Using Faculty Communities to Drive Sustainable Reform: Learning from the Strategic Instructional Initiatives Program

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Abstract

In February 2012, the College of Engineering allocated an unprecedented level of funding to solicit proposals for the Strategic Instructional Initiatives Program (SIIP) – a new program targeting the improvement of undergraduate engineering education. Faculty proposed large-scale renovations of a specific undergraduate course or closely-related group of courses, with the goal of improving student engagement, learning outcomes, and faculty teaching experiences. While our faculty possess requisite expertise in their course content, they are less aware of effective teaching practices. This weakness was particularly detrimental to our large enrollment gateway courses, undermining student persistence and subsequent academic success. Consequently, in addition to providing funding, the SIIP initiative attempted to provide on the fly faculty and community development. In this paper, we will discuss our observations and reflections on successful and halted reforms and will describe modifications to our approach to administrating and leading this pedagogical change effort.

Introduction

In February 2012, the College of Engineering (COE) allocated an unprecedented level of funding to solicit proposals for the Strategic Instructional Initiatives Program (SIIP) – a new program targeting the improvement of undergraduate engineering education. Faculty proposed large-scale renovations of a specific undergraduate course or closely-related group of courses, with the goal of improving student engagement, learning outcomes, and faculty teaching experiences. Alternatively, faculty could propose to develop teaching technologies that would facilitate the implementation of evidence-based teaching practices. Priority in funding was given to projects that would impact large numbers of students or provide critical interventions early in students’ learning careers.

“Live deep, not fast,” is an admonition coined in the early 1900’s by literature professor, critic, and editor Henry Seidel Canby 1. Faculty participating in SIIP were invited to think deep, not fast, about what is core and what is periphery in our efforts to provide the best undergraduate engineering experience that we know how to provide. Rather than rely on solitary faculty champions to initiate reforms, SIIP participants were required to form teams of faculty dedicated to creating and sustaining reforms. Faculty were challenged to act as reflective practitioners engaged in collaborative efforts 2,3.

Like faculty at most institutions, our faculty possess expertise in their course content but are less aware of effective teaching practices 4,5. This weakness was particularly detrimental to our large enrollment gateway courses, undermining student persistence and subsequent academic success. To complement the faculty commitment to reflectively and collaboratively develop reforms, the college committed resources to provide just-in-time faculty training and community development experiences for SIIP participants.
In this paper, we report on the reform efforts that are currently underway as well as the efforts to provide just-in-time faculty training and community development. We will discuss our observations and reflections on successful and halted reforms. Finally, based on an examination of the research literature and critical reflection, we will describe how we are adjusting the administration of SIIP to deepen the impact and success of SIIP.

Structure of SIIP

While the COE faculty are generally pleased with the technical content of our courses, the depth of student learning and level of student engagement vary substantially from course to course or even from semester to semester within a course. This variability is particularly concerning in the large undergraduate gateway courses that are pivotal to students’ persistence and subsequent academic success. Target courses for the program were defined as those that 1) enroll large numbers of students, 2) enroll students from multiple departments, 3) are regarded as challenging teaching assignments, and/or 4) provide a foundation for subsequent courses. Accordingly, SIIP initially adopted three goals for improving these courses with the explicit expectation that these goals would be sustained beyond the life of SIIP funding.

1. Perform a large-scale renovation of a single course or tightly-related group of courses by making a coordinated set of changes in course pedagogy, organization and delivery methods.
2. Improve student engagement and learning outcomes for the selected courses.
3. Make the courses attractive and rewarding experiences for both instructors and students.

During the second year of SIIP, a fourth goal was added.

4. Develop innovative uses of information technology providing significant enhancement of the student experience or creating novel educational opportunities.

An overarching concern for the sustainability of reform efforts guided both the selection of the aforementioned goals and the administration of SIIP. Inspired by the successful, sustained revisions and improvements to the introductory physics sequence by a cohort of physics professors and a recent collaboration between the COE and the math department to revise introductory calculus, SIIP focused on creating teams of faculty dedicated to executing reforms. To be eligible for funding, projects required the collaboration of at least three faculty members to increase the chance that reforms would extend beyond a single instructor. Similarly, while non-tenure track faculty were encouraged to participate in, or even lead, efforts, each team needed at least two tenure-track faculty as well as the endorsement of the department head so that the efforts would have the political cache to institutionalize changes and to raise the visibility and acceptance of reforms. Further, all funded teams were required to collaborate with a team of education evaluators to collect data about the success of reform efforts.

Finally, each funded team was expected to meet monthly with the other funded projects to build community, share successes and warnings, and receive just-in-time training. These monthly meetings have covered a range of topics, including backwards course (re)design, student motivation, promoting productive student group work, creating effective faculty communities for reform, flipping the classroom, and classroom technologies. Other supports for faculty included a
one-time pre-proposal workshop as well as program and course evaluation provided by an external unit.

**Funded Projects**

SIIP has funded 12 reform efforts to date. Table 1 lists the reform efforts and provides brief descriptions of the objectives of each effort.

<table>
<thead>
<tr>
<th>Course/Technology</th>
<th>Description of Reform Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systems Engineering and Engr Risk</td>
<td>Improve student engagement by integrating video lectures, classroom response systems, and mini-projects</td>
</tr>
<tr>
<td>Computer Engr Core</td>
<td>Reorganize curriculum to modernize course content and integrate more laboratory experiences and active learning experiences</td>
</tr>
<tr>
<td>Computer Science Core</td>
<td>Develop tools and mechanisms to identify at-risk students earlier and enable instructors to provide remediation</td>
</tr>
<tr>
<td>Engr Mechanics Core</td>
<td>Improve student engagement by using collaborative, context-rich problem solving sessions, online simulations, and faster feedback</td>
</tr>
<tr>
<td>Student Test Prep in Physics</td>
<td>Identify students with poor study habits and provide additional structure to help those students</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Projects funded for 2013-2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedagogy-focused initiatives</td>
</tr>
<tr>
<td>Civil Engr Projects</td>
</tr>
<tr>
<td>Building Information Modeling</td>
</tr>
<tr>
<td>Systems Modeling and Control Systems</td>
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<tr>
<td>Mechanical Design</td>
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<tr>
<th>Instructional-technology-focused initiatives</th>
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<tbody>
<tr>
<td>Adaptive Learning</td>
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<tr>
<td>Engr Simulations</td>
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<tr>
<td>Sketch-Based Homework System</td>
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**Observations on the First Year of SIIP**

The first year of SIIP has led to a mixture of successful and halted reforms. Relying on a combination of evaluation results, critical reflection, and the research literature, we present some observations on what distinguishes the successful from halted reform efforts. During the first year of SIIP two teams made excellent progress toward creating sustainable pedagogical change while the other teams were busy attempting change, but demonstrated little evidence that the changes were effective or sustainable. Perhaps more troubling, some efforts were clearly not
sustained after even one semester and some revisions worsened students’ experiences and ratings of the courses.

Contrary to the commonly cited barrier of disengaged faculty, our faculty, especially those involved with SIIP, care deeply about helping students learn and improving the quality of instruction. Similarly, all of the SIIP teams enjoyed excellent departmental and college support for their efforts. Every pedagogically focused team received funding and support from the Dean’s office as well as additional funding and support from their departments. Departments supported efforts by providing summer salary, providing additional graduate teaching assistants, accommodating changes in teaching schedules, and funding the development of new laboratory space and equipment. Further, the department heads and associate heads were supportive of the vision of SIIP, with many attending review meetings, attending team meetings, and even pushing teams to venture further in their changes.

In this context, the common reasons for the slow adoption of evidence-based pedagogies (e.g., lack of incentives or support, lack of training, and indifference among the faculty) were inadequate to explain the relative successes and failures within SIIP. Teams with some of the strongest levels of support and incentives made the least progress in sustainably adopting evidence-based pedagogies while other teams with less support accomplished much more. Similarly, some teams that included faculty with established track records in engineering education research fared no better than teams with relative novices in implementing educational best practices.

Rather than these traditionally cited barriers, ineffective models of collaboration served as the distinguishing characteristic of the less effective teams. Each of the teams was composed of a loosely associated group of faculty who would all be responsible for teaching one of the targeted SIIP courses at some point. The ineffective teams did not meet regularly, apart from those who had regular staff meetings to deliver a specific course. Critically, faculty who were not currently teaching a course did not participate in these staff meetings. At the end of each semester, these instructors would hand a packet or website of course materials to the next instructor. These new instructors would then work independently, selecting or rejecting any or all of the previous instructors’ materials. The hand-off of course materials from one instructor to the next resulted in a low fidelity of content, course design, policies, and pedagogies from semester to semester. Ideas like the importance of respecting each other’s academic freedom were commonly expressed among these teams’ project review meetings.

In contrast, the two teams that made the most progress over the semester developed a common vision for the priorities and end goal of reform efforts. They also met weekly, and collaboratively developed interventions and pedagogies. Notably, these teams transcended simply establishing a team, but rather established a community of invested faculty. Faculty who were not responsible for teaching a course during a specific semester still attended the weekly meeting, acting as advisors or mentors for the development and delivery of interventions and pedagogies. These teams developed a collaborative joint ownership of the targeted SIIP courses. Members of these reform communities agreed explicitly to use communally developed teaching materials. Perhaps more importantly, because these teaching materials were developed communally, the participating faculty developed implicit agreement to use, and enthusiasm for, the materials.
Having just completed the mid-year review of projects funded for 2013-2014, we are observing similar trends in groups’ successes or frustrations in making progress toward creating sustainable, evidence-based reform. Groups that meet regularly and form communities are performing well, while groups that have failed to see the benefit in meeting regularly have made little progress or have had unsustained progress.

**Discussion**

The past 15 years have created a surge in research documenting how instructors’ implicit epistemologies, beliefs, and commitments drive decision making during instruction and cause resistance to productive changes toward evidence-based pedagogies. Unfortunately, the standard methods of dissemination in academia (e.g., articles, workshops, seminars, etc.) are ineffective at changing these belief systems, because these methods are appropriate for technical change efforts rather than adaptive change efforts. Transformational Learning Theory tells us that technical changes simply require the acquisition of new skills or knowledge to effect change, while adaptive changes inherently challenge core beliefs or epistemologies of the individuals or institutions who are adopting the change. Adaptive changes may be technically simple (e.g., asking more questions in class), but they are difficult to achieve because challenging core beliefs activates a psychological “immune system” that resists change (e.g., asking more questions challenges a primary identity of “instructor as knowledge disseminator”).

Through our administration of SIIP, we have discovered that the common faculty identity centered on “academic freedom” stands as a major barrier to the sustainable and wide-spread adoption of evidence-based teaching practices. Our teaching culture has a fierce independence. Faculty are hired for their expertise in content knowledge and then asked to teach with the implicit assumption that their expertise makes them uniquely qualified to teach disciplinary courses. Even when multiple faculty teach the same course during the same term, they often teach with different syllabi, content, and pedagogies. This implicit acceptance of academic freedom as applied to teaching, is further revealed through faculty’s discussion of teaching as they discuss teaching “my course” rather than “our course.”

We believe that this implicit belief in the centrality of academic freedom during teaching is in many ways responsible for faculty’s reluctance to form communities of practice focused on implementing pedagogical reform. To work collaboratively with other faculty, faculty must sacrifice part of their academic freedom. This sacrifice activates their “immune systems” and leads them to adopt transmission models of dissemination. Unfortunately, just as transmittal of information through lecturing leads to poor learning and retention, these transmission models of reform led to frustrated adoption of evidence-based pedagogies.

In response to these observations, we are adapting the administration of SIIP to focus on addressing faculty’s reluctance to form communities of practice. The principle of “think deep, not fast” is critical both for our administration and our faculty. The “fast” solution of forcing faculty to work collaboratively is a poor solution precisely because it infringes on the faculty identity constructed on academic freedom. Similarly, the ineffectiveness of the “fast” solution of relying on independent, “academically free” faculty to create widespread reform has been well documented.
New Policies for SIIP and Future Work

Moving forward with the SIIP reform effort, we are adopting a long-term strategy focused on creating community and cultural change. Rather than focus on getting faculty to implement specific pedagogical reform, we need to focus on fostering environments from which adoption of evidence-based pedagogies will emerge. Creating this environment must rely on messaging and methods that help faculty feel that their academic freedom is still deeply valued within the context of community. Further, the messaging and methods must tap into other core faculty identities such as an identity of scholarship.

