AC 2011-1771: LEARNING IN CONTEXT: RECOGNIZING CHALLENGES AND REWARDS OF ENGINEERING CURRICULUM REFORM

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Learning in Context: Recognizing Challenges and Rewards of Engineering Curriculum Reform

Abstract
This paper examines the learning experiences of engineering faculty from four institutions as they engaged in the first stages of a yearlong curriculum reform project. Focus group discussions provided insights of the personal and institutional challenges and rewards of curriculum development, the implications of which are described in detail.

Background
Over the past few decades there has been a renewal in engineering education to improve its quality and direction. Former president of the National Academy of Engineering, William A. Wulf, said it best in his statement, "Incorporating a set of "new fundamentals" into the engineering curriculum and encouraging faculty to practice their craft are among the steps needed to bring engineering education into the 21st century." [1]The engineering student can no longer be instructed through "chalk and talk" practices, but rather, there is a need to make engineering education more dynamic and engaging to produce well-rounded engineering students for the careers of the 21st century[1,2]. According to the National Academy of Engineering (NAE) Engineer of 2020 Attributes[3] report, engineers will be called upon to adapt to new trends in technology, biosciences, societal attitudes and politics. In order to succeed in these new roles, the Engineer of 2020 needs to be trained in traditional areas such as science, technology, and mathematics, but also in leadership skills, creativity, communication, flexibility and resilience[3].

The challenge, therefore, lies with engineering faculty to use or develop new courses and instructional practices with which to teach and assess engineering knowledge, skills, and qualities. Faculty must simultaneously address how these concepts apply to real-life problem solving, reasoning in engineering and uses beyond the classroom. Research has demonstrated that incorporating student-centered curriculum can improve student understanding and retention. Unfortunately for many engineering faculty, this may be a novel approach and require a new approach to curriculum development, implementation and assessment[2]. Furthermore, faculty who engage in systematic curriculum reform may experience frustrations and tensions based on the conceptual shifts experienced. Specifically for engineering faculty, these tensions could arise from moving from a predominantly quantitative approach to incorporating qualitative data[4,5].

While there is discussion among faculty about how to best revitalize changes within engineering departments, there also needs to be support and encouragement for continuous review and revisions at the department level as well as the institutional level. One way for these governing bodies to show their support is by providing the opportunity for faculty to attend workshops, professional meetings, and collaborate with like-minded engineering faculty. Thus, the faculty is provided with personal and professional support necessary for the daunting challenge of curriculum reform[2]. An additional opportunity is support for navigating the unique challenges of programmatic changes, the kinds of changes that might be necessary for preparing the Engineer of 2020.

There are many professional development opportunities for engineering faculty such as workshops and seminars that seek to help faculty develop a more student-centered approach to their teaching, and teaching centers that provide one-on-one consultations[6]. Workshops have focused on such issues as effective active learning techniques[7] (The National Effective Teaching Institute), problem and case-based learning[8], identifying learning objectives and assessment measures[6], and preparing new faculty for academia[6] (e.g., Preparing Future Faculty Program or the Center for Integration of Research on Teaching and Learning programs). Evaluations of such efforts often focus on measuring changes in teaching practices, changes in awareness of or self-confidence in teaching techniques, the extent to which participants found the program as useful or enjoyable, and some efforts evaluate the extent to which participants became a community of practice[6,9] . To a lesser extent, evaluation efforts focus on individual cases that reveal competing commitments between a desire to teach better and the complexities of working in academic contexts and managing multiple decisions[10, 11, 12, 13], or in-depth studies of how educators deepen their knowledge and transform their teaching[14] , although these are more prevalent in K-12 contexts.

While there are many examples of professional development programs and associated evaluations of these programs, a meta-analysis of efforts to change STEM undergraduate curriculum suggests that there is limited research on actual evidence of success[15]. One reason may be that evaluation efforts tend to focus on self-reports of changes in teaching practices, rather than investigating the ways in which professional development experiences impact participants' understanding of teaching and learning concepts in relation to developing curricula. Studies that focus on the ways educators experience professional development workshops can help understand the how and why participants change their teaching practices, thereby moving the focus from studying curricular outcomes to learning outcomes.

