New Orleans JAZZED about Engineering Education

Paper ID #15517

A Philosophical Perspective on ABET's Proposed Changes to Criterion 3

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A Philosophical Perspective on ABET's Proposed Changes to Criterion 3 and Criterion 5

This paper critiques the proposed changes to the ABET criteria through the lens of the philosophical system outlined in 20th Century Scottish philosopher John Macmurray's Gifford Lectures. Changes to ABET criteria reflect beliefs about the purpose of education, and philosophy enables a dialog about underlying beliefs and assumptions; thus this analysis is intended to provoke discussion of alternate forms and processes of accreditation. Macmurray's philosophical system is chosen by replacing Descartes' "I think" with "I act" he developed a framework that is focused on developing human agency which aligns well with both engineering education and ABET's continual quality improvement (CQI) processes. In Macmurray's system intention and reflection (evaluation) play an important role not only in the agent's own human development, but in the form of societal entities that emerge from the interactions of many agents. Macmurray proposes three major modes of reflection by which an agent judges whether their action satisfies intention: scientific/pragmatic, artistic/contemplative, and personal/moral. It is claimed that ABET focuses predominately on pragmatic modes of reflection. It is also claimed that the mode of reflection faculty participate in through assessment/evaluation activities impacts the processes (means) of engineering education and engineering education's ability to envision/achieve desired goals (ends). Given the overall scientific/pragmatic nature of engineering assessment, Macmurray's philosophy predicts that the common modes of engineering reflection will likely result in focusing on efficiently improving students' ability to act as engineers without simultaneous emphasizing their growth as a person and citizen. While philosophy is distinct from pedagogy and assessment practices, Macmurray's philosophical system provides guidance for developing other modes of reflection that may enable engineering to recognize and work towards more student-centered ends.

Changes to the ABET Engineering Criteria

Since practically all engineering programs in the United States, and an increasing number internationally [1], are ABET accredited, program review processes have a strong impact on how engineering is constituted and enacted; i.e. what engineering ought to be. When any group makes a claim that things should be one way rather than another it is worthwhile to examine those claims and the position from which they are made. Philosophy is one method of such examination. Philosophy has been defined as "truth estimation" where facts, experience, common sense, public opinion, and traditions form the data by which individuals develop a self-sustaining and coherent belief system [2]. The purpose of this paper is to explore the proposed changes to the ABET EC-2000 criteria from the perspective of the philosophical system outlined in 20th Century Scottish philosopher John Macmurray's Gifford Lectures [3, 4]. As will be

discussed subsequently Macmurray's philosophy provides a framework that aligns significantly with ABET's own processes.

In 2009 the Accreditation Board for Engineering and Technology (ABET) constituted a task force to recommend improvements to the ABET criteria focused on student learning outcomes (Criterion 3). This process led to draft recommendations to two ABET criteria—three and five—that address student outcomes and engineering curricula. The current version (as of this writing) also contains changes to the preamble. The process and rationale for the proposed changes can be guessed at from internal ABET documents, which provide a simplified view of what must have been a complex process. About six years ago it appears there was a perception by program evaluators (PEVs) that there were a substantial number of shortcomings on Criterion 3. One of these shortcomings was that some of the outcomes were difficult to assess which in turn led to inconsistencies in how institutions were evaluated which was viewed as leading to injustice. The fact that there were eleven outcomes schools were responsible for was also seen to stifle innovation within engineering programs. In reconsidering Criterion 3, the outcomes were broadly constituted into five topics: technical, business, communication, professionalism, and individual. Outcomes that were seen as difficult to assess or that weren't seen as necessary for engineering practice—lifelong learning and knowledge of contemporary issues—were dropped. The eleven outcomes in Criterion 3 initially dropped to six with changes to Criterion 5 that provided a definition of engineering design as a process to meet needs under constraints that were originally part of the eleven a-k outcomes. These changes were presented to various constituencies in 2015 and a web portal was set up for commentary. The changes were generally positively received by engineering programs, but some in the engineering education community strongly objected to changes they perceived would undermine diversity and liberal education.

Following public commentary and internal deliberation a modified proposal with seven criteria was given to the ABET Board of Delegates. Additionally the more detailed definition of design in the draft was removed from Criterion 5 and added to the preamble. Other changes to the preamble of the ABET criteria address the role of ABET in professional preparation of engineers. The preamble was expanded to list three elements of this preparation: being able to participate in diverse workplaces, knowledge of their discipline, and awareness of engineering risks. It is not clear whether the preamble is binding on programs in the same way the eight criteria are. The current ABET a-k outcomes and the proposed seven outcomes of Criterion 3 are listed in Table 1.

The ABET criteria attempt to be comprehensive about all aspects of engineering degree programs: ensuring students get evaluated for admission and graduation (Criterion1), the purpose of the program and whether it serves the needs of its constituents (Criterion 2), what students should learn (Criterion 3), the need to have a process to improve (Criterion 4), the requirements for a curriculum to be deemed as engineering (Criterion 5), and the faculty,

Table 1: Comparison of current and proposed ABET Criterion 3

Current	Proposed
(a) an ability to apply knowledge of mathematics, science, and engineering (b) an ability to design and conduct experiments, as well as to analyze and interpret data (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability (d) an ability to function on multidisciplinary teams (e) an ability to identify, formulate, and solve engineering problems (f) an understanding of professional and ethical responsibility (g) an ability to communicate effectively (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context (i) a recognition of the need for, and an ability to engage in life-long learning (j) a knowledge of contemporary issues (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	(1) An ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics. (2) An ability to apply both analysis and synthesis in the engineering design process, resulting in designs that meet desired needs. (3) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions. (4) An ability to communicate effectively with a range of audiences. (5) An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts. (6) An ability to recognize the ongoing need for additional knowledge and locate, evaluate, integrate, and apply this knowledge appropriately. (7) An ability to function effectively on teams that establish goals, plan tasks, meet deadlines, and analyze risk and uncertainty.

facilities, and institutional support (Criteria 6-8). Given the wide range of higher education institutions worldwide, ABET does not mandate specifically how a program is to fulfill the criteria; innovation is valued. However given that the path to professional registration in the US requires a degree from an ABET accredited institution ABET has an outsize impact on the discipline of engineering. Given the increasingly technological nature of our society and the role engineers play in envisioning, creating, and sustaining technical infrastructure this impact may be felt at a societal level.

This paper probes the philosophy that underlies ABET. The word "philosophy" often is seen negatively in engineering, given the highly practical, nuts and bolts focus of the discipline [5]. Here the inquiry from a philosophical perspective seeks to provide a critical examination not of the details or process of ABET accreditation, but to shed light on the underlying ideas and values and whether or not they are aligned with the goals defined by ABET.

Philosophical Framework

The ABET process of continual quality improvement (CQI) will be explored through the philosophical system laid out in the Scottish philosopher John MacMurray's Gifford Lectures [3, 4]. The choice of examining ABET through Macmurray's philosophical system is based on the centrality of Macmurray's reflection-action cycle that aligns with the continual quality improvement framework ABET has adopted. This section briefly lays out the relevant aspects of Macmurray's philosophical system.

John Macmurray was a mid-20th century philosopher who was well known for making philosophy accessible through radio broadcasts. Macmurray was a systematic thinker who was interested in the broader application of philosophy to human society rather than the more narrow questions addressed by many academic philosophers. He developed a philosophy based on thought being secondary, and in service to, action much in the way that ABET claims engineering makes actionable the discoveries of science (cf. the revised outcome 1 "*an ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics*"). Macmurray was active in many political groups since he believed that the political movements of his time—fascism, communism, and corporate capitalism—did not sufficiently value being human. Macmurray argued that the organic and mechanistic values that much Western philosophy was based on support these political beliefs and systems. Macmurray sought to develop a philosophy of the personal to complement the logical (mechanical) or organic (romantic) thought addressed by many previous philosophers. His goal in developing a philosophy based on the personal was to put primacy on the values of communities and individuals and extend the boundaries of scientific and rational thought to encompass human endeavors such as art and faith so they could stand on the same footing as rational thought.

Macmurray builds his system by exploring the forms of thinking that developed from Descartes' "I think therefore I am". Descartes skepticism was a response to the religious authority of his age since it valued rationality, or a systematic process of doubt, as the basis for belief. While Macmurray values this rationality he claims that too much doubt has the practical effect of eliminating potential good from the world. To Macmurray the view of a human as a rational, disembodied mind creates a dualism in the Western system of thought which enabled a widening contradiction between science and morality. This dualism arises from an inability to align the

theoretical and practical aspects of reason (Kant's noumenal and phenomenal). The separation between thought and action has, in Macmurray's view, helped to cause many of the problems society faced in the 20th Century.

To resolve this dualism Macmurray claims that moral choice relies upon individual freedom since one must be free to act in a way that is right. However instrumental and positivist belief systems cannot guide such choice since they are ultimately deterministic. Macmurray summarizes this tension as "*We can only know a determinate world; we can only act in an indeterminate world*." In line with Western traditions Macmurray valued individual agency, a belief reflected in the preamble to the ABET criteria: "*provide a framework of education that prepares graduates to enter the professional practice of engineering*" [6]. However for Macmurray rational thought and action must be holistically integrated with idealism that envisions what moral action is. The reason is that while purely practical reason provides the ability to act in the world, action alone inevitably leads to totalitarianism since a society that imagines "the greater good" will develop ever-better heuristics to achieve the envisioned end and this single-minded focus on an ideal drives society towards determinism and eventually totalitarianism. To compensate for this tendency it is necessary to support individual freedom so agents understand "what is right to do". This system he terms a philosophy of the personal since individual agency and community are foundational principles.

Macmurray's philosophy of the personal starts with the view of a person as an agent capable of action that creates change in the world rather than a rational, disembodied mind. In this he reframes Descartes' "I think therefore I am" to "I act therefore I am". For Macmurray "I do" must include "I think" in the sense that one must learn about the world to be able to act upon it. There are analogies with ABET through the requirements for science and math (Criterion 5a) and definitions of engineering design as a process "*in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs*" (Criterion 5b). As reflected in the ABET criteria, for Macmurray knowledge may or may not inform action; the value of any given knowledge is determined through action. It is by acting that one makes knowledge personal. Knowledge and action are distinguished temporally; action generates a past by actualizing a possibility and the knowing gained from this process illuminates possible future actions. Thus to be able to act as engineers students must study knowledge gained from others' actions and internalize it enough to inform their own actions. The analogy in ABET is found in Criterion 5: "*Students must be prepared for engineering practice through a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints.*"

Macmurray's philosophical system outlines a loop in which knowledge informs action, which in turn refines knowledge to enable better actions. This occurs in a continuous cycle as shown in

Figure 1 below. The upper center part of the cycle corresponds to acting and the lower part to knowing and/or knowledge gained through reflection. The left part of the cycle corresponds to the self and the right part to the Other, which is Macmurray's term for anything that is not self. When an agent has an intention to act it is to achieve some desired outcome by changing something in the world, and thus the future, in a way that will benefit the agent. This intention is derived from the agent's knowledge and is forward looking into the future. The agent anticipates the outcome of the action and such anticipation is not purely intellectual, but necessarily involves elements of emotion. The agent then makes a choice of the most effective way to perform the action in a way that aligns with their overall intention, what outcomes they anticipate, and their access to knowledge. Following the action the agent starts the reflective phase of the cycle. However for Macmurray the type of reflection and agent engages in is defined by attention since what the agent pays attention to informs what they reflect upon. Since humans are not omniscient we must choose which result of our action to pay attention to. By observing results of the action they took the agent then forms a mental representation of the relation between their original intention and results of the action. The agent's construction of a mental model improves their knowledge thus completing the cycle. With better knowledge the agent can improve their capacity to act and thus better align the intended results to the results of their action. Macmurray termed this the cycle of withdrawal and return [from action].

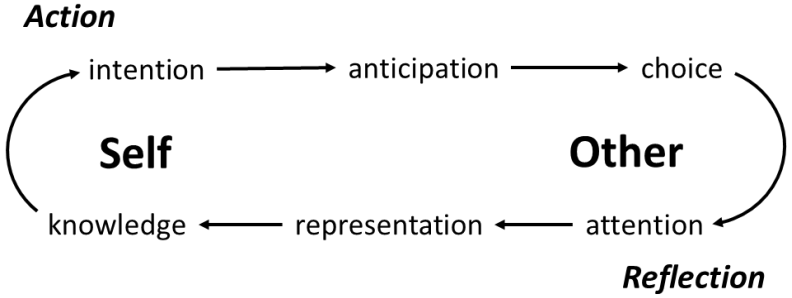

Figure 1: Outline of Macmurray's "cycle of withdrawal and return" from action.

A very similar process is given in ABET's Criterion 4 that discusses a program's need to practice continual quality improvement:

> "*The program must regularly use appropriate, documented processes for assessing and evaluating the extent to which the student outcomes are being attained. The results of these evaluations must be systematically utilized as input for the continuous improvement of the program. Other available information may also be used to assist in the continuous improvement of the program.*"

In this case the Self of Figure 1 is replaced by the faculty who teach and manage the ABET process. The Other is the program which acts upon students. Intention corresponds to outcomes and objectives, anticipation is the threshold for student achievement on the outcomes, and choice is which pedagogies are enacted in the curriculum. How the process of assessment is enacted are what faculty choose to pay attention to when measuring learning outcomes and evaluation along with the guidance provided by ABET frames the representation faculty develop of their program.

The knowledge gained through the ABET process is then fed back to refine achievement of the program outcomes and objectives.

It is this correspondence along with the focus on action as the basis of being that led to the choice of Macmurray's system to critique the ABET process. However the intent of Macmurray in framing this cycle as part of his Gifford lectures was simply to outline how a person serves as an agent, or able to act to change the world and thus the future. What Macmurray's system aims at is not simply how to act more effectively, but ultimately to be able to do what is right. It is this question of doing what is right that is explored next.

Where Does Continuous Quality Improvement Lead?

The current ABET process and corresponding criteria are designed to:

> "*…assure quality and to foster the systematic pursuit of improvement in the quality of engineering education that satisfies the needs of constituencies in a dynamic and competitive environment.*" (preamble to revised criteria).

It is worth asking towards what end these improvements are being made? The answer provided by Criterion 2 is that of better meeting the university mission, the needs of constituents, and the ABET criteria themselves. It is, however, unclear whether the CQI process outlined by ABET that is designed to improve the means of education will actually serve the desired ends. For example how should the program respond to if the institutional mission, the needs of constituents, and the ABET criteria are in conflict? Insight may be gained from Macmurray's system which addresses the various outcomes the action and reflection cycle can generate, and points to the stage of representation—where the results of actions are incorporated into mental models and schemas—as critical.

To Macmurray the representation stage is critical since an act is defined as the realization of an intention which in turn is defined through the agent's beliefs and values. The start of an act is associated with a feeling of dissatisfaction which provides the rationale to act; the agent's valuation of this feeling determines both whether an action occurs and which action occurs. Thus *a-priori* the ABET process seems to assume some dissatisfaction with the current outcomes of engineering education. The dominant narratives behind the establishment of EC2000 confirms this sense of dissatisfaction [7]. Given the impetus to act, the agent's choice of action is determined by what possibilities for action are present which in turn depends on the agent's knowledge and mental representation of the Other or in this case the degree program. For humans attention is selective so the choice to act in some way eliminates, at least at a given time, other avenues of action. Thus how faculty develop a representation of the learning outcomes in the degree program, i.e. what they pay attention to, is critical.

Macmurray frames three different ways to develop representations (i.e. models or schemas), that are shown in the expanded cycle, Figure 2. The form of representation developed by the left path is that of science where specifics or particulars of the Other are ignored and the agent generalizes the result of the action such that the representation will apply broadly. An example would be to draw from assessment general principles of education that apply to all students. The path on the right MacMurray connects to art because this representation focuses on particulars to create as detailed and accurate a representation of the specific Other at the moment that the action occurred and captures elements of emotion. An example would be using assessment to develop a rich picture of a given student's educational experience. The center path is that of the personal where the agent's concern focuses on relations with other people as individuals and this path builds community. An example in education might be using assessment to inform a Community of Practice [8]. These modes of reflection are not mutually exclusive and we can engage in more than one. Macmurray states, however, that in different societies or organizations different modes are dominant.

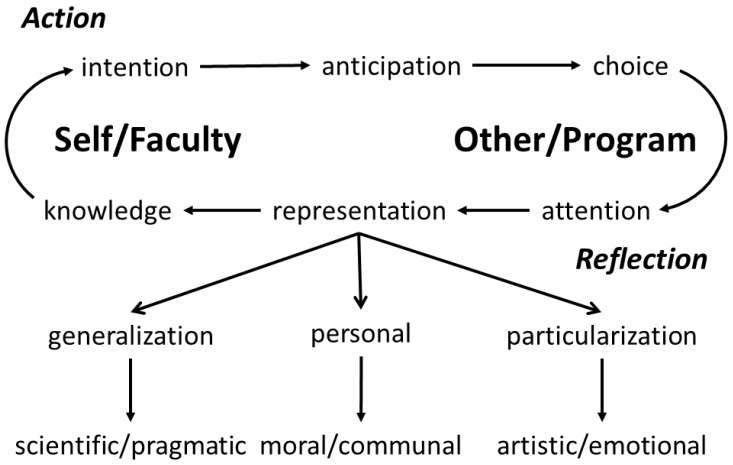

Figure 2: Expanded cycle of withdrawal and return illustrating three representational modes.

The importance of the representations we develop through reflection emerge from Macmurray's philosophical system through the principle of "the world as one action". In essence the cycle of Figures 1 and 2 is not only a series of disconnected actions and reflections taken by an individual, but can be viewed as an ensemble of continuous, connected actions of which the agent (or in the case of ABET, program) is but one part. It is through these shared intentions that individuals (programs) become bound together in a society (engineering profession). Thus the "the world as one action" applies if people or programs are bound together in action, which is what the ABET criteria effectively accomplish. The one action viewpoint implies strong interconnection, or viewing the world as a system. From this perspective as the world and humans become more reliant on technology the importance of engineers' actions increases as does the need for engineering students to obtain a more liberal education [10] that encompasses societal and human concerns. Thus which mode of reflection a program adopts has a small, but

not insignificant effect, particularly if others adopt the same mode which then steers the direction of a society. In other words, how we reflect on the results of our actions determines not just what we as individuals, but the perceptions of a community or society as well.

Which mode of reflection is appropriate depends upon the agent's intention. If the agent seeks truth—defined by Macmurray as choosing the right means to achieve a given end—then the scientific mode is appropriate. This mode addresses means only, and ultimately finds laws that are for the sake of action. To frame this in the ABET CQI process this mode of reflection would enable a program to find general principles that improve ABET's Criterion 3 outcomes. In the scientific/pragmatic mode the agent reflects on how control their own response or the response of what is being acted upon. This mode of viewing the world is one in which power matters and a society or organization based on this mode is technological and guided by efficiency. In such societies rules serve both to regulate issues of right and wrong and to maintain equilibrium in relationships; moral behavior arises through self-control. A central authority capable of enforcing cooperation is found in such systems. Philosophically Macmurray identifies the archetype of the pragmatic mode of reflection as Hobbes' *Leviathan*. Underlying this view is an assumption that the fractious nature of individuals (programs) requires a strong regulatory force in order to bind together a society (profession). Macmurray is critical of this mode since the assumption that people seek advantage does not adequately represent the better nature of humans. In other words, societies and organizations that evolve from the scientific/pragmatic mode of reflection are support predominately hierarchical rather than personal modes of existence.

However if the question the agent seeks to answer is not about the effectiveness of means, but whether or not the end chosen is satisfactory to them personally then the emotional form of reflection is more appropriate. In other words, if faculty were to assess whether changes to the outcomes improved their own satisfaction with the outcomes of their teaching, then they would be in the emotional mode of reflection. The artistic/emotional mode of reflection is one in which ideal mental representations of the world predominate. According to Macmurray a society in which this is the dominant mode of reflection is based on forms and roles as exemplified by Plato's *Republic*. Another archetype of this mode is Rousseau who assumed man in his natural state is inherently good. In a society where idealized forms and roles are held in common esteem the society advances when citizens give themselves over to these ideals; this may well represent the idealized university. Macmurray is critical of this mode of reflection as well since by focusing inwardly on the ideal, it is easy for society to mistake what should be for what is. Since such societies support an internal life of the mind they can be prone to tyranny by those who set the ideals.

Finally the personal mode of reflections addresses human relations and what constitutes a moral action. If the question facing a person (program) is "what is right to do?" then the personal mode

is appropriate. If an engineering degree program's mission and constituents defined what constituted moral action and the program assessed whether students were equipped to perform these actions, this mode would be in use. The communal mode arises when one acts for the greater community and seeks to build bonds between agents. This mode is supported by successful actions on the part of the agent that reinforce the agent's awareness of their connection to the larger world and their role in it. In other words the personal mode is concerned with basic issues of human relations which in Macmurray's philosophy is based upon four precepts: (1) caring for others rather than oneself, (2) treating all persons as individuals, (3) a recognition that each of us is only realized through others, and (4) treating relations with others as an end in itself rather than as a means to my end. Macmurray also calls this a religious mode since it reflects the fundamental tradition common to many religions we know as the Golden Rule. According to Macmurray this mode of reflection is important to develop because as we extend our economic relationships within a society we tend to depersonalize others. This mode of reflection can help us, as much as we are able, to retain the notion of persons. For Macmurray it is this struggle, to see all others as persons, that defines what it is to be human. This mode of reflection constitutes Macmurray's criticism of the Cartesian emphasis on rationality; that the rational mind can exist in isolation but as humans we cannot exist as people without other people.

Thus from the perspective offered by Macmurray's system how assessment and evaluation is performed, for what purpose, and the mental models developed by this activity have a large role in the form of the engineering profession that we all contribute to creating. The next section provides several critiques of the existing ABET criteria and the potential impacts the proposed changes to criteria three and five may have.

Critiques

This section provides several critiques of the EC 2000 process from the perspective of Maymurray's philosophy system. These critiques are not intended to say the process does not function adequately since what is adequate or not is determined by one's own point of view and personal philosophy of education. Rather the critiques are framed from Macmurray's system with its personal focus based on idealism.

Before the critiques are offered it is worth summarizing the major changes to ABET that will occur if the revisions are adopted. Note that only major additions, subtractions, or rewrites are considered since the number of small changes and their implications are quite numerous.

- The Preamble
    - Now specifies that graduates should be prepared to enter the "professional practice of engineering". These graduates should be able to participate in diverse workplaces, have knowledge relevant to their discipline, and an awareness of the

larger, global implication of their engineering solutions. It is not clear whether the preamble is as binding on programs as the criteria are.
    - Several terms are redefined including expanding the definition of sciences; defining engineering science as being used to solve problems; the definition of engineering design now includes the need to meet specifications, codes, and standards; and teams may include diverse individuals.
- Criterion 3
    - Outcome 1: old outcomes (a) and (e) have been combined into outcome (1) making clear knowledge is used for problem solving.
    - Outcome 2: the constraints (economic, social, etc.) listed in outcome (c) moved to the preamble and the outcome now states that students need to apply analysis and synthesis in the engineering design process.
    - Outcome 3: outcome (b) moves down in the hierarchy and the ability to use judgements to draw conclusions is added.
    - Outcome 4: outcome (g) moves up and a range of audiences is added to the ability to communicate.
    - Outcome 5: the old outcomes (f) and (h) are merged. The emphasis on "broad education" is lost from (h) and ethical and professional responsibility is recognized in the context of impact of engineering rather than understood.
    - Outcome 6: life-long learning in outcome (i) goes away but recognizing when more knowledge is needed and the ability to find and apply it is added.
    - Outcome 7: the ability to function on teams is expanded by stating what actions the teams should be able to perform.
    - Two old outcomes have been eliminated. These are (j) which focused on knowledge of contemporary issues and (k) which was skill and tool oriented.
- Criterion 5:
    - The curriculum now is judged by whether it supports students attaining outcomes, not by the attention and time spent.
    - In Criterion 5(b) tools from outcome (k) has been included in the requirement for 1.5 years of engineering topics.
    - Additionally the broad education language from outcome (h) is incorporated into Criterion 5(c) and inclusion of the humanities and social sciences consistent with the program's objectives is added.

  It should be noted that by moving these outcomes to Criterion 5 they are mandated to be part of the curriculum rather than assessed.

Seven critiques are offered below. The conclusion of the papers then discusses ways that the ABET process might be reconsidered from the perspective of a philosophy of the personal.

Focus on Means at the Expense of Ends

The first critique is that the ABET process focuses predominately on the pragmatic mode of reflection. This mode is used to refine means but does not address the ends for which an engineering education should serve. As currently written, the ABET criteria leave any definition of what an engineering education is for to the university mission and constituencies. In theory this gives programs the freedom to define the aims of education since they are free to select constituencies that align with their own objectives and set program goals that align with the overall institutional mission. However programs must still meet the outcomes of Criterion 3 which are pragmatic in form; i.e. "a graduate has an ability to…" Despite the attempt to provide independence to faculty—reworking the criteria were partly in response to this concern—faculty must devise additional outcomes which has a significant opportunity cost. Faculty thus have little incentive to consider or discuss the end for which their program is preparing students. The concern that emerges from Macmurray's philosophy is that over time focusing programs on the scientific mode of reflections will limit their ability to work towards their own ends.

Predominance of Scientific/Pragmatic Representations

Related to the above concern ABET strongly leans towards the scientific mode of reflection at the expense of the personal and artistic. This may be because engineering is seen to be a pragmatic discipline that had its founding in the integration of science-based processes to American industry. Never-the-less the focus on this mode tends towards an engineering profession, if not a society, that is means-focused, predominately technological, and rules-oriented. A criticism of this approach that will be discussed in more detail subsequently is the mechanistic viewpoint that can arise from this focus leads to a world (or degree program) that is almost mechanical in nature. A quote from Macmurray's writings on education illustrates his perspective [10]:

> *"The attempt to turn would-be teachers into technicians by teaching them classroom tricks is as stupid as it is ineffective…Here, I believe, is the greatest threat to education in our own society. We are becoming more and more technically minded: gradually we are falling victims to the illusion that all problems can be solved by proper organization: that when we fail it is because we are doing the job in the wrong way, and that all that is needed is the "know-how". To think thus in education is to pervert education. It is not an engineering job. It is personal and human."*

Emphasis on Professional Practice

From the perspective of the changes made to the criteria the focus on "professional practice of engineering" is both ambiguous and constraining. Ambiguous in that what professional practice of engineering is not defined. It could be professional licensure or preparation to work in an engineering firm. It is constraining in that it is unclear how the large number students who go to work in other fields [9] are well served by programs constituted under the new criteria. A purely philosophical question that should be asked of faculty responsible for ABET is to what extent a

student who achieves what we deem as competency on outcomes a-k or 1-7 has the capability to work towards the world they wish to bring about? In other words does professional preparation enhance or inhibit the agency of a graduate?

Focus on Constituents

Related to the above points is ABET's emphasis on the "*needs of constituencies in a dynamic and competitive environment*". Constituencies drive the program educational objectives (Criterion 2) which in turn drive outcomes. This is positive in the sense that it can build a sense of community and personal relationships between the program and its constituents. This can help the program connect its graduates to their role in the world. However the phrasing "dynamic and competitive" has implications for the types of constituents that are acceptable. Furthermore programs do not seem to have the freedom to define objectives that stray from the outcomes provided by ABET.

Contextualization of Ethics

The new criteria change the outcomes from understanding professional and ethical responsibility to recognizing it in the context of engineering situations. This change seems highly problematic from the perspective of Macmurray's system. Macmurray recognized that acting in a right way is central rather than peripheral to being an agent. This change further separates ethics from an integrated knowledge-action cycle to the knowledge side. From Macmurray's perspective simply understanding, now recognizing, one has ethical responsibilities reinforces the duality between thinking and acting his philosophy sought to overcome. It is only through acting that we directly confront questions of right and wrong that will enable us to improve our knowledge of right and wrong as well as develop ethical habits. For Macmurray what is important is "*How can I do what is right not how can I know what is right to do*." [3].

Furthermore what is and is not an engineering situation is not clear. From the viewpoint of "the world as one action" principle separation may not be possible. There is not an absolute truth or a right answer to most ethical dilemmas. Knowledge and action are always in dynamic relationship with the outcome determined both by reflection (knowledge) and intention. Navigating this dualism is extremely difficult and it is never an easy task to act in the right way towards others. However separating ethics from action or confining it to one part of our lives, our engineering identity, seems to have little justification.

Failure to Address Relationships

From the perspective of Macmurray's philosophy one of the most glaring omissions from the ABET criteria, both old and new, is the failure to address personal relations. To Macmurray the individual unit of humanity is not humans, but humans in relation. We do not exist as people without other people. From this perspective a key factor in becoming an engineer is our relationships with those who are responsible for our professional development. Key to being an

engineer is how well we address the personal needs of others through our engineering work. All of our acts, in our role as a teacher, a student, or an engineer are played out on a field of other agents. There are likely practical reasons the criteria do not address the form or expectation of relationship or the environment that can support them. However for Macmurray acting morally is to intend greater community for agents. If my intention is to support greater freedom and agency for others then my actions are moral. If I intend benefits for myself or my organization without regard for others my actions are immoral. From the perspective of the world as one action we are defined by our relationships that take place in communities of others and affect each other so that our intentions are always reflected back upon us. In more engineering terms we are all part of a highly interconnected system, and our intention drives feedback loops that determine the state of the system, not only for ourselves but for others.

By failing to address relationship or community in the training of engineers Macmurray might argue that it is not possible to ensure engineering practice enables moral good. This said, the new criteria are somewhat better than the old given diverse audiences are addressed in the ability to communicate as is the ability to participate in diverse multicultural workplaces mentioned in the preamble. Additionally teamwork becomes better defined which may help build community within the engineering team.

Proposed Changes Aligned with the Philosophy of the Personal

While the ABET criteria have significant flaws from the perspective of Macmurray's philosophy of the personal, there are positive features that emerge from the revisions. Several of these have been mentioned previously. One additional positive change is the merging of outcomes (a) and (e) since this shift more closely integrates knowing and acting. Another positive shift is the inclusion of language on codes and standards in the preamble. This has the opportunity to engage students into a larger community and consider how personal relations can be extended to those we do not directly interact with. Furthermore the culminating design project outlined in Criterion 5 can be seen as a way to further integrate knowledge with action.

Conclusions

This paper has outlined John MacMurray's philosophical system and presented several critiques of the ABET criteria and the proposed changes from this perspective. From Macmurray's principle of "the world as one action" the forms of reflection faculty participate in through assessment/evaluation activities impact the processes (means) of engineering education and engineering education's ability to envision/achieve desired ends. Of the modes of reflection which connect action with logic and intention, it is shown that the ABET criteria are based on the scientific/pragmatic mode which concerns itself primarily with efficiency of means but does not address or question the aims of education. This mode of reflection leads to a largely technological organization focused on power and rules. By not sufficiently addressing the

emotional and personal modes of reflection ABET potentially contributes to an engineering which is instrumental and highly means-focused. Given the overall scientific/pragmatic nature of engineering assessment, Macmurray's philosophy predicts that the common modes of engineering reflection will likely result in focusing on efficiency, the continuous improvement of means while remaining unclear on the desired ends.

Macmurray's philosophy suggests that accreditation processes aligned with the emotional and personal modes of reflection are needed if engineering degree programs are to become more aware of the aims of an engineering education. The emotional mode of reflection would help illuminate if the ends toward which ABET worked were satisfactory, and would support programs considering an ideal of what an engineer should be. Clearly such an ideal cannot be centrally mandated; the American system of education is too diverse for such a measure. However allowing faculty to consider their satisfaction with the results of their program taking into account due consideration of their population of students might lead to a more reflective accreditation process. Macmurray intended the personal/moral mode reflection to seek a "middle path" that integrates reflection with action, or one's inner life with the external life in society. In this mode actions taken to improve the program would be evaluated on whether they improved and strengthened relations within the university, a term derived from the Latin *universitas magistrorum et scholarium*, translated roughly as "community of teachers and scholars." As mentioned previously the framework of communities of practice [8] provides guidelines that might be useful for accreditation.

By focusing solely on criteria ABET has not taken full advantage of the opportunity to make substantive changes to the process of accreditation that could meaningfully accomplish the aims they sought to achieve, including encouraging innovation. By allowing programs to adopt other modes of reflection, particularly those focused on the ends they seek to accomplish, more innovative ideas could flourish. A suggestion would be to significantly reduce the outcomes to key attributes of engineers and require programs to develop their own definitions of these attributes that align with their institutional mission. Another approach is to require that with the ABET-mandated outcomes each degree program develop some small number, perhaps two, institution-specific outcomes. This would test how innovative programs actually seek to become under ABET. Another suggestion is to add language to the criteria about how inter-personal relationships are built and strengthened in the program, and allowing programs to define the forms and commitments of these relationships. Evidence indicates this approach might significantly strengthen student preparation to be engineers [11]. Macmurray would say without the ability to develop personal relationships it is not possible to work for the benefit of humanity.

In a system as widespread as ABET accreditation that serves the needs of many stakeholders it is not realistic that a critique from a particular philosophical position could or should have much influence. Philosophy in a role as truth estimation can, however, help clarify the belief systems

and claims that underlie accreditation and allow meaningful dialog among all constituents who are affected by accreditation.

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