Potential Minimum Viable Value Propositions for Engineering Education Scholarship

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***Abstract*—While scholarship in engineering education is growing in quality and quantity, the extent to which engineering education scholarship influences practice is hotly debated. Multiple factors influence the extent to which research influences practice in any field. While many highlight the reward system as the pivotal factor, changing the reward structure is difficult and assumes extrinsic motivators are effective for faculty. Therefore, this change alone is unlikely to affect faculty priorities vis-a-vis scholarship and teaching. The paper assumes two premises that provide necessary but not sufficient conditions for engineering education scholarship to influence practice. First, the authors assume that the reward system is at worst neutral and may at best reward faculty members who demonstrate they improve student's attainment of learning outcomes. Second, the authors assume that there are effective channels that provide engineering faculty members with concise, accessible, and effective information that they can use to make informed decisions about their teaching. Starting with these two premises, the authors claim another reason research is not influencing practice sufficiently is that, in the language of entrepreneurship, the engineering education community has not provided sufficiently compelling value propositions for engineering faculty members to adopt research based instructional strategies. While the value proposition of engineering education research is clear to researchers, it may not be clear for the majority of engineering faculty members who do not engage in these knowledge-creation activities. An untested claim of this paper is that research advances in engineering education need to be paired with minimum viable value propositions (MVVPs) in order to influence practice in engineering classrooms. Herein the authors offer a set of preliminary adoption-based value propositions intended to stimulate active, substantive conversations.**

Keywords—value proposition; engineering education scholarship; insert (*key words*)

I. Introduction

Scholarship in engineering education is growing in both quality and quantity; however the extent to which engineering education scholarship influences practice is hotly debated. Many efforts in the early 2000's focused on raising the level of rigor in engineering education to a status on par with traditional disciplinary research [1], [2]. These efforts were supported by the growth of engineering education programs housed in colleges of engineering and the concomitant focusing of journals on education research. For example, the Journal of Engineering Education (JEE) published in partnership with the American Society for Engineering Education (ASEE) clearly states its mission is to develop a 'body of knowledge derived from scholarly research.' Guidance to the authors specially states that non-research articles are not appropriate: "*Manuscripts that primarily describe a curricular or pedagogical innovation are generally not appropriate for the Journal*" [3]. The European Journal of Engineering Education recently took a different stand to the intended impact of that journal [4]. The editor clearly stated that engineering education is *"a field of practice rather than a research discipline"*. These different statements of intent raise questions, not about the value of research *per se*, but about the degree to which research in engineering education does or should influence practice in engineering classrooms across the world.

If articles published in the *Journal of Engineering Education* are used as examples of current and accepted research in engineering education, then perusal of the articles in the last ten years suggests that engineering faculty members teaching in classrooms will have to do significant work to synthesize results from multiple studies to extract out of set of practices (i) that can be applied in their specific instructional contexts (e.g., can be used in large enrollment courses and will be accepted by students), (ii) that are aligned with their beliefs and values (perhaps unstated) about engineering education, and (iii) and have been shown to be, by a standard of evidence they accept, sufficiently efficacious that their adoption of these practices are likely to improve student learning. Studies have shown that a number of factors influence adoption of research-based teaching practices, but one of the factors is time that faculty members think is required to analyze, synthesize, and translate research on engineering education to practice.

While many highlight the reward system as the pivotal factor [5], changing the reward structure is difficult and assumes extrinsic motivators are effective for faculty. Therefore, this change alone is unlikely to affect faculty priorities vis-a-vis scholarship and teaching.

This paper assumes two premises that provide necessary but not sufficient conditions for engineering education scholarship to influence practice. First, the authors assume that the reward system is at worst neutral and may at best reward faculty members who demonstrate they improve student's attainment of learning outcomes. A corollary, however, is that rewards offered to recognize teaching are typically of less value than those associated with original research. Second, the authors assume that there are effective channels that provide engineering faculty members with concise, accessible, and effective information that they can use to make informed decisions about their teaching. The degree of truth of these premises is open to debate.