This paper details the experiences of engineering educators from four diverse institutions who participated in a year-long workshop, "Curriculum Development for Student Learning", designed to foster, improve, and optimize student learning through curriculum reform. While the program includes an initial workshop and a follow-up session approximately ten months later, this paper discusses the participants' reflections on their experiences at the initial workshop and expectations about their own institution's future curriculum reform efforts.

The Curriculum Development for Student Learning Workshop

For over thirty years, hundreds of educators from around the world have attended the Connecting Student Learning Outcomes to Teaching, Assessment, and Curriculum workshop at Alverno College in Wisconsin. The workshop highlights successful curriculum design and assessment practices that focus on student-centered learning. Educators learn about its innovative, evidence-based and externally validated curriculum during an intense three-day experience. Using the tools and information gained from the workshop, participants develop a curriculum for use at their own institutions. In a two-day follow-up session, participants discuss their projects and engage in peer and consultant review with constructive feedback. Workshop participants have the opportunity to consult with workshop facilitators as well as Alverno College faculty and staff while creating their new curriculum[16].

For the first time in the summer of 2010, the existing curriculum development workshops were adapted for engineering and engineering technology design teams. These teams were mentored in the development of department-level, undergraduate curriculum reform. The workshops were attended by four teams, resulting in fifteen educators in total. The activities were designed to develop curriculum design capacity with an emphasis on the National Academy of Engineering (NAE) Engineer of 2020 Attributes[3]. Learning goals for the engineering focused workshop participants included: understanding commonalities and differences among participating schools' curricula and choosing learning outcomes appropriate for their setting; understanding the relationships between student learning outcomes, learning principles, and assessment principles; observing student assessment in action and learning how to foster student learning; examining issues surrounding the design and implementation of curriculum that integrates theory, research, practice and policy in the context of campus-based issues; seeking and receiving feedback on curriculum designs; and engaging in team assessment of selected workshop learning outcomes.

Each institution team arrived at the workshop with initial ideas about how they would like to reform the engineering curriculum at their respective institution. While each team was at a different phase in the process (i.e. one institution was attempting a full departmental reform, where as another group was focused on the redesign of a single course), instruction focused on taking a curriculum perspective for reforming engineering education. A curriculum perspective includes incorporating departmental goals in individual course syllabi, changing student learning outcomes to include outcomes that students can transfer across courses and departments and seeking feedback from colleagues for continuous review for improvement of curriculum[5]. As such, the concept of "taking a curriculum perspective" is in contrast to "having a curriculum perspective." Engineering educators were pushed to shift their focus from "my course" to taking a holistic/systems view for curriculum and considering "my course" as part of the full curriculum[16].

The Alverno workshop model suggests that a 'curriculum' is a system level view of the educational program; such that it includes student experiences, school culture, faculty objectives as well as formal learning practices. The framework for the workshops articulates the importance of taking a curriculum perspective in order to generate life-long learning for college students. The workshop participants are encouraged to consider the curriculum as an ongoing dynamic process with interactive elements that are specific to a given institution. The workshop model encouraged participants to 'take a curriculum perspective' and not just 'have a curriculum perspective'. While most educators can identify their curriculum, either at the department or institutional level, most of the descriptions are superficial. The Alverno workshop model, however, challenges participants to infuse the curriculum into every aspect of the student's learning, including designing course activities, assessment methods, student advising and resource allocations and institutional accreditation, doing so creates a holistic approach to curriculum development[16].

