Development of Professional Competency through Professional Identity Formation in a PBL Curriculum

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***Abstract*— This research paper describes a study of the student professional competency development as experienced by students in an upper-division project-based learning (PBL) curriculum that emphasis the development of the student professional identity. The specific professional competencies of focus for this study, based on the ABET student outcomes in Criteria 3, are: 1) an ability to function on multi-disciplinary teams (3.d); 2) an understanding of professional and ethical responsibility (3.f); and 3) an ability to communicate effectively (3.g). The motivation and background for this research is to build on existing efforts and research in bridging the professional competency gap between the ability of current graduates and the current and future needs of the engineering profession. This research work focuses on the experiences of students at a two-year, upper division, PBL engineering program. During the design of the PBL program, an approach for professional identity development was created and implemented. It builds on previous work from what is currently understood about how students develop professional competencies in engineering education and the role that professional identity formation has in developing the professional competencies. The approach and its curricular elements will be presented as part of the research paper. The student development was evaluated through two quantitative instruments developed for this research. One instrument focused on professional competency practice as an individual, and the other focused on professional competency practice in a team setting. Results of this study show an increase in professional competency performance for students completing the PBL program. The non-PBL group showed no overall growth in performance. Neither group showed growth in importance from before to after completing their upper-division experience. The quantitative study results will be presented and discussed as part one of a two part mixed methods study.**

Keywords— project based learning; professional competencies; reflection; professional identity; outcome-based

I. Introduction (*Heading 1*)

Engineers are a vital part of developing technological solutions and innovations to meet societal needs. This role is becoming even more evident as we experience rapid rates of change in technology and the ways it integrates into every aspect of daily life. Accordingly, engineers can no longer solely focus on technological solutions that are primarily based upon functionality and profitability; they are now expected to develop complex, comprehensive solutions that incorporate environmental, societal, ethical, and sustainability considerations. Yet, the way engineers are educated has not changed to the same extent. Engineering education is still focused on transmitting technical knowledge. While this approach provided a level of student knowledge and ability development that met the educational needs of the profession at a point in time, the expectations society has for practicing engineers have changed and so must engineering education if it and the profession of engineering are to play a lead role in society for current and future generations.

This means shifting the student development focus to go beyond just technical competencies to developing the whole engineer. Goldberg and Somerville [1] state that "helping students develop as complete human beings, with whole minds and bodies engaged in learning, who are practiced in understating in a variety of ways, is the education mandate of our times." Not only will this better develop engineering students to meet the needs of their profession and society, but also it should increase the appeal of engineering education to a broader spectrum of student intelligences and thus increase the pool and the diversity of new engineers [1].

This paper focuses on the professional identify development of students as an approach for developing the whole engineer and their professional competencies. The specific professional competencies of focus for this study, based on the ABET student outcomes in Criteria 3, are: 1) an ability to function on multi-disciplinary teams (3.d); 2) an understanding of professional and ethical responsibility (3.f); and 3) an ability to communicate effectively (3.g). ABET developed these outcomes in 1997. However, little has changed in engineering education since that time.

The student development of professional identity takes place in a project-based learning (PBL) program. PBL continues to emerge as a pedagogical model in engineering education [2]. The program is a two-year, upper-division, completely integrated PBL model of engineering education that is a collaboration between a midwestern community college and a midwestern university [3]. The program has 75 graduates to date and has earned ABET-EAC accreditation.

II. Background

The upper-division PBL program began in 2009 as an adaptation of the Aalborg PBL model to meet [4] the need for

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change in engineering education [3]. It was designed to address the three interrelated domains of professional, technical, and design competence [5]. Design projects became the central theme upon which design learning, technical learning, and professional learning took place [6]. Each semester, students select from several options for engineering projects from industry clients. Based on the project selected, students are placed into teams. With the guidance of a faculty mentor, students complete the design process from an initial scoping phase to a final deliverable. Students acquire skills in engineering design, practice ideation, manage resources, and produce products. Integral to the design is the acquisition of technical knowledge required to complete the design. Faculty members scaffold the self-directed learning skills students will need upon graduation to independently acquire the technical competence they will need as practicing engineers [5]. The third domain of professionalism is highly integrated into the design work. Specifically targeted are written communication, verbal communication, project management, entrepreneurialism, lifelong learning, professional responsibility, personal marketing, and inclusivity. Students, working with faculty, characterize their initial competence level in each area on a scale from deficient to exemplary [6]. They then write improvement goals and action plans followed by a self-monitoring of goal progress.