If, for argument's sake, these two premises are accepted, the authors claim another reason research is not influencing practice sufficiently is that, in the language of entrepreneurship, the engineering education community has not provided sufficiently compelling value propositions for engineering faculty members to adopt research based instructional strategies. While the value proposition of engineering education research may be clear to those engaged in that research, it is not clear for the majority of engineering faculty members who do not engage in these knowledge-creation activities and therefore have different values. An untested claim of this paper is that research advances in engineering education need to be paired with minimum viable value propositions (MVVPs) in order to influence practice in engineering classrooms, e.g., deemphasize lecture and emphasize research based instructional strategies more. Herein the authors offer a set of preliminary adoption-based value propositions intended to stimulate active, substantive conversations.

The next two sections of the paper provides some background on the concept of value propositions (Section II) and minimal viable value propositions (MVVPs) (Section III) for readers who may not be familiar with the terms. Section III also presents a set of MVVPs developed by the authors. These MVVPs are offered as starting points, not conclusions, for further conversations are needed so that research in engineering education can influence practice to a greater degree than is currently observed. Finally, the authors offer recommendations (Section IV) that will hopefully be next steps in the conversations.

II. Value Propositions

The term value proposition comes from the areas of marketing and entrepreneurship and is generally defined as making a product or service attractive to customers. On a more general level it can mean making a company attractive to the free market. While definitions and interpretations of value propositions vary there are a number of key components:

1) A value proposition implies a comparison followed by a decision to choose one option over other viable alternatives. In this sense the choice is rarely obvious or binary in nature; instead, choice may require balancing multiple factors and be based on emotion as well as reason.

2) Value proposition are targeted, that is they focus on specific customers or sectors. Understanding customer needs is critical in creating effective value propositions.

3) A value proposition defines the product or service being offered in a way that helps customers make informed choices.

4) A value proposition clarifies the benefits the customer will gain in comparison to the short- and long-term costs of the choice.

5) A value proposition is supported by data that substantiates the claim made.

There are several different formulations of value propositions such as capability – impact – proof – cost [6] or need – approach - benefit/cost ratio – competition [7]. While the usual conventions of monetary exchange and customers do not apply to research-based instructional strategies, the five points above are applicable if one considers faculty in the classroom as potential users of innovations and factors such as time, satisfaction, and status as potential costs.

III. Minimum Viable Value Propositions

The descriptor "Minimum Viable" comes from the idea in a community of innovators of the minimum viable product [8], or the leanest version of a new product that can be released to identify enthusiastic early customers. The idea is that since it is impossible to predict the features of a product that will be valued until feedback is received from users, it is better to push out innovations at some (difficult to define) minimal level rather than spend time developing features that may never be used. Thus the term Minimum Viable Value Proposition (MVVP) is thus loosely intended to mean one or more benefits of an instructional strategy that can create a meaningful user base or community. The authors propose the following set of MVVPs as means to generate conversations across the engineering education community about potential value propositions for research in engineering education.

MVVP No. 1 – Save Faculty Time: Using concise, accessible, effective resources (if they existed) would save faculty members some of the time that they currently invest in teaching. Studies of factors influencing faculty adoption of research based instructional strategies (RBISs) suggest that the one of the most frequently cited reasons for decisions not to adopt these strategies is the time and energy that faculty members would have to invest to apply these strategies [9], [10]. While many studies of RBISs have shown that, compared to lecture, these strategies influence student learning positively, far fewer studies look at the time required by faculty members who adapt RBISs. However, some results/anecdotes suggest that faculty members, especially new faculty members who adapt RBIS, spend less time preparing for class than faculty members who rely almost exclusively on lecture during class. Further, efforts to analyze, synthesize, and extract instructional strategies in formats that would reduce the time and energy, which faculty members must invest to use these instructional strategies, might aid adoption better than making the effort to read and synthesize the engineering research literature.

MVVP No. 2 – Increase Sense of Belonging by Engineering Faculty Members through Engineering Faculty Learning Communities: Each engineering faculty member can develop and engage in a community of learners who are engineering education practitioners. If, as stated in the first MVVP above, the research was accessible to the broader audience, then faculty colleagues could easily learn from each others' experiences. Currently research scholars are prone to having their work become confided to 'silos' of the small group of like-minded researchers [11]. The more practitioners discuss educational innovation amongst their peers, the more those innovations will be spread in engineering education.