For educators to consider taking a holistic curriculum perspective, there first needs to be an understanding and internalization of learning assumptions and learning principles that define the expectations that are defined for their institution. The expectation for the Alverno model is that assessment is incorporated and valued in the curriculum development and review. For example, while the Alverno model proposes that educators consider assessment as part of the curriculum

design, the degree and manner in which assessments are used is dependent upon the institutional goals for student learning. Traditional approaches to assessment evaluate student abilities and skills specific to curricula and coursework for external rewards such as exam or course grades which indicate success or competence in a particular discipline. The Alverno approach to assessment, however, evaluates students' internal motivations for success, such as self-efficacy or learning for competency. While both approaches to assessment attempt to interpret what students are learning, the Alverno model attempts to incorporate both student satisfaction and student perspectives on learning in order to assess the student more thoroughly. For educators this requires attention to student perspectives of what students consider essential to learning, while also maintaining fidelity to required coursework in the given discipline, thus necessitating continual review and revision of the curriculum from a holistic perspective[16].

Throughout the workshop, participants were asked to iteratively design curriculum plans that were learning centered and to implement these plans at their own institution. In addition, participants were encouraged to connect with other workshop participants to discuss possible successes and challenges in implementing engineering curriculum reform at their institutions. While discussing curriculum reform, participants reviewed and attempted to relate their curriculum goals to the National Academy of Engineering (NAE) Engineer of 2020 Attributes[3].

Participants received instruction and feedback from facilitators, some of whom are nationally-recognized experts in educational curriculum development and some who served as "bridge-builders" between the engineering / technology profession and curriculum designers who are well versed in the usage of workshop models in other contexts and disciplines. While learning to incorporate these attributes into an engineering curriculum, participants engaged in individual and collaborative inquiry on identifying constraints, strategies, and supports to transforming curriculum.

Workshop Evaluation

Curriculum inquiry, as defined by the Alverno model, includes the process of *designing* curriculum from a student learning-centered perspective and *implementing* curriculum at their institution. Both of these processes will be influenced by participant's prior knowledge and beliefs (assumptions, values, etc.) about curriculum inquiry and the context in which the curriculum will be designed and implemented. As such, the workshop evaluation plan focused on the impact of the workshop on (1) participants, in particular their professional development as it relates to curriculum inquiry in an institutional context, and (2) institutions through the implementation of participants' curriculum projects.

The evaluation plan includes formative and summative elements, and seeks to provide answers to the following questions:

1. What are the outcomes from the workshop in terms of curriculum development and institutional development?
2. How did participants experience the workshop and in what ways did this contribute to an understanding of curriculum inquiry and the development and progress of their curriculum projects?
3. What conceptual challenges regarding curriculum inquiry did participants experience and in what ways were these characteristic of incremental or transformative learning?

Research data was collected to understand how participants experienced this workshop (its structure, goals, objectives, content) and came to understand curriculum inquiry in an institutional context. Data was collected from surveys, observations during the workshop, end-of-day reflective questionnaires, and focus groups.

The focus of this paper is on the experience of the participants during the initial workshop as revealed through the focus group data. As such, the findings presented address evaluation questions 2 and 3 as listed above. Future publications will add to these findings and specifically address the first evaluation question.

Method

Four institutional teams of varying sizes and composition attended the workshop (see Table 1). School A is a large public institution brought a six-person team of five engineering faculty and a department chair. The team from school B was from a small public four-year special STEM interest institution and consisted of three engineering faculty and a humanities professor who is also the department chair. School C is a military institution represented by two faculty members who are also program leaders. School D is a medium-sized private technical institution represented by two engineering faculty and an Associate Dean.

Table 1. Description of Workshop Participants

School	Description	Area of Focus	Workshop Participants
A	large public institution	comprehensive	5 engineering faculty 1 engineering dept. chair
B	small public institution	STEM interest	3 engineering faculty 1 humanities dept. chair
C	military academy	comprehensive	1 program director 1 division director
D	medium private institution	technical	2 engineering faculty 1 associate dean

In order to allow for participants to share their attitudes, perspectives and opinions, evaluation researchers divided the fifteen workshop participants into two focus groups, one focus group had eight participants and the other had seven. Focus groups as an evaluation method allow in-depth knowledge elicitation and collaborative sense-making that may not be as readily obtained using a structured, quantitative method[17]. To encourage deep engagement and discussion, members of institutions teams were distributed over the two groups. Each focus group was guided by a moderator using a set protocol and recorded for transcription. Each session lasted approximately one hour.