III. Professional Identity Development

The process of developing professional competencies is both about developing the competencies themselve as well the ability to succesfuly use them in the professional workplace. The student acquisition of professional identity has been identified as an important factor in the adaptation to the professional workplace [7] and for its potential in meeting the needs of the engineering profession [8, 9]. Dehing, Jochems, and Baartman [10] stated that professional identity formation should be the aim of engineering education curriculum and cite several recent studies that suggest this [11-15].

Professional identity is more than just knowing professional competencies; it is the basis from which individuals have the ability to create a narrative that they continue to construct, use and refine [16] in their educational and professional careers, to better position themselves in relation to the profession [14]. Their identity is the base from which the students act out professional competencies. In the identity develop process, Dehing, Jochems, and Baartman, found that the professional identity development process has both a social and individual dimension [10, 17-19]. If identity formation is both an individual and social process of students becoming engineering professionals, a standard four-stage model of role acquisition can be used to develop a curriculum to create this process acquiring the value for professional competencies [8]. Thorton and Nardi [20] proposed that the identification within a professional role is a developmental process where the student goes from having an idealized perception of the professional role to a more personalized role that aligns with his or her own values and goals. They use the term "role acquisition" to describe the process for developing a professional identity through a four-stage process: 1) Anticipatory Stage, 2) Formal Stage, 3) Informal Stage, and 4) Personal Stage. It is the basis for the professional identiy development in the PBL curriculum:

Anticipatory Stage: Individuals start with a highly idealized understanding of the role of the profession. It is very generalized, and usually very stereotyped, concept of the professional role they are entering. It is not based on the normative standards or professional competency expectations of the professions. Instead, the expectations are often based on the perspective of members in the society as a whole. This leads to individuals often having an incomplete understanding of the professional role for the career they are entering.

Engineering students often enter programs with idealized knowledge of the daily work life of engineers [18]. Student professional identity is generally formed by interactions with their relatives and friends [8]. The degree of the accuracy sets the initial trajectory of the student's professional role development. Inaccuracies at this point can be detrimental to the individual's development.

Formal Stage: Individuals undergo formal learning experiences with the purpose of learning the duties, responsibilities, and knowledge for a professional role. A shift begins in viewing the role from the outside to experiencing it as an "incumbent." Understanding and expectations for the role now come from individuals and peers in reciprocal roles. They also come as individuals themselves experience responses from others in regards to their professional performance. Expectations at this point are generally formal and explicitly stated. The individual often views them as "a set of must behaviors." These formalized expectations focus more on the "behaviors, knowledge, and skills" of the individuals in the role acquisition than the actual attitudes held by the individual. This stage appears to most as a process of the individual conforming to the professional role.

Engineering education primarily focuses on this stage of role acquisition through formal and traditional educational methods as part of the intentional learning outcomes of the curriculum [21]. This approach alone is generally identified as inadequate in preparing students for their professional engineering roles [22].

Informal Stage: Individuals also encounter the unofficial or informal expectations associated with the professional role. They may align with or contradict the formal expectations. In contrast to the formal stage, role expectations are transmitted through informal interactions with both colleagues and individuals in reciprocal roles. Peers and colleagues have the greatest credibility during this stage. Expectations become more of the "mays" of the profession than the "musts" found in the formal stage. These expectations tend to be more "implicit and refer to the attitudinal and cognitive features of role performance." [20] This stage is where the individual starts shaping or adjusting the role to fit her individual perspectives and desired outcomes versus her conforming to the role in the formal stage. In engineering education, these are often the accidental competencies and incompetencies developed by the students in the curriculum [21].

Personal Stage: As individuals encounter the different role expectations of the earlier stages, they eventually reach a point in their development where "personal role expectations develop." Individuals begin the internalizing of the professional role and attempt to align it with their values and goals. This is the point that their identity as an engineer forms and continues to develop with repeated experiences of the cycle. Thornton and Nardi [20] state that this final stage, in role acquisition, cannot occur until the individuals experience the various expectations of the earlier stages.

At the heart of this experience is a sense-making process that the engineering students must undergo as they grow from their highly idealized model for an engineer at the beginning to internalizing the role as part of who they are.

Ibarra's [23] three basic processes for the development of professional identity add to these four stages:

Engagement with professional activities: professional competencies are an important aspect of professional identity. Individuals build their professional identity through activities associated with the use of the professional competencies.

Developing social networks: identity development is a social process. Steps 3 and 4, from the Role Acquisition model, are about the formal and informal interactions in the student social networks as they acquire the ability to perform competencies. The interactions are reinforced as they are practiced.

Sense-Making: as with the Personal Stage of the Role Acquisition model, students must go through the sense-making process of coming to terms with professional competency expectations of the profession as it compares to their own personal beliefs and goals.

