Deliberating Public Welfare in Engineering – The Capability Approach

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Abstract

This paper addresses the theme of "the Moral and Ethical Responsibility of Engineers and Engineering", particularly responding to the question of how to *define or deliberate the meaning of 'public welfare' and 'common good' in engineering degree programs*. Drawing from decades of international work on human development, particularly in the global south, this paper reports on adapting the capability approach to an engineering degree program. Developed by Amartya Sen, the capability approach sought to replace GDP-based models of welfare economics by framing the goal of development as enabling individuals to live a life they value. The things a person values, what they are and can do (determined by their opportunities, experiences, and cultural affordances) are their '*functionings'*. In Sen's framework each individual has a unique '*functionings vector'* based on what they value. Although someone's functionings vector indicates valued goals, they will be unsuccessful in achieving their goals unless they have access to needed resources, can effectively utilize those resources, possess agency, and have the '*capability'* to enact the functionings. '*Capabilities'* determine the set of functionings that are actually available to a person.

Although rarely used in engineering, the capability approach offers a mature and well-developed framework to address issues of public welfare. Public good is defined through an individual's freedom to pursue a life they have reason to value, and such freedom defines both the means and end of development. The role of engineering in society—through development of infrastructure—is to support equitable access to capabilities for all individuals. Through support of an NSF Revolutionizing Engineering Departments (RED) grant, an ECE department in a mid-Atlantic liberal arts university has adapted the capability approach to inform change in an undergraduate degree program. Specific examples from four years of implementation are shared.

Introduction

The topic of "the Moral and Ethical Responsibility of Engineers and Engineering" is a large one, building on over a century of both mistakes in practice and the changes in practice to avoid public harm. There are many texts that discuss engineering ethics – [1], [2], [3] are some examples. To set reasonable boundaries on this broad topic this paper adopts several constraints. First, we address one specific call in the request for proposals: "*define or deliberate the meaning of 'public welfare' and 'common good' in engineering degree programs*." This framing first limits the scope to the education of engineering students within degree programs. Limiting the scope to education excludes impact outside degree programs. Engineering education is highly intersectional with other aspects of human existence such as politics and governance, technology impacting on how people live their lives, and the economy and quality of life in the developed and developing world; a very large scope. A second limit is the focus on degree programs. While pedagogies, content, and faculty development impact upon degree programs, they are not the program itself. Here we take a more systemic view, looking at how a program can reassess

its purpose or rationale in ways that better support preparing students to address the common good.

Another self-imposed constraint is that of pragmatism. By choosing to address the issue of moral and ethical responsibility at the program level, there needs to be substantive evidence that change is both possible and effective. As Machiavelli noted [4], changing the existing order is difficult and doubters need evidence that changes will result in improvements. This is easier If change is built on existing and tested frameworks.

A third constraint arises through the unit of analysis. In making systemic changes at a degree program level to have impact upon the common good, what exactly is to be changed? One can analyze the program, those who manage the program, the outcomes of the program at a cohort level, or at the individual students who go through the program. Here individual students are chosen as the unit of analysis. This reflects the author's bias towards personalism [5], which broadly focuses on the centrality of persons, seeing human growth and development as central to the common good. Personalism developed in the 19th century in reaction to depersonalizing movements in philosophy such as absolute idealism, political movements, and the sense of determinism arising from physics and evolution. Personalism assumes individuals have significance, are unique, and serve as ends-in-themselves [6]; that is persons do not serve as means to a larger social end. Personalism also recognizes that humans exist in relation to other persons and society rather than as isolated, rational, Cartesian minds. In regard to educating future engineers, personalism posits that to become engineers, students should undergo both professional and personal development. Thus, the focus of any degree program should be on developing individuals in fullness.

