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Critical Review and Refinement of a Professional Development Survey for Engineering Undergraduates, Toward an Integrated Tool for Reflection Across the Curriculum

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Abstract

In this evidence-based practice paper, we aim to explore considerations for supporting the professional skill development of students in engineering education particularly when surveys are utilized as the reflection and data collection intervention. Surveys are commonly used as mediums for programming or instructional change but are not necessarily approached through a research lens. We use an annual Professional Development Survey (herein referred to as PDS) developed at a large North American institution as a frame of analysis. The PDS was established in 2015 and implemented each year to enable student reflection on their role, responsibilities, and professional skill development for each of their active co-curricular experiences. By adopting a critical analysis methodology from medical education, we draw from educational literature and best practices of research design to investigate the PDS and inform additional considerations and alternatives for future rounds. Our motivation is to highlight areas of change in surveys such as the PDS that can contribute to a more transparent understanding of professional development in engineering education for the students, institutions, administrators, and researchers.

keywords Co-curricular, Experiential Learning, Professional Development, EDI, Motivation, Engineering Identity, Engineering Education

Introduction

In this evidence-based practice paper, we aim to explore considerations for supporting the professional skill development of students in engineering education, particularly when surveys are used as the reflection and data collection intervention. Research done on co-curricular engagement and competency development deploys surveys (e.g., electronic questionnaires, interviews) as the medium to elicit student reflection and/or collect insight for programming (e.g., curricular or co-curricular) change [1]–[5]. While each study may test a different educational intervention or hypothesis, most of the work done depends on students' self-reflection and reporting of their co-curricular experience and professional skills gained. Research studies may then utilize the findings along with some formal assessment data to evaluate the quality of their intervention or hypothesis. We consider the Professional Development Survey (PDS) implemented at a large North American institution. All undergraduates are asked to complete the survey annually and the results are used for internal quality assurance purposes as it relates to accreditation.

Institutions may not see surveys (e.g., PDS) as interventions that cause a change in student learning. However, if findings from the reports of survey data guide institutional decision-making, then we contend that such surveys can be considered as a research tool and embedded in a research framework, appropriately to provide a better understanding of professional development [6]. At our institution, for example, the PDS was neither created as a tool for research and reflection purposes nor utilized by the institution or faculty as a research tool.

However, the data from the PDS are drawn by the institution to inform the number of students who participated in various co-curricular activities and students' self-reported professional skill development through those experiences.

This gap motivates our work to explore important considerations for surveys such as PDS when re-imagined through a research lens. Specifically, we share considerations per key stages of research to better support the authentic professional development and collection of meaningful student data. We focus on the present caveats of the PDS survey by adopting a critical analysis lens and applying it to three key areas of survey research design, namely conceptual framework, structure, and data collection and analysis. In meeting this objective, we consider the body of literature on professional competencies and reflection in engineering education, and higher education more generally. We contextualize the meaning and purpose of, identify present assumptions held about, explore who may be disadvantaged or advantaged by the assumptions, as well discuss the implications and potential future remedies for each of the three key research stages.

A review of literature on professional learning from the past twenty years suggests a need to shift from delivering and evaluating professional development programs to methodical understanding and contextualization of authentic professional learning [6]. The development and assessment of professional competencies is an important complement to the technical competencies that are the focus of engineering curricula [7], [8]. While curricula increasingly work to integrate learning opportunities -- both in and out of the classroom -- that require such coordination, students rarely receive formal training on professional competencies [9]–[11]. Instead, such competency development is often assumed as an emergent and purely experiential learning outcome. Thus, understanding and assessing professional competency development as it evolves is an expressed concern and is often a blind spot for engineering programs [1], [12].