The focus group questions were designed to elicit diverse perspectives of the participants' workshop experience, aspects of the workshop that challenged their views on curriculum development, insights into the possible struggles and process through which they made sense of "taking a curriculum perspective", their concerns about curriculum reform, and their expectations about curriculum implementation (see Figure 1).

Figure 1: Focus Group Protocol

Starting a conversation…

- What brought you here; what did you want to get out of this experience?
- How do you hope your curriculum project will impact your institution, directly and indirectly?

Experience of workshop and impact on understanding of curriculum development (includes conceptual challenges)…

- What aspects of this experience (either working on your project or participating in sessions) have been most rewarding?
- What aspects have caused the most frustration for you or your team?
  - Has this pushed on you to think in new ways?
- As you worked on your project or participated in the sessions, what surprised you or challenged the way you thought about curriculum development?
- What provided new insights (or aha moments)?

Understanding of curriculum inquiry and institution's readiness for change

- If a colleague asked you for advice on how to "take a curriculum perspective", what advice would you give?
- In what ways would you say your institution is "ready for change"? (Not ready for change?)
- At this time, what does "curriculum development" mean to you?
  - How does this compare to what you thought prior to your arrival at the workshop?
- In planning for the April workshop, what kinds of experiences can best enhance your ability to be successful in your curriculum project?

Results from both focus groups were combined to form one data set from which responses were analyzed. Data were analyzed using NVIVO software. An open coding approach provided the researchers with an insider's perspective in order to more completely understand the challenges and concerns of engineering educators regarding curriculum reform. Through an iterative process, concepts, themes and storylines were identified. Four members of the evaluation research team reviewed the focus group transcripts individually for common themes. Members of the research team then discussed themes identified and through a collaborative process the final four themes were identified. For example, participant's responses concerning the challenges associated with curriculum development were coded for curriculum development as well as more specific types of challenges (i.e. language, uncertainty, frustration, institutional policy, etc.). This paper identifies and describes the themes raised in the focus groups as well as specific examples directly from the transcripts to illustrate the participant experiences.

Results

Findings from focus groups revealed a variety of internal factors that influence engineering faculty concerns, frustrations and confidence in engineering education curriculum reform. Four reoccurring themes related to participant change in approaching curriculum development emerged: making sense of curriculum inquiry, institutional support, recognition of the value of qualitative data, and assessment as part of the curriculum. Each of these themes is discussed in more detail in the following paragraphs.

Theme I: Making Sense of Curriculum Inquiry

One of the most often discussed concerns was the challenges and frustrations that resulted from learning a new curriculum model. In taking a holistic approach, educators should consider all aspects of student learning; while thinking beyond individual experiences that faculty have with their students to what students experience cumulatively[16]. For most workshop attendees, the idea of considering all aspects of the curriculum development process, including revising grading structures, incorporating ABET requirements and the NAE Engineer of 2020 attributes seemed to be overwhelming. When presented with a new and challenging framework, it is natural to feel some anxiety and uncertainty. The information gained at the workshop caused some participants to rethink their previously conceived notions about curriculum reform. One of the young faculty members stated,

> For me it has made me less certain….Before we[the institutional team] left we had all these objectives, we're going to evaluate…day 1 we have to rethink … we have to refocus[on] what are we going to be doing. Every time we have new information we rethink again.

The expectations gave rise to feelings of general uncertainty, concerns about appropriate assessment and frustration about how to attempt these changes. Furthermore, the language and terms used to describe the new curriculum model was confusing to workshop participants. Several participants expressed concern with learning a new "language" while attempting to develop a new teaching model. The Alverno model redefines certain words that are common in an engineering educator's lexicon. For example, the word 'content' for engineers means subject matter, however, in the Alverno model, 'content' refers to knowledge, values and intellectual capabilities. Further confusing the language use and intent for the workshop participants, the Engineer of 2020 attributes refers to a list of capabilities, which has a different connotation than is used in the Alverno model[16]. A female participant from school D, said

> I have frustration that made it [seem] more about my educational process. I am reading the words on the slides or the questionnaire … I am not sure what they mean by this word or how to interpret this phrase. Getting into that language for me is nontrivial and figuring out what is meant by all of these things really for me is a hard work.