The adoption of personalism—an individual-focused philosophy—as a constraint needs some explanation in relation to the concept of a "common good" since individual wants and desires often conflict with notions of the common good (as is playing out currently through populist movements). While a longer treatment is given in [5], briefly for a common good to exist there must be actions taken by individuals to maintain it. There is no moral consequence without action. Engineering has adopted primarily deontological frameworks to determine ethical codes that support public welfare. However ethical decisions depend on an underlying, but often unarticulated, morality upon which ethics is based; i.e. a conception of the common good. This is particularly true for engineers since to serve public welfare in practice the engineer must make implicit assumptions about what is good. Alternatively, they can abrogate these decisions to the client [7], which from the perspective of personalism is essentially moral cowardice. While traditionally morals have been assumed to be well-developed by the time a student enters college [8], as higher education becomes more diverse this assumption may no longer hold. Furthermore, morals matter since there is not universal agreement on how to achieve the common good. Personalism partially defines moral good as emphasizing freedom, friendship, and community for persons. Thus, to be able to act to work towards a common good education should provide students space and resources to develop a stance on the common good. As Newman argues, one of the ideas underlying a university is to provide a forum for students to

refine these belief systems among their peers [9]. To briefly summarize, the argument for personalism supporting the common good lies in the fact that engineering education produces agents who can work toward beneficent ends. The common good is not defined canonically, but rather developed in an environment that supports dialog about the common good and allowing agentic action within a community dedicated to such good [10].

Note that personalism as defined above takes a perspective of action; what matters is that agents are able to act to serve the common good. Thus, any frameworks to re-envision engineering education degree programs to better support the common good should emphasize developing student agency and freedom. This stance is not completely in alignment with all belief systems in education, some of which focus more on the role of the student to contribute to society or maintain and advance disciplines [11].

The final constraint arising from considering the common good is that any frameworks need to be for the benefit of all. Given the tensions within higher education's role in supporting inequality, current models of higher education in the US do not always meet this criterion [12]. While there are counter-examples, the higher education sector overall in the US has been demonstrated to promote inequality, particularly among socio-economic status. Thus, frameworks that have been shown to work not just in the developed world or for wealthy and high-status individuals, but also in the developing world for those without resources or political power are desirable.

Note that there are many frameworks for supporting the common good. These include Catholic social teaching [13], utilitarianism [14], Confucianism [15], ubuntu [16], Islamic principles of the common good (Maslaha) [17], the human rights framework [18], Elinor Ostrum's approach to the commons [19], and the framework developed here – Amartya Sen's and Martha Nussbaum's capability approach [20], [21].

The Capability Approach

The capability approach in economics sought to shift the paradigm for assessing human well-being and development away from societal/economic metrics like GDP to more individual measures. The capability approach seeks to measure development by the expansion of individuals' freedoms to lead the kind of lives they have reason to value rather than by more quantitative metrics such as economic growth or income levels [21]. Thus, it meets the criteria of focusing on individuals as both the end goal and unit of analysis. The capability approach is well-documented in terms of impact on people's lives, many of whom are among the least well-resourced on the planet, satisfying other constraints. The primary constraint, adapting the capability approach to engineering education will be discussed subsequently.

The language used in the literature on the capability approach can be difficult to understand since the framework has very broad application across many domains. Briefly, *capabilities* are defined as the substantive freedoms or opportunities to achieve various valuable states of being

for and doing for individuals. These include being healthy, having access to education, political freedoms, and participating in community life. In these ways the capability approach aligns with the Universal Declaration of Human Rights [18]. Individuals who able to truly access capabilities choose how to convert them to individualized *functionings*, which are defined as the achievements individuals have chosen to attain based on the capabilities they have access to. Note that agency and choice are central to the capability approach, making it widely applicable to different cultures and value systems (assuming agency and freedom are valued in those cultures). Thus, the capability approach is inherently flexible; this is both an advantage in that it is widely applicable, and a disadvantage since it needs to be interpreted and adapted for various contexts. The capabilities approach has found applications across a broad spectrum of disciplines, including economics, philosophy, social policy, and development studies since it is able to address complex issues of human development and social justice. Although the application domain of capabilities/opportunities is broad, applying the capability approach to a specific context requires considerable work to place the lives of individuals into the broader structures that affect their lives [22]. It is for these reasons that the capability approach is a pragmatic choice, since it can be adapted to engineering education.

In brief, the capability approach focuses on creating opportunities for individuals, and its claim to enhance the common good arises through prioritizing human well-being, equity, and freedom in governance systems and through policy decisions. It does these by enabling individuals to lead meaningful lives through providing opportunities that expand their range of choice – i.e. how to live. Central to the capability approach is the assumption that individuals can best choose for themselves what makes a good life – by providing local opportunities one enhances the common good. In this it overlaps with elements of Catholic social teaching. The capability approach views individuals as agentic, capable of reshaping their lives and their communities. Thus, the capability approach, in part, evaluates the common good based on the real freedoms individuals have to achieve their potential, rather than merely assessing income, wealth, or resource distribution. There is thus a focus on addressing structural inequalities through policies and practices.