Theoretically, learning in co-curricular engagements is rooted in experiential learning perspectives [13]. Such learning is different from didactic and discipline-focused forms of learning that are commonly seen in curricular spaces [14]. Experience-based learning holds that: "(i) experience is the foundation of, and the stimulus for, learning; (ii) learners actively construct their own experience; (iii) learning is a holistic process; (iv) learning is socially and culturally constructed; and (v) learning is influenced by the socio-emotional context in which it occurs" [15]. Student reflection of co-curricular experience often takes place sometime after the experience is concluded. This time gap can alter the way students self-assess their engagement in co-curricular experiences. Further, the social and holistic characteristics of experience-based learning can pose various internal and external confounds to student learning. Examples include but are not limited to the students' learning styles, personality type, educational personalization, professional career choices, and adaptive competencies [14], [16], [17]. We thus wish to reimagine PDS to better align with the mentioned needs.

Methods

We aim to open discussions on potential caveats of surveys, particularly the PDS survey, that may hinder student reflection on their experiential learning as it occurs year-over-year, and thus limit our understanding of professional development among engineering undergraduates. Using a

critical analysis lens, we highlight how PDS, and more broadly, curricular and co-curricular programming might change to better facilitate student reflection on their professional skills.

Data Collection Instrument

The PDS was established in 2015 and is conducted through an online survey once at the end of each year to enable student reflection on their roles, responsibilities, and professional skill development for a variety of co-curricular experiences. Students who have participated in at least one co-curricular activity are asked to complete the survey by first identifying the type of co-curricular activities in which they participated (e.g., student club, technical work experience, non-technical work experience, service, study abroad, and others). An example survey for the Technical work experience stream is provided in Appendix. For each activity that they report, students are then asked to provide additional detail about the experience, including the:

- Semesters the student engaged in,
- Curricular courses relevant to the co-curricular experience,
- Types of professional skills developed out of a list of 10 presented by the survey which includes “Critical thinking/problem solving", "Engineering design, including use of relevant codes/standards", "Foreign language", "Use of appropriate computer technology", "Use of engineering tool", "Oral/written communication", "Teamwork/collaboration", "Leadership”, "Professionalism/work ethic/integrity", and "Project/time management,
- Description of role/responsibility within the activity.

Critical Analysis of PDS Survey Adapted from the Seven-step Model in Medical Education

Using a critical analysis approach that is grounded in critical theory, we aim to re-evaluate the PDS survey in the context of a few common stages of research design [18]. By doing so we examine and critique the co-curricular culture that the engineering students participate in to gain professional skills. We use this framework to inform some of the limitations and areas of improvement surrounding the PDS survey to fulfill student reflective learning, quality assurance purposes, or drive change. Critical analysis has been used in pedagogy and scientific areas [19], [20] where the neutrality of knowledge is rejected, justice (e.g., pedagogical or societal) is considered, and the participating individuals (e.g., students) are seen as subjects rather than objects. We use the seven-step critical analysis framework previously applied in the domain of medical education to gain a more holistic view of PDS limitations through evaluation of the PDS survey against the common stages of research [21].

We focus on important stages of research that are universally established and deemed as an integral part of any study, namely: a) conceptual framework, b) research structure such as questions and participants, and c) data collection and analysis. For each research stage, we aim to evaluate the PDS survey by adapting the seven-stage model [21] as follows:

1. Name the practice (stage of research design) (step 1 of the seven-step framework),
2. Summarize the purpose of the research stage (step 2),
3. Uncover assumptions about this research stage relating to the PDS survey and professional skill development (step 3),

4. Identify individuals who may benefit and/or be disadvantaged by current assumptions of this practice (steps 4 and 5),
5. Identify implications of assumptions and potential society level patterns (step 6), and
6. Conceptualize alternatives that may alleviate some of the current limitations (step 7).

The remainder of this paper details our critical analysis of the PDS survey using the above six steps for three main stages of research, namely conceptual framework, research structure, and data collection and analysis.

