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Problem-oriented Project Work and Problem-based Learning: "Mind the gap!"

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ABSTRACT

This paper addresses one of the major confusions in the study and practice of problem-based learning today, namely the use of the term "problem-based learning" to refer to both the small-group tutorial method pioneered by McMaster University and Maastricht University in medical education, and the problem-oriented project-work method developed in Denmark at the universities of Roskilde and Aalborg, which has gained prominence in recent years in the field of engineering education. This paper offers a comparison of the models using a thematic analysis of key elements of PBL, namely the nature of problems, the role of teachers, the nature of the educational process, and the underlying principles of the method, to conclude on a discussion of the causes of the confusion taking place today, and its potential ramifications for the study and practice of PBL in the future.

Keywords: problem-based learning, medical education, engineering education, comparative study

Introduction

An interesting phenomenon has been occurring in higher education over the past two decades: the term "problem-based learning" (PBL) was once upon a time exclusively used to describe a method of medical education based on group work, focused on patient problems and guided by a tutor (Barrows & Tamblyn, 1980; Schmidt, 1983). However, it began surfacing in engineering education literature and practice to mean a mode of project work in which small groups of students work on authentic problems under the guidance of a supervisor (Kjærsdam & Enemark, 1994; Kolmos, Fink, & Krogh, 2004). Even more interesting, this is not a case of one discipline copying, adapting, or otherwise borrowing an educational method from the other. These are evolutions of distinct educational innovations that were developed around the same time in the 1970s, at two medical schools in Canada and the Netherlands on the one hand, and two reformed universities in Denmark on the other. To understand how this came to be requires a short step back into the history of problem-based education.

The term "problem-based learning" was coined in 1974 by Howard Barrows, a leading figure at McMaster University Medical School (Barrows & Neufeld, 1974). He used it to retroactively describe an innovative approach to medical education, which had been developed at McMaster by Dean John Evans and his team, starting in 1965 (Spaulding, 1991). It was a new program with room for experimentation. Its main characteristics were the prevalence of small-group education, a patient case or the description of a biomedical phenomenon as a starting point for learning, the integration of disciplines under an organ systems approach, and the absence of formal examinations, as well as a disregard for lectures (Servant-Miklos, 2019). In 1974, Maastricht University, which at that time only had a Faculty of Medicine, adopted the McMaster model and called it probleemgestuurd onderwijs [problem-steered education]. They made some important modifications: first, the method was formalized into a seven-step procedure to cater to students fresh from high school. Secondly, students, along with their tutors, were given comprehensive training in PBL. Given the structure of Dutch medical education, the curriculum was enlarged to cover six full years of study, while the problems veered away from patient cases and focused on biomedical phenomena. Finally, a medical skills lab was added into the students' schedule of educational activities (Knegtmans, 1992; Servant, 2016). From there on, PBL spread like a wildfire in medical education and beyond, into psychology, law, economics, vocational education etc. All of these programs adopted some variation of either the McMaster or the Maastricht approach. It must be said, however, that PBL remains more popular today in medical education than in any other field.