MVVP No. 3 – Intrinsic Motivation 1: Engineering faculty members, if they used RBISs, would find their teaching more energizing. For example, one of the most commonly accepted evidence-based research results states 'active' learning strategies promote increased student learning [12]. What is less recognized is that these strategies also increase the active engagement of the faulty member. By applying these strategies, resources and redesigning their teaching, students would be more engaged; if students were more engaged, faculty would find interaction with students more rewarding; and with greater reward, we hypothesize that faculty members would have more energy for their lives, their research.

MVVP No. 4 – Intrinsic Motivation 2: This is related to the previous MVVP: Engineering faculty members need to maintain energizing interest in what one is teaching over time. Faculty members often have long careers and teach the same (or very similar course) multiple times over several years or decades. For some core engineering classes, e.g., circuits, statics, thermodynamics, course content (what is taught) is often fixed by negotiation or often must be aligned across multiple sections or with other courses. In this case a faculty member's autonomy can be limited and motivation can suffer. However, developing abilities to teach course material more effectively through new teaching approaches and exploring new options in technique opens up other pathways to faculty autonomy. Autonomy, along with purpose and mastery, are three keys to intrinsic motivation [13].

MVVP No. 5 - Diversity: By applying scholarship on diversity in engineering education, administrators and/or faculty members would be able to formulate action plans to increase numbers of engineering students from underrepresented groups. Current literature [14] indicates that the issue of diversity is more than numbers. The interactions between faculty and students, especially in the classroom, are important components of the environment for diverse students. If faculty members have resources that helped them understand the complexity and nuances of the classroom environment, diverse students would be more engaged in their education. This would also stimulate faculty engagement leading to the type of diversity-based improvements discussed by Page [15]. Faculty members could then more easily see the value of diverse populations to the future of the engineering profession.

MVVP No. 6 – Student Preparation: Engineering faculty members often complain that students in a course they are teaching are not adequately prepared. Preparation may have to do with mathematics, requisite course content... or it may have to do with more generic abilities, such as abilities to estimate or interpret technical diagrams. Engineering faculty members who apply scholarship in engineering education and improve preparation of students for subsequent courses might be valued by their colleagues who teach these courses. By taking a systems view of the curriculum faculty would clearly see themselves as belonging to an interconnected community, see MVVP 2 above. This could lead to substantive discussions on student learning across the curriculum and result in greater sharing of curricular and pedagogical innovations beyond the individual classroom.

MVVP No. 7 – Continuous Improvement: One of the current emphases by accreditation organizations agencies is that engineering programs demonstrate continuous improvement. These cycles of improvement include first some type of assessment of learning, followed by an evaluation of the attainment shown by the assessment, resulting (possibly) in a determination for a need for improvement. The final, critical step, to design an improvement, is often the neglected component. Faculty need to have access to curricular and pedagogical innovations that they can draw upon when faced with shortcomings in the attainment of student learning outcomes. By having concise, assessable resources related to implemented approaches for improvement, accreditation would be viewed as a more positive and effective process. Currently accreditation is often seen more as a burden than an opportunity. The goal of accreditation is quality through improvement so producing and sharing resources focused on improvement would improve faculty members' engagement with the accreditation process.

MVVP No. 8 – Connections with Students: There are times all faculty realize that a large gulf exists between our perception of students and their actual experiences at college; disparate perceptions can lead to experiences of isolation or discomfort on the part of both students and faculty. For example isolation is commonly reported by students who are not from dominant cultural groups [16]. Labeling students—Generation X, Generation Y, Millenials—and pointing out differences between students and faculty has become a cottage industry. Research in learning, however, often searches for commonalities and similarities rather than differences. For this reason many RBISs are effective at engaging students in collaborative modes of learning. Such collaboration effectively stimulates more conversation and sharing between faculty and students. Similarly, some strategies such as flipped classrooms open up time for meaningful conversations that isn't available otherwise.

MVVP No. 9 – Transferable Knowledge: By learning how to effectively apply available resources well-grounded in the scholarship of learning, faculty members would gain new perspectives that could transfer to social and human problems within their own discipline. As Norman Augustine has stated: "The bottom line is that the things engineers do have consequences, both positive and negative, sometimes unintended, often widespread, and occasionally irreversible"

[17]. These consequences are rarely purely technical in nature, often involving social, economic, or other fields of inquiry with their own epistemologies that differ from the purely positivist tradition in engineering. Faculty who engage with more research-based pedagogies to a level where they begin to understand the "why" as well as the "how" can gain insights into perspectives held by educators and social scientists that broaden their own view of engineering.