Critical Analysis

Conceptual Framework

Step 1 – Practice: Conceptual framework can be considered as the lens through which research is set up and findings are analyzed. Rooted in educational philosophy, conceptual frameworks may broadly belong to more traditional (e.g., positivist) or reformed (e.g., interpretivist) schools of thought [22]. An interpretivist perspective recognizes that there are multiple knowledge constructions and realities around how students learn, perceive the world, and reflect. Alternatively, a positivist perspective holds that high merit learning and reflection are a set of absolute constructs and realities that are external to individuals and their variable perceptions. An interpretivist takes students on an inward journey and appreciates their different ways of knowledge construction. A positivist on the other hand requires students to look outward and obtain and conform to external reality (e.g., behaviors, attributes).

Step 2 – Purpose: The purpose of conceptual frameworks is to help establish the positionality and goals in pedagogical research and uncover how individuals and their ways of interactions are viewed and interpreted. They are an integral part of social science research and consider [23]:

- "What epistemology-theory of knowledge embedded in theoretical perspective--informs the research (e.g., objectivism, subjectivism, etc.)?
- What theoretical perspective-philosophical stance lies behind the methodology in questions (e.g., positivism and post-positivism, interpretivism, critical theory, etc.)."

Step 3 – Assumptions: A primary assumption held towards conceptual frameworks is that they are the same as research questions and so are often hidden or misunderstood by individuals in educational settings [22], [24]. In co-curricular programming and the design of reflective surveys such as the PDS, conceptual frameworks can play an important role in how findings are interpreted and learning and advising are shaped.

Step 4 – Impact of assumptions: Neglecting the conceptual framework in co-curricular reflection and PDS survey can as a result pose challenges to how educational interventions are moderated and utilized by the individuals who get to participate in educational settings. Engineering faculty or staff that advise co-curricular programming or students and practitioners who come to engage in co-curricular activities may adopt different (e.g., interpretivist, positivist) models of learning that may be incongruent with one another. The clash of interpretivist and positivist world views could ultimately have consequences on the student learning experience and outcomes. For example, institutions and surveys such as the PDS may maintain a subjective and interpretivist

stance by asking students to self-reflect on their roles to define and re-define their professional skills through co-curricular engagements. Yet, the supervisor or team with which the student engages may discredit or disengage some of the student's professional skills based on a positivist lens (i.e., does not know how to use a tool because the student exhibited behaviors that did not match the criteria supervisor had in mind). Or, students themselves may perceive that there is a "right answer" and thus forgo an interpretivist lens for a positivist one to align with much of their academic experience. If the voice of academic administrators or supervisors is echoed in every student's co-curricular engagement, this may lead to students':

- Misunderstanding or uncertainty about their professional skills, causing students to swap their understanding of their skills with the voice of administrators,
- Lack of opportunities and practice in the student's weaker facets of professional skills and hence no development.

Step 5 – Implications: The dichotomy of conceptual frameworks or more broadly pedagogical world views such as interpretivism and positivism may remain because both make some compelling arguments, challenging academic practitioners of what perspective to take. One argument is that an interpretivist lens that appreciates the diverse internalization of skills by students could motivate the more creative and authentic formation of professional skills in students as compared to a yardstick positivist approach. On the other hand, there may be considerations on the degree to which students have the autonomy to form and define their professional skills. This is because students are inherently novice learners and may not realize the complexity of authentic engineering problems, and the professional skills and ethical responsibilities that are used as part of problem-solving.

Step 6 – Alternatives: Deciding on a perspective may be difficult but educating about the existence of different conceptual frameworks is possible. Students and even academic practitioners may carry out their curricular and co-curricular duties without ever noticing or acknowledging such perspectives and their clash thereof. As a remedial alternative to neglecting conceptual frameworks altogether, it may be useful to acknowledge multiple epistemological and conceptual perspectives in PDS or more broadly curricular and co-curricular programming [22]. This is because the quality of students' professional skill development can be dependent on the conceptual and pedagogical lens that is adopted by the learner(s), supervisor, and other individuals involved in a learning environment such as a co-curricular experience [6].