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At the same time as PBL was making its way from McMaster to Maastricht, two new University Centres were scheduled to open in Denmark, against a backdrop of social discontent and an explosion of student numbers (Hansen, 1997). One was poised to open in 1972 in Roskilde and the other in 1974 in Aalborg. Starting in Roskilde, faculty and student advisory boards were tasked with devising a new way of delivering higher education. The system they came up with upended the existing modus operandi of Danish higher education: students in Roskilde University Centre (RUC) would be divided into three faculties—humanities, natural sciences and social sciences—with no further specialization until their third year of bachelor education. These two years of interdisciplinary "basic education" (basisuddannelsen) would be constructed around problem-oriented project work, driven by students and supported by professors acting as "supervisors" (Berthelsen, Illeris, & Poulsen, 1977; Hansen, 1997; Illeris, 1974). Such projects were more (in social sciences and humanities) or less (in natural sciences) designed with a socialist and critical view of science and society. When the model was transferred to Aalborg University (AAU), its socialist component met with immediate resistance from regional industrial interests and the two pre-existing engineering education institutions that needed to be subsumed into the new university. What a difference two years makes: by 1974, RUC was facing the wrath of the government for its Marxist inclinations, and the model that was transferred to AAU was therefore stripped of its political activism, save for a few radical teachers and students in the faculty of social sciences (Clausen, 1984). The interdisciplinary basic education was reduced to one year, and the time spent in problem-based projects was split 50/50 with traditional courses (Servant-Miklos & Spliid, 2017; Whitehead, 2007). While Roskilde went from one political crisis to the next, Aalborg went from strength to strength, particularly in engineering sciences (Kjærsdam & Enemark, 1994). In the 1990s, AAU's rector decided to open the "Aalborg Model" up to the world. However, it must be noted that the application of the "Aalborg Model" at AAU was and is far from uniform across all faculties. Rector Kjærsdam's idea of the "Aalborg Model" was more strongly oriented towards its application in engineering than towards the humanities or social sciences. With this caveat in mind, keen to find a user-friendly name that educators would be able to recognize, Kjærsdam, by his own admission, pragmatically latched onto the name "problem-based learning" to describe the pedagogical model at Aalborg University (Servant, 2016). A 20-year effort to justify and enshrine the new "PBL" moniker for the Aalborg Model of project work in academic literature and educational practice ensued. This effort was led by the Technical Faculty. It started with a paper written by Kolmos in the field of engineering education research (Kolmos, 1996) entitled "Reflections on Project Work and Problem-based Learning." At the time, a clear desire to justify the use of the term "PBL" for engineering project work was apparent. By the time the follow-up article "Characteristics of problem-based learning" (De Graaff & Kolmos, 2003) emerged, the question of the name was no longer asked. The article took as a given the use of "PBL" to mean problem-oriented project work. Kolmos and her team successfully applied for a "UNESCO Chair for Problem-Based Learning in Engineering Education," established at Aalborg in 2007, and later "the Aalborg Centre for Problem Based Learning in Engineering Science and Sustainability under the Auspices of UNESCO," launched in 2014. Had the same name "PBL" then been used to describe two distinct pedagogical approaches confined to two separate disciplinary fields, this might have been accepted as different disciplines using the same words to mean different things. However, the issue of what PBL is has spilled over from a disciplinary issue, as some programs blending both tutorial groups à la McMaster and project work have started to emerge in medical education, in engineering education, and in other fields of study—and therefore one cannot claim that differences in application are merely due to disciplinary imperatives. Neither can we claim that the differences are merely regional: RUC has always refused to refer to its method as "PBL" despite its common history with AAU. They have most recently preferred the acronym "PPL," which stands for problem-oriented project learning (Andersen & Kjeldsen, 2015). As Roskilde doubles down on its critical heritage and Aalborg moves away from it, it becomes more difficult to speak of a "Danish" model of problem-oriented project work despite their common ancestry (see Figure 1 for the timeline of key events).

All of this has sparked considerable confusion about what type of education "PBL" designates, raising questions about whether differences in the interpretation of "PBL" are owed to regional, disciplinary, or institutional divergences, and whether such differences stretch the term "PBL" too far, to the point where it ceases to mean anything specific. These questions are surfacing at a time where the popularity of PBL in educational parlance shows no sign of wavering. It is therefore important to clarify to what extent the principles and practices underlying the programs that can credibly claim to have started the problem-based movement in higher education overlap or diverge. The question is whether there is cause to extend the use of the term "PBL" coined by Barrows (for the specific medical education innovation proposed by McMaster and adapted by Maastricht) to the problem-oriented project work approach, either in its critical iteration at Roskilde University or in its pragmatic engineering iteration at Aalborg University. The stakes are high. In