An engineering curriculum focused on developing professional competencies should offer multiple opportunities for students to engage in these processes. Passow [24] identifies the need for utilizing the "context of professional practice study of ABET competencies". Sheppard, et. al, [13], in Educating Engineers, identifies the need for professional practice or a "spine" where students experience "practice-like" experiences as a central component to the educational process, thus enabling students to "move from being passive viewers of engineering action to taking their places as active participants or creators within the field of engineering." Through this professional practice students will develop the professional identity of an engineer.

PBL and reflection activities, as part of the curriculum, have been identified as an instructional model that can be readily adapted for developing an environment that faciliates students achieving the desired professional identity and professional competencies competency development desired in engineering students [25, 26]. Several prominent publications identify the use of PBL as a critical component of transforming engineering education to develop the necessary professional competencies and the identities of engineering students [2, 13, 26, 27].

IV. PBL Professional Identity Cycle

The incorporation of these processes and curricular elements creates a curricular approach best described as a circular student development cycle. Ibarra [28] and Marcia [29] identified that professional identity development is, by its nature, a cyclical process of exploration and reflection. The proposed professional competency development cycle purposefully incorporates the four stages of the Thornton and Nardi [20] role acquisition model and embeds them in a professional practice spine of a four-semester design sequence in a PBL curriculum.

Each semester, students build upon the professional competency knowledge of the previous semester. The professional identity development cycle starts directly with the anticipatory stage at the beginning of every semester. Students create a professional development plan in which they reflect upon and identify where they are in regards to their understanding of and ability to perform the professional role of an engineer. Through a faculty-guided professional development self-assessment process, each student identifies:

- their current professional performance and abilities,
- their professional growth goals for the semester, and
- what planned activities they will participate in for the coming semester to achieve their professional development goals.

Throughout the semester, in the context of industry projects, students experience the formal and informal stages of their role acquisition. The formal stage is centered on the PBL program's weekly professional development seminars. The first day of the week starts with a session called "seminar" where all students and staff participate in a formal structured seminar on a relevant professional development topic. On Wednesdays, this topic is a structured part of the team's two-hour meeting with their project mentor. In this meeting, a discussion is conducted on the development of the project, but just as importantly the discussion also focuses on the professional development of the individuals in the team as it relates to that week's professional development topic. The week ends with each student reflecting in a journal on their development, including their professional development. The entire week's professional development activities are about formalizing the expectations around a specific professional engineering competency and for the students to practice it in the PBL program.

The program's formal professional development seminar, the weekly reflection structure, and the team structure are all designed to set up the informal stage and guide students towards the intentional professional learning outcomes and avoid the accidental incompetencies. As students look to adapt the expectations of that week's professional development seminar to fit their own individual perspectives, their peers have all heard the same message around professional competency. This is intended to provide guidance and common language for their informal conversations amongst themselves. The mid-week meeting with their project mentor facilitates them in making this adaptation in a professionally supportive atmosphere. The difficulty of the adaptation is recognized and

they are coached through the adaptation process. The end of the week reflection provides the opportunity and expectation for students to identify how they will accept that week's professional topic within their own professional identity.

For the informal stage, vertically integrated teams provide for a professionally supportive collegial atmosphere. Students, at the beginning semesters of the program, benefit from peers on their teams that are further along in their professional development by providing them with a positive peer perspective on the value of the professional competencies. Thorton and Nardi [20] identify these types of interactions as ones on which students place the most value. In addition, the students who are further along in the curriculum benefit from having to guide the newer students. To do this, they must first reflect on their own understanding and experiences with a particular professional competency before they can guide other students in their development of that competency. The student interactions with their clients and faculty leaders also give them many venues to practice the use of their professional competenices and get formative, non-graded feedback on how to improve.

At the end of the semester, the personal stage is an integrated part of the assessments and grades for each student. The student's mentor evaluates her or his performance in all of the professionalism areas through a formal performance evaluation. It is meant to be similar to that which practicing engineers periodically undergo in the professional setting. The results of all of these experiences culminate in a chapter of the student's individualized personal development plan (PDP) for the semester. The PDP chapter starts with a summary of the learning activities during the semester, the level of attainment of the goals from the previous semester, and is then followed by a summary of the feedback the student has gotten during the performance evaluation. These inputs lead to the development of new goals for the next semester. Finally, the students create specific action plans detailing steps that can be taken to achieve the new goals. Critical to this process is the recognition that student competency development is facilitated by reflection upon their development in conjunction with assessment from instructors. Cajander, Daniels, and von Konsky [30] found this to be an essential part of their 2011 study of student professional development.