The PDS survey can in its basic form provide insight to engineering education researchers around the common conceptual perspectives taken. The PDS survey for instance can elicit from administrators and students to share their perceptions and feelings/values towards assessments across different activities. Analysis of reflections can illustrate the majority and diversity of perspectives taken from an individual up to a disciplinary group and program level. For example, the PDS survey can ask:

- Administrators share the major assessment they have created for an activity (can be curricular or co-curricular) and discuss their positioning around evaluation criteria and learning outcomes. The PDS can ask if the administrator is comparing student performance against a pre-existing set of behaviors and profiles of deliverables that can be replicated by diverse student groups or a set of adaptive criteria that shapes its meaning through interactions and negotiations with the students themselves,

- Students share the major deliverable created and assessment obtained for an activity (can be curricular or co-curricular) and discuss their perception of the assessment values and constraints. The PDS can ask if the student faced any challenges when trying to understand and meet the expected learning outcomes of the assessment and whether they were shared with the student during student practice and before the evaluation was being made.

To complement appropriate student reflection on conceptual frameworks, institutions and the industry can further recognize and formulate their activities and associated assessments, so they are inclusive of different conceptual frameworks. Educating administrators to design curricular or co-curricular spaces with an awareness of conceptual frameworks could consequently lead to a more connected engineering education experience for students. Faculty, for instance, can learn to construct or identify conceptual frameworks in their courses to connect them better to complementary activities housed in co-curricular spaces. More holistically, the institution and industry can attempt to develop assessments that are adaptive and can take on different conceptual frameworks depending on student objectives and characteristics such as learning styles [16]. Such bold realization, however, requires appropriate training and understanding of how assessments and hence teaching and learning change depending on the conceptual framework taken for all individuals involved (e.g., administrators, students).

Research Structure

Step 1 – Practice: Complementing the pedagogical/philosophical perspectives are the structure (e.g., research question, participants, and their way of participation) that shape the research. The research structure can be considered as the detailed plan of steps taken throughout the research, with the overarching goal of answering a research goal. To study the research question, participants such as students are needed to be either observed in their natural setting or before, during, and or after the implementation of a research intervention. In engineering education, qualitative, quantitative, and mixed methods research structures are deployed for studying a research question of interest [25].

Step 2 – Purpose: The purpose of implementing and following a research structure is to scope down the research and cue the main variables involved. The research steps or methodology ensures that the procedure is as rigorous and reproducible as possible and helps in collecting and analysis of variables that best map to the research questions and goal of a study, appropriately [26]. Participants in engineering education research often play an active role in driving change and serve as subjects, rather than objects of research. This suggests specific care must be put when outlining who gets to participate, how participation is made, and for what overall purposes.

Step 3 – Assumptions: A primary assumption held towards the research structure is that it rigorously and comprehensively captures the questions and objectives of the research and is well linked to the participants recruited and their way of participation. Research questions in the context of the PDS survey can consider: 1) what can we do to help the students have an improved experience and reflection on their professional skills post co-curricular engagement? and 2) how can student responses from the survey help inform programming (both curricular and co-curricular) change? The participants are primarily students, who engage in co-curricular

activities and the survey afterward to self-reflect and shape their professional skills. At our institution, the PDS survey does not have any specific research question but follows a research structure like Figure 1. The PDS survey assumes engineering students who had completed at least a co-curricular experience in a given year to respond to the survey and report on their professional skill formation and work performed. Another known structural challenge with survey-based research is confusion, deception, or deflection. Students may forget about the details of the work they completed if the survey is conducted months after the experience. Students may also not see any direct educational benefits or academic or financial rewards from completing the survey. In other circumstances students may find responding to survey questions in a certain light to bring them benefits, leading them to deception and not reporting their work with honesty or accuracy. Alternatively, students may not exactly know how to reflect, what to reflect on and what to take from the survey reflection experience.