In agreement that learning the definitions and terms was a challenge for the group, a male from school C stated,

> I will tell you specifically one of the things we wrestled with as we looked through the questionnaire. It seems like some of the questions were focused on student learning outcomes at the program level and some were at different level than program whether they institutional or whether they were down more at course level so we sometimes struggled with the definition.

In other words, the language itself may have been familiar, yet the use of the language may have been different than their prior experiences. A female participant from school B noted that there was a certain culture at the school where the workshops were being held that may not translate to other institutions,

> There is a dialect spoken here that is very much their own and on the one hand that's really great because that is a hallmark of a very cohesive culture. On the other hand that dialect doesn't necessarily translate for the rest of us...

Although workshop facilitators had anticipated this language barrier challenge for the engineering educators and thus had invited a "translator", an individual who has experience in engineering who actively takes a curriculum perspective in his classroom; participants struggled with understanding the terms and language presented throughout the workshop. Interestingly, although the participants were from a variety of academic institutions, each expressed concern with instituting a new form of student learning outcomes, grading structures and alternative lesson plans. The participants seemed to be struggling with integrating the new model with the knowledge they already had about previous teaching strategies. One individual from school A said,

> So what they [workshop facilitators] were saying is there is not a cognitive developmental model, there are levels. It is a pedagogical model which is different. And there is difference and so that just tore out a whole set of assumptions underlying our whole model.

This participant stated what several of the other workshop participants had been concerned about, whether undertaking a new model of engineering education actually discounts the current model in place at their university and what are the implications of adopting a new pedagogical model. This concern led to the participants getting frustrated at the tension between their expectations for attending the workshop, their excitement in taking on their curriculum reform effort, and the level of work required to make sense of and use a new model. A male participant from school A stated,

> Oh yeah, I am frustrated. I am frustrated because it is too big. Even though coming into this I thought and still think that we are a lot further along from a lot of engineering schools. [We are] not the best but we got through developmental models. We created project based curriculum. But when I look at what still needs to be done to get it so that I think that it is good like it is here, it is daunting. The effort it took with the clean slate design to get a curriculum even as far as we have was a lot. Now I look at it and I go aah! It is exciting but aah! Are we going to get the whole thing there? What's frustrating to me is seeing how the whole thing gets there. It's a big elephant.

As engineers, they had been taught a certain framework in which to discuss and design coursework and departmental goals, and the ability-based teaching model seemed to conflict with certain areas of instruction. The instruction about "taking a curriculum perspective" had been given in the context of humanities and social sciences. For engineering faculty, there is not always an easy bridge to connect or translate the teaching tools and assessment from the social sciences to engineering. Another male participant from school A indicated his concern with implementing the new model within an engineering course, "No offense to humanists but it was nice to speak [with] a chemist [at the workshop], someone who talks math [and] science, about what it's like to do this model in their type of class."

Fortunately, the participants in the workshop were open to new ideas and are dedicated to finding new ways to teach engineering students. In other words, some of the frustration around language appeared to bring out participants' internal beliefs about curriculum development and place them in contrast with the Alverno model. While the challenges were raised in the focus groups, there was also some excitement about the opportunity to review current practices and make changes where possible. The same individual from school A, who had expressed concern about the enormity of the curriculum reform, also stated, "I think we have more clarity than we had before in terms of where we are. I don't think we are completely framed yet but you have got at least a basic plan." The participants were encouraged to frame their coursework in terms of a bigger picture, confirming that "taking a curriculum perspective" included considering departmental goals as well as specific classroom outcomes. In expressing his realization of this broad picture idea, a male from school C said,

> That's really neat – that slide [that showed] 'take ownership for an entire curriculum'… [and] 'taking a curriculum perspective.' When you are a new faculty member, teaching a course as part of a bigger picture, it's hard to figure out how you fit within a bigger curriculum. It's hard to figure out how you fit in an overall curriculum…getting the message that you are a part of the whole organization, link in the chain, if you fail the chain breaks. It's important to get across [that] you are important for the process …and take ownership as if it is their own. If you achieve that …it's a team thing …no longer herding cats … all going in the same direction. That is hard to achieve.