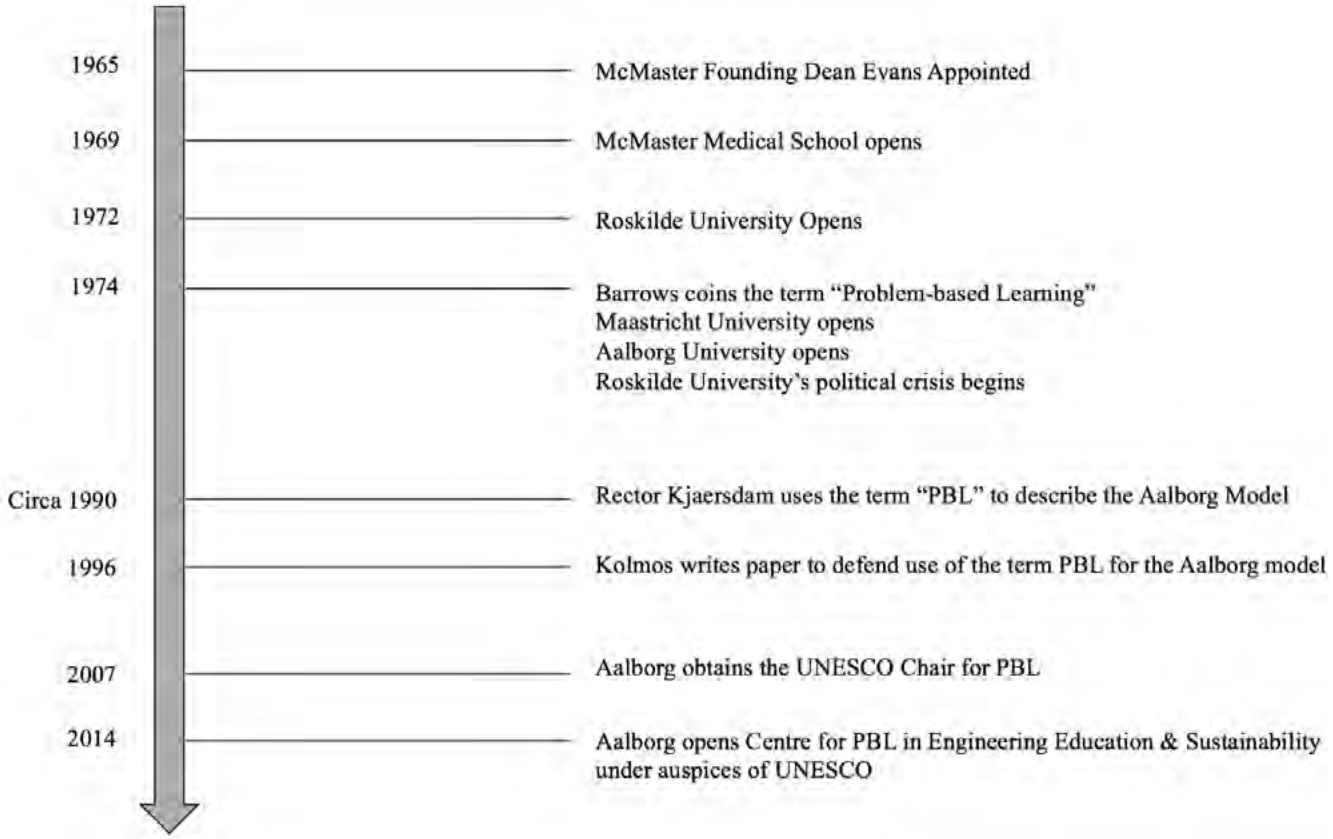

Figure 1. Timeline of key events in the PBL versus project work debate.

the past two decades, many tertiary institutions have come under pressure from their governments, ministries of education, and governing boards to adopt "PBL" to close the gap between education and workforce needs, or what has often been termed "twenty-first century skills," in all disciplinary areas of higher education. This urgently calls for clarifying what exactly one is liable to find under the label "PBL." The definition of the boundaries of PBL acts as a prescription for the development of future educational programs.

The aim of this paper is therefore to offer a historical institutional comparison of the approach to learning with problems developed at McMaster University in the late 1960s, adapted in Maastricht in the 1970s, and the original Roskilde approach to problem-oriented project work and its pragmatic adaptation in Aalborg. We will seek to determine: 1. If there is a priori sufficient overlap in the original construction and underlying principles of these four programs to justify merging these models under the appellation "problem-based learning," and 2. If the current practice of these programs today justifies merging the models a posteriori under the label "problem-based learning." We have chosen to anchor this paper in a historical institutional analysis because attempts to tackle the subject based on present practice have tended to descend into fractal interpretations of what is and is not PBL (see literature review). We submit that basing our analysis on historical sources provides more solid grounding for the debate. After briefly describing the methodological approach, this paper will present a literature review of authors arguing for and against using the term "PBL" to describe project work. Then, a side-by-side historical comparison of key aspects of the education offered in these programs will be provided. Finally, a discussion will offer some analysis on the use of the term "PBL" in higher education today.