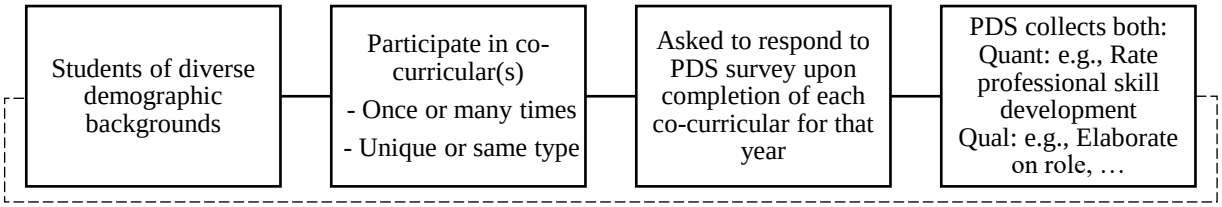

Figure 1. PDS Survey Research Structure Currently Missing Synthesis of Data as shown in dashed lines

Step 4 – Importance of assumptions: Such assumptions bring about positive and negative outcomes for individuals. Often only a fraction of the population may respond to the surveys and not in a detailed fashion, and so the findings drawn from surveys can be inaccurate or misrepresent the entire population. Students who participate may gain some benefit from the reflection in the PDS survey, and the institution may benefit from the student insight, though not accurately representative of the entire student population. However, students who do not participate in co-curricular activities of any sort do not get to respond to the PDS survey and lose the chance to reflect and share their experiences with the institution. Further, students may be unclear about what is being asked and take a very holistic or granular view towards responding to survey questions. When asked about their role in the PDS survey, we find some students focus on the details of the tool or intervention they had used, while some others may reflect on their position as part of a larger team or the most important problem they had solved. Students may further not be honest towards their responses. For example, in the PDS survey some students do not put time and effort to respond to survey questions in detail or do not respond to the survey for each of their engagements, and instead provide surface-level and uninformative responses.

Step 5 – Implications: The broader implication of a misaligned research structure is that intuitional and student efforts are likely to go to waste. Developing research question(s) and structure based on records data can be challenging especially with large-scale institutional surveys that collect an array of variables and data points and purposefully seek to be open-ended and exploratory. Further, students have different levels and views of understanding towards their professional skills, and combined with their personality their perception and communication of skill formation may be different (e.g., aggrandized, underscored) [14]. For example, we see that some students who participated briefly may report acquiring all or a high number of skills, and

some others who were engaged in a similar co-curricular environment report only a few skills even though they had participated for much longer terms. The students' self-confidence and belief combined with their cognitive abilities and self-assessment standards may therefore blur the picture painted around students' professional development by self-reported surveys. Such differences may thus make analyzing students' responsibilities within and between co-curricular activities difficult. As such, there need to be mechanisms to establish a shared understanding of professional skills and require the population which includes all of the students who did or did not engage in co-curricular activities to self-report their experiences and concerns.

Step 6 – Alternatives: As a remedial alternative, efforts can be put into making the research structure less dependent on indirect (self-reported) and more on direct (measurable performances in actual co-curricular setting) measures of data collection. Many students engage in co-curricular activities but may not necessarily respond to the annual PDS survey that is conducted sometime after the experience was completed. On the other hand, students who engage in co-curricular activities and respond to PDS get to reflect on their learning. Having synchronous measures for the collection and analysis of student reflection on their professional development can lead to more timely feedback for both the institution and students. When the institution collects student artifacts and associated reflections in real-time, an authentic reflection experience is created for the student and timely evidence is gathered for the students' potential professional development portfolio. As such, the timing of data collected is better to be immediately after or as close as possible, while students will best remember the details of their roles, responsibilities, and learning moments. Further, institutions may want to acknowledge and account for gray areas of co-curricular recruitment and participation. If, for example, certain demographics repeatedly refrain from participating in co-curricular activities, this may suggest that either the co-curricular infrastructure or the administrators who come to engage in that infrastructure may be affecting the educational experience of certain groups.