Students complete this four-stage cycle, which is repeated in each of the four semesters of the upper-division program, with substantial progress toward the desired graduation level professional outcomes being the requirement. At the heart of this process is Cowan's [31] reflection model of "in – before – on – after reflection." The revisiting of the professional development topics with increasing level of sophistication each semester reflects the intent of the spiral configuration of the Networked Components Model proposed by Sheppard, et. al. [13]. The cyclical model better reflects what is understood about learning and role acquisition than the more traditional linear "one-time" through from theory to application model. Professional competencies account for three credits of student work each semester. Their grade is solely dependent on the growth in these competency areas. The model is illustrated in Figure 1.

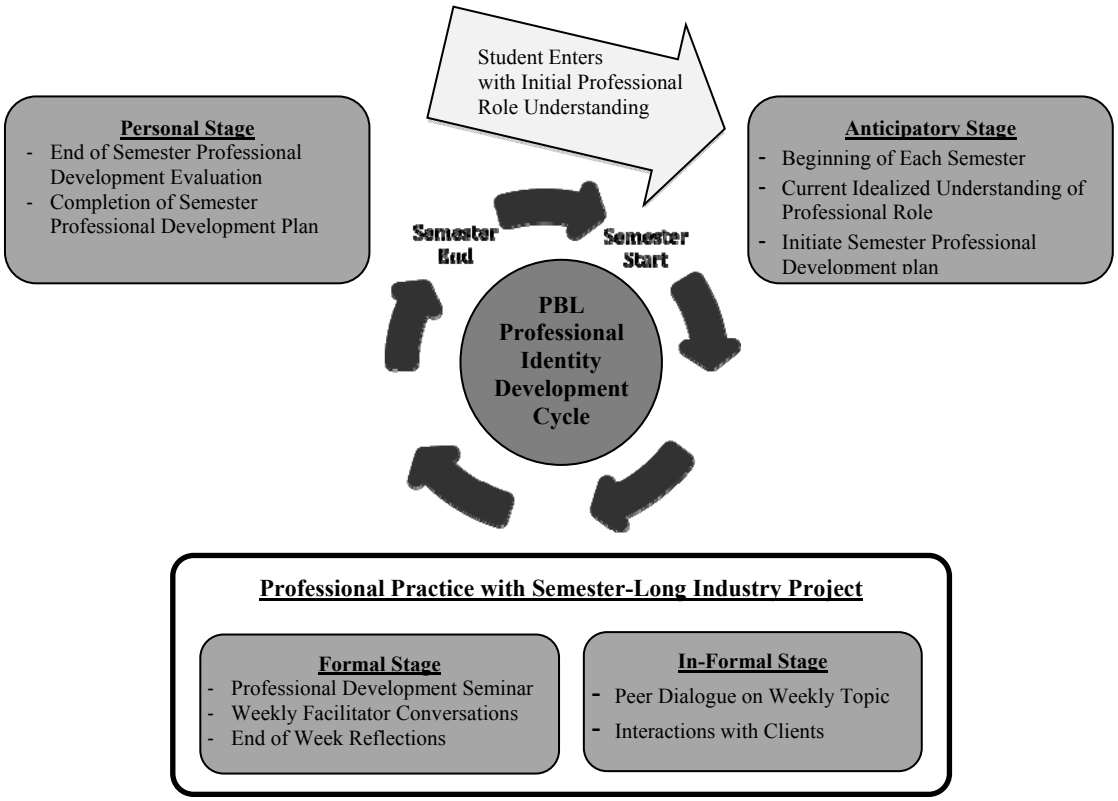

Fig. 1. PBL professional identity development cycle.

V. METHODS

This paper looks at, "In what ways does the development of the student professional identity in a Project-Based Learning (PBL) curriculum influence the development of professional competencies?" The quantitative part of a mixed methods study will be presented. It will focus on the second of three sub-research questions:

1. What do students define as professional competencies?
2. What is the growth of the student professional competencies in a PBL curriculum?
3. What are the development experiences for professional competencies in the PBL curriculum?

As part of the quantitative study, two instruments were developed to evaluate the develoment of professional competencies for students in the PBL model as compared to students studying in a more traditional model. Currently there are limited well-established resources for assessing student attainment of professional skills [32]. The quantitative study seeks to identify if a difference exists between PBL and non-PBL students in their pre- to post- self-reported importance and performance for the professional competencies.

The first instrument (Individual Professional Development Instrument) focuses on the individual professional abilities and was developed to allow students to position themselves relative to normative standards [14].The normative standards are the ABET student outcomes of 1) an ability to function on multi-disciplinary teams (3.d); 2) an understanding of professional and ethical responsibility (3.f); and 3) an ability to communicate effectively (3.g). These three outcomes were framed, in a context and way that is identifiable for the students at this point in their professional careers, with the 19 individual professional behavioral expectations listed in Table 1.