Although he expresses enthusiasm for the benefits that could come from changing his curriculum outlook, he also recognizes that it is a complicated and difficult task. During the workshop participants began to realize that undertaking a different method of teaching was exciting but daunting.

Theme II: Institutional Support

The focus group data revealed a second theme that there was some hesitation to develop and implement new curriculum when considering the need for institutional support and personal time constraints. Every year, well intentioned faculty attempt to implement a new course or curriculum at an institution, but without institutional and administrative support these programs have a higher chance of failure[2]. These concerns were expressed by several of the focus group participants. In particular, a female participant from school D said,

> I think we are very fortunate to be part of a program that is in its development. Institutional norms haven't yet been formed. A lot of changes can happen [because] we have a very receptive faculty [who will] at least hear… and consider… these ideas. If we do something solid out of the work here, there is a good chance it can have an impact.

School D was fortunate to be in that position. A few participants expressed their concerns about departmental support. Specifically, a male faculty member from school B said,

> I think it's a great model and worth trying but the logistics and the time and labor intensiveness I'm just not sure we'll be able to get widespread vouching on our campus. [We'll] have to do some more research. A concern I haven't figured out in my … head

> [is] how to get widespread use even in my department.

In any curriculum reform project obtaining the support of colleagues and the institutional administration is imperative. While the discussion of the possible lack of support from the institution is not a novel or surprising one, what was encouraging is that the participants discussed ways in which to succeed in obtaining support. These ideas included speaking with a provost directly to request more faculty receive the training, inviting a representative from the workshop to present on campus in order to reach more faculty, collecting data on successful student improvement outcomes, and making the changes visible and transparent to other faculty (both within and beyond engineering departments).

In addition to obtaining institutional support, many of the workshop participants commented on being able to find enough time to dedicate to curriculum reform without sacrificing other areas of responsibility. An example of the appreciation of the time needed to discuss curriculum reform was expressed quite clearly by a female faculty member from school D,

> It [the workshop] was nicely timed for us. Having time carved out of your schedule where this is what you are supposed to be doing and you are not distracted by the e-mails and the phone calls and students showing up at your door, makes it a wonderful opportunity to actually work on those … bigger picture issues.

One of the institutions was so committed to the curriculum reform process that the department had provided for a majority of the engineering department to participate in the workshop. When certain concerns were raised about institutional support, the faculty from school D had each other to turn to for encouragement. One female participant from that department stated, "It's an advantage, we're here with our chair. It's endorsed by him[making it]much more likely that others who aren't here will become much more involved… doesn't put the burden just on us, those at the workshop."

Theme III: Recognizing the Value of Qualitative Data

The third theme that emerged from the data was the acknowledgment and initial acceptance of the value of qualitative data outcomes in engineering education. Not surprisingly, the engineering educators participating in the workshop felt more comfortable with quantitative assessment measures. As a woman from school D eloquently stated, "This is fairly a small point but the assessments can be …as easy as yes and no. And not 53% or 87% or 95% you got it or you don't. And that is sort of liberating." A similar statement was captured from a male participant from school C,

> I think the biggest thing that surprised me as someone who has always been very comfortable with quantitative measurement and defaulting to some sort of measure based on a scale of 1 to 10 or 1 to 100, was really this recognition that in fact qualitative measure can actually provide much more information than a quantitative number.

Although the act of changing from a quantitative system to a qualitative one seems minor, the implications are actually quite broad and in a sense this is the underlying expectation of the ability-based approach addressed in the workshop.