From organizational psychology, we know that creation of community relies on new members of the community being “invited in” by core members of that community (even if that community is currently only one person) 19. Further, communities are formed around common passions and interests rather than common tasks 2,3. To facilitate this invitation process and identification of common passions, we are restarting SIIP with a competitive renewal process. All proposals are required to participate in a pre-proposal period during which faculty can invite in their community and work on establishing common interests among the community without the time pressure goal of accomplishing a task (e.g., deliver a course or meet deliverable deadlines). This structure supports the “academic freedom” identity because faculty are given the freedom to invite the members of their community. Similarly, by creating community before executing a task, the team has a chance to find common interests and priorities so that faculty still feel academically free while they execute reforms. Finally, this process taps into the faculty “scholarly” identity as the proposal process reflects what faculty must commonly do when seeking funding for research grants. Faculty understand the importance of working alongside grant program officers, so the SIIP administration team will work alongside emerging communities to help them make competitive proposals and inform them of research literature that can inform their efforts and evaluation tools that can refine their efforts. Further, the hope is that this process will also help these faculty teams seek and procure external funding to extend their SIIP efforts.

In addition to focusing on creating faculty communities through this pre-proposal process, we plan to further tap into the “scholarly” identity of faculty by facilitating the adoption of implement-evaluate development cycles, beginning with a needs analysis. As faculty engage in the pre-proposal process, we can begin dialogues with them about what is going well and what is not as well as how they know. These conversations can lead to discussing what evidence they would accept as demonstrating the effectiveness of their reform efforts. Keeping the focus on what evidence faculty will accept further respects the “academic freedom” identity and increases the probability that faculty will accept and respond to collected evidence.

Finally, we are mandating weekly meetings for the faculty communities to ensure eligibility of future funding, but the messaging for this mandate builds on our faculty’s own best practices for their research. Our faculty view weekly research group meetings as normative and maybe even critical for the success of their research programs. More importantly, faculty do not find these weekly meetings to infringe on their academic freedom, because these weekly meetings flow out of their common communal interest. By establishing faculty community first, these weekly meetings should align with the academic freedom of the faculty and build on their beliefs of what practices support good scholarship. We plan to have at least one member of the SIIP
administration team present at each of these meetings to provide just-in-time faculty training and to facilitate the agreed upon evaluation efforts of the faculty. Additionally, this constant presence will allow the administration team to better publicize and celebrate the efforts and successes of the faculty communities.

We believe that this new administrative structure for SIIP can create a new paradigm for faculty development and the sustainable adoption of evidence-based pedagogies. Rather than focusing on changing the practices and beliefs of individual faculty, the goal of faculty development will be to change the practices and beliefs of faculty communities. We believe that this new paradigm offers many advantages in terms of effectiveness by aligning with faculty identities and the principles of cooperative learning. This paradigm also promises greater sustainability as it fundamentally targets the creation of cultures and identities that will sustain engagement and practice beyond the life of the program. We expect that this program will lead to many new avenues for research on faculty development as well, opening doors to learn about how faculty learn through collaboration and for tracking how faculty beliefs about teaching and learning change over time.

**Acknowledgments**

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**References**


Analysis of Students’ Feedback in a Faculty Award System

Dr. Pradeep Kashinath Waychal, College of Engineering Pune, Innovation Centre
Analysis of Students’ Feedback in a Faculty Award System

Introduction

The ABET report ‘Engineering Change: A Study of the Impact of EC2000’ refers to the Criteria for Accrediting Engineering Programs, which states that the teaching faculty is the heart of any educational program. We contend that the motivation and quality of faculty members is the most critical success factor for an educational institute. It also significantly influences the other success factors - student intake and infrastructure. Furthermore, the faculty is an active and more stable factor and requires more attention. Therefore, administrators need to pursue various organizational and managerial techniques to keep the faculty at their best motivation level.

A properly designed award system could help to improve the motivation of faculty members. There are two types of motivations: intrinsic and extrinsic. A faculty member is said to be intrinsically motivated if there is no apparent reward other than the activity itself or the satisfaction which results from the activity. While such faculty members do not require external awards for their motivation, they are far fewer in number. We argue that majority of the faculty members move up the ladder of motivation only when they receive external rewards. We verified this premise by conducting a survey of 22 faculty members at a workshop on engineering education. We asked them to rate the statement, ‘A proper reward and recognition system must be developed at colleges’ on the Likert scale of 1 to 5 and received the rating of 4.54, which underlines the desperate need for an award system.

Richardson, et al. conducted a study to find the factors that influence faculty motivation wherein they spoke to 26 faculty members at a college across ranks, genders and departments. They found that 19 of the faculty members referred to ‘Incentives and rewards: Types of external benefits including monetary awards, grants, and release time’ as one of the factors.

We decided that the award system must primarily depend on students’ feedback. Michael Johnson, et al. state that SETs (student evaluations of teaching effectiveness) are widely used metric to assess effectiveness of teachers. Benton and Cashin have concluded that SETs are primarily a function of the instructor who teaches a course. They are reliable and stable, do not depend on the course that is taught, are relatively unaffected by a variety of potential biases, and are seen to be useful by faculty, students, and administrators. At the same time, one has to cognize that no single source of information – including student ratings – provides sufficient information to make a valid judgment about an instructor’s overall teaching effectiveness. There are several important aspects of teaching that students are not competent to rate. There are many other dimensions that must be taken into account to judge performance of a faculty member. Some of the examples are, research in education domain, academic initiatives like developing new courses, specifics of the courses taught like such as class size, and other organizational initiatives.

Literature is replete with studies pertaining to student rating of faculty but is lacking with its use for awards – even though such schemes are available at some institutes. We believe that analyzing such schemes and the data emerging from them, can significantly help understand the dynamics of education and improve the performance of faculty.
The major contribution of this paper is in analyzing student rating used in an award system. It brings out the fact that poor performers tend not to participate in such polls and the faculty appears to be not doing very well on student centeredness factor as compared to other factors. The short list prepared based on the poll had better representation of female and PhD teachers i.e. percentage of female and Ph D teachers in the short list were higher than percentage of female and Ph D teachers in the total faculty population. We also noticed that male teachers are rated better on knowledge and devotion factors.

The paper explains the award system, dwells on the factors and process used in the student poll and analyses its result. It ends with concluding remarks.

Award System

At our college - College of Engineering, Pune - we have come across many splendid performers amongst faculty members but not any formal recognition programs. We seem to largely rely on self-motivation for better performances which is not very common and posited that we require an award system. We validated our assumption by carrying out a survey of a heterogeneous group of 22 faculty members and designed an award system.

The system is based on two unequivocal findings that have stemmed from years of research in the area. They are 1). Student ratings are the most reliable and valid method of measuring teachers’ effectiveness. 2). The ratings are only one source of data and must be used in combination with multiple sources of information if one wishes to make a judgment about teaching. 4,5

Student Poll

This section describes the method that we adopted for polling students. There probably are more studies of student ratings than all of the other data used to evaluate college teaching combined4. In general, student ratings tend to be statistically reliable, valid, and relatively free from bias or the need for control, perhaps more so than any other data used for faculty evaluation 4. Benton and Cashin4 also quote McKeachie who argued that, when it comes to personnel decisions, student ratings of attainment of educational goals and objectives are preferable to many other dimensions. Benton and Cashin9 have also found that multiple classes provide more reliable results and average split half reliability - even for 10-14 student size - is as high as 0.78. The multi-section studies show that classes in which the students gave the instructor higher ratings tended to be the ones where the students learned more (i.e., scored higher on the external exam)4. Based on the above, we accorded the highest score of 50 % to student ratings in our award system.

Factors

Centra, Braskamp and Ory4 have identified six factors commonly found in student-rating forms: 1. course organization and planning; 2. clarity, communication skills; 3. teacher student interaction, rapport; 4. course difficulty, workload; 5. grading and examinations; and 6. student self-rated learning. Hoyt and Lee 4 reported five dimensions of teaching based on
IDEA Diagnostic Form Items 1 to 20: 1) providing a clear classroom structure, 2) stimulating student interest, 3) stimulating student effort, 4) involving students, and 5) student interaction. Marsh’s Students’ Evaluations of Educational Quality (SEEQ) form has nine dimensions: learning/value, enthusiasm, organization, group interaction, individual rapport, breadth of coverage, examinations/grades, assignments, and workload. Other student-rating instruments have items measuring some or all of the above dimensions.

Based on these prior studies, we developed our award system that sought the three best teachers from students. We chose students who had spent at least one year at the college. We also asked them to rate those three teachers on knowledge, delivery, student centeredness, devotion and discipline on a 1-5 Likert scale as defined in the table below;

<table>
<thead>
<tr>
<th>Factor</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>The teacher has all round and complete knowledge - Not only in his subject area but also beyond.</td>
</tr>
<tr>
<td>Delivery</td>
<td>The teacher uses various means very effectively to impart his / her knowledge.</td>
</tr>
<tr>
<td>Discipline</td>
<td>The teacher has a very high degree of self-discipline.</td>
</tr>
<tr>
<td>Student Centeredness</td>
<td>Students go to this teacher whenever they come across any technical or non-technical problem.</td>
</tr>
<tr>
<td>Devotion</td>
<td>The teacher has the highest devotion / passion for the teaching profession.</td>
</tr>
</tbody>
</table>

Table 1: Factors and their definition

Course organization and planning, clarity, communication skills, providing a clear classroom structure group interaction / stimulating student effort involving students are covered in delivery and to some extent in discipline. Teacher student interaction, individual rapport; stimulating student interest and student interaction are covered in Student Centeredness. While enthusiasm is covered in devotion, breadth of coverage reflects in knowledge. We did not explicitly include grading and examinations but believe that they (grading and examination) may have impacted rating of Student Centeredness. We did not use student self-rated learning, assignments, course difficulty and workload as that could vary based on the courses taught by the same faculty.

Process

We formed an award committee consisting of the head of the college, his deputy, and the head of the Innovation Centre. The committee deliberated all the aspects of the award process and ran it by all the deans and department heads. Their feedback was taken into account to baseline the system.

The baseline system was announced to all 2879 eligible students over email to seek an ordered list of three best teachers from amongst 251 teachers along with a comment for each nomination and a comment about the overall award system. We chose online polling over Moodle. Online delivery offers several advantages over paper-and-pencil administration. Students can respond outside of class at their convenience, freeing class time for other activities. Response rates to open-ended questions posted online tend to be higher and written comments lengthier. Moreover, online directions and procedures can be uniform for
all classes, enabling instructors to be less involved in the administration process\(^4\). The chief disadvantage of online ratings is lower student response rates to the fixed items, which threaten class representation. Lower response rates occur for several reasons. Among them student concern about anonymity, difficulties in using computers, and the time required outside of class to respond appear to impact the most\(^4\).

We ensured student confidentiality and asked only for department and enrollment year information to allow us to monitor responses by class. We also announced an award for the class providing the maximum response to increase the % polling. A special meeting of all the student leaders - Class Representatives (CRs) - was called to explain the system, and they were requested to relay the message to all students. We received response from 511 students in 3 weeks. We conducted another meeting with the Class Representatives (CRs) that took the count to 673 resulting in overall yield of 23 %. We monitored response rates on continuous basis and informally encouraged students to participate in the process.

The details of the voting summary are given in table 2. There are three reasons for lower yield; 1. The system was seeking the best three teachers and some students were probably unhappy to choose any one. Some students chose only one or two teachers. 2. There was apathy about faculty evaluation programs – in general - as some students perceived that it is not acted on. 3. We used an online system which some students were not comfortable with.

<table>
<thead>
<tr>
<th>Year wise Total Votes</th>
<th>UG Votes</th>
<th>% UG Votes</th>
<th>PG Votes</th>
<th>% PG Votes</th>
<th>Total Votes</th>
<th>Available Votes</th>
<th>% Total Votes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil</td>
<td>248</td>
<td>15%</td>
<td>107</td>
<td>12%</td>
<td>355</td>
<td>2879</td>
<td>14%</td>
</tr>
<tr>
<td>Computer &amp; IT</td>
<td>223</td>
<td>42%</td>
<td>18</td>
<td>33%</td>
<td>535</td>
<td>2879</td>
<td>42%</td>
</tr>
<tr>
<td>Electrical</td>
<td>60</td>
<td>12%</td>
<td>38</td>
<td>76%</td>
<td>293</td>
<td>2879</td>
<td>20%</td>
</tr>
<tr>
<td>E &amp; TC</td>
<td>80</td>
<td>22%</td>
<td>75</td>
<td>29%</td>
<td>339</td>
<td>2879</td>
<td>24%</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>55</td>
<td>28%</td>
<td>36</td>
<td>53%</td>
<td>165</td>
<td>2879</td>
<td>33%</td>
</tr>
<tr>
<td>Mechanical</td>
<td>69</td>
<td>12%</td>
<td>56</td>
<td>11%</td>
<td>584</td>
<td>2879</td>
<td>12%</td>
</tr>
<tr>
<td>Metallurgy</td>
<td>92</td>
<td>26%</td>
<td>44</td>
<td>68%</td>
<td>284</td>
<td>2879</td>
<td>32%</td>
</tr>
<tr>
<td>Production</td>
<td>44</td>
<td>10%</td>
<td>72</td>
<td>28%</td>
<td>324</td>
<td>2879</td>
<td>14%</td>
</tr>
<tr>
<td>Total</td>
<td>673</td>
<td>22%</td>
<td>446</td>
<td>33%</td>
<td>2879</td>
<td>2879</td>
<td>23%</td>
</tr>
</tbody>
</table>

Table 2: Voting Summary.