TABLE I. INDIVIDUAL PROFESSIONAL DEVELOPMENT INSTRUMENT ITEMS

Function on Multi-Disciplinary Team (3.d)	Understanding of Professional and Ethical Responsibility (3.f)	Ability to Communicate Effectively (3.g)
• Arrive at all meetings on time • Treat all others with respect • Meet the needs of your team by completing work on time and of high-quality • Give proactive feedback to others • Do not take frustrations out on those around you	• When told something, record and act upon it • Dress and groom appropriately • Work hard to create an environment free of harassment and conducive to learning • Willingly help others inside and outside of University • Meet all deadlines • Schedule time to better yourself through reading current events • Act ethically in all respects • Continually seek to improve yourself • Maintain a positive attitude • Act safely while completing all tasks	• Read memos and respond appropriately • Speak professionally, free of vulgarities and with appropriate grammar • Pay close attention to your emails and respond to requests in a timely manner

The second instrument (Team Professional Development Instrument) identifies students' beliefs about the importance of professional competencies and their current performance level within the context of functioning as a member of a team. Unlike the individual professional competency instrument development, the literature review identified the IDEALS professional development work of Davis et al. [33] in a team context. It was used, with permission, as a framework to guide the development of this instrument. All twelve behavioral expectations are used verbatim from the IDEALS Professional Development Model [34]. The adaptation is the addition of the 1-5 Likert-scale to place their ability on a continuum for each of these constructs. The IDEALS professional expectations with descriptions are:

Analyzing information Applying analysis methods/tools to understand & explain conditions

Solving problems Formulating, selecting, and implementing actions for optimal outcomes

Designing solutions Producing creative, practical products that bring value to varied stakeholders

Researching questions Investigating, processing, interpreting information to answer important questions

Communicating Receiving, processing, sharing information to achieve the desired impact

Collaborating Working with a team to achieve collective & individual goals

Relating inclusively Valuing and sustaining a supportive environment for all knowledge & perspectives

Leading others Developing shared vision & plans; empowering to achieve individual & mutual goals

Practicing self-growth Planning, self-assessing, & achieving goals for personal development

Being a high achiever Delivering consistently high-quality work & results on time

Adapting to change Being aware, responding proactively to social, global, & technological change

Serving professionally Serving with integrity, responsibility & sensitivity to individual & societal norms

Both instruments were adapted to a web format utilizing Survey Monkey [35]. Each instrument used relevant language to establish the context of the individual and the team nature of each instruments. Students were asked to rate each item for themselves (1 = Low, 5 = High) for a) *its importance to your personal and project success* and b) *your current level of performance*. The scale was described as:

- Low (1) if not relevant to the project or to my personal/professional life
- Medium (3) if moderately important to the project and/or my personal/professional life
- High (5) if important or very important to the project and my personal/professional life

The results for each instrument item and the overall composite instrument score for each data set were initially analyzed for means and standard deviations. An Independent-means t-test was then conducted, using the SPSS software package version 22, to test whether differences exist between the groups' means in the above comparisons [36]. A Levene's test was completed regarding the assumption of homogeneity of variances and used to determine which SPSS test statistic output to use from the t-test. Table II details the number of students completing both instruments.

TABLE II. NUMBER OF STUDENTS COMPLETING BOTH INSTRUMENTS

	Comparison Group		PBL Group	
	Pre non-PBL	**Post non-PBL**	**pre-PBL**	**post-PBL**
Number of students (n)	108	101	56	30

VI. RESULTS

Multiple comparisons of the results for each instrument were made to see if there are differences between the groups:

- PBL students taking instrument prior to (pre) PBL upper-division compared to non-PBL taking the instrument pre traditional upper-division program.
- PBL students taking instrument prior to pre PBL upper-division compared to PBL students taking instrument after (post) PBL upper-division program.
- non-PBL students taking instrument pre traditional upper-division compared to non-PBL students taking instrument post traditional upper-division program.
- PBL students who took instrument post PBL upper-division compared to Non-PBL who took the instrument post traditional upper-division program.

These comparisons are graphically displayed as boxplots in Fig. 2 and Fig. 3. Table 3 shows the compartive data.

