the various stakeholders. Creating a passion for learning and a specific field of study is what motivates most faculty members as well as many students. Universities care about their reputations. Most projects are born out of a desire to improve and are sustained by creativity. Members of a technology-related project team often have chosen non-commercial career paths in order to participant in challenging and inspiring activities. This is often true of those at the funding agencies. As such, they look to sponsor and be associated with exciting, leading-edge and successful endeavors. These inspirational elements are as important as any of the other four, more measurable outcomes.

Integrating the framework with project development, deployment and evaluation

The process of integrating this framework into an effective evaluation requires engaging the team early in the project. By having the project team consider these multiple perspectives, the evaluation can become synergistic with development and deployment. An initial workshop with the project team can refine and prioritize goals and objectives. This in turn can focus development and assure evaluation is both utilized as a formative process throughout the project and is focused on meaningful and measurable outcomes. Early consideration also permits identification of those outcomes for which baselines can be most effectively established thus permitting the highest possible quality for summative evaluations. In addition, the framework provides a context for raising sensitivities to unintended outcomes.

In order to maximize utilization, assessments of outcomes should be timely, succinct and aligned with project objectives. One of the easiest forms of feedback is tracking and communication associated with milestones. This has the benefit of keeping everyone informed of project status and better management of project resources. Functional reporting of results will facilitate timely corrective action for development and deployment, support prioritization and sequencing of improvements and dissemination and identify new or alternative opportunities for innovation that may not have been part of the original project design. Often seemingly negative results will be as valuable, if not more so, than positive ones in that they will be most challenging to the project team if presented in an actionable framework.

Expectations for demonstrating summative outcomes are increasingly emphasized in government-funded projects. Results collected incrementally throughout the project are important in assuring fulfillment of the associated deliverables. These outcomes and the communication of them to stakeholders also serve to motivate the project team and, equally important, can foster on-going support for the project from host departments and institutions, affected faculty, and the broader community that may be subsequently engaged as part of a dissemination phase.

Evaluation of OWL

Initial evaluation of OWL considered one fundamental question: could OWL reduce the cost of homework administration while maintaining or enhancing student learning. To answer this, the main focus fell on resource and performance outcomes, but in the course of the evaluation, the other outcomes became increasingly important, and a variety of measures were used to assess them as well.

Learning Outcomes

Partway through the evaluation of OWL, it became clear through triangulation of the results that the system was, in some cases, positively impacting student performance. This raised the question of whether or not OWL was impacting student learning.

This question became even more important with the introduction of tutors and discovery modules that were designed to address specific topics where students typically showed difficulty in grasping the concepts. The first of these discovery modules were introduced in Chemistry, where certain sections made use of the modules while others did not. The extent to which students learned the material was tested by presenting them with questions on the exam that addressed the topic generally but did not contain specific problems of the type encountered in the modules. The result wherein students in module-using sections outperformed those who had only been exposed to the standard lecture and OWL questions was seen as an indication that the material had been learned more effectively through the use of the modules.

An attempt was also made to ascertain whether an increase in general scientific reasoning skills occurred through the use of discovery modules (Stillings et.al., 2000). It was found that the modules had little notable effect on scientific reasoning skills when compared to the skills of non-module users. This may have been due to the limited role of the modules in the overall course curriculum.

Performance

Performance outcomes were measured by comparing exam performance between cohorts of students who did homework using paper-and-pencil methods to those who used OWL. Measuring the impact on student performance was difficult since trying to isolate the impact of one technological intervention in a large course, where student performance is affected by so many different and uncontrolled factors (i.e. instructor, syllabus, student ability levels, exam-difficulty, etc.), required collection and evaluation of a large body of data to control for as many of these other factors as possible.