We decided to choose approximately the top 10 % teachers from each department to realize a short list of 25 teachers.

There were four emeritus faculty members in the list. They proposed their withdrawal from the process so that the younger and regular faculty members receive awards. We also had two regular faculty members who opined that they do not need such extrinsic motivation and requested their withdrawal from the process. We honored views of all the six faculty members that reduced the short list to 19 faculty members.
Other factors

Since the student ratings are only one source of data and must be used in combination with multiple sources of information if one wishes to make a judgment about faculty, we researched and decided to use additional factors like teaching plans, research in the area of education, developing new courses, redesigning old ones, guiding UG, PG and research scholars, helping other colleagues, teaching electives versus core courses, involvement in any other organizational activities, and results of interview with the award committee.

The top three awards and a special jury awards were announced over email to the entire college community. The awards carry cash component, a memento and a certificate. We have not planned any explicit linking of these awards with annual appraisal process; however, we do expect that the award winners will have a distinct advantage in the appraisal process. We have appealed to all the faculty members to discuss better practices that the short listed teachers have been following. We also have proposed to start a regular weekly digest to highlight the better practices and other education methodology material.

Result

The section examines overall ratings as well as the results with respect to profile of participants in the poll and correlation between overall and factor-wise rating between PhD and non PhD, and male and female teachers.

Overall Ratings

One way stacked ANOVA (Tukey Method) of Minitab Version 16 was used to find out grouping between different factors of student poll (Table 3). As per Tukey’s method, the factors that do not share a letter are significantly different. It is interesting to note that student-centeredness has received the least rating as compared to the other factors. This could be due to heavier expectations from faculty by the students.

<table>
<thead>
<tr>
<th>Factor</th>
<th>N</th>
<th>Mean</th>
<th>Grouping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Devotion</td>
<td>25</td>
<td>4.5543</td>
<td>A</td>
</tr>
<tr>
<td>knowledge</td>
<td>25</td>
<td>4.5467</td>
<td>A</td>
</tr>
<tr>
<td>Discipline</td>
<td>25</td>
<td>4.4649</td>
<td>A</td>
</tr>
<tr>
<td>Delivery</td>
<td>25</td>
<td>4.4340</td>
<td>A</td>
</tr>
<tr>
<td>Student Centeredness</td>
<td>25</td>
<td>4.1474</td>
<td>B</td>
</tr>
</tbody>
</table>

Table 3: Grouping Information Using Tukey Method

Participants

We analyzed the academic performance of students who voted in the poll. The two sample T test (using Minitab version 16) for both SGPA (Semester Grade Point Average) and CGPA (Cumulative Grade Point Average) indicated that the responding students had better academic performance than the entire student contingent.
Davis has concluded that there is little or no relationship between student ratings and GPA based on various studies performed by different researchers. We did not find any reported research on participation of students in the survey based on their academic performance. It seems that poor performers don’t participate in such surveys thus impairing the survey results.

Gender of Teacher

We studied the short list of teachers and found contribution of female teachers to the list to be 40% although we have only 30.4% female faculty teachers. We also compared rating on the five factors between male and female teachers resulting in the following table;

<table>
<thead>
<tr>
<th></th>
<th>Knowledge</th>
<th>Delivery</th>
<th>Discipline</th>
<th>Student Centeredness</th>
<th>Devotion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female Average</td>
<td>4.4</td>
<td>4.4</td>
<td>4.4</td>
<td>4.1</td>
<td>4.4</td>
</tr>
<tr>
<td>Male Average</td>
<td>4.6</td>
<td>4.4</td>
<td>4.5</td>
<td>4.1</td>
<td>4.6</td>
</tr>
</tbody>
</table>

Table 4: Rating by Gender of teachers

The two sample T test indicated statistically significant difference in knowledge and devotion for male faculty members (p value for knowledge was 0.1 and for devotion 0.09).

Literature reports slightly higher rating for women faculty on student-centeredness – but not an overall high rating. We did not find any gender based difference on student-centeredness but found proportionately more female faculty members making it to the short list. The female faculty members fared much better, even though; the male ratio in the 2879 eligible student was 70%. We found male faculty’s rating to be statistically different (higher) on knowledge and devotion. This could be because of some emeritus faculty members – all of them being males – having very high ratings on those attributes. We did not capture the voting pattern based on the gender. That may have been helpful for doing further analysis.

PhD and non PhD Teacher

We studied the short list of the teachers and found contribution of the PhD teachers to the list to be 40% although we have only 32% PhD faculty teachers. We also compared ratings on the five factors between PhD and non-PhD teachers resulting in the following table;

<table>
<thead>
<tr>
<th></th>
<th>Knowledge</th>
<th>Delivery</th>
<th>Discipline</th>
<th>Student Centeredness</th>
<th>Devotion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non PhD</td>
<td>4.5</td>
<td>4.4</td>
<td>4.4</td>
<td>4.1</td>
<td>4.5</td>
</tr>
<tr>
<td>PhD</td>
<td>4.6</td>
<td>4.5</td>
<td>4.5</td>
<td>4.1</td>
<td>4.6</td>
</tr>
</tbody>
</table>

Table 5: Rating by PhD teachers

The two sample T test indicated no statistically significant difference in any of the five dimensions. The fact that there is better representation of the PhD Teachers in the short list may have to do more with their experience than having PhD degree.
Concluding Remarks

The greatest asset of an educational institute is its faculty which requires a great deal of nurturing. This is more pertinent in engineering education due to the significant shortage of faculty members with a very few of them having intrinsic motivation. A properly designed and implemented award system can be of great help towards that objective. The award system has to hinge on ratings given by students that can be analyzed to understand the dynamics of the educational processes at play.

We designed an award system and analyzed the student feedback data. We found that students rated faculty less on student centeredness than on other factors. We also found that academically poor performers’ participation in the poll was significantly lower. While doctorate teachers’ representation in the short list was better, they did not fare better on any of the five factors. Female teachers had better representation in the short list but were found lacking on knowledge and devotion factors as compared to the male teachers.

An award process is a human process and therefore cannot be perfect. While majority of the faculty members welcomed the initiative, there were some detractors. While a few of them believed that the faculty members should have intrinsic motivation and need not require such award system, some others felt that the award system is not completely fair. It provided undue advantage to teachers who teach junior classes, they felt.

The study can be extended in many ways. The process is just the first step and will evolve into a better one. While we can perform more analysis and repeat the experience over years, the most important extension would be to use the data to develop a performance improvement plan for the faculty, to track the plan and achieve its objectives. The plans need to be made keeping in mind that research indicates that combining consultation with feedback is significantly more useful for bringing in improvements. The earlier study has showed that female faculty members are often rated lower on the knowledge scale even when they are as knowledgeable as their male counterparts. It may be due to the disproportionately higher number of male students. We need to analyze the voting pattern and see if there was any gender bias in voting and explore possible ways of correcting it. The study is performed only at one college and must be repeated at other colleges in different cultural and geographical settings to validate the findings.

Acknowledgements

We acknowledge the support of the college management to allow us to introduce the faculty reward system and to analyze that. We also acknowledge Mr. Abhay Joshi for reviewing all the early manuscripts of the paper and bringing it to this level. We also would like to thank the All India Council for Technical Education (AICTE) for funding of the project on Effective Employability – that has made possible this study and the paper.
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A Comparison of Adult Learning Characteristics between First-year and Senior Capstone Students

Dr. James J. Pembridge, Embry-Riddle Aeronautical Univ., Daytona Beach
A Comparison of Adult Learning Characteristics between First-year and Senior Capstone Students: A Pilot Instrument to Measure Andragogical Constructs

The ability to teach engineers who are capable of working effectively in a field or discipline relies on an education that is situated in a realistic and comparable environment commonly seen in project-based learning (PBL) courses. A common example of these types of learning environments is represented in design courses, both at the first-year and senior levels. These types of courses require students to exhibit a high level of motivation and advanced cognitive development, representative of an adult learner, in order to successfully meet the requirements of the course.

Studies have acknowledged that in order to develop critical thinkers and capable problem solvers, teachers must understand the needs of today’s engineering student and design instruction to meet those needs. The development of students in undergraduate curriculum varies widely as undergraduates have been identified as being in a transitional phase of life between children and adults. This variation has increased recently as an increasing number of non-traditional students enter academia as a result of delayed college enrollment, second career adults, and military veteran undergraduates.

This study explores student motivation and intellectual development by addressing research questions: How do adult learning (andragogical) characteristics of students in first-year design courses compare to those in senior design? and What is the relationship between andragogical characteristics and design learning? These questions will be answered through a survey of student andragogical characteristics composed of several pre-developed and validated instruments associated with their corresponding theoretical framework. This paper describes the development of the pilot instrument to assess the andragogical characteristics based on four theoretical frameworks inferred from Knowles’ assumptions: self-directed learning, expectancy-value theory, emerging adulthood, and epistemological beliefs. The frameworks establish a theoretical basis and offer significant insight for the collection of data to assess the role they play in the development of an adult learner. Analyses included several statistical analyses to explore the underlying factor structure of andragogical constructs, key andragogical constructs associated with design learning, and comparison of first-year and senior students.

Findings have identified five major factors that support the use of the theoretical frameworks to operationalize andragogy, while identifying discrepancies among their sub-constructs. Student differences have been primarily associated with developmental areas associated with emerging adulthood. These differences can greatly impact the way design educators mentor their students and coach them through teaming issues, especially for non-traditional students.
Adult Learners in Undergraduate Education

Arnett has recognized that the classification of adult has changed since the 1970’s. He has identified a new life stage named “emerging adulthood” where the individual has more autonomy than a child, but is still in a state exploration and just beginning to display the adult characteristics. Because of this new stage, little is known as to whether undergraduate engineering students exhibit the characteristics that meet Knowles assumptions to be considered adult learners. Knowles himself, stated “I don’t see andragogy as an ideology at all, but a set of assumptions about learners that needs to be tested for different learners in different situations”. If these assumptions are incorrect for a given population of students, the use of andragogical approaches may be limited in their effectiveness.

At the same time undergraduate education is experiencing a surge of enrollment by non-traditional students (over the age of 25). As a result of a more fluid and volatile global economy, characterized by more frequent job and career changes, there is a present need for continual learning and skill enhancement that require adults to remain employable by learning new skills and adapting to new job roles. Therefore, increasing number of adults have begun engaging in some form of adult education over the past decade leading to approximately 44% of the U.S. postsecondary students comprising of adult learners over the age of 24.

Another large source of nontraditional students includes military undergraduates; undergraduate students who are veterans or military service members on active duty or in the reserves. Over the past few years there has been an increase in the enrollment of military undergraduates as a growing number of undergraduates experienced deployment and re-enrollment transitions, particularly as a result of Operation Noble Eagle, Operation Enduring Freedom, and Operation Iraqi Freedom. As defined by 2009 American Council on Education Report of Military Service Members and Veterans in Higher Education, their military experience is an identifiable difference from traditional undergraduate student (students who are under the age of 24, fiscally dependent on their parents, and are not veteran or military service members) and nonmilitary nontraditional undergraduates (students who are typically 24 years and older and/or financially independent from their parents, and are not veterans or military service members). While a large focus is placed on support programs, literature has recognized that once the veteran is in the classroom, additional efforts are required as academics are most often listed as a cause for failure. Therefore the current group of student service members and veterans serve as pioneers and invaluable sources of information concerning their own experiences, concerns, and questions in the classroom that can shape the landscape of adult education.

DiRamio et al. found that both military undergraduates and other non-traditional students can find it difficult to adjust to academic life after being out of the classroom for an extended period of time. They have difficulty in their relationships with college faculty, perceive younger students being immature which leads faculty to underestimate the abilities of the entire class, and treating all students in the course as child learners.
Andragogical Frameworks

Knowles 2 coined the term andragogy, meaning the art and science of helping adults learn, whereas the traditional term of pedagogy is the “art and science of teaching children” 13. Knowles approaches the concept of andragogy and pedagogy as a theory of practices that lies on a continuum, where pedagogy is at one extreme and andragogy at the other with defining assumptions for each (Table 1). The assumptions were developed from Knowles’ recognition that the concept of the learner, life experience, readiness to learn, and orientation to learning of the student are different when comparing a child to an adult 2. He acknowledges that through the process of maturation a person becomes increasingly self-directed, accumulate an increasing amount of life experiences that provide both content and context for learning, and view education as a process to develop competence in professional areas needed to achieve life goals 14.