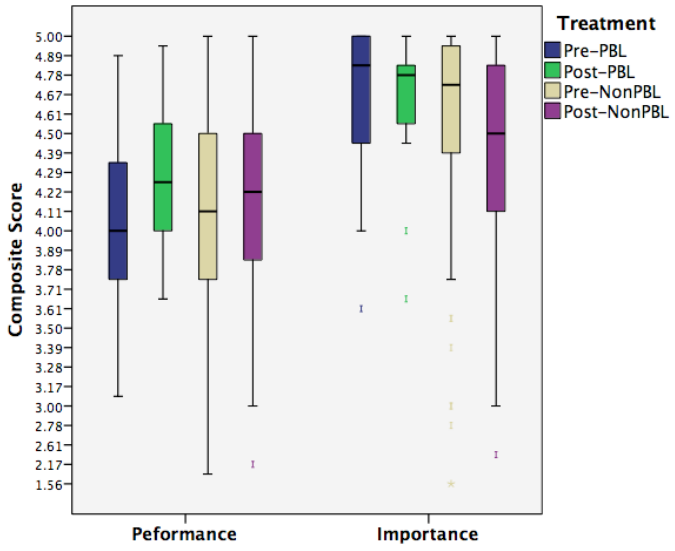

Fig. 2. Composite scores for individual professional competency instrument

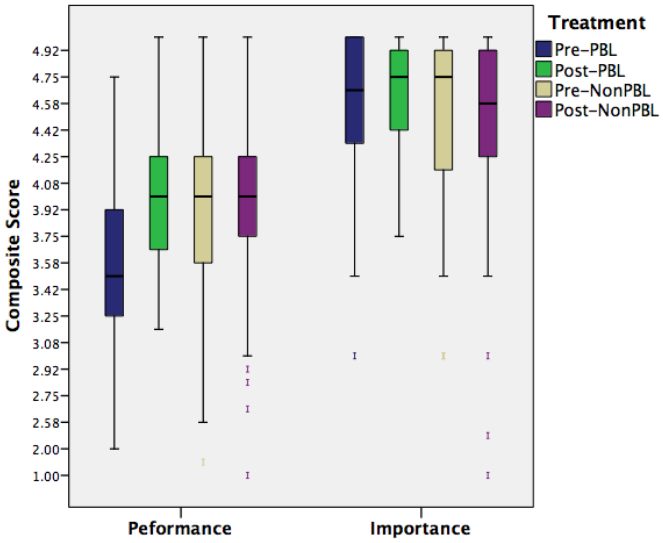

Fig. 3. Composite scores for team professional competency instrument

TABLE III. COMPOSITE PRE- AND POST- PROFESSIONAL COMPETENCY DIFFERENCES WITH STANDARD DEVIATIONS (SIGNFICANT RESULTS BOLDED)

	PBL Group Composite Scores			Non-PBL Group Composite Scores		
	Pre	***Post***	***Difference***	***Pre***	***Post***	***Difference***
Individual Instrument *Performance*	***4.03*** SD= .48	***4.28*** SD= .33	***0.25*** *t = 2.48* *sig. = .015*	4.06 SD= .58	4.15 SD= .51	0.09 *t = 1.13* *sig. = .257*
Individual Instrument *Importance*	4.70 SD= .35	4.69 SD= .28	-0.01 *t = -.084* *sig. = .933*	**4.56** SD= .54	**4.42** SD= .52	**-0.14** *t = -1.97* *sig. = .050*
Team Instrument *Performance*	***3.59*** SD= .52	***3.98*** SD= .47	***0.39*** *t = 3.48* *sig. = .001*	3.89 SD= .58	3.93 SD= .54	0.05 *t = .514* *sig. = .609*
Team Instrument *Importance*	4.56 SD= .44	4.64 SD= .30	0.08 *t = .926* *sig. = .357*	4.54 SD= .48	4.47 SD= .58	-0.07 *t = -.914* *sig. = .362*

PBL to non-PBL Pre Comparison - The composite Pre scores for each group indicate no differences between PBL and non-PBL groups in Performance for the *Individual Instrument*; Importance for the *Individual Instrument*; and Importance for the *Team Instrument.* There is a difference in the Performance for the *Team Instrument* t = -3.36, $p < .05$. The Pre- non-PBL (M = 3.89) mean composite score was 0.30 higher than the Pre- PBL cohort (M = 3.59).

PBL Student Pre to Post Comparison - Results indicate that students who experienced the PBL curriculum reported a Pre-Post difference in performance for *Team Instrument* t = 2.48, $p < .05$. The Post composite score (M = 4.0) was 0.39 higher than the Pre- composite score (M = 3.6). There was an increase of 0.25 in the Pre to Post Performance composite score for the *Individual Instrument* t = 3.48, $p < .05$. The results indicate no difference in the Pre-Post composite scores for the PBL students in Importance for the *Individual Instrument* or for the *Team Instrument*.

Non-PBL Student Pre to Post Comparions - The results for the non-PBL students indicate no change in the composite

score for Performance in either instrument or Importance for the *Team Instrument.* There was a composite score decrease of -0.14 for Importance Pre (M = 4.56) to Post (M = 4.42) in the *Individual Instrument.*

PBL to non-PBL Post Comparison - The Post scores for each group indicate that there are no probable differences between the Post scores for Performance in the *Individual Instrument* or the *Team Instrument*. The Importance for both instruments does show a difference in composite Post scores. The Importance score for *Individual Instrument* Post score $t = 2.76$, $p < .05$ is 0.27 higher for the PBL group (M= 4.69) than the non-PBL group (M = 4.42). There is a 0.17 difference in the composite Importance score for *Team Instrument* Post scores $t = 2.21$, $p < .05$ between the PBL (M = 4.64) and the non-PBL (M = 4.47).