We should also note that most student co-curricular engagements happen in teams and so participation and reflection change from a personal (commonly seen in curricular activities) to a team-based and social experience. The way student engages with reflection through the PDS survey, therefore, needs to account for the social dimensions of students' experience. It is established that inputs to teamwork include both individual contributions and ones made collectively by the team [27]. Productive teams, therefore, exhibit professional skills that are not confined to individuals but run at a group level. Examples include supporting team relationships and enabling the smooth operation of joint work. Yet there are few instructions around such facets in both curricular and co-curricular spaces [11], [28]. Surveys such as PDS can provide a medium for student reflection on teams' professional skills as well by enabling data collection during co-curricular experiences rather than at the end of the academic year, eliciting student skill acquisition reflection on both individual and team levels, and triangulating student responses within teams as a way to combine students' assessment of self with peers, leading to a more shared understanding of professional skills gained.

Data Collection and Analysis

Step 1 – Practice: The final research stage of research data collection and analysis explores the brevity and quality of results. Data collection in survey research often takes on qualitative and

quantitative forms, though with the emergence of educational technologies more visual and natural forms of data collection are also becoming possible. Surveys such as the PDS collect a mix of expressive data in qualitative and quantitative forms, with larger use of quantitative data collection for a quicker response rate and more convenient data collection and analysis [25]. Depending on the survey data collection method adopted, analysis of data may also take on qualitative and/or quantitative forms using descriptive, inferential, and content analyses.

Step 2 – Purpose: The purpose of data collection and analysis is to systematically and continuously gather information about a phenomenon. The phenomenon could be a pedagogical goal that may examine a research intervention or a naturalistic setting. Systematic information gathering about a phenomenon requires constructing relevant variables and appropriate measurement and allocation of the units to the variables [26].

Step 3 – Assumptions: By conducting data collection and analyses, we are often able to define research questions and find trends and patterns from an individual up to the population level. But there are arguably infinite ways to define variables and criteria for pedagogy and research on professional skills. The PDS in its current form provides insight into student attendance, a selection of professional skills, and a description of their responsibilities and roles in the co-curricular involvement. The PDS lacks clarity about what the variables constructed for professional skills are and how they can be assessed as competencies. Another common assumption in data analysis with survey data is that we are taking the face value of student responses and not accounting for variations in student interpretation and understanding of survey constructs. To provide an example, the PDS survey presents students with a set of 10 skills to select when reporting their learning in a co-curricular experience. Skills such as “Foreign language” or “Teamwork” may be relatively easier to describe but skills such as “Critical thinking” may have very different meanings for students of different abilities and performance levels.

Step 4 – Impact of Assumptions: Such assumptions can again pose both benefits and disadvantages to the individuals involved. If for example, the PDS survey aims to take a closer look at students’ professional development before and after each co-curricular experience and throughout their 4-year program, one may argue some potentially useful components are missing in the data collected. First, PDS, as it stands, elicits information about each co-curricular experience in isolation, and does not offer questions or reflections that allow students to compare their participation across their co-curricular activities. The PDS does not provide training or exemplars on what each professional skill is about and what is deemed as a passing versus failing performance level. Further, the PDS asks students to note the courses that they found relevant per experience and select which skills out of a list of 10 (list held constant) they had gained upon participating in different types of co-curricular activities, without self-assessing or reasoning how well or to what merits they obtained that skill.

Step 5 – Implications: The broader implications of a misaligned data collection and analysis approach are that both student reflection and institutional quality assurance programming can be easily misconstrued. The survey wording and terminology used, the information presented and how student data is collected can all impact both how students come to make meaning of their co-curricular activities, themselves, and how institutions interpret students’ meaning-making.