The change in thinking from a strictly quantitative method to incorporating qualitative outcome measures was the moment that many participants seemed to grasp the intention behind the curriculum reform. A senior faculty member from school B said,

> I've had a real shift in my thinking. In the past...if you think of continuous improvement, the model in my head [was] you do a strategy, implement, see if it worked, do a strategy, implement it, see if it worked... Now my thinking is to do the embedded assessments to get at assessing results and tying those two much more closely together… that is a real shift for me. Something I am actually excited to try.

In a similar excited response in beginning to understand the benefits of curriculum reform, a male participant from school A expressed his moment of insight also while considering the different types of assessments that can be used in the classroom,

> …and they put it in assessment exercise where they were using them and measuring them in a different way it was just that way of creating assessments… So that to me it was oh! It was richness of how you design assessments. I still don't know how to do that but it just became very intriguing and surprising to me that what's the integral, what's the design process.

During the workshop, the participants had the opportunity to learn about successful alternatives to quantitative student assessment outcomes. Through challenging themselves to think through the implications of these assessment tools and outcomes in engineering education, workshop participants were able to broaden their personal views and beliefs about student assessments.

Theme IV: Assessment as Part of the Curriculum

As participants began to alter their belief about assessment, the fourth theme emerged. The engineering educators were able to see assessment as an integral feature of a curriculum design approach. It is important to note that the workshop participants had considerable experience in assessment, particularly course and program level assessment. As such, their realizations regarding assessment suggest that these ideas were in contrast with their prior work and more indicative of a shift in thinking than a lack of awareness around assessment.

The workshop participants expressed their interest in curriculum reform not for simply the sake of change, but rather with the expectations that by identifying and implementing a student-centered learning curriculum, future students in engineering would benefit from the changes in engineering courses and would be able to transfer those skills to their professional careers. A female from school A said,

> I liked the… the mapping of the abilities to the program outcomes, course outcomes … that [is] traceability. Now it's a goal [for me]. I have to … do my lesson plans so I can see clearly how to map them [and] translate them to my students. That will be a big help for us if we can work better on breaking it down and going thru the steps, We will be much better at what we attempt [to reach] our goals.

The workshop participants showed a genuine interest in revising current assessment approaches in order to promote student learning. As previously discussed, the use and impact of self-assessment in engineering education was a great source of concern for workshop participants. A male faculty member from school B said, "I always saw assessments as getting the answer to what was working, [and] what isn't working. But now I see that the assessment can be part of the strategy itself for generating deeper learning." This insight is consistent with previous research that demonstrates that when subject matter is presented in a context and students can imagine the usefulness of a skill, the student is more likely to pay attention, engage in classroom activities and retain information[2]. The Alverno model proposes a holistic approach to assessment in which the skills learned are not just specific to the course material, but rather can be applied to a broader arena. The ability for a student to generalize and apply skills demonstrates a deeper understanding of the material than simple recall for an exam[16].

Discussion

Data gathered from the focus groups provided the evaluation team with insight about how participants were beginning to understand, internalize and apply a novel curriculum development perspective. Through understanding the perspective of the participants, evaluators and workshop facilitators can improve the workshop experience and expand the curriculum reform process to benefit engineering students in the future.

One of the consistent main concerns for the participants was the learning and deeper understanding of incorporating a "transformed" language into their curriculum development efforts, specifically, what is meant by "curriculum", "assessment" and "self-assessment". Understanding the relationships between student learning outcomes, learning principles, and assessment principles was one of the main learning goals for the engineering educators during the workshop. Therefore it was important for participants to understand the language used during the workshop. While the language was not new to them, the way this language was represented in the Alverno model required a new way of thinking. Several times during the focus group discussions, participants raised the issue of understanding these terms and others that were presented during the workshop. In order for participants to truly "take a curriculum perspective" participants must first have an understanding of the definitions and how they directly relate to engineering education.

In order for the understanding to occur, participants need a context from which to draw an understanding. For example, workshop participants completed questionnaires to assist in their project development. The questionnaires gave participants common ground from which to have a conversation about what they would each need at their institution for the curriculum reform projects to thrive. By participating in the exercise, participants were engaging in "assessment-as-learning", thus not only providing concrete examples of the materials addressed in the workshop but also assisting in the curriculum development process. Learning in a context seemed to alleviate some, but not all, of the frustrations and concerns experienced by workshop participants. Another approach would be to help participants compare and contrast prior understandings of this language with those present in the new model.