Difference in Individual Instrument Item Scores – a review of the scores at an individual item level identifies the PBL group showing a positive difference in 15 instrument items and the non-PBL group showing a positive difference in two instrument items, as shown in Table 4. The non-PBL group had four items of decrease.

TABLE IV. *INDIVIDUAL INSTRUMENT ITEMS OF INCREASE OR DECREASE* (***I:*** - INDIVIDUAL INSTRUMENT, **T*:*** - TEAM INSTRUMENT)

PBL Group Increase Items	**Pre Score Mean**	**Post Score Mean**	**Diff-erence**
I: **Performance:** When told something act upon it	3.76	4.17	0.41
I: **Performance:** Willing help others outside of engineering environment	4.22	4.70	0.48
I: **Performance:** Meet team needs by getting work done on time & quality	4.04	4.37	0.33
I: **Performance:** Act safely while completing tasks	4.11	4.40	0.29
I: **Performance:** Attention to email - timely response	3.96	4.47	0.51
I: **Importance:** Act safely while completing tasks	4.67	4.90	0.23
I: **Importance:** Attention to email - timely response	4.70	4.93	0.23
T: **Performance:** Analyzing information	3.38	3.97	0.61
T: **Performance:** Solving problems	3.39	3.97	0.60
T: **Performance:** Researching questions	3.45	4.00	0.55
T: **Performance:** Communicating	3.59	4.23	0.64
T: **Performance:** Relating inclusively	3.66	4.17	0.51
T: **Performance:** Leading others	3.55	3.93	0.38
T: **Performance:** Practicing self growth	3.41	3.90	0.49
T: **Importance:** Researching questions	4.39	4.77	0.38
Non – PBL Group Increase Items			
I: **Performance:** Read memos - respond appropriately	3.87	4.16	0.29
I: **Performance:** Attention to email - timely response	3.88	4.22	0.34
I: **Importance:** Speak professionally	4.56	4.25	***-0.31***
I: **Importance:** Meet all deadlines	4.74	4.51	***-0.23***
I: **Importance:** Schedule time to better yourself	4.06	3.76	***-0.30***
T: **Importance:** Serving Professionally	4.63	4.41	***-0.22***

Cronbach's Alpha was used to indicate the overall reliability of the both instruments [36]. A Cronbach Alpha analysis was completed for each instrument for both Performance and Importance; a total of four analyses. In each analysis, the *Correction Item-Total Correlation* was above 0.3 for each instrument item and no items were identified for an increase in the "*Cronbach's Alpha if Item is Deleted."* The Cronbach's Alpha for all four instruments was above 0.8 indicating that any score variance is more likely due to actual differences than specific item variability [37, 38].

VII. DISCUSSION

Looking at the means comparison for the Pre treatment condition of each group, the two groups appear similar in their Importance as indicated by both instruments. Focusing on the Performance items for the professional competency instruments, there was no difference indicated between the Pre scores for the groups in the *Individual Instrument.* These results indicate that, as expected, the life experiences and lower-division curricular experiences of the students are similar for the development of the Importance for professional competencies and their self-reported ability for Performance of professional competencies as an individual.

However, the *Team Instrument* does indicate a probable difference between the two groups in their starting point for self-reported Performance in a team context. The non-PBL cohort had a higher mean composite score of 3.9 for the Performance items in the *Team Instrument,* as compared to the composite 3.6 mean score for the PBL cohort. The difference between the two groups was not expected. One plausible explanation is that the students who entered the PBL program primarily came from the same lower-division community college engineering program that is nationally recognized for its use of engineering projects in its lower-division curriculum [39]. This increased exposure to engineering team experience could have led to students having more context in the complexity of team work and therefore rated themselves lower in their performance ability. Although the difference is interesting, it is not the focus of this research work and therefore will be left for further investigation. It will be revisited in the Post- score discussion.

The Pre and Post differences for each group are the main focus of this study. The students who experienced the PBL curriculum do indicate a difference in their professional ability performance and this difference is greater in comparison to the difference shown by students in the non-PBL control group. The non-PBL group showed no significant difference in their self-reported performance of the professional competencies. Based on the literature, the increase for the PBL group is an expected outcome of the PBL treatment. Support for this is also found in a follow-up study of graduates from the PBL graduates and their employers [40]. This study found that the graduates and their employers were satisfied with the engineering preparation of the PBL model graduates as compared to the performance of non-PBL graduates.