As mentioned previously, the capability approach (CA) has built-in flexibility, making it widely adaptable to multiple domains, including engineering education. Walker has developed lists of capabilities that apply in higher education contexts [23] that takes account of both personal and relational flourishing and morality. Given that education can be viewed as both a capability and a functioning, other work [24], [25], [26], [27] has explored how the CA approach both captures, and can fail to capture, the many ways that education contributes to human development. The CA has also been used to develop sustainable models of education, looking at power distribution in educational systems across scales [28]. Others have looked at the idea of adaptive preferences through the lens of young people who reject higher education [29], [30]. The capabilities approach explains various aspects of higher education that align with its normative frameworks. For example it has been used to understand the impacts of living-learning communities that are agentic and student led in social justice education [31]. Related to one of the big issues facing engineering education, disparities in representation, the CA has been used to explore and critique

deficit thinking in educational policy [32]. Similarly the CA has proven valuable to explore access to higher education from the perspective of resources [33] and admissions policies affecting diversity, equity, and inclusion [34]. The CA has also been applied to academic support functions such as broadening conceptions of student well-being and mental wellness in higher education [35] and in guidance counseling [36], factors important in student retention.

Because the terminology used in the capabilities approach is specialized, it has been adapted in this paper for an engineering education audience. Along with 'capabilities' we use the word 'opportunities' that individual students have access to since it frames the issues in a way that is more approachable and understandable for engineering educators. Similarly 'achievements' is used as well as 'functionings' to refer to what individual agents (persons) have attained by utilizing the opportunities they have access to. It is important to note, as stated previously, that education is both an opportunity *and* an achievement. Providing opportunities can lead to achievements which then provide more opportunities in a dynamic way; this will be discussed later.

Comparison with the Status Quo – Outcomes-Based Education

In making the claims that adaptation of the capability approach can impact engineering degree programs to better support the common good, it is necessary to take a critical look at existing paradigms. While engineering education in the US spans a diverse range of institutions with their own values and mission, engineering programs have in common ABET accreditation requirements. Thus, it is worth quickly reviewing the major points of the dominant current ABET paradigm. ABET, since adoption of EC-2000, has been outcomes-based. As graduation from an ABET accredited program is somewhat mandatory for working in engineering, it affects all US, and many international, engineering students. Research has shown the initial shift to EC had substantive impacts on how program operated; effect of ABET on practice is documented [37], [38]. Subsequent studies have shown, however, many degree programs follow procedural adherence but that there are significant differences in the extent of compliance [39].

The origins of outcomes-based education dates back more than sixty years, but came to prominence in the 1980s, focusing attention primarily on the outcomes or outputs of the education process. Outcomes-based education has certain characteristics that have informed education practice and policy from the primary to higher education spaces, with particular variants in engineering education. One of these is a focus on accountability (e.g. *No Child Left Behind* in 2001) and standards (e.g. *Common Core* in 2010s) that makes programs responsible for learning outcomes. Another aspect is a procedural focus, which is exemplified by ABET through its emphasis on iterative program improvement. The continual quality improvement movement from which these ideas are drawn arose in the 1980's due to concerns about competitiveness of the US economy and is adapted from industrial continual quality management (CQM) methods such as ISO 9000, Six Sigma, and Kaizen which themselves have roots in 19th century industrialization. Another aspect of outcomes-based education is that the unit of analysis is the program or sub-elements of it. This focus on the program can emphasize the intended

curriculum rather than the received curriculum. The intended curriculum is what programs believe that students learn rather than what is actually experienced (received) by students.