Because co-curricular activities often focus on problems with boundaries that are unknown to the learner and even the problem designer (e.g., supervisor or assessor), there lies subjectivity in quantifying objective criteria and performance levels around professional skills. We would like to explain this through an example as shown in Figure 2. Imagine two instructors from the same course (e.g., thermodynamics) or supervisors from the same team (e.g., internship) who wish to evaluate a professional skill such as communication within the assessment(s) of their activity (can be curricular or co-curricular). Even though the pair are working on an identical topic, they may come to regard, define, manifest, and evaluate a professional learning outcome such as communication in variable ways, painting different pictures of student competency development around the same skill. Not to forget, both administrators may even adopt the exact view towards a skill such as communication but in practice have different expectations or mechanisms around differentiating between novice and expert communicators.

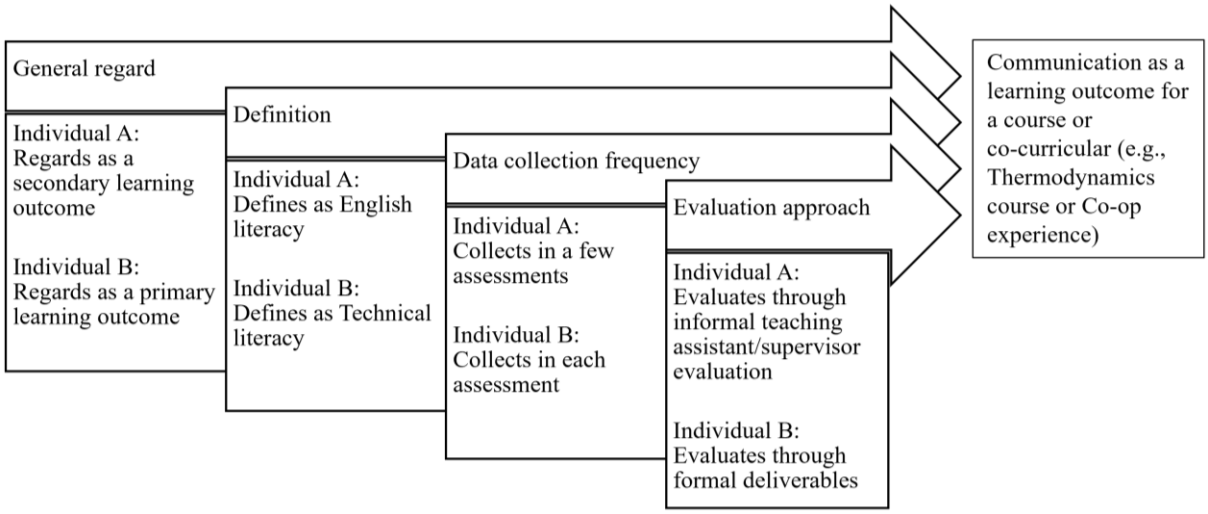

Figure 2. Example of ways in which professional skills can be constructed and evaluated differently by individuals in the same space

Step 6 – Alternatives: Ultimately, the pedagogy and assessment of professional skills (e.g., through the PDS survey) is tied to all three key research stages and especially dependent on the shared values constructed between the individuals involved. Institutions and the industry should be wary of what they signal to the students, and that professional development is neither “fake it till you make it” nor “fake it and you’ve made it”. Professional development is prone to be distorted and or confused. For example, a student may sound professional by following all the rules of trade on their project’s façade and masking inappropriate or unethical parts of their work. Institutions and administrators may instead want to accept that students are inherently novices because they lack experience and failures, and exposure to ethical issues and dilemmas to appreciate the intricacy of professional skills. Moreover, professional skills are intertwined with soft skills and personalities, putting some groups into a disadvantaged position. Answering what fuels professional development is challenging because many traits and attributes qualify as professional skills [8]. For example, professional skills may be seen as the development of the student’s motivation to become a lifelong learner, metacognition, self-regulation about own strengths and weaknesses, skilled voice and persona, or moral conduct and ethics.