Clearly not all of the above MVVP's fit all faculty members nor apply to all RBISs or institutions. However some work in the business and NGO community shows that persistent problems need to be approached from multiple angles. Thus, it is not intended that one find the best MVVP to match with a RBIS in a given setting, but multiple MVVPs may align with a RBIS.

IV. Recommendations

Using the preceding as an initial list of MVVPs, some potential next steps to engage the engineering education practitioners in the discussion need to be identified. In the introduction we highlighted the fact that in engineering education the current focus is firmly on the production of research-quality scholarship. A first step towards developing a focus on the MVVPs is to expand our definition of engineering education scholarship to also include discussions on pedagogical and curricular innovations. "Engineering education has had a rich tradition of educational innovation, but until the 1980s assessment of innovation was typically of the "We tried it and liked it and so did the students" variety" [18]. The work shared ideas, but authors did not emphasize evaluating impact of the activities in ways that could convince other of their efficacy. This was a valid criticism of much of the published work. The pendulum may have now swung to a point where the sole emphasis may be research. For quantitative studies, impact is now characterized by the statistical significance—the sometimes-elusive significance factor, $p<0.05$—of one's results. For qualitative studies the bar is not lower, but lack of emphasis on generalization of results from qualitative studies may make it more difficult for those formally trained in positivist engineering traditions to discern value and applications.

Value propositions need to be based on good research; one should be convinced that an innovation claimed to be effective at one institution will provide similar results when applied to one's one class. However there is a middle ground that accepts both types of scholarship, the proof offered by research and the many trial implementations needed verify that an RBIS is widely scalable and the limits of that scalability.

Looking at the definition of a value proposition in Section II, how can researchers present their work in a way that allows meaningful comparisons that lead to choice, target their research to potential adopters, honestly address the multiple factors that can hinder adoption, describe potential benefits in a multi-faceted way, and present data in a way potential adopters can grasp? Clearly the engineering education community can do a better job of describing implementation aspects of innovation; however, conversations need to establish expectations for adequately supporting implementation findings.

To facilitate a redefined scholarship will also require venues for that scholarship. Let's start with this particular conference, FIE. Faculty practitioners could be welcomed to meetings such as this if a track for implementation discussions and presentations was included. This does not replace the current focus on research; instead it complements it. Currently, the research-focused rhetoric increasingly used at these meetings can make it difficult for the larger practitioner population to understand the value proposition to them of many of the presentations. Researchers could also benefit from hearing the issues that practitioners are most concerned with. As mentioned previously, practitioners are often concerned about time to learn and apply a RBIS, yet few studies of RBIS directly address time to implement.

Journals are a second venue for discussion across the community. Currently the *European Journal of Engineering Education* invites topics of direct interest and use by practitioners while the ASEE-sponsored *Journal of Engineering Education* does not. Would practitioners be drawn to these journals if they contained innovation and implementation articles in addition to the research articles? For a model of how this might look it is suggested that the approach taken by the *Journal of Professional Issues in Engineering Education and Practice* sponsored by American Society of Civil Engineering might be a starting point. They have a section for technical papers and also case studies.

Research has value to those outside the research community only to the extent that it enables something that is valued, e.g., money, time, or status. In all fields of inquiry there is a cost to implement research in ways that are widely scalable so that its value is realized. In areas such as physics or computer science there are well established methods through which discoveries are commercialized and either succeed or fail in convincing the market of their value. It is not obvious that these mechanisms are established in engineering education at this time, or that effective channels for scaling innovations exist. By better defining, then using, the lens of value the engineering education community may be better equipped to meaningfully impact practice.

A note of caution is in order here. While this article has adopted ideas from economics, entrepreneurship, and innovation communities to make a case that the concept of "value" can better link the research and practitioner communities, such ideas carry grave dangers when blindly applied to education. Newman [19] persuasively argued that education, like health, has intrinsic value to the individual that is independent of (and perhaps greater than) any economic or utilitarian value to society. It is important to keep in mind the multiple benefits an engineering education provides that accrue to individuals, families, organizations, and society. Thus value propositions must remain multi-faceted, contested, and diverse rather than be used as a forge to create one pedagogy to rule them all, one pedagogy to find them, one pedagogy to bring them all, and in the darkness bind them…

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