Table 1. A comparison of pedagogical and andragogical assumptions based on a continuum 2, 15, 16

<table>
<thead>
<tr>
<th>Pedagogy</th>
<th>Andragogy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learner is dependent on decision of teacher</td>
<td>Self-directed learner</td>
</tr>
<tr>
<td>Few life experiences</td>
<td>Large amount of life experiences</td>
</tr>
<tr>
<td>Learning needs are dictated by the teacher</td>
<td>Learning needs closely related to social roles</td>
</tr>
<tr>
<td>Subject/content-centered</td>
<td>Problem-centered</td>
</tr>
<tr>
<td>Extrinsically motivated</td>
<td>Intrinsically motivated</td>
</tr>
</tbody>
</table>

Since the development of the modern definition of andragogy there have been several attempts to develop a generalized instrument to measure andragogy. These attempts have been focused on the identification of andragogical practices and andragogical learners. The majority of studies that explore andragogy have typically explored the practices associated with teaching in an andragogical manner and employed a quantitative descriptive design to develop a profile of andragogy in an effort to support the theory of andragogy 17. Few studies have taken steps to explore how learning is different from the pedagogical approach and the andragogical approach through empirical studies. Moreover one of the major criticisms associated with andragogy questions whether the assumptions are either good practices for all learners or key characteristics of the adult learner 18, 19. This differentiation furthermore relies on the key conception of the andragogical learner involves the clear contrast of life experience between a child and an adult. However at the collegiate level coupled with assumptions related to emerging adulthood, the definition of the adult learner through age, life experience, and social roles used by other studies 19-21 becomes blurred.

Despite attempts, prior studies have had limited due to an emphasis on practice over theory, fail to produce credible outcome measurements, are limited in scope, and do not follow a systematic strategy 22, 23. As a result Holton et al. 22 state that there has yet to be an “instrument with sound psychometric qualities that validly measure andragogy’s six assumptions. While Merriam 16 acknowledges it may be difficult to develop an overarching theory of adult learning, the use of underlying characteristics and theoretical frameworks associated with andragogy make it possible to utilize pre-existing validated instruments to measure the assumptions. This theoretical
and empirical approach facilitates the need to move beyond the philosophical and practice based rhetoric commonly associated with andragogical studies. There are four main theoretical frameworks that can be inferred in Knowles’ assumptions: self-directed learning, expectancy-value theory, emerging adulthood, and epistemological beliefs (Table 2). The frameworks establish a theoretical basis and explore the assumptions of andragogy.

<table>
<thead>
<tr>
<th>Andragogical Assumptions</th>
<th>Motivation</th>
<th>Human Development</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Self-directed Learning</td>
<td>Expectancy-Value</td>
</tr>
<tr>
<td>Self-directed learner</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Large amount of life experiences</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Need to know</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Problem-centered</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Intrinsically motivated</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Readiness to learn</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

**Figure 1.** Intersection between theoretical frameworks associated with andragogy.

*Self-Directed Learning*

Merriam identified self-directed learning as one of the pillars to adult learning. As learners mature they become increasingly more self-directed in their learning. Houle interviewed 22 adult learners and categorized them into three groups: goal oriented, activity oriented, and learning oriented. The learning oriented students were those students that saw “learning as an end in itself.” In his studies, Guglielmino identified that self-direction in learning is
something that all individuals have to some varying degree. He also adds that despite the classroom environment, the student’s attitudes, values, and abilities indicate their level of self-directed learning. Based on these factors, a self-directed learner can be described as one who has initiative, independence and persistence in learning.

**Expectancy-Value Theory**

Expectancy-value is comprised of the students’ expectancy for success in engineering and the value that they attach to activities related to engineering, like design courses. Eccles et al. identified that value includes *attainment value*, the importance of doing well in an engineering, *intrinsic value*, the enjoyment of engaging in activities like engineering design, and *utility value*, the usefulness of participating in design classes in reaching ones short and long term goals. These components are directly tied to the assumptions for andragogical learners related to their need to know, intrinsic motivation, and readiness to learn respectively.

**Emerging Adulthood**

Since the 1970’s there has been a shift in the demographics of what is perceived as adult as the median age of marriage and first child birth is occurring later, more students are pursuing advanced degrees than any time in the past, and there is little normalization of demographic information between the ages of 18 and 25. People in this age range have been identified as emerging adults, that are currently in the phase of their life that represents identity exploration; symptomatic of instability, self-focus, a feeling of in-between, and presentation of numerous possibilities. People in this point in their life do not recognize with either being an adolescent nor an adult. When pursuing advanced degrees, it has been seen that this group of emerging adults have higher levels of cognitive functioning than adolescents. This cognitive function paired with the independence of developing oneself leads to a recognition that the students are understanding that their learning is important to the definition of their social roles and will lead to a more intrinsic need to identify oneself as an adult and have a competent role in society.

**Epistemological Beliefs**

Many students enter college in what Kroll refers to as a state of “ignorant certainty,” believing that knowledge is certain, beliefs are either right or wrong, the authorities, including their professors, have the answers, and their job is to memorize those answers and repeat them on tests. At best they are only beginning to recognize that not all knowledge is certain and still relying heavily on authorities as sources of truth. As a student becomes an adult learner, they begin to rely less on the teacher as a sole source of knowledge and begin to recognize the complexities of understanding and knowledge for a given domain. Through their life experiences and interactions with teachers and classmates, their beliefs are continuously challenged, the rigidity of their beliefs diminish, intellectual growth increases, and they begin to recognize that not all knowledge is certain. Epistemological beliefs refer to the nature of knowledge and knowing. Through their work, Hofer and Pintrich identified four dimensions of epistemological beliefs: certainty of knowledge, simplicity of knowledge, source of knowing, and justification for
knowing. This model provides an insight into the adult learner’s perspective of being problem-centered and having enough life experiences to promote intellectual growth.

**Research Questions**

As the development of traditional students in undergraduate curriculum varies widely due to being in a transitional phase of life between children and adults as described by emerging adulthood and the increasing population of non-traditional and military undergraduates increases there is a need to explore how student motivation and intellectual development changes through the curriculum. This study explores these issues guided by the theoretical frameworks associated with self-directed learning, expectancy-value, emerging adulthood, and epistemological beliefs answering the following research questions:

- **RQ1.** How do the andragogical characteristics of students in first-year design courses compare to those in senior design?
  - **RQ 1a.** How are the differences impacted by age and military status?

- **RQ2.** What is the relationship between andragogical characteristics and design learning?

**Methods**

This study employs an exploratory quantitative research design, that statistically examines responses to a composite survey of andragogical concepts by first-year and senior engineering students enrolled in a design course.

**Participants**

The sample included students enrolled in the first-year engineering design course and capstone students in the mechanical engineering, civil engineering, and aerospace engineering departments at a small private university in the southern region of the United States. The survey received a 31% response rate for all students enrolled in the courses with 63% representation by the first-year design students with the remainder enrolled in the capstone courses for a total of 325 survey responses. 79% of the total sample respondents were male.

When examining the common descriptors of adulthood (age), the average age of the sample was 20 with a maximum age of 38 and a minimum age of 16. 5% of the sample was over the age of 24 with 6 of those students enrolled in the first-year design course. All of the students above the age of 24 had prior military experience and were classified as military undergraduates. Years of employment can also be an indicator of adult learning orientation as the traditional college student has not had more than 2 years of full-time employment. The sample included 65% who had no prior employment experience, 18% with at least 1 year employment, 17% with 2 or more years and the maximum of 12 years employment.
Data Collection

A student survey was developed as a composite of several pre-developed and validated instruments associated with their corresponding theoretical framework (Table 3). In total the survey has 82 Likert-type items requiring the student to select their agreement with each item’s statement. Since the survey is made up of several instruments the Likert-type questions range from selections on a scale of 1-4 and 0-100. Additional items identify survey participants as military undergraduates and will examine common identifications of adults as specified by Knowles 7. The survey has been validated for content validity by researchers familiar with survey development. It was also validated by a small student pilot to ensure the items were clearly stated. The validation and preliminary data collection indicated the survey takes approximately 20 minutes to complete, thus limiting survey fatigue.

The andragogical measure includes instruments directly measuring the sub-constructs associated with the theories that make up an andragogical perspective identified in Figure 1 and Table 2. The self-directed learning aptitude scale (SLDAS) includes 26 four-point Likert items that range from strongly disagree to strongly agree. The instrument involves questions concerning self-management, motivation, and self-monitoring to learn. Each of these constructs were identified as three distinct, but correlated constructs as a result of factor analysis and correlations 39. Each of the items associated with the instrument has a composite reliability greater than .75 and a Cronbach alpha greater than .82 39.

Table 3. Test blueprint for student survey

<table>
<thead>
<tr>
<th>Theory</th>
<th>Instrument</th>
<th>Question Type</th>
<th># of Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andragogical Measures</td>
<td>Self-directed Learning</td>
<td>Likert</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Self-Directed Learning Aptitude Scale (SLDAS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expectancy-Value</td>
<td>Likert</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Engineering Expectancy and Value Scale (EV)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Epistemological Beliefs</td>
<td>Likert</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Epistemological Beliefs Assessment for Engineering (EBAE)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Emerging Adulthood</td>
<td>Likert</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Inventory of the Dimensions of Emerging Adulthood (IDEA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outcomes</td>
<td>Self-Efficacy</td>
<td>Likert</td>
<td>9</td>
</tr>
<tr>
<td>Groupings</td>
<td>Engineering Design Self-Efficacy Instrument</td>
<td>Varied</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Demographic Questions</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total Items</strong></td>
<td></td>
<td><strong>105</strong></td>
</tr>
</tbody>
</table>

The expectancy-value is measured using the Engineering Expectancy and Value Scale (EEVS). The instrument is composed of 9 Likert-type items developed by Eccles and Wiggfield 42 and utilized by Jones et al. 27 in the context of first-year engineering education. The items involve a seven-point scale that has a variety of scales that range from negative to positive evaluations of the items. The items cover the expectancy for success, intrinsic value, attainment value, and utility value of the design course. The evaluations include perceptions of worth, importance, and usefulness. As the study is situated in the context of an engineering design course, the items have been directed towards the students’ expectancy and value of the respective design course that they were enrolled in. The instrument was evaluated for content validity and readability by
Jones et al. 27 through a review by experts in engineering education and several first-year students. Additional factorial validation by Eccles and Wigfield 42 indicated strong factorial validity. In their study Jones et al. measured a Cronbach alpha of .82 for success scales, .73 for intrinsic scales, .64 for attainment scales, and .36 for value scales. While .36 was recognized as being a low reliability, Jones et al. note that Eccles and Wigfield saw Cronbach alpha around .62 for their studies.

As the epistemological beliefs that student hold are highly contextual, the epistemological beliefs measure, Epistemological Beliefs Assessment for Engineering (EBAE), has been developed specifically for the context of engineering. The instrument examines the students’ nature of knowledge, which includes the certainty and simplicity of engineering knowledge, and the nature of knowing, which includes the source of knowledge in engineering and the justification for knowing engineering. The instrument is made up of 16 items with a 100 point 10 increment Likert scale that ranges from strongly disagree to strongly agree. The items were validated using a confirmatory factor analysis and identified that each of the items were factorial loaded greater than .5 among four factors and accounted for 61% of the variance 40.

The students’ status of emerging adulthood is measured using the Inventory of the Dimensions of Emerging Adulthood (IDEA). The instrument includes 31 four-point Likert items that range from strongly disagree to strongly agree. The items require students to answer the questions regarding the identity exploration, experimentation, instability, self-focus, and feeling of in-between over the current five year period that include the past few years and the few years to come. The instrument was supported by exploratory and confirmatory factor analyses for the five subscales with most items having loadings greater than .45 31. Cronbach alpha among the sub-scales ranged between .70 and .85 with test-retest reliability correlations ranging from .64 to .76 with the exception of the feeling in-between scale which was lower than .4 31.

A self-efficacy measure is also included in the survey as self-efficacy has been directly correlated to academic success in engineering courses. The Engineering Design Self-Efficacy Instrument 41 is composed of 9 items that require students to rate their degree of confidence to perform design tasks on a scale of 0 (cannot do at all) to 100 (highly certain can do). The instrument was criterion validated using respondent engineering experience, in which individuals with varying degrees of engineering experience were successfully differentiated, and content validated, by confirming theoretical relationships between motivation, outcome expectancy, and anxiety 41. The self-efficacy instrument has a reported Cronbach alpha of .967 41.

Data Analysis

Data analysis techniques draw on quantitative methods in order to answer the proposed research questions. The first research question: How do the andragogical characteristics of students in first year design courses compare to those in senior design? will be analyzed using the parametric statistical comparison, ANCOVA, to determine quantitative changes in the survey sub-concept scores between the first-year and capstone design students while controlling for age and military undergraduate status as covariates. Research question two, What is the relationship between andragogical characteristics and design learning will be analyzed using a Pearson
correlation to determine a quantitative relationship between student learning and andragogical characteristics.

Findings

Validation and Relationship of Andragogical Frameworks

Analyses also included a principle axis factoring to explore the underlying factor structure of the components of andragogy based on the proposed theoretical frameworks. The principal axis factoring identified 5 major factors: self-directed learning, emerging adulthood, epistemological beliefs, expectancy-value, and a miscellaneous category. A correlation analysis among the 5 factors (Table 4) shows that there is little to no correlation with the exception of expectancy-value that showed a weak correlation to self-directed learning. When analyzed for one factor, all the sub categories explained 24% of the variance. This begins to support the concepts, but identifies discrepancies among sub-measures with low communality.

Table 4. Correlation matrix of identified factors

<table>
<thead>
<tr>
<th>Factor</th>
<th>Self-Directed Learning</th>
<th>Emerging Adulthood</th>
<th>Epistemological Beliefs</th>
<th>Expectancy-Value</th>
<th>Misc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Directed Learning</td>
<td>-</td>
<td>-.280</td>
<td>-.037</td>
<td>.446</td>
<td>.110</td>
</tr>
<tr>
<td>Self-Directed Learning</td>
<td>-.280</td>
<td>-</td>
<td>.015</td>
<td>-.226</td>
<td>-.255</td>
</tr>
<tr>
<td>Epistemological Beliefs</td>
<td>-.037</td>
<td>.015</td>
<td>-</td>
<td>.018</td>
<td>-.163</td>
</tr>
<tr>
<td>Expectancy-Value</td>
<td>.446</td>
<td>-.226</td>
<td>.018</td>
<td>-</td>
<td>-.022</td>
</tr>
<tr>
<td>Misc.</td>
<td>.110</td>
<td>-.255</td>
<td>-.163</td>
<td>-.022</td>
<td>-</td>
</tr>
</tbody>
</table>

Differences between First-year and Senior Design Students

When examining each of the constructs identified in Table 2, several statistically significant differences are identified between first-year and senior year design students in the areas of self-directed learning, emerging adulthood, and motivation as described by expectancy-value theory (Table 5). In contrast, no significant differences were identified between the two groups with respect to epistemological beliefs (Figure 2). In addition, age and military undergraduate status was identified to be a significant covariate, especially concerning the construct of epistemological beliefs.
The only significantly difference in self-directed learning scores concerned self-management (p < .01). As students’ progress through undergraduate curriculum they begin to understand their personal approaches to learning and management of time and resources to complete course goals. By proceeding to the capstone design course they have demonstrated an ability to become a better student and should begin to develop skills of life-long learning.
Significantly large differences are observed in undergraduate students with respect to measures associated with emerging adulthood when comparing the two groups. The measures of identity exploration, experimentation and possibilities, self-focused, and feeling “in-between” are all significantly higher (p < .01) for first-year design students. Students in the first-year of engineering undergraduate degree often encounter frequent changes in degree focus and life goals and are generally open to new opportunities. In contrast, senior design students experience a significantly higher (p < .05) sense of negativity and instability. This can be attributed to identifying and securing a job in the near future and moving onto a new life stage.

**Figure 4.** Comparison of first-year and senior student responses to the Inventory of the Dimensions of Emerging Adulthood (IDEA) concepts scores

Additional, significant differences were identified when examining the sub scores of the expectancy-value measure. Findings indicate that the first-year students have higher sense of attainment (p < .01) and value (p < .05), whereas senior design students have a higher sense of expectancy for success (p < .01).
Both military undergraduate status and age were identified as significant covariates for the constructs of emerging adulthood and expectancy-value (Table 5). In comparison to traditional (non-military) undergraduates, undergraduate students with military experience identified less with the emerging adulthood characteristics of identity exploration, experimentation and possibilities, feeling “in-between” while having higher intrinsic motivation than their traditional peers. The military experience has transitioned these students to a more confirmed sense of adulthood, and their decision to pursue an engineering degree, despite academic level is a clear and definitive decision on their part.

While age is highly correlated to military undergraduate status it appears as a statistically significant covariate for the measures of self-directed learning, emerging adulthood, and expectancy-value that is not present for the covariate of being a military undergraduate. Older students identified with more self-monitoring, less negativity, and a higher attainment value than their peers. Once again the lessons learned through age and experience present that as the undergraduate student ages they begin to move out of emerging adulthood and into traditional norms of adulthood, are more capable of monitoring their own learning, and place high motivation on attaining life goals.
Table 5. Statistical findings associated with comparison between first-year and senior year engineering design students

<table>
<thead>
<tr>
<th></th>
<th>Cronbach α</th>
<th>First-year</th>
<th>Senior</th>
<th>F-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SLDAS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-Management</td>
<td>0.735</td>
<td>25.10</td>
<td>26.15</td>
<td>4.038**</td>
</tr>
<tr>
<td>Motivation</td>
<td>0.752</td>
<td>31.50</td>
<td>31.59</td>
<td>0.166</td>
</tr>
<tr>
<td>Self-monitoring</td>
<td>0.752</td>
<td>29.68</td>
<td>30.20</td>
<td>0.2365 a</td>
</tr>
<tr>
<td><strong>IDEA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identity Exploration</td>
<td>0.830</td>
<td>3.33</td>
<td>3.21</td>
<td>8.687 ** b</td>
</tr>
<tr>
<td>Experimentation/Possibilities</td>
<td>0.782</td>
<td>3.50</td>
<td>3.36</td>
<td>5.741 ** b</td>
</tr>
<tr>
<td>Negativity/Instability</td>
<td>0.785</td>
<td>2.77</td>
<td>2.80</td>
<td>2.650 * a,b</td>
</tr>
<tr>
<td>Other-Focused</td>
<td>0.628</td>
<td>2.63</td>
<td>2.55</td>
<td>5.875 ** a</td>
</tr>
<tr>
<td>Self-Focused</td>
<td>0.654</td>
<td>3.44</td>
<td>3.34</td>
<td>3.625 **</td>
</tr>
<tr>
<td>Feeling &quot;In-Between&quot;</td>
<td>0.768</td>
<td>3.09</td>
<td>2.77</td>
<td>20.502 ** a,b</td>
</tr>
<tr>
<td><strong>EBAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Certainty of knowledge</td>
<td>0.501</td>
<td>4.47</td>
<td>4.62</td>
<td>0.409</td>
</tr>
<tr>
<td>Simplicity of knowledge</td>
<td>0.472</td>
<td>7.45</td>
<td>7.36</td>
<td>0.239</td>
</tr>
<tr>
<td>Source of knowledge</td>
<td>0.535</td>
<td>8.06</td>
<td>7.78</td>
<td>2.068</td>
</tr>
<tr>
<td>Justification for knowing</td>
<td>0.502</td>
<td>6.80</td>
<td>7.26</td>
<td>2.257</td>
</tr>
<tr>
<td><strong>Expectancy-Value</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expectancy</td>
<td>0.807</td>
<td>5.42</td>
<td>5.87</td>
<td>6.736 **</td>
</tr>
<tr>
<td>Intrinsic</td>
<td>0.724</td>
<td>6.27</td>
<td>6.27</td>
<td>1.457 b</td>
</tr>
<tr>
<td>Attainment</td>
<td>0.473</td>
<td>6.47</td>
<td>6.24</td>
<td>5.971 ** a</td>
</tr>
<tr>
<td>Extrinsic</td>
<td>0.471</td>
<td>5.69</td>
<td>5.37</td>
<td>2.917 *</td>
</tr>
<tr>
<td><strong>Self-Efficacy</strong></td>
<td>0.935</td>
<td>70.72</td>
<td>81.66</td>
<td>11.903 **</td>
</tr>
<tr>
<td>(Listwise N)</td>
<td>(198)</td>
<td>(6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p < .05, ** p < .01
a age, b military undergraduate

Relationship between Design Learning and Andragogical Concepts

Self-efficacy has been recognized to have strong positive relationships to student outcomes in a respective course or degree. The self-efficacy of engineering design measure only identified week correlations to the scores related to self-directed learning and expectancy value and no correlation with the emerging adulthood and epistemological beliefs measures (Table 6). The statistical comparison does not present a complete understanding of design learning and more examination is required that can be enhanced by qualitative examinations of student learning with respect to the theoretical frameworks.
Table 6. Statistical correlation between design self-efficacy and andragogical subcomponents

<table>
<thead>
<tr>
<th>Group</th>
<th>Subcomponent</th>
<th>Self-Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLDAS</td>
<td>Self-Management</td>
<td>0.320</td>
</tr>
<tr>
<td></td>
<td>Motivation</td>
<td>0.316</td>
</tr>
<tr>
<td></td>
<td>Self-monitoring</td>
<td>0.334</td>
</tr>
<tr>
<td>IDEA</td>
<td>Identity Exploration</td>
<td>0.027</td>
</tr>
<tr>
<td></td>
<td>Experimentation/Possibilities</td>
<td>0.063</td>
</tr>
<tr>
<td></td>
<td>Negativity/Instability</td>
<td>-0.087</td>
</tr>
<tr>
<td></td>
<td>Other-Focused</td>
<td>0.039</td>
</tr>
<tr>
<td></td>
<td>Self-Focused</td>
<td>0.065</td>
</tr>
<tr>
<td></td>
<td>Feeling &quot;In-Between&quot;</td>
<td>-0.083</td>
</tr>
<tr>
<td>EBAE</td>
<td>Certainty of knowledge</td>
<td>-0.105</td>
</tr>
<tr>
<td></td>
<td>Simplicity of knowledge</td>
<td>-0.069</td>
</tr>
<tr>
<td></td>
<td>Source of knowledge</td>
<td>-0.026</td>
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<tr>
<td></td>
<td>Justification for knowing</td>
<td>-0.074</td>
</tr>
<tr>
<td>Expectancy-Value</td>
<td>Expectancy</td>
<td>0.353</td>
</tr>
<tr>
<td></td>
<td>Intrinsic</td>
<td>0.275</td>
</tr>
<tr>
<td></td>
<td>Attainment</td>
<td>0.153</td>
</tr>
<tr>
<td></td>
<td>Extrinsic</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Conclusion

The proposed use of a composite theoretical model of andragogy identifies several key elements that aligns with Knowles assumptions. However, additional work is need to further verify their impact with respect to the inclusion of epistemological beliefs and the theories correlation to self-efficacy. Despite these limitations it is clear that there are developmental and motivational differences between first-year and senior design students.

The primary difference between first-year and senior design students is clearly noted in the senior students ability to be stronger at self-directed learning and a stronger sense of adulthood that begins to move them away from the traditional understandings of adolescence and emerging adulthood thus confirming the key transitional period that students encounter in their undergraduate degree. The significance of the covariates for age and military undergraduate status indicate that these are two categories that can alter a student’s perception of the course despite limited connection to course outcomes as described by their sense of self-efficacy.
Implications for Practice

These differences between first-year and senior students offer insight into the ways that design educators can mentor students through problem/project-based (PBL) courses with respect to student accountability, understanding of the nature of knowledge, and ensuring quality teaming experiences necessary for many PBL experiences. The following are recommendations that are supported in other PBL literature, but highlighted here with respect to this study and its findings.

First-year students require significant more observation and guidance while proceeding towards the completion of the goal as a result of their lower scores of self-maintenance. Structure is critical for these first-year design students to support their career and psychosocial development throughout their pursuit of engineering an engineering degree. Their higher sense of identity exploration, experimentation, and feeling “in-between” require the support that is need to ensure their commitment and belonging to the engineering discipline. In addition, the first-year students’ higher sense of self-focus may present issues related to teaming. Faculty teaching these students may need to provide additional mentoring with respect to teaming and maintain a closer observance of the functionality of the teams.

Non-traditional students exhibit a higher sense of self-monitoring, more focused on the task at hand and have a higher intrinsic motivation and attainment value for the course material. These traits should be capitalized by providing these students with more opportunities for tailored projects and problems. The difference between non-traditional students and their traditional peers with respect to extrinsic and intrinsic motivation support the andragogical assumptions of the student’s focus on being problem-centered and focused on attaining their degree for specific life goals. However the lack of difference amongst the groups when examining epistemological beliefs illustrates the need for faculty to advance the students’ level of certainty, simplicity, and source of knowledge and justification for knowing to be common across all students, independent of their academic level, age, or prior military experience.

Acknowledgements

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References

Using Recorded Lectures and Low Stakes Online Quizzes to Improve Learning Efficiency in Undergraduate Engineering Courses

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Dr. Dimas has over 25 years of experience which centers on consulting in simulation and design and developing and teaching a curriculum of related engineering analysis and product development courses in both commercial and academic settings. He served in a number of top-level management positions at both PDA Engineering and MSC Software including director of training services, customer support, educational sales and product documentation in the computer aided engineering (CAE) market. At MSC Software he pioneered new techniques and guided the development of two highly successful inter-active DVD based courses in the application of finite element analysis (FEA) in product development. He also developed a unique, low-cost, exible method to produce and maintain DVD versions of a curriculum of 15 courses related to CAE. Both provided increased knowledge access, transfer and retention. His industrial background also focused on applying theoretical aspects of numerical methods in simulation and design to wide variety of product development issues. He has served on the faculty at UC Irvine since 1986 and has brought these practical applications into the classroom, providing students with significant improvements in their ability to learn the theory and "art" of engineering simulation and design. He received his B.S. and M.S. in Mechanical Engineering and Ph.D. in Civil Engineering all from UC Irvine.

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Using Recorded Lectures and Low Stakes Online Quizzes to Improve Learning Efficiency in Undergraduate Engineering Courses

Abstract

STEM disciplines, especially at research universities, have been measurably slow to integrate online modalities into undergraduate classes. Current and future students are now “digital natives” interacting with the world and absorbing information in a very “YouTube” style, characterized by short, on-demand, and entertaining chunks of information. Faculty have been reticent to adopt what they perceive to be unproven technologies while administrators often are unable to allow faculty extra time or budget to investigate the efficacy of new approaches to teaching. This paper describes the results of experiments designed to help improve this situation by accessing the effectiveness of two key online modalities that are often the easiest first steps for faculty to adopt and can be very effective in improving the operational effectiveness and learning outcomes of the course: Recorded lectures and Online Quizzes. Recorded lectures and Quizzes were integrated into two undergraduate engineering courses. The two courses were a sophomore level Dynamics class and a senior level Finite Element Analysis course. The Dynamics course is required and the enrollments range from 160-360, and the Finite Element Analysis course is an elective with enrollments between 60-80. In the Dynamics course, recorded lectures were often used in place of the live lecture and the in-class lecture time was often “flipped” and used for discussion and interaction rather than a traditional one-way lecture. In the Finite Element Analysis course, the lectures were recorded and made available to the students prior to the in-class version of the lecture. Quizzes were designed as an assessment tool (rather than purely for grading) aimed at "real time" feedback. This allowed both students and instructors to measure the learning achievements in the previous week of the course and let the instructor modify the subsequent week’s lectures accordingly. The results show that student-reported learning efficiency improves when recorded lectures are utilized. This was the case whether the class period was subsequently used to teach a similar lecture or if lecture time was flipped to provide more interactive discussion based learning. The availability of recorded lectures prior to class did not affect students’ decision to attend class. Students reported that having weekly “low stakes” quizzes and reviewing them in class helped them understand key concepts better. These results provide more evidence of an ever increasing amount of data that supports the learning efficiency gains that can be attained using a variety of hybrid course pedagogy and online learning modalities.
The debate over the need to adjust teaching methodologies based on the prominence of Digital Natives within undergraduate college courses has continued since the term originated (Presnky, 2001) early in this millennium. Recent studies have focused this debate away from the terminology and towards those activities that can help improve learning outcomes for students not easily described by a single term. It is important to consider the nature of how students interact with the world around them terms of behavior, learning styles, and use of technology. Students have indeed changed in the past two decades and adapting to those changes improves learning outcomes and student satisfaction.

Regardless of the technology utilized, students still prefer Blended/Hybrid classes that employ a course website to compliment live class meetings. In a recent study of over 112,000 undergraduate students, a majority (57.7%) indicated that their preferred type of courses were those that had some online components. Only 22.1% of these students preferred courses with no online components and a very small 7.8% preferred online only courses (Allen, 2013). In the same study, students reported lecture capture as their number one priority for faculty to use more of in the future. Students also report that having some control of the pace of learning can help them be more effective (Wibee, 2011). This study was designed to address the changing needs of students and their stated preferences related to their use of recorded lectures and online quizzes in hybrid STEM classes. This paper summarizes some initial qualitative results that are part of a broader and more quantitative study that is planned for the 2014-2015 school years.

There is still some variation in the use and definition of term such as "blended" and "hybrid" in related research. To be clear, in this study the term “hybrid” is used to describe courses which have live, face-to-face meetings in a physical classroom each week and include a significant amount of additional materials as well as technical and procedural innovations available from the course website. This includes “flipping” the classroom in which lectures are recorded but students still attend live class for discussion of the material and other active learning activities.

Students Use of Technology

The debate over the nature of how students may or may not be learning differently continues. However, there is clear evidence that their use of technology continues to change. In a 2013 survey of student ownership of technology, laptops still occupied the top spot with over 89% of U.S. students reporting ownership (Allen, 2013). This number was 4% higher than 2012. Smartphones held the number 2 spot with 76% of student reporting ownership. Smartphone ownership, however, increased an impressive 15% between 2012 and 2013. Laptop and smartphone use by students significantly outpaces use in the general population. Student use of e-readers, desktop computers, and especially tablets all increased during the same period. However, students still use these devices less than the general population.

Students are using more technology in all areas (laptops, smartphones, desktops, tables and e-readers). However, according to the same study, smartphones posted an impressive 20% gain in
importance to students while other devices remain the same or even dropped in value to students. While in-class use of smartphone's is not widespread (in fact many faculty discourage their use in class and some schools are experimenting with blocking WiFi access in lecture halls) more and more students report using smartphones to interact with the course website, take quizzes and listen to recorded lectures. Younger students reported using smartphones more than older students and used tablets less often, further accentuating the direction of the use of technology in the college level academic setting.

Recorded Lectures

While attendance in live lectures still remains the preferable method of instruction, utilization (and availability) of recorded version of lectures is increasing (Cardall, 2008; McCann, 2010; Berret, 2012). Other researchers caution that when live lectures are given, students who only view the recorded lectures are at a disadvantage when compared to those who use the recorded version of the lecture as a compliment to the live class attendance (Williams, 2012). Giving students the option to slow down the pace of the lecture or review selected topics via a recorded version of the lectures can be especially important for struggling students or those with language issues (Gyspers, 2011; Gosper 2008, Larkin, 2010). Additional studies found that there is a clear miss-match in the perception of the value of recorded lectures between students who had a 67% positive rating and faculty who had a 30% positive ranking (Gosper, 2008). Students want more recorded lectures but faculty do not always see the value or think they have the time to record the lectures. Often the issue is their perception of the required amount of work and unfamiliarity with the tools and process. The faulty members involved in this study required time to refine their lecture capture process. Both used different approaches and are still in the process of refining their use of tools and methodology to record lectures.

Recorded lectures can take a variety of forms from a simple audio-annotated screen captures to a lecture that is well rehearsed, story-boarded, and often recorded using at least one videographer. The latter "high production value" recordings are those that are often used in MOOC courses. Some recent research indicates that utilization and effectiveness of recorded lectures is directly related to the quality of the recordings (Yoon, 2011). Similar studies have found there are significant improvements in learning outcomes and student satisfaction when more time is spent in the design and preparation of the recorded lecture.

Online Quizzes

Studies have shown that students who feel "in control" of their learning perform better in class (Wiebe, 2011). Recorded lectures give students control of the pace of the learning and frequent online quizzes provide students with a good “dashboard” to monitor their performance in the class and then make corrections and prioritize their total workload as needed. These low-stakes, online quizzes also enhance student performance on final examinations and studies have shown that performance on weekly online quizzes do correlate with final exam performance (Dobson,
2008). In other studies, students rated low stakes and related “practice quizzes” as their favorite and most effective online activity (Brown, 2004).

Online, “low stakes” quizzes and polls were also utilized in this study to provide bi-directional feedback between students and faculty. Feedback from quizzes and polls was used by the faculty to modify content in subsequent lectures to ensure key concepts are understood. Time spent on each quiz was recorded along with quiz grades and were correlated.

Lecture Capture Techniques

In this study, faculty used three methods to create content that was subsequently captured adding both audio and video annotations with Camtasia. In order of difficulty from least to most, these are (1) document camera used in the instructors’ office, (2) handwritten text, equations and drawings that were digitally captured via tablet computers and a stylus and (3) digitally typeset and drawn materials using text, drawing, and equation creation tools in PowerPoint.

Two different methods for lecture capture were used in this study. For the MAE80 class (Dynamics), a laptop computer with a tablet screen (Lenovo 230T) that allows easy use of stylus was used. All segments were hand-written, intentionally, to keep the material accessible and “warm.” The handwriting was clear and legible, with occasional use of different colored pens, but it did not look like professionally developed content (e.g. a textbook). Lectures were written ahead of time and the narration was added to the fully written (and drawn) pages to provide a reasonably fast pace to prevent boredom (those who wish, can always rewind). The effort is not trivial. The tablet, while one of the easiest one tested, required care and a deliberate pace -- perhaps twice the time it would take to write neatly on paper.

![Lenovo’s 230T Tablet Computer](image)

For the MAE152 class, lecture notes were prepared using a combination of PowerPoint and some handwritten but digitally captured notes using the Pentel’s Airpen. The AirPen uses a typical ink pen surrounded by electronics that allow the separate tracking device (attached to the top of any sheet of paper) to capture the written content. This provides a very natural feel to the writing.
Pentel’s AirPen

For a majority of the recorded lectures for MAE152, existing handwritten lecture notes were converted to PowerPoint images using a combination of student workers and faculty. This proved to be a very effective process since the majority of the repetitive work was done by much lower cost student labor and faculty served to review and check the work. Student workers converted the first 10-20 pages of the content with frequent feedback from the faculty. However, students quickly got a “feel” for the process and improved the required drawing and equation creation skills which allowed subsequent conversions to require much less faculty interaction.

For both classes the lecture materials were annotated with an audio track and additional notations via stylus or mouse input by using Camtasia Studio v8. When the lecture materials were prepared in this manner subsequent recording of lectures took much less time than would have been required to teach a live version of the same content. During a live lecture the "dead time" required to write content on the board can be a valuable part of the lecture - allowing students to copy the content into their notes, or even better, process the content while the instructor is not speaking. Students viewing a recorded lecture do not need this "dead time" since they can start and stop the lecture as needed.

This reduction in the length of a recorded lecture when compared to the same lecture given live is more pronounced in STEM classes. Complex drawings and detailed mathematical equations are commonplace in STEM lectures but take time for the instructor to transcribe and for students to copy into their notes.

In an effort to resonate with some of the Digital Native characteristics of the students in this study (watching a YouTube video with an average length of 4 minutes), recorded lectures were cut into shorter chunks. Content that was often presented in a continuous live lecture ranging between 50-80 minutes was cut into short segments that ranged from 9 to 34 minutes.

Once these lectures were recorded they were submitted to the campus servers which would further compress the files and then provide URLs for both a PC and iOS version of the lectures (MPEG-4 and Windows Media File). Faculty then posted these URLs to the course website.

Study Design

Two courses taught in the Department of Mechanical and Aerospace Engineering in the winter quarter of 2013 were used in this study. Each course was 10 weeks in length and each carries 4.0
units of credit. The first class was a lower division course in *Dynamics* which is a required class for several engineering undergraduate degree programs. Enrollment in this course can vary from 160-360. This course covers kinematics and dynamics of particles and rigid bodies using Newton-Euler, Work/Energy, and Impulse/Momentum methods. The course is 4.0 units including 1.0 unit of design. The second course in the study is an upper division elective course titled, *Introduction to Computer-Aided Engineering (CAE)*. This course covers the theory and application of the finite element method to practical design issues. The course is also 4.0 units and includes 2.0 design units. The faculty for each of these courses has taught their respective courses for over 10 years.

Both courses were taught with the use of a related online course website. These websites utilize the Moodle learning management system. The University provides support for these websites via a set of campus resources structured under a unit called the Distance Learning Center (DLC). The DLC also supports a large number of purely online courses that are part of the University’s extended education, Open Courseware and MOOC (Massively Open Online Course) offerings. The DLC provided guidance in use of the Moodle system, technical support for enrolled students and some instructional design guidance for the faculty for both courses in this study.

In both classes recorded lectures were captured as noted above and then added to the resources available to the students on the course website. Each course followed a different method with respect to using the recorded lectures. In the *Dynamics* course, the focus was on the use of recorded lectures as a component of a “flipped” classroom. In this initial experiment, recorded lectures were provided for the first 20% to 30% of the 10-week course in which the material in the text was supplemented by significant amount of additional content. The lecture segments were relatively short, ranging from 8 to 15 minutes each. This class meets twice a week for 80 minutes. The corresponding recorded lectures averaged just over 40 minutes, considerably less than the time required to present this same material live. The recordings were made to ensure students have access to the material and to make sure there was enough time to incorporate the extra material not always presented during the live lectures due to time constraints. A PDF version of the lectures was also provided for possible paper-based (and static) review and to allow students to take notes directly on the paper or electronic copy. During those weeks when recorded lectures were used, the live lecture period was “flipped” and used for answering questions, working out homework problems and additional examples. Each recorded lecture in the *Dynamics* class was followed by a brief, low-stakes, quiz (3 to 5 multiple choice questions). The questions were conceptual and were meant to evaluate the level of comprehension of basic concepts as well as the ability to apply the concepts to different -- and more complicated -- problems. The results of these quizzes were used as a feedback mechanism to help the faculty modify subsequent lectures.

In the *Finite Element Analysis* class, lectures were recorded for 50% of the 10-week course. To contrast the approach used in the *Dynamics* class, the *Finite Element Analysis* class lectures were usually made available to the students 3-5 days prior to the live lectures and during each week’s
live lectures, the same lecture content was covered as was available in the recordings. Recorded lectures for the Finite Element Analysis class ranged in length from 10 to 29 minutes. In contrast to the Dynamics class where a quiz was given after each segment of the recorded lectures, the Finite Element Analysis course included a single required quiz taken at the end of each week. These quizzes were "low stakes" comprising (in total) less than 5% of a student’s grade. The quizzes were designed to access key learning objectives for the previous week and, similar to the Dynamics class, served as a feedback mechanism both for the students and the instructor. Quizzes varied in length from 4-8 multiple choice, true/false and short answer responses. The faculty reviewed the answers to the quizzes via live feedback in the lectures. In the Finite Element Analysis course, students were also given a “Muddiest Point” poll via the online course shell in which the students were asked which of 4-6 topics covered during the previous week was the most difficult to understand. The faculty used both quiz and poll results as a feedback loop to alter future lectures similar to the process used in the Dynamics course.

The quizzes were the most challenging parts of the endeavor for both classes: short enough to prevent loss of interest while covering enough material; low stakes enough to prevent any inducement to dishonesty; yet important enough for students to take them and devote a reasonable amount of attention. Their short term value to the instructor was to identify concepts that remain problematic for a large number of students. Longer term, they serve as guide to students regarding what concepts are considered important by the instructor.

In the last week of both classes a survey was conducted to assess student feedback on the use of various recorded lectures and online quizzes in these courses. These surveys were integrated into the online course shell as ungraded student Polls and could be filled out in less than 10 minutes. Aggregate data was also collected related to student activity on the website and their performance in class assignments, quizzes and exams.

Results

A majority of students in the study indicated that the overall quality of the learning improved when recorded lectures were available. Students also indicated that the most valuable aspect of having recorded version of the lectures available on the course website was being able to access them after class to review topics they did not fully understand. Access to the record lecture prior to coming to class was also highly rated by the students. In both classes students agreed that recorded lectures gave them more control of the pace of learning, were useful to listen to after class and should be available in more classes. Interestingly, the availability of online versions of the lectures did not have a significant effect on students reported motivation to attend class.
Table 1. Recorded Lecture Survey

<table>
<thead>
<tr>
<th>Student Responses to the following questions related to recorded lectures:</th>
<th>Mean Student Response (Standard Deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MAE152 (Finite Element Analysis) N=78</td>
</tr>
<tr>
<td>Gave me more control of the pace of learning</td>
<td>4.54 (0.61)</td>
</tr>
<tr>
<td>Helped me decide when to come to lecture</td>
<td>3.38 (0.88)</td>
</tr>
<tr>
<td>Should be available in more classes</td>
<td>4.24 (0.73)</td>
</tr>
<tr>
<td>Made it less likely that I would go to class</td>
<td>2.95 (1.09)</td>
</tr>
<tr>
<td>Had no effect on what I learned in this class</td>
<td>2.03 (0.78)</td>
</tr>
<tr>
<td>Were useful to listen to after class</td>
<td>4.29 (0.78)</td>
</tr>
<tr>
<td></td>
<td>MAE80 (Dynamics) N=193</td>
</tr>
<tr>
<td>Gave me more control of the pace of learning</td>
<td>4.38 (.075)</td>
</tr>
<tr>
<td>Helped me decide when to come to lecture</td>
<td>2.9 (1.11)</td>
</tr>
<tr>
<td>Should be available in more classes</td>
<td>4.13 (0.88)</td>
</tr>
<tr>
<td>Made it less likely that I would go to class</td>
<td>2.24 (1.06)</td>
</tr>
<tr>
<td>Had no effect on what I learned in this class</td>
<td>1.99 (0.98)</td>
</tr>
<tr>
<td>Were useful to listen to after class</td>
<td>4.41 (0.69)</td>
</tr>
</tbody>
</table>

The students also filled out a follow-up survey related to recorded lectures that was focused on the possibility of having all lectures recorded and posted to the class website after class. These results are presented in Table 2. Students reported that they did not support the idea of having only recorded lectures (no live lectures) even if we added more live discussion sections.

Table 2. Recorded Lecture Follow-Up Survey

<table>
<thead>
<tr>
<th>Student Responses to the Following Situation: We are considering recording all lectures and putting them online after class.</th>
<th>Mean Student Response (Standard Deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MAE152 (Finite Element Analysis) N=78</td>
</tr>
<tr>
<td>I think we should have recorded lectures only and add more discussion sections</td>
<td>2.91 (1.19)</td>
</tr>
<tr>
<td>Even with recorded lectures available I still want live lecture to plan my day and ask questions</td>
<td>3.81 (0.91)</td>
</tr>
<tr>
<td>I'm not sure I have the discipline to pace myself and stay focused without attending a live lecture</td>
<td>3.22 (1.06)</td>
</tr>
<tr>
<td></td>
<td>MAE80 (Dynamics) N=193</td>
</tr>
<tr>
<td>I think we should have recorded lectures only and add more discussion sections</td>
<td>2.18 (1.06)</td>
</tr>
<tr>
<td>Even with recorded lectures available I still want live lecture to plan my day and ask questions</td>
<td>4.22 (0.82)</td>
</tr>
<tr>
<td>I'm not sure I have the discipline to pace myself and stay focused without attending a live lecture</td>
<td>3.31 (1.16)</td>
</tr>
</tbody>
</table>

Students in MAE80 are generally two years younger than students in MAE152 and this age difference resulted in slightly different responses. Younger students tended to be slightly stricter with respect to attending lectures if a recorded version was available. Older students were a bit more open to only having recorded lectures and increasing the number of discussion sections although the older group was still fairly neutral on this response.
In general, recorded lectures were well received (repeated surveys, in different contexts over a two year period) and showed only a small fraction of students unsatisfied (6-8% typically) and strong majority either highly appreciative or modestly supportive. There was significant number of requests for narrated homework solution, as the typical static posting of solutions often lack any explanation on why specific steps are taken or how the solution technique 'flows'. This has led to incremental enhancements: additional segments covering important examples or concepts or the addition of weekly quizzes throughout the course.

With respect to online quizzes, students reported that taking them and reviewing the answers in class helped them understand the materials and prioritize key concepts. In contrast with these results, students also reported that taking the online quizzes had little effect on their study habits.

<table>
<thead>
<tr>
<th>Table 3. Quiz Survey</th>
<th>Mean Student Response (Standard Deviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 = strongly disagree, 5 = strongly agree</td>
</tr>
<tr>
<td>Student Responses to the following questions related to online quizzes:</td>
<td>MAE152 (Finite Element Analysis)</td>
</tr>
<tr>
<td>Helped motivate me to study for class each week</td>
<td>3.46 (1.03)</td>
</tr>
<tr>
<td>Had no effect on my study habits for this class</td>
<td>2.99 (1.07)</td>
</tr>
<tr>
<td>Taking quizzes online and reviewing them in class help me understand the material</td>
<td>3.81 (0.79)</td>
</tr>
<tr>
<td>The online quizzes helped me prioritize key concepts in this class</td>
<td>3.58 (0.96)</td>
</tr>
</tbody>
</table>

Regression analysis on time spent on quizzes and recorded lectures and final grade in the class will be added prior to the final submission of the paper. The initial indications are that there is a positive correlation between time spent on quizzes and quiz grade and time spent listening to recorded lectures and final course grade.

Conclusions

Recorded lectures were used differently in the two classes in this study. In the Dynamics course subsequent lectures were “flipped” and used for both discussion and to work out additional homework problems. In the Finite Element Analysis course subsequent lectures were a “repeat” of the same content that was available in the recorded lectures. In both cases, however, the responses from the students were clear - they would like to see more lectures in more classes recorded and available to them and they want to continue having live lectures. Interestingly, the availability of online versions of the lectures did not have a significant effect on students reported choice to attend class. This result is similar to other research (Allen, 2013) where only
14% of students reported they would skip class if recorded versions of the lectures were available online. This percentage of students who would skip class in this situation remained constant from the survey from the previous year indicating that the attendance issues when recorded lectures are available are not increasing. The age of the students did have an effect on their responses; younger students reported they would miss class less than older students when a recorded version of the lecture was available. This is different than other studies which have reported that younger students would miss more class when recordings of the lectures are available. One possible cause of this difference is that the courses in the current study are only from the STEM disciplines offered at a major research University while the previous study included a much broader set of classes at both research and non-research schools.

The compressed nature of recorded vs. live lectures was a key benefit of the lecture capture process producing an online asset that is more effective for students. Both faculty agreed that the length of a recorded version of a lecture was roughly half that of the corresponding live version. Another benefit of recording a lecture is that the materials have been essentially “rehearsed” during the process of capturing the content electronically which forces additional planning and re-evaluation, improving the quality and usability of the recorded lecture.

The quality of the recorded lecture is key to its effectiveness as a learning tool. However, simply having a videographer sit in the back of the classroom and record a live lecture does not always yield an asset that is valuable to students. This is especially true since lectures recorded using other lecture capture methodologies are much shorter and therefore more accessible to students. Conversely, spending the time and money to produce a lecture that would be worthy of a PBS special may not produce results that are improved enough to warrant the investment of time and money. In this study a modest amount of design time, coupled with a similar investment in learning various lecture-capture technologies, proved to be a sustainable model that provided measurable results.

Feedback from the students indicated a preference for shorter segments of lectures. Students reported that it was much easier to insert several short viewings of recorded lectures into their busy schedules than it was to set aside time to watch a full hour lecture. Faculty plan to keep future recorded lecture segments higher than the YouTube average of 4 minutes but much lower than the traditional lecture period of between 50-80 minutes.

A review of student activity data on the course websites also indicated that students watched recorded videos more often when the posting on the course website indicated the length of the video. While the students could have easily opened the video to see how long it was, the minor additional work for the faculty to annotate the website with the length of each video seemed to increase the number of views of each lecture. These and other related minor adjustments to the design of the course website focused on increasing student use of online assets seemed to have a highly positive ROI.
One of the most interesting insights that resulted from this study was that our current generation of students, when given additional resources such as recorded lectures, will indeed use them often in addition to what they are already doing (attending lectures). Continued research is needed to quantify this and to determine how much additional hybrid course related work they can absorb since clearly they have a limited bandwidth.

Students indicated that they find short, low-stakes, weekly quizzes a valuable learning tool. The automated grading of the quizzes significantly reduced grading effort and allowed the faculty to immediately use the results of the quizzes as a feedback loop to modify subsequent lectures. The work required for the initial development of these quizzes was effectively mediated by the use of student workers. Utilization of these online assets in subsequent offerings of the course was relatively easy and allowed the faculty to build upon the existing asset, improving the effectiveness of the online quizzes, with each iteration.

It is interesting to note that while students found quizzes helpful as a learning tool; they did not see them as an asset that motivated them to study. Generally students report that midterm and final exams provide significant motivation to study. One explanation is that these quizzes were too “low-stakes” (3-5% of their grade) and study time is often proportional to the weighting of class assignments. For future offerings of these courses, faculty plan to add more weight to quizzes and possibly add quiz points directly to a midterm or final exam score.

There was a correlation of time spent on quizzes and both quiz grades and course grades (need to expand)

In this work faculty invested substantial time to create recorded lectures, quizzes and flipped classrooms. Based on student feedback, changes to these assets and how they were delivered to the students were then made aimed at increasing student utilization of this online content. During this process, faculty considered that students are now more often characterized as Digital Omnivores (Li, 2012) in that they use and consume information from a variety of computational devices (laptops, smartphones, desktops and tablet devices) more equally. Therefore, changes were then focused on resonating with the way students use currently use technology and included for example, offering shorter segments of recorded lectures in formats compatible with both major smartphone platforms (Android and iOS).

One key take away from this study was that adding online assets is not enough. Online content must also consider the changing nature of how students are using technology to insure these assets are accessible, attractive and fully utilized by students.

Further Work

This initial work related to online quizzes, recorded lectures and flipped classrooms has been primarily based on qualitative responses from student surveys. However, the results have been positive enough to encourage further quantitative research and to expand to include a broader
spectrum of online asserts. This additional work will also consider changes in student use of technology with a particular emphasis on Smartphones.

The key focus of our future work is not only to create a variety of online assets for hybrid classes but also to investigate how to get students to spend more time using these online components of the class. As with many commercial products, much of the initial use is based on the existence of the content and its perceived value. Subsequent expansion of use is often rooted in, stability and ease-of-use of the product. Together both initial and long-term use is a function of quantity and overall quality of the assets (both content, organization and GUI), faculty interaction, stability of the platform and customer support. To quantify this broader spectrum of the quality and effectiveness of hybrid courses, future work will also include a a Hybrid Course Maturity Model (HCMM) which includes quality and quantity ratings in the following areas: (1) recorded lectures (2) discussion forums (3) online quizzes (4) online worked-out homework (5) online homework submission and grading (6) student polls/feedback (7) online course shell design and ease of use (8) technical support and (9) LMS platform stability. Coupling this with the knowledge of trends in student use of technology (especially Smartphones) should provide added insight aimed at improving the effectiveness of hybrid STEM courses.

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Good to Great – Enhancing Services to Professional Working Adult Learners through a Campus-Wide Benchmarking Study

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Dr. Springer currently serves as the Executive Director for Purdue University’s College of Technology located in West Lafayette, Indiana. He possesses over 30 years of theoretical and industry-based practical experience from four disciplines: Software Engineering, Systems Engineering, Program Management and Human Resources. Dr. Springer possesses a significant strength in pattern recognition, analyzing and improving organizational systems. He is internationally recognized, has contributed to the literature more than 100 articles, presentations, books and reviews on software development methodologies, management, organizational change, and program management. Dr. Springer sits on many university and community boards and advisory committees. Dr. Springer received his Bachelor of Science in Computer Science from Purdue University, his MBA and Doctorate in Adult and Community Education with a Cognate in Executive Development from Ball State University. He is certified as a Project Management Professional (PMP), Senior Professional in Human Resources (SPHR) and in Alternate Dispute Resolution (ADR) and mediation.

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Mark is a member of the American Society for Engineering Education and serves on the Executive Board of the Continuing Professional Development Division. He is also a member of College/Industry Partnerships, Engineering Technology and Graduate Studies Divisions of ASEE. Mark is a Lifetime Certified Purchasing Manager with the Institute of Supply Management (formerly NAPM).
Enhancing Services to Professional Working Adult Learners through a Campus-Wide Benchmarking Study

Abstract

With a new university President, a two year freeze on student tuition rate increases and the challenges of a contracting State general fund for higher education, the Purdue University Center for Professional Studies in Technology and Applied Research (ProSTAR) underwent a highly visible assessment of value addedness. This study compared all on-campus continuing professional education organizations to determine efficiencies through a reduction in redundancies and subsequent cost savings.

In 2009, Purdue University’s College of Technology centralized professional studies into a single fully supported Center for Professional Studies in Technology and Applied Research (ProSTAR). ProSTAR (as it became approved in 2009), on October 13, 2000, was approved by the full committee of the Indiana Commission on Higher Education (ICHE) to provide a fee-based distance learning Master of Science degree in Technology, versus, the traditional tuition-based on-campus residential program.

As a fee-based organization, ProSTAR receives no state funds. It is entirely funded through fee-based revenue. To this end, organizational success in delivering quality programs to professional working adult learners is paramount.

Over the five years since its inception, ProSTAR has demonstrated significant success by increasing enrollments over 200%, graduate students 154% (representing 41% of the total college) and gross revenue 300%; this while dropping overhead from 56% to near 24%.

With a new University President and renewed focus on efficiencies and cost savings, ProSTAR was invited to participate in a benchmarking of its operations against other internal university similar fee-based program organizations.

This paper focuses on the results of this five month benchmarking study; including the recommendations for improvement to serve professional working adult learners in the areas of:

- Reduction of administrative overhead
- Creation of an expense and residual financial model
- Unbundling of services – a la carte service provider
- Increasing Program specific expense transparency
- Enhancing marketing expertise
- Standardization of a faculty compensation model
- Administrative department teaching to reduce overhead
Additional this paper focuses on the emotional and psychological implications on the administering organization’s personnel during the above referenced organizational success.

Methodology

The time-phased activities of the study were spread over seven months; from March through October, 2013. Deliverables included an initial 44 page white paper detailing the ProSTAR current infrastructure and financials, a follow-up 19 page delivery with detailed responses to Dean inquiries, and, a final 13 page delivery in response to Dean specific questions.

- 2013, March 9, Sticking a Fork in It – Dean announcing intent to benchmark ProSTAR
- 2013, April 19, Evolution of ProSTAR – Delivered a 44 page document to benchmarking committee kick-off meeting
- 2013, July 22, Final committee report sent to Dean
- 2013, Aug 1, Dean improvement request
- 2013, Aug 6, 19 page improvement response to Dean
- 2013, Sep 16, Meeting on ProSTAR improvements with Dean
- 2013, Sep 21, Addendum (13 pages) submitted to Dean; full combined 96 page document submitted
- 2013, Oct 14, Final Dean actions and recommendations meeting

Analysis

The first delivery to the benchmarking review committee was a 44 page document describing the ProSTAR organization from the following perspectives:

- The current organizational design model and its origins and applicability to other similar campus organizations
- The roles and responsibilities of this and other organizations
- Budget models used for incentivizing departments and faculty
- Student and enrollment growth and future projections
- Overhead reductions; past, present and future
- Collaboration activities with the College of Engineering
- Capitalizing on the engineering-technology educational continuum
- The five-year marketing forecast
- The five-year pro forma rolling window budget with 18 month projections
- Initiated and sustained academic scholarships for females and underrepresented minorities
- Future growth opportunities with other colleges across campus

In a subsequent meeting, post benchmarking review committee’s recommendations, ProSTAR was asked to respond to the findings of the committee. Below reflects the seven improvement categories of response:
Improvement #1 – in response to reducing overhead expense, ProSTAR proposed the use of a growth strategy aligned to increasing the activity base of students and attendant enrollments (credit hours taken).

Improvement #2 – in response to overhead fees, ProSTAR proposed a tiered structure taking into consideration credit versus non-credit courses and certificate offerings.

Improvement #3 – in response to the potential unbundling of services, ProSTAR proposed a growth strategy to avoid interdepartmental contention.

Improvement #4 – in response to greater financial transparency, ProSTAR proposed monthly, quarterly and annual performance reporting.

Improvement #5 – in response to increasing marketing expertise, ProSTAR proposed increasing marketing expenditures and strategic alignment to engineering’s marketing personnel.

Improvement #6 – in response to a college-wide faculty compensation model, ProSTAR proposed following a similar model as that used since 1957 by the College of Engineering. The model focuses on:
- Fairness
- Equity
- Functioning to incentivize maximum participation from the most applicable talent
- Considering the compromising realities of normalizing a model

Improvement #7 – in response to reducing the ProSTAR overhead through ProSTAR personnel teaching, ProSTAR agreed to negotiate with participating departments to transfer teaching incentive to off-set overhead expenses within an academic year.

On submission of the above seven improvement initiatives, ProSTAR was asked to respond to three additional questions below, which was submitted in a 13 page response.

- Create a plan which maps current and future overhead (personnel) growth to a rational model of revenue growth. I.E., tie overhead to revenue growth considering type/delivery of program.
- Create a ProSTAR expense allocation model differentiated by type/delivery of program: non-credit, distance and distance-hybrid.
- Compare and contrast the hiring of a marketing resource given two scenarios: (a) an internal marketing individual, serving traditional programs and ProSTAR programs, and (b) a .5 FTE resource combined with the engineering equivalent resources targeting individuals (professional working adult learners) in both engineering and technology fee-based programs.

In summary, ProSTAR presented the following 2012-2013 academic year end information:

- 5 Years – year over year exponential revenue growth
- 41% of the College of Technology’s total number of graduate students
- 32 States and Countries represented
- 67 companies represented
- 70 degrees awarded in 2013
- 21% women representation
- 13% underrepresented minority representation

The following three charts depict a 200% increase in enrollments with an attendant 300% increase in gross revenue over the five academic years beginning 2009-2010. Reflected on these charts is the exponential curve for each.

**Graduate Students**

154% increase in number of graduate students; representing 41% of total graduate students in the CoT

**Enrollments**

200% increase in enrollments over 5 years
ProSTAR is a not-for-profit organizational entity with a semi-fixed overhead and overhead rate calculated as the actual expense base divided by the actual prior year gross revenue activity base (in terms of credit hours taken). Using this method of calculation is more accurate, assuming a semi-steady state enrollment, than applying an estimated overhead rate based on projected future enrollments. This method of rate determination also protects the College of Technology from having to fund the ProSTAR organization.

Given this model, and in accordance with general accounting practices, there are two complementary methods for reducing an overhead rate reflecting fixed expenses: (1) controlling fixed and variable expense growth and/or reducing expenses, and (2) increasing the activity base (gross revenue). Reducing expenses, while typical in mergers, acquisitions and restructurings, is usually perceived as a pessimistic view of future growth and a protectionist approach. Increasing the activity base (gross revenue) is perceived more positively as a growth strategy and typically viewed as a methodology associated with a competitive spirit.

While reducing overhead can work in some instances, it is widely held there exist a floor expense which if reduced will actually hurt, or create erosion in the underlying activity base (gross revenue). Reducing the overhead to the point of eroding the underlying activity base is one reason business and industry cautiously approaches reductions in bid and proposal and internal research and development dollars; to reduce these two areas is essentially minimizing opportunities for product and/or service innovation and subsequent awards from available funding sources. The United States is no different in this perspective; frequently measuring the
social-economic well-being of competitive nations through innovation as measured by investment in research and development (R&D).

To this end and in proof of concept, ProSTAR’s overhead rate has demonstrated a steady decline since the 2009-2010 academic year. The overhead rate decline is directly related to three factors: (1) ProSTAR is a not-for-profit administrative organization, (2) an increase in the activity base (enrollments) as measured by credit hours taken in an academic year (fall – summer), and (3) a conscious effort to manage sustainable cost growth within the administrative organization.

Given the distribution of the expenses against overall overhead, the solution to lowering overhead would appear most readily to be a growth strategy.

To control ProSTAR expense growth, ProSTAR has created policies, procedures, methodologies and practices aligned to the university and College of Technology. This alignment creates a seamless transition of ProSTAR activities which in turn creates efficiency and effectiveness and subsequently reduced cost through cost avoidance.

These combined thrusts will continue to maintain and reduce ProSTAR overhead rates, therefore resulting in increased residuals to the university, college and participating departments.
Quality Factors

A prior paper shared the results of a longitudinal follow-up study of nearly 300 professionals, most from business and industry, who graduated from Purdue University’s Center for Professional Studies in Technology and Applied Research (ProSTAR) programs. This cohort-based set of programs employed a hybrid classroom and distance-supported, innovatively-delivered graduate degree (MS) in technology. An online survey collected the data and cross-tabulation and frequency analysis identified the findings. Consequences; with respect to career experiences, advancement and salary; were reported and evaluative perspectives – generated in retrospect – shared. The paper also included the context for the evaluation and follow-up and a benchmarking of its findings against a previously reported research initiative from 2002.

On the whole, the data suggested the:

- Program of the study received an increasingly positive assessment over time,
- Program enhanced the students’ portfolio of skills, i.e., to assess, assimilate and apply learned content
- Program and students benefited from the continuous quality improvement process,
- Directed project was perceived as being an important part of the program and also important to the students,
- Program provided a positive impact on student career, opportunities, job responsibilities and salary, and,
- Employers of the students were largely supportive with both time release and educational assistance and many with significant financial contributions.

The results of the longitudinal surveys coupled with the increasing number of program participants and enrollments (as measured by credit hours taken) are testaments to the quality of the program and effective outcomes of the program to promote individual participant personal and professional growth.

While program quality, as determined by longitudinal surveys, increasing number of graduate students, increasing enrollments and exponential revenue growth are important, they were not directly addressed by the benchmarking review committee or the final recommendations. Intuitively implied, however, is had these quality and growth factors not have been perceived as positive, yet, other changes to infrastructure, processes or practices would have been additionally impacted.

Final Outcomes

The findings of the Benchmarking Review Committee were forwarded to the Dean of the College of Technology for further analysis. The report offered numerous and significant
accolades for ProSTAR and further found that ProSTAR compared favorably to other organizations outside of the college.

The Dean’s final recommendations were to:

- Maintain a 20% maximum overhead structure
- Evaluate provided services for efficiencies
- Provide quarterly reports to departments
- Align to globalization and engagement
- Provide a common faculty and department compensation model

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