Employers find further competency development of students during college necessary [29]. There may be, therefore, benefits to re-structure the points in time in which students can participate in co-curricular activities and when student response from PDS is collected. Using exemplars or online training modules at the beginning or during an experience and using reflection via PDS survey at the same time may better help to socially construct professional skills among students and administrators and enact learning in students. The reflection gathered from the PDS can also take on different modalities, such as submitting a video reflection to a prompt or asking students to answer an interview question.

We know self-regulation plays a key role in improved learning [30], so we may need to change the nature of the PDS survey to allow students to not only reflect on what they did and the skills they gained but to reason why they believe they obtain a reported set of skills and piece it with their other prior experiences. Students need to find a sense of intentionality and autonomy in their co-curricular engagement and so more work needs to be done by the institution and/or accreditation agencies such as ABET to clarify the breadth and depth of competencies the students can develop [13].

The PDS survey currently only captures students' reflections about a co-curricular experience months later after they had completed it in one sitting. Surveys can act as check-in points throughout student experiences, harmonizing and bringing together curricular and co-curricular experiences. This could allow treating all student experiences as more of "real-world industry" experiences by bringing in instructors and supervisors to communicate and reflect on a student's learning trajectory socially. Moreover, the institution and faculty can play a role in creating spaces in curricular courses that allow students to link what students learn to the different types of co-curricular activities they had recently engaged in. What is necessary, however, is to document assumptions in pedagogical objectives and research interventions to construct a social and shared understanding of professional development.

An important piece missing in reflective surveys are variables that serve as confounds to student learning such as class size faculty to student ratio and interaction frequency [31]. The institution can create learning analytics dashboards to track as many of these confounds happening to each student in real-time. In addition, the power of machine learning and artificial learning algorithms can be harnessed to conduct a more advanced and systematic analysis of students' closed- and open-ended survey responses [2], [32]. But most critically, the assessment of students' professional development should not just have a localized course view but encompass a more holistic undergraduate lens that better connects curricular and co-curricular experiences to the real world that awaits graduating students [33].

Conclusion

Professional development happens everywhere and not just in certain artifacts or assessments in an experience. The cultural values, informal interactions, rewards, and punishments all come to shape students' perceptions, identity, and professional conduct. Surveys such as the Professional Development Survey (PDS) can be an affordable and useful remedy to the challenge of promoting student engagement and reflection on their co-curricular engagement and professional development. However, efforts should be made to make more informative, personalized, and adaptive surveys to increase student participation, motivation, and scaffold reflective and active learning promptly. In addition, there needs to be a discussion on the extent to which the conceptual framework of professional development and its assessment needs to be constructed externally (I.e., through a positivist lens) or varyingly by the participating individuals (I.e., through an interpretivist lens). The engineering education community may therefore want to further explore the role of professional development training that transcends beyond graduation by considering how both curricular and co-curricular structures in engineering education can be modified for learning based on students' constraints, learning styles and needs.

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Appendix: Professional Development Survey for Non-Technical Work Experience

Non-Technical Work Experience

(Items with * are required)

*** Company Name:**

*** Semesters :**

- ☐ Fall 2020
- ☐ Winter 2020
- ☐ Spring 2021
- ☐ Summer 2021

*** Length :** -- select an option --

*** Work Type:**

○ Part time ○ Full time

Hourly pay rate? -- select an option --

Briefly describe your overall responsibilities

Were any of the following courses relevant to your work experience? (check all that apply)

*** Check which of the following competencies you developed or improved during this experience:**

- ☐ Critical thinking/problem solving
- ☐ Engineering design, including use of relevant codes/standards
- ☐ Use of appropriate computer technology
- ☐ Use of engineering tool
- ☐ Oral/written communication
- ☐ Teamwork/collaboration
- ☐ Leadership
- ☐ Professionalism/work ethic/integrity
- ☐ Project/time management
- ☐ Foreign language

Provide a brief explanation of your response to the question above: