Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #46161

PBL Students do not perceive their competencies as digital competencies

Prof. Euan Lindsay, Aalborg University

Professor Euan Lindsay's focus is on future models for engineering education, and in particular the intersection between PBL approaches and digitalisation.

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Abstract

This empirical research full paper investigates the extent to which students in a Problem-Based Learning (PBL) environment perceive the competencies they develop as being digital in nature. All degrees at the Faculty of Engineering and Science (ENG) and The Technical Faculty of IT and Design (TECH) at Aalborg University currently incorporate a PBL Competency profile as a compulsory exercise for all students in the second semester of their Masters study. These profiles are intended as a reflective exercise for the students; they are also designed to assist students in communicating their overall competence while searching for internships and graduate employment.

The profiles are structured around the Aalborg PBL Competency Framework. This framework contains 48 individual competencies, grouped into four categories: meta-reflective, problem-oriented, interpersonal, and structural. Students are free to choose which of these competencies they incorporate in their profile. On average, students include between six and eight of these competencies.

This study investigates the relative prevalence of different competencies in the profiles developed by students. A total of 1095 PBL Competency profiles were reviewed in this study across more than 50 STEM study programs, and each was evaluated for the presence or absence of each of the 48 competencies in the PBL competency framework, and the extent to which these competencies were presented by the students as digital competencies.

Analysis of these distributions shows that very few of the students present or evidence their competencies as digitally supported. Further, a significant proportion of the competencies in the framework are never presented by the students as digital *per se*. Of those that are presented, however, there are meaningful differences between categories with regards to the type of digitalization reported by the students.

These findings have significance for how students are scaffolded to develop digital literacies within a PBL curriculum and for the development of their self-efficacy regarding these competencies.

Keywords – Active Learning, Problem Based Learning, Digital Competencies

Introduction

This empirical research full paper investigates the extent to which students in a Problem-Based Learning (PBL) environment perceive the competencies they develop as being digital. All degree programs at the Faculty of Engineering and Science (ENG) and The Technical Faculty of IT and Design (TECH) have included a Competence workshop in the second semester of their

Masters programs – the 8th semester of their studies overall. At this workshop students engage in an active reflection process over which PBL competences they have developed and wish to communicate while searching for employment and/or internships [1]. These competences are captured in a PBL competency profile, which the students submit for feedback.

To assist students in their reflective process they are provided with a PBL competency framework [2]. This framework is a catalogue of different PBL competences divided in four areas: problem-oriented, interpersonal, structural and metareflective competences (figure 1). Each of these areas have 12 competences embedded in them, and the students are encouraged to include competences from all areas in their profile. Students are also provided written guidance for preparing their competency profiles [3]. On average, students include between six and eight of these competencies in their profile.

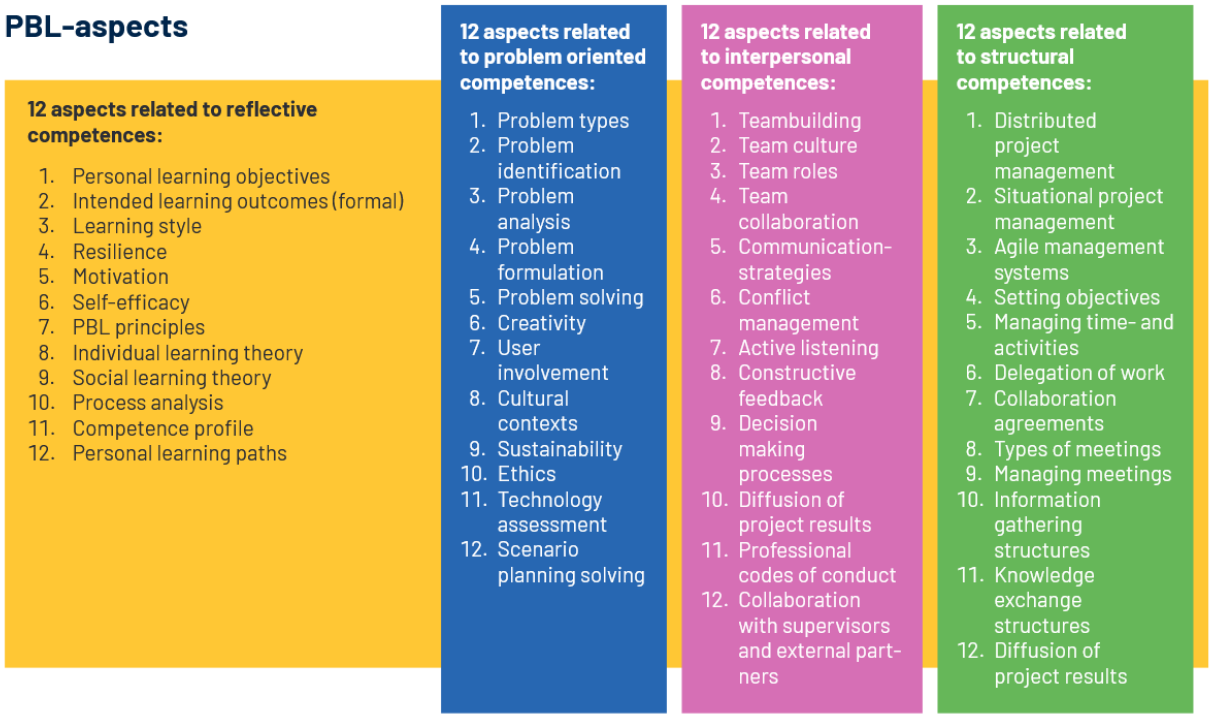

Figure 1: The PBL competency framework (Holgaard et al, 2020)

The Competence Workshop has now run for three years, and so it is timely to explore the relative prevalence of the different competences that students choose to report in their profiles. We are educating graduates to thrive in a digitally enabled and distributed world, but at Aalborg University we do so through a primarily on-campus experience. This research explores whether our students present their PBL competencies as being expressed digitally. Students are not explicitly prompted to consider digitalization as they are preparing their profiles; rather we are exploring the extent to which their expressed competences have been evidenced through examples of authentic practices that manifests in digital ways.

The framework for considering digitalization in this study is the work of Pernille Kræmmergaard [4]. Kræmmergaard's framework (figure 2) presents five distinct levels of digital maturity for

organizations. While originally intended to be utilized in a business context, it nonetheless has explanatory power in an educational setting. The framework develops from utilizing IT for 1) automation, 2) efficiency, 3) change of practices, 4) new solutions, to 5) personalization.

Figure 2: The Kræmmergaard framework

For this study, it is not necessary (or meaningful) to distinguish between all five levels of the Kræmmergaard framework; it is in fact sufficient to consider only lower-level versus higher-level. At the lower levels of the framework, the digitalization is used in ways that replicate non-digital approaches (1), such as zoom meetings replacing face-to-face meetings – digitally supported learning and doing this in more efficient ways (2). At the higher levels of the framework (3-5), digitalization is used to provide functionality that would not be possible without digital tools – digitally enhanced learning.

Not all competencies in the PBL competence framework necessarily lend themselves to being expressed digitally, whereas others would be expected to have considerable digital influence. The competencies of *resilience* and *motivation* are largely expected to be internal to the students, whereas *information gathering structures* in the 21st century would be expected to be digital in nature.

Furthermore, the primarily on-campus context of Aalborg University will affect the way in which students approach their interpersonal competencies. While all students in the cohort have experienced emergency remote instruction during COVID, learning has returned to the on-campus mode. This means that students have had the opportunity to develop these competencies in their studies, but that these may no longer be front of mind at the point where they develop their competency profile.

Generally speaking, the reflective competences are not expected to have a high level of digital use, the structural competences would be expected to have a high level of digital use, whereas the interpersonal and problem-oriented competences are expected have a mix of both.

Reviewing the competencies reported by our students allows the opportunity to investigate the extent to which these competencies manifest digitally. By capturing the extent to which our senior students report their competencies in a digital context, we will develop a sense of the level of digital maturity in our student cohort.

Method

The dataset for this analysis is a convenience sample of the 1095 PBL competency profiles submitted in the spring 2024 semester. In parallel with the regular assessment and feedback process for this assignment, each of these profiles were evaluated by a marker, and each of the competencies included in the profile was scored according to a four-point rubric (Table 1). In this study, practices that represent the lower levels (1-2) of the Kræmmergaard framework were labelled as “digitally supported learning” whereas practices that represent the higher levels (3-5) were labelled as "digitally enhanced learning”.

Table 1: Rubric for evaluating level of digitalization

Score	Label	Description
Null	Absent	This competency is not mentioned in the profile
0	Non Digital	No mention is made of digital for this competency
1	Digitally Supported	Digital tools are used in ways that replicate non-digital approaches
2	Digitally Enhanced	Digital tools are used to provide functionality that would not be possible without digital tools

The resulting dataset has scores for each of the 48 competencies for each of the 1095 participants.

The key limitation of this study is that the competency profiles are ultimately self-reported data, and the choice of competencies to include is ultimately made by the students according to their own priorities. Students are not explicitly prompted to consider the digital nature of their competence, and as such there is no specific trigger for them to consider and thus report their competence through this lens. These data cannot directly tell us whether they consider their competence to be expressed digitally; rather they tell us whether the way students evidence their competence in their competency profiles by describing use of digital tools.

Students also make decisions about which competences to include in their profiles, which are space limited to two pages. As such it is possible that students do have other competencies that they do consider to be digital in nature, but that these were omitted from the profile in favor of other competences that were seen to be more important, or were more preferred, or had better examples to include within the narrative.

While this limitation may affect the ability to draw conclusions regarding an individual student, the size of the dataset allows for conclusions to be drawn in the aggregate.

Findings Part One: Students do not present their competencies as digital

The very clear finding of the dataset is that the majority of the students do not present their competencies as being digital, either at the digitally supported or digitally enhanced level. Of the 9,444 total competencies claimed in the dataset, only 328 of those claims (3.5%) were assessed as being digital in nature; 168 at the digitally supported level and 160 at the digitally enhanced level.

When considered through the lens of which proportion of the students presented a digital competence, the prevalence is even lower. The overwhelming majority (78.8%) of students presented a PBL competency profile that did not contain a digital competence. Only eight of the competencies were presented digitally by 1% or more of the students, with only the competency "manage time and activities" having a prevalence of 10% or more (figure 3). One third of the competencies – 16 out of 48 – had a zero prevalence, meaning that none of the 1095 students presented that competency in a digital way in their profile with a further nine competencies appearing exactly once in the dataset. These 16 were primarily individual traits or communicative competences: eight of these were reflective competences, six were communicative competences, one a structural competence (*collaboration agreement*) and one was a problem-oriented competency (*cultural contexts*).

Figure 3 shows that the four categories of PBL competencies are not equally represented when it comes to digital competence. 51% of digital competence claims are in the structural category, with "Managing time and activities" comprising 32% of all claims overall. Problem oriented competencies represent 39% of all claims, while interpersonal skills represent only 8% of all claims. Only four reflective competencies appear, each appearing only once in the dataset.

Nevertheless, digital competence is not a foreground theme in the minds of most students. While an individual student may make specific decisions about which competencies to include, the aggregation of these decisions over 1095 students shows that the cohort as a whole is not emphasizing digital competence when asked to reflect upon their competency development.

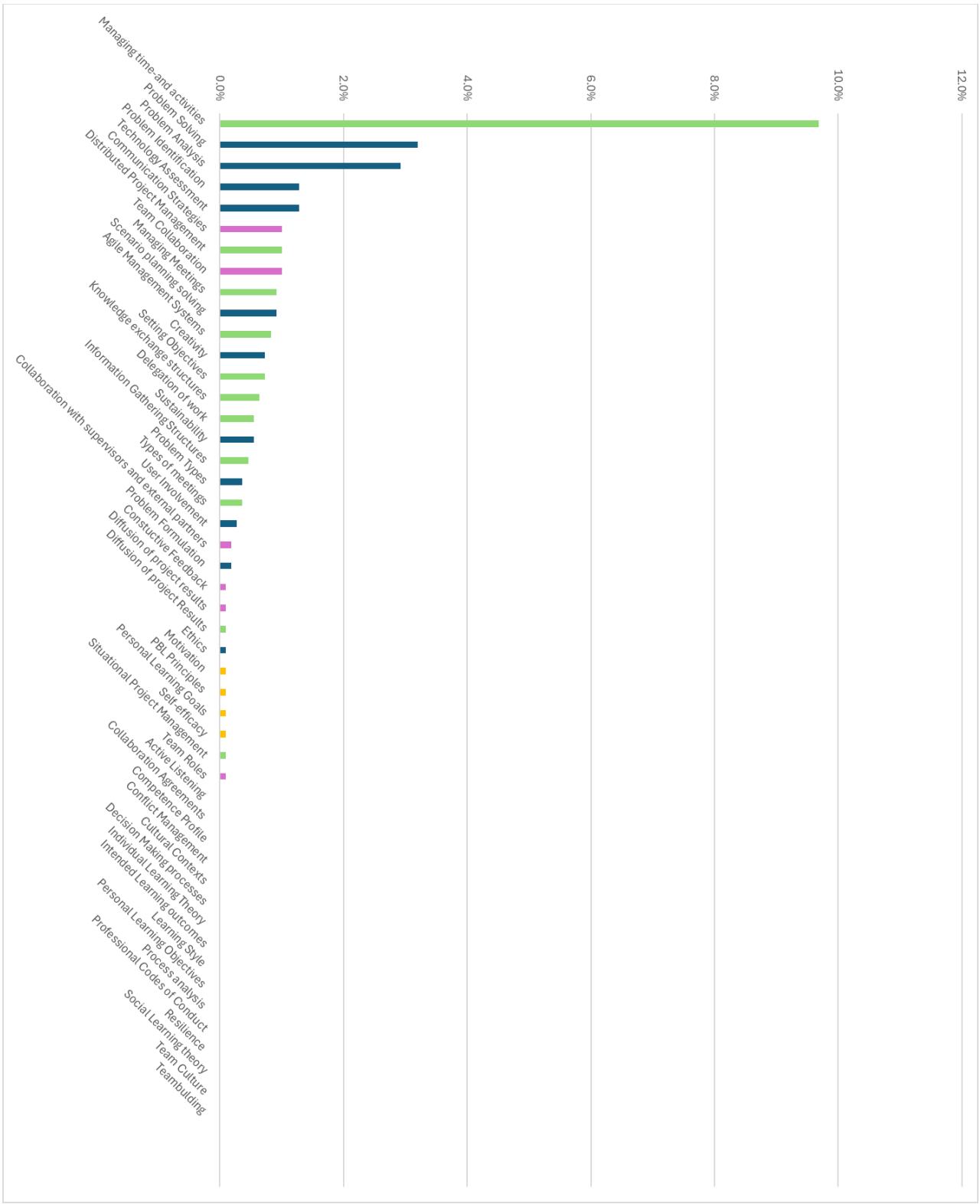

Figure 3: Prevalence of digital competencies

Findings Part Two: Different competency categories digitalize differently

While the prevalence of digital competency is low, it is nevertheless instructive to explore further into the 20.2% of students whose profiles do contain a digital competence. In particular, it is insightful to contrast the balance between digitally supported and digitally enhanced competences in each of the categories (figure 4).

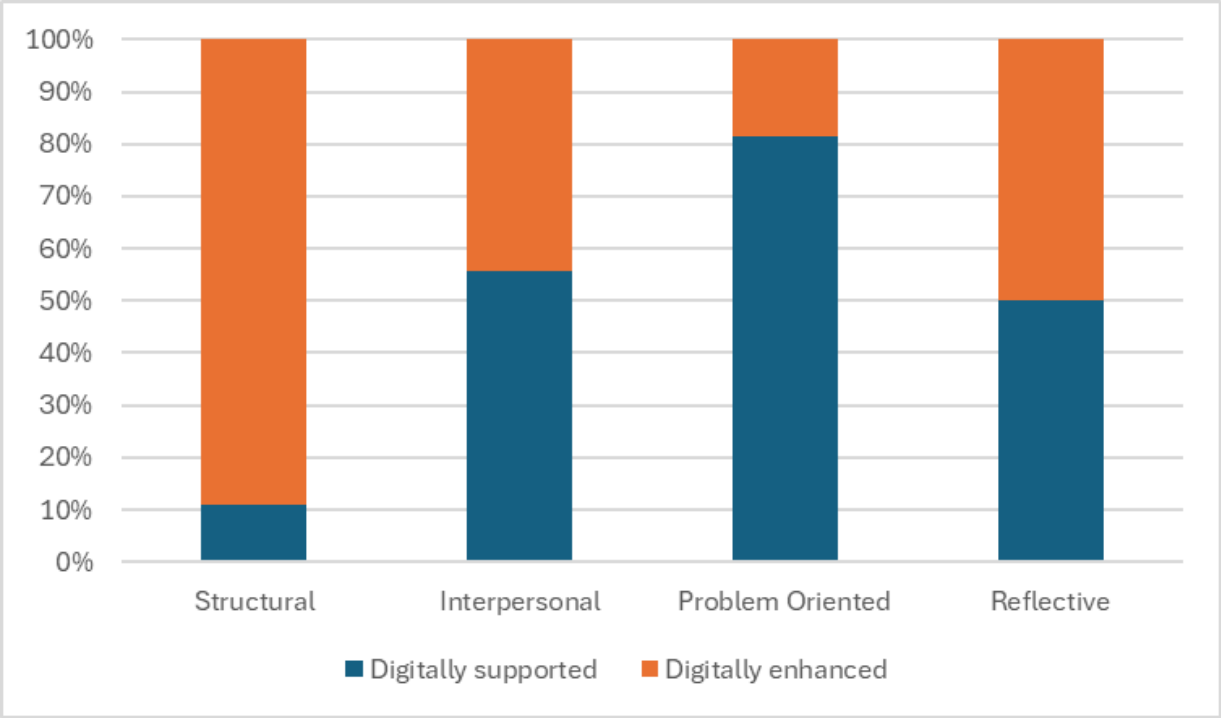

Figure 4: Proportions of Digitally supported vs Digitally enhanced competencies

Figure 4 shows that for the categories of interpersonal and reflective competencies, the categories are evenly balanced between digitally supported and digitally enhanced, albeit on very low numbers (15:12 and 2:2 respectively).

For structural competencies, digitally supported instances dominate over digitally enhanced instances, by a ratio of 137:31. This is primarily comprised of the single most common individual competence of "managing time and activities", which is overwhelmingly digitally supported (93 : 13), but the effect is also present across the other competencies in the group, 44 : 18. This means that students are three times more likely to report a structural competency to be digitally supported as they are to report it as digitally enhanced.

For problem oriented competencies, the picture is reversed, with digitally supported competencies in the minority compared to digitally enhanced competencies 14 : 114.

Conclusion

The overwhelming result of this study is that Aalborg university students do not present their competencies as digital when they are asked to describe them. For the minority of students that do present their competence as digital, however, there are differences in the way in which the digitalization of their competence is manifesting.

For structural competences, which revolve around how students organize and manage project work, the majority of digitalization is at the digitally supported level. Students are using digital technologies to achieve the same things that they would achieve with non-digital technologies – they are operating at the lower levels of Kræmmergaard's framework. This suggests that they are changing tools, but not changing the ways of working, with regards to how they are structuring their work.

For the problem oriented competencies, which revolve around how students identify and perceive problems, the overwhelming majority is at the digitally enhanced level. Students are using digital technologies to achieve things that would not be possible without those technologies. This suggests that they are in fact changing their ways of working with regards to their understanding of problems thanks to the availability of digital tools.

Digital competency will be an increasingly important part of engineering education. This study shows that the PBL environment can help students utilize digital tools to develop competencies that are not available in the non-digital world. It also highlights, however, that this is far from universal, both with regards to the student cohort, and to the competencies being developed.

If deliberate and self-aware digital competency is a goal of the curriculum, more must be done to develop these skills in students. Furthermore, students will need to be explicitly prompted to reflect upon these skills, and to capture evidence of episodes where they use these skills, so that they are consciously aware of their digital practice.

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