One of the learning goals for workshop participants was to be able to examine issues surrounding the design and implementation of curriculum that integrates theory, research, practice and policy

in the context of campus-based issues. Throughout their discussions, participants raised concerns with incorporating the NAE Engineer of 2020 attributes[3] into an existing or new curriculum. Many of the participants had recently experienced the process of satisfying the ABET requirements in their departments. Many participants expressed concern with having to follow a new set of guidelines in engineering education and how to best address both sets of criteria within the classroom, department and institution. In other words, the issues participants were experiencing were not around the importance of these ideas but rather what it means to implement them in their institutional contexts, especially after undergoing a major transformation to adopt a continuous improvement process as guided by ABET requirements.

Participants also expressed a willingness to attempt to alter their previous beliefs and teaching style to include alternative forms of self-assessment and curriculum development. In the teaching model advanced at the workshop, qualitative methods were highlighted, as well as illustrating student self-assessments when possible. Initially, the idea of using qualitative assessments was rejected by some workshop participants as not possible in engineering, however, through the course of the workshop, participants were able to identify courses and student outcomes for which qualitative self-assessments could be implemented and add value. Furthermore, faculty also realized that student self-assessments could be used to review and revise coursework content, thereby making assessment a part of the curriculum process and not just an outcome.

Perhaps most significant, is the realization by workshop participants that undertaking a different method of curriculum development was simultaneously exciting and terrifying. Participants openly struggled with how to realistically accept what is feasible in their program and how to reform engineering curriculum at the program level as well as the challenge of following accreditation requirements versus implementing a novel approach to engineering education. The educators believe they are faced with an "either-or" choice, for example, *either* I incorporate the Engineer of 2020 attributes *or* I introduce a curriculum perspective model. However, as previous educators have demonstrated, it is possible to adopt a "both-and" mentality in developing effective teaching methods[18]. The challenge for engineering educators is how to *both* incorporate Engineer of 2020 attributes into their coursework *and* take a holistic curriculum perspective based on the Alverno model. Fortunately for future engineering students, the workshop participants were eager to return to their institutions and work through this challenge with like-minded colleagues, institutional administrators and fellow workshop participants. A male participant from school C captured the concern and enthusiasm of all of the workshop participants when he said,

> My colleague and I had a lot of discussion about trying some radical things; things that would be very radical for our program and really just engaging in the discussion of why wouldn't that work there or what would it take in order to make that work and has caused me [to]critical[ly] think… about our process. What are the constraints? What would it take to break through some of those constraints if we want to try some of that?

Conclusion

This paper summarizes themes that emerged from focus groups during the initial phase of a yearlong workshop on "taking a curriculum perspective" in engineering education to foster, improve, and optimize student learning. These themes illustrate what participants experienced

and how these experiences influenced their views on curriculum development broadly and in relation to their institutional setting.

Emergent results provided researchers with an insider's perspective of the challenges and concerns of engineering educators as they participate in a workshop designed to revise their approach to curriculum design and implementation. Data revealed four reoccurring themes related to participant change in approaching curriculum development: making sense of curriculum inquiry, institutional support, recognition of the value of qualitative data, and assessment as part of the curriculum.

The need to reform engineering education is evident and engineering faculty members are charged with a challenging task. Revising ideas, coursework syllabi, and curriculum expectations requires exposure to and practice of new curriculum development models. The participants at the workshop were selected for their interest in and previous work in curriculum reform, and yet the workshop ideas and concepts were somewhat complex to grasp.

Curriculum reform is a complicated process that is going to require the support from institutions as well as the patience of engineering education faculty. Educators recognize that there is no simple fix to this problem, that it is not possible to simply add new elements to an established course or curriculum. Through observing the struggles and listening to the concerns of engineering educators, program evaluators can continue to learn about the process of understanding and using a new curriculum development model.

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