Students in the PBL curriculum group do not show statistically significant difference Pre to Post in the overall importance for professional abilities. The results were the same

for the non-PBL group for Importance in the *Team Instrument*. The non-PBL group actually showed a decrease in Importance as measured by the *Individual Instrument.* It could be attributed to the result of Walther's "Accidental Incompetencies" [21].

The similarity of the scores in Importance at both the starting point, and to some extent the ending point for both groups, indicates that the importance was primarily established prior to beginning the upper-division programs. It also indicates that upper-division has no significant impact on the importance students have for the professional competencies. This will be explored further in the qualitative analysis.

The Post comparison of the two groups shows no difference in the self-reported Performance of professional competencies for both instruments. This is interesting given that the PBL group reported an increase in both instruments and the non-PBL group did not show a Pre- to Post- comparison increase in either instrument. Did the PBL students just start lower and then rise up to the Non-PBL students after upper-division? Did the PBL students have a better understanding of their own Performance abilities of professional competencies to start with as compared to the Non-PBL students? Therefore, they then rated themselves more realistically in the beginning. The Non-PBL students either had no real growth or their understanding of the Performance of professional competencies increased over the two-year period and therefore resulted in a more realistic rating of themselves in the Post- state such that any growth Pre- to Post- indicated no difference. Developing a better understanding of what happened with the Non-PBL students would require developing an understanding of how the two groups interpreted the scale at the Pre- and Post- conditions and comparing them.

Focusing on the individual *Importance* items, the PBL cohort did show growth in three individual items. In the *Individual Instrument,* the items of growth for importance are "Act Safely" and "Pay Close Attention to Email & Timely Response." For the *Team Instrument,* the item of growth for importance was the "Researching Questions (Investigating, processing, interpreting information to answer important questions)." All three of these items were also items of self-reported growth in performance.

The non-PBL group had a decrease in four items for Importance. Three from the *Individual Instrument:* "Speak professionally, free of vulgarities and with appropriate grammar," "Meet all deadlines," and "Schedule time to better yourself through reading current events." One from the *Team Instrument*, "Serving Professionally" Having items of decrease is not surprising given the *Individual Instrument* composite score decreased Pre- to Post- for the non-PBL group.

Focusing on the individual Performance items, the PBL group had 12 of the 30 items increase. The non-PBL group had only two items increase.

VIII. Future Work

Although the quantitative data indicates promising results for the PBL curriculum's influence on the student performance of professional competencies, it does not provide insight as to how the students experienced the curriculum in developing their professional identity and the development of professional competencies. The follow-up qualitative study is focused on gaining an understanding of the student experience and to also identify which elements of the PBL curriculum affected the student professional identity and competency development experience. Of equal interest is gaining an understanding of the student experience in developing their importance for the professional competencies, as the quantitative study indicates that this was developed prior to upper division for both groups.

Through a phenomenological study, a deeper understanding of the participant experiences will develop through a close examination of each individual's experience to "produce rich thematic descriptions that provide insight into the meaning of the lived experience" [41]. The results will produce a culminating experience, as described by participants, depicting the basic structure of the professional competency development experience as their professional identities develop. This aligns with the first and third research sub-questions.

IX. Conclusion

Both groups appear to start with similar potential in their motivation and therefore similar potential in their identifying with or finding importance in the learning process of professional competencies. Therefore, any differences in growth between the two groups could be attributed to the learning process and curriculum they experience in the upper-division. The quantitative results reported growth in performance of the professional competencies by the PBL group, but not for the non-PBL group. This supports that the PBL curriculum and its explicit focus on professional identity development to facilitate the student professional competency development. Neither group showed growth in their *Importance* of the professional competencies. Scores started and stayed high. The only exception was the non-PBL growth showing a decrease in *Importance* through the *Individual* profession competency instrument. The key findings of the quantitative study are:

- Non-PBL group reports higher Pre *Performance* in *Team* context as compared to PBL group
- Non-PBL group reports lower Post *Importance* for both instruments as compared to PBL Group
- Non-PBL group reduces in *Importance* (Pre to Post) in *Individual* context
- PBL increases in *Performance* (pre to post) for both *Team* and *Individual* contexts
- PBL has no change in *Importance* (pre to post) for both contexts. Scores start and stay at a high level.

This quantitative study indicates promise for the student professional identity development in the Project-Based Learning (PBL) curriculum and also for its influence in the development of professional competencies. The focus of the future qualitative study is to gain an understanding of the student experience and also identify which elements of the PBL curriculum affected the student experience. It will provide further explanation of the promising quantitative study results.

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