Continual quality management (and outcomes-based education) has an implicit assumption that quality can be defined sufficiently well to make some sort of measurements which then inform efforts to improve processes and operations. From the basic assumption that quality is definable, measurable, and can be improved, CQM systems incorporate a series of other hypotheses and assumptions [40] and which are subtly instantiated into educational systems that follow this model:

a) CQM systems are based on top-down management which then involve all employees in pursuit of quality; changes come from top-down to create an environment for quality.
b) Production is accomplished through processes, processes have variation, and excessive variation leads to wastage and rework. CQM systems prioritize adherence to standards. Models based upon 'conformance to requirements' in turn imply that the requirements are known *a-priori* (hence the need to define common outcomes in ABET).
c) Pursuit of quality is both a means to a desired end and an end in itself since quality is perceived to be a 'guiding value'. As both a means and end, the pursuit of quality is a self-sustaining model that operates by showing measurable increases in desired outcomes, e.g. Deming's chain reaction theory [40].
d) The determination of quality is negotiated between producers and customers rather than being defined a-priori by the producers [41], [42]; it is important to be customer-driven. The analogy of customers in education are program stakeholder.
e) Quality processes should be externally, as well as internally, validated to determine alignment with best practices. This is the role of accreditation agencies.
f) Because pursuit of quality becomes measurable, CQM systems incorporate notions of gamification, hierarchy, and expertise.

As a model for educational accreditation CQM has the advantage of being epistemologically aligned with engineering ways of thinking, thereby making it an easier conceptual framework for engineering faculty to adopt [43]. This is advantageous since engineering faculty themselves have implicit or explicit notions of quality; however, there is no *a priori* reason why CQM, rather than some other framework, should be the framework upon which to build accreditation. In fact, several authors have identified reasons that CQM can be misaligned with higher education. Roffe [44], in commenting on implementation in Great Britain, highlighted that the pressure to adopt CQM came from higher education itself becoming more global and competitive. Yet CQM can be a poor fit to the culture and processes of higher education since systems designed for manufacturing processes do not always work well with people-focused organizations. In manufacturing processes a relatively small range of indicators can be used to determine quality, but the same is not true with individuals; differences between CQM in manufacturing and service companies demonstrate this effect [45]. This is highly relevant given this paper's focus on personalism. Another issue, common to much of education, is that the variance of people is high so CQM methods that seek to implement long-term, incremental improvements may have challenges in measuring change, a situation familiar to faculty

undertaking ABET reviews. Variations are also built in to internal processes in higher education through electives or offering multiple appropriate pathways to a degree [46], creating a potential tension between adherence to process and the needs of students. Another issue is that to be effective higher education needs to respond to changes in society, models focused on control by management may not be able to respond sufficiently rapidly [44].

The author has previously done a comparison [47] of ABET's outcome-based process to Walker's educational capabilities [23]. This analysis found that there is not a great deal of overlap between the opportunities Walker found were needed for students to thrive in higher education and ABET outcomes. The low level of overlap is not surprising since the inherent values of the two frameworks differ – the CA approach focuses on individuals while ABET focuses on program output needed for the engineering profession. Areas of minimal overlap included developing a learning disposition; the need for respect, dignity and recognition; students' emotional integrity and emotions; and bodily integrity. While such low-overlap capabilities certainly are important to student development, they do not align with program quality and therefore are not considered by ABET. There are no surprises here – outcome-based frameworks care about the process and the output, not the individual.

The RED Project – Shifting the Paradigm

Through NSF support of a Revolutionizing Engineering Departments award Bucknell University's electrical and computer engineering (ECE) department has been adapting the capability approach to our engineering degree program. While the full project efforts are too much to report here, descriptions of activities are shared to highlight aspects of how the capability approach can be adapted in engineering education.

The overarching goal of the projects is to show how degree programs can undertake credible efforts to shift to activities and programs to better prepare students to address public welfare and the common good.

The introductory paragraph of the RED proposal submitted to NSF laid out a vision for the ECE degree program:

> *The underlying vision of this project is simple. Engineering is and will remain a technical discipline defined by addressing meaningful problems. However, in the century since the Mann Report first outlined the state of engineering education, the nature of what constitutes meaningful problems has fundamentally changed. Engineering at the start of the 20th Century sought to marry science and industry for production, and as the means of production changed so did engineering education, serving as a technological means to an economic end. Engineers have succeeded dramatically in fulfilling this vision. Products today are churned out at high rates and are much cheaper and widely accessible than a century ago, creating new challenges – inequities in access, increasing recognition of the environmental costs of high levels of production, and economic turbulence as economies shift away from goods. Rather than being guided by a need to marry science to industry to support material production, the challenges we face are those related to social justice, ecological sustainability, and tectonic shifts away from the goods-based economy engineering education was*

designed to support. The problems of the 21st Century will be more systemic, wicked, and convergent requiring yet-to-be-understood changes not just in the processes of engineering education but its values and culture. Yet evidence indicates that many engineering programs as currently constituted do not prepare students to address societal as well as technical problems, creating tensions in the long-standing relationships between engineering and other parts of society. In the early part of the 21st Century we see a critical need to both educate engineers who can navigate these tensions and to prepare faculty to provide such education.

This vision lays out how the PIs on the grant saw our degree program contributing to the common good. The choice of the capability approach as a framework (described previously) framed the types of changes that would help the program achieve this vision.

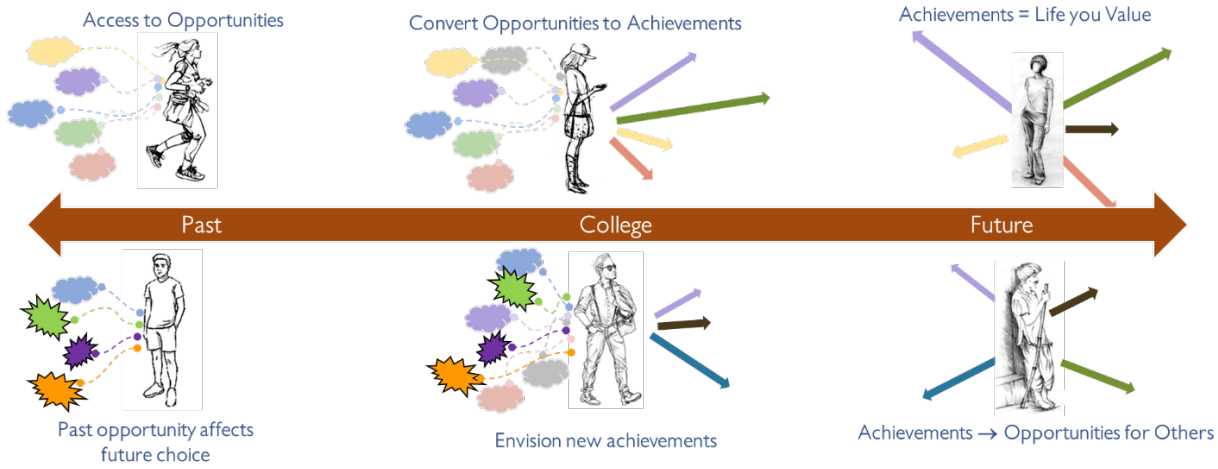

Figure 1: Illustration of the capability approach in terms of looking at past access to resources and opportunities (shown as clouds for opportunities that align with university norms and jagged shapes for opportunities that are misaligned), a student's time in college as converting opportunities to achievements (vectors), and how achievements result in future freedoms.

As discussed previously, the capabilities approach shifts the unit of analysis away from the program to the student. This results in looking not just at the outputs of education processes, but also considering the inputs. Inputs are not content (ABET's old model of bean counting) but actual, achievable, and accessible opportunities that college offers for students to achieve a life they personally value; broadly conceptualized as shown in Figure 1. Students have different access to opportunities (capabilities) prior to arriving college. Some of these opportunities align with those that will help them achieve in an academic environment (cloud shape), while some are misaligned (jagged shape). Two student trajectories are shown, representing differential access to college preparation. Students convert their opportunities to societally-recognized achievements (functionings) in college which then provide access to a life they personally value. However, because limited prior opportunities can limit vision, college also should enable students to envision new life pathways. From this perspective college not only serves to help students generate achievements, but also to point out alternative life pathways students might have reason to value. Achievements are societally recognized credentials—grades, experiences, stories, networks, etc.—that help a student gain access to a desired life; this will be explained

subsequently. Since achievements are more than just academic grades, it refocuses attention on the types of experiences students have in college and how to recognize them.

The program adapted existing models of the capability approach [22] to the space of higher education; details of this process will be provided in subsequent publications. The model, in its current form, is shown in Figure 2. There are three elements: those in green are integral to the capabilities approach, those in black are factors that influence individual development and structural factors, and in blue are educational components. The model applies to individuals, not to a degree program. In this model each person converts resources to capabilities (their opportunity set). These opportunities support their learning. Although learning is complex and individual, to simplify the model we identified two broad learning pathways that represent different pedagogical methods and learning outcomes styles in our curriculum: knowing/doing and being. These are derived from Barnett and Coate's [49] framework separating learning into knowing, doing, and being since being captures the ontological commitment of choosing to become something which aligns well with the CA. The two paths recognize the necessity of different pedagogical methods/goals, some of which are supported by the university in co- or extra-curricular spaces.

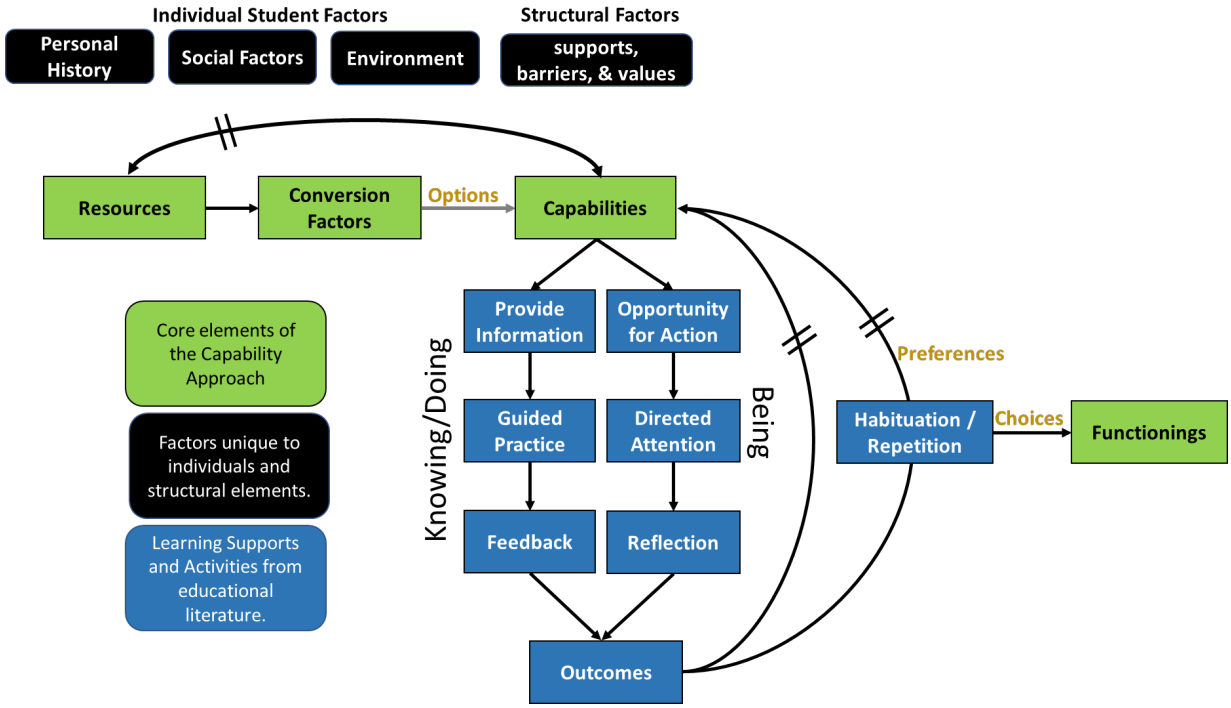

Figure 2: Adaptation of capability model approach from [22] to higher education. The || symbol on feedback loops represent delays as described in works on systems thinking.

Both educational pathways lead from opportunities (capabilities) to outcomes, which in this model exist in an interstitial space between opportunities (capabilities) and achievements (functionings). Here outcomes are things a student can do, i.e. competencies [27], but are not yet achievements (functionings) since the student may not find intrinsic value in an educational

outcome defined for them. Additionally, curricular outcomes are not necessarily recognized outside the educational institution. However, as outcomes-based education is currently the predominant form in engineering education it is important to recognize the role outcomes play in current practices.

Recognizing that education is both an opportunity and an achievement, three feedback loops are built into the model, each with delays – "||" in the language of systems thinking [50]. These loops recognize that: 1) access to the opportunities college provides can unlock new resources or change conversion factors, 2) educational outcomes lead to new or enhanced opportunities, and 3) that student agency and valuation of some educational outcomes over others help define which outcomes are converted to achievements. In the diagram opportunities (capabilities) give students options, mandated outcomes identify preferences, and through guided practice student preferences lead to choices in what achievements (functionings) to develop. While not shown explicitly on the diagram, this model changes assessment and evaluation strategies. Rather than focusing solely on achieving outcomes, two different evaluations are performed: what a person is capable of (opportunity set), and what a person has achieved (functionings). Equity of access becomes the evaluative criteria for opportunities, while achievements are evaluated on how robust or effective they are in supporting a life the individual values. In other words, judging degree programs is not made solely by determining whether students achieve internal or externally-mandated outcomes, but the degree to which they share access to opportunities within the program and the extent to which the program supports individual achievements that help graduates live a life they value. ABET currently requires programs to identify very broad achievements in collaboration with program stakeholders, but does not require evaluation of them.

Throughout the rest of the paper we focus on opportunities and achievements. The majority of the work on the RED project to-date has been on understanding opportunities since this is the basis of the capability approach. Briefly, defining opportunities involved inductive and deductive group brainstorming by the five-person research team. Since existing capability lists were focused broadly, that is not specific to a discipline or program, we sought to identify capabilities at the discipline level. To organize the capability set we created an ecosystem metaphor dubbed the "prairie grass" model since a team member was originally from the prairie state of Kansas (Figure 3). The metaphor draws from the fact that in challenging environments plants develop complex root systems that allow them to draw water and nutrients from different levels of the soil. While the shallow root system is rich and detailed, the deep roots allow the plant to survive in times of drought. The deepest level in this metaphor corresponds to core human capabilities such as those identified by authors such as Nussbaum [20] and Sen [48]. These are basic nourishments humans need to thrive regardless of education or job. At the middle level are capabilities relevant to higher education in our institution, such as those developed by Walker [23]. At the shallowest level are engineering education capabilities that are specific to our degree program. A key aspect of the CA is that it is a contingent model, applied to particular contexts (e.g. degree programs) rather than a generalized framework (e.g.

engineering education). Thus, the opportunity set developed only applies only to Bucknell University; other programs would go through a similar process.

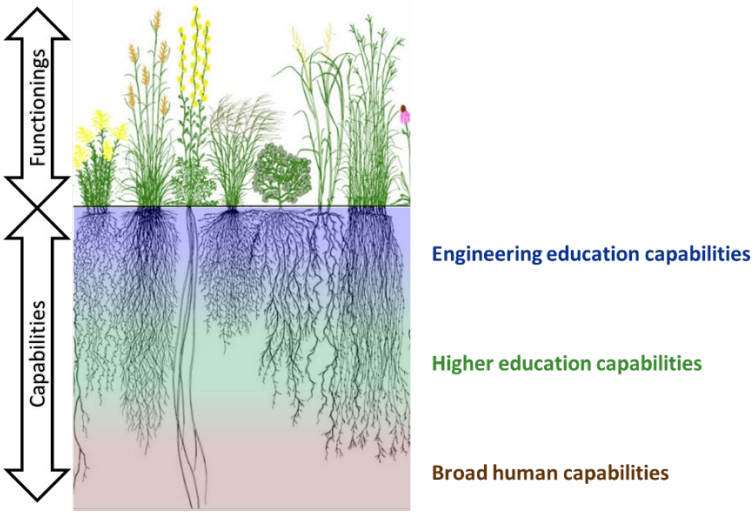

Figure 3: Ecological prairie grass metaphor illustrating capabilities defined at three different levels.

As experienced educators but relative neophytes to the capability approach, initially we could not help but frame opportunities as educational outcomes, the dominant paradigm under which engineering education functions. We had been thoroughly enculturated by outcomes-based education. Opportunities, however, are not what students can do but rather what affordances the university and degree program offer them to help live a life they have reason to value [27]. This difference, which is central to the capability approach, is two-fold. First, an outcome can be required by a program without providing a pre-existing and accessible opportunity. **Outcomes are difficult to achieve without access to opportunities.** Second, even if an opportunity is available, actually attaining the outcome is dependent on student interest and choice. **Not all outcomes, even if mandated, help students achieve a life they have reason to value.** Eventually a detailed list of opportunities was developed at each level; these will be discussed in future publications.

At this point in time our thinking on achievements, the result of the degree program, is still preliminary. We have found it helpful, however, to turn to William James' classic essay [51] 'The Will to Believe':

> *…just as the electricians speak of live and dead wires, let us speak of any hypothesis as either live or dead. A live hypothesis is one which appeals as a real possibility…[and]…let us call the decision between two hypotheses an option. Options may be of several kinds. They may be: living or dead; forced or avoidable; momentous or trivial and for our purpose we may call an option a genuine option when it of the forced, living, and momentous kind.*

A living option is one in which the choice is between two equally desirable choices. A forced option is one you must integrate into your life. A momentous option is one for which the impact of declining the choice is as consequential as accepting it. James argues that we have the right to

believe what we will, at our own risk, as long as our belief is living, forced, and momentous; but that we must respect the freedom of others to believe as they will. However, engineers need to understand that the consequences of their beliefs impact others in ways that are also real, significant, and may be impossible to predict. How to build such consequential choice into a degree program, overcome the real fear such choice creates, and providing needed support and mentoring is challenging. However, a degree program that centers student agency must undertake the difficult work of looking externally for markers of how educational achievements are recognized in society at large, and internally at what types of lives our students have reason to value.

Based on James' insights the evolving definition of achievements includes the following aspects:

1) They are phrased such that they are apply to individual students in order to distinguish achievements from outcomes (defined at the program level in aggregate for all students);
2) they are transportable, that is achievements are valued and visible outside of the college environment;
3) they serve both as desired characteristic of one's own values as an end in themselves as well as potentially being a means to further ends;
4) achievements are objective (the standards for possessing them are clear);
5) they serve as 'conversation catalysts' to build shared understanding and start new relationships;
6) they are obtained through individual effort or action beyond what is inherent in completing graduation requirements; i.e. they distinguish graduates;
7) achievements can further developed following graduation - there is no inherent stopping point.

Summary & Conclusion

In this paper the author has discussed how the ECE department at Bucknell University through support of an NSF RED project is consciously and actionably creating a definition of 'public welfare' and 'common good' in our engineering degree program. To summarize the previous material, we have defined support of the common good in engineering degree programs through personalism, putting the individual first. The working definition of finding a framework to support the common good has been highly constrained:

1. limit the scope of inquiry/action to what is possible in engineering degree programs,
2. be pragmatic by adopting an evidence-supported framework,
3. have the unit of analysis be the individual,
4. assume ethical action happens through supporting individual agency (enactivism), and
5. choose a framework that applies to all humans.

From these constraints the capability approach was explored to replace the current outcomes-based education paradigm. The capability approach is highly adaptable and essentially agnostic to revelation-based definitions of the common good, which fit the pragmatic epistemological frames of engineering. Briefly, the capability approach suggests two major shifts in engineering

degree programs: 1) focus on creating opportunities for students rather than measuring program outcomes, and 2) prioritizing developing student agency in order that students are better equipped to utilize educational experiences to live a life they have reason to value. How to identify opportunity sets and a model for student development that informs program structure were presented – Figures 2 and 3. This is, however, a drastic simplification of the overall effort to focus on its intersection with the common good.

One cannot define the common good without specifying values; there is no universal definition. Here we have framed the common good in terms of personalism, particularly with friendship and community as ends for human thriving [52], [53]. Central to being a person is the concept of freedom, expressed through agency. The capability approach supports such agency, more we argue than outcomes-based education. Students are seeking to connect with and support a greater good – 75% of freshman chose engineering because they want their work to have social impact [54]. But focusing too much on utilitarian outcomes can undercut the opportunities for students to pursue lives they value.

There a humorous quote attributed to the anthropologist and evolutionary biologist Matt Cartmill: "*As an adolescent I aspired to lasting fame, I craved factual certainty, and I thirsted for a meaningful vision of human life - so I became a scientist. This is like becoming an archbishop so you can meet girls.*" This quote captures that there will always be misalignment between students' perception of a degree and the reality of working in a field. However, minimizing those misalignments and creating programs that allow ongoing conversations about becoming can enhance the common good. We are seeing in real time what happens to public welfare in common spaces when engineers develop scalable technologies to meet girls [55]. Intentions matter.

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