The most robust evaluation of student performance was done in Physics, where a single professor using the same syllabus with offerings using both paper-and-pencil and OWL homework systems had taught a number of courses. In this analysis across five separate instructor offerings it was found that the use of OWL was associated with an average raw exam score increase of approximately 5 points out of 100. Further analysis of a single course in which exams were kept identical across the semesters saw a comparable increase in scores with the introduction of OWL. (Rath & Hart, 2001)

Assessing performance goals among the instructors was primarily through the use of faculty surveys. These surveys repeatedly revealed faculty users to be pleased with the effectiveness of the course management and grading capabilities, and that OWL allowed them to spend more class time engaged in instruction or discussion. Chemistry instructors as a group expressed a desire to have more hands-on control over details of their course sections such as the due-dates of assignments – previous to the focus group these details had been managed by one of the two course administrators. As a result, a training workshop was held to help them become more proficient users of the OWL authoring and course management tools, after which they assumed control over their own sections.

Quality

Extensive use has been made of surveys and focus groups, with students, departmental faculty, and receiving faculty, in order to assess the quality of the system and the classes using it. Students are generally very positive about OWL finding the system an easy and effective way to complete assignments. However, the degree of satisfaction is strongly related to being successful in the class more so than any specific feature of OWL. Students will be very quick to point out system defects, facilitated by the fact that OWL includes e-mail capabilities for communicating with either the instructor or the system administrator. Student feedback about OWL has repeatedly revealed details of gamesmanship employed by clever students to overcome time-consuming aspects of using the system. Other surveys and focus groups have provided valuable information that has led to improvements in the sorts of feedback OWL provides and have allowed the conclusion that, in general, students and faculty are pleased with the general usability of the OWL system. They especially like the convenience of 24/7 web-based access to their assignments (students) and authoring tools (instructors).

Resource

A cost model was created that included both the reductions in cost made possible by the elimination of discussion sections and manual grading, and the new costs introduced by investments in technology and instructor time to create online homework activities. It was determined that there was a substantial cost associated with the development of OWL questions and the provision of equipment for enabling access to the student body, especially when departments wanted to create a computer center where students could access the system an receive help from instructors. This was found to be offset in large classes by the fact that, since OWL graded the homework automatically and provided feedback, there was no need to continue using the old discussion group class model, which freed up teaching assistant and instructor time for other pursuits and thus cost the department far less to maintain the course. This savings was, in many cases, far greater than the expense associated with OWL implementation, and, as in the case of the Physics Department, led to a departmental savings in the order of $60,000 to $80,000 per semester (Rath & Hart, 2001).

Inspiration

At a student level, focus groups revealed an appreciation for courses that provide the opportunity to learn in a manner that fits individual learning style. They stated that OWL created a course environment that permitted a wider variety of learning styles, which led to a higher probability of student success. This was especially true in courses in the Math and Chemistry departments that are required for fulfilling the requirements for one's major.

Faculty and teaching assistant focus groups revealed that the instructors were more willing to teach courses now that OWL was available for them when previously they were considered to be very burdensome. This was the result of the time that OWL freed up from grading and in-class quizzing, allowing the instructors to spend their time on more creative pursuits.

A telling example of evaluation and its connection to inspiration arose from work with the Art History OWL development team. There, the lack of a positive impact on performance measures and the emphasis on summative evaluation led to a lukewarm acceptance within the department and discouragement on the part of the project team. Based on the analysis of various stakeholders' perspectives, the project team reevaluated their core motivation for starting the project and began to challenge the basic Art History pedagogy. This drove a new creativity into the development of OWL modules and homework questions, inspiring new energy and excitement into the newest phase of the project and further directions. Subsequent results demonstrated significant change, not only in acceptance of the new systems, but also in increased willingness for Art History faculty to become part of the project.

Conclusions

The utilization of the stakeholder-outcome framework has proven to be an effective means of supporting the development, deployment and dissemination of OWL. New projects are utilizing this framework in the development of proposals and initial project plans. The evaluator-facilitated exercise of considering the impact of the proposed new developments from multiple perspectives has led to engaging a broader set of stakeholders earlier in the project life cycle.

Current evaluation research is focuses on synthesizing parallel analysis across different disciplines and campuses. This is being facilitated by the introduction of common core pre-and post-course surveys, surveys that track development of new modules or tutorials, and the development of tracking metrics that can be applied across disciplines.

Efforts are also underway to identify and/or develop evaluation tools that will allow comparison of OWL with comparable online homework systems.

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