Methods

This study is based on an analysis of historical materials collected at the Universities of McMaster, Maastricht, Roskilde, and Aalborg. These materials, totalling over 1000 pages of written materials and 50 hours of interviews, include archival materials collected by the universities themselves (in the case of McMaster, Roskilde, and Aalborg) or by regional archives (in the case of Maastricht), as well as unsorted historical documents given to the author by people who were present at the time of the founding of the universities. In addition to this, 39 students, teachers, and administrators who were present at the time of the founding of these universities were interviewed using a form of oral history (Thompson, 2000). Thirdly, published and unpublished papers written by faculty

members and students of all four universities were used. They were either found through an online search engine (if they had been digitalized), the archives of the universities, or donated by the papers' authors, often in accompaniment to their oral history interview. Where relevant, these have been cited in the text of this paper. These three types of primary sources were then analyzed thematically in constant comparison with secondary accounts such as Spaulding's history of McMaster University Medical School (Spaulding, 1991), Knegtman's history of Maastricht University (Knegtmans, 1992), Hansen's history of Roskilde University (Hansen, 1997), and Clausen's history of Aalborg University (Clausen, 1984), among others. The data on the modern iteration of these models used in the discussion section came firstly from secondary sources from the current literature on these models, secondly from the author's direct experience of working in institutions from both models, thirdly from observing these models in action in all four original institutions through sitting in on tutorials and project groups and interviewing students and teachers, and finally from visiting other (mostly Asian) institutions whose PBL was developed from trainings given by either Maastricht or Aalborg.

The analysis of the historical material was based on an inductive and hermeneutic approach to the sources. The meanings and interpretations of the features of each PBL model were triangulated across the different sources, with preference given to written sources over oral accounts where interpretations conflicted. The themes discussed in this paper represent the meeting point between salient themes emerging from the historical data and the topics most often discussed in the general literature on PBL. These themes were the nature of problems, the role of teachers, the external and internal educational processes, and the education principles underpinning the models.

Literature Review

The purpose of this literature review is to cover what has been written about the differences between project work and PBL as described by Barrows. Thus, the review summarizes what authors have written in arguing for a distinction between PBL and project work and those who have argued for merging the two. The purpose of this literature review is not to fit PBL and project work into a larger theoretical framework.

Arguing for a distinction between PBL and problem-oriented project work

Most authors admit that there are common points between PBL and project work. Schmidt (1986), originally from Maastricht University, acknowledged they both promote student-centered rather than teacher-centered learning, both take place in small groups, both enable the students to apply knowledge to real-life situations, and both increase student motivation to learn, which could improve lifelong learning. In addition, he admitted that both problem-based learning and project work encourage self-directed learning and interpersonal skills. Perrenet, Bouhuijs, and Smits (2000) recognized that PBL and project work shared a commitment to interdisciplinarity, self-direction, and collaboration in an analysis focused specifically on the Maastricht model of PBL and the Aalborg model of project work. However, they argued in line with Schmidt that self-direction is far greater in project work, but given that knowledge needs to be acquired prior to the project, the latter has to be run alongside extensive hours of regular courses.

Schmidt (1986) suggested that project work is too complex to be used in the early stages of study, as students need a fair amount of prior knowledge to work in this way, whereas PBL is suitable for beginners—we will show in the analysis that this was a misconception on part of Schmidt, who only saw project work as a method for the application of prior knowledge. Another consequence of this difference according to Schmidt was that much more attention has to be given to problem crafting in PBL, as problems are the cues to learning, whereas when learning has already taken place prior to the project, the format of the problem therein is not so important and can be left to the students themselves. This point was also strongly put forward by Andersen and Kjeldsen (2015) from RUC, who wrote that the crucial historical difference in who gets to write the problem and the underlying philosophical rationale for this sufficiently differentiates PBL from problem-oriented, interdisciplinary, participant-directed project work to warrant considering them as two different pedagogical methods, choosing to refer to their own model as "PPL." Additionally, Schmidt (1986) argued that projects and PBL make different demands on teachers: in projects, teachers are equal members of the team, as invested in the outcomes of the project as the students themselves. However, in PBL, the problems being purely educational, they do not constitute intellectual challenges for the tutors, who can concentrate on their pedagogical function. Savery (2006) disagreed with this statement, making the case that the scope of projects is usually defined by teachers, and therefore their role in the project is simply to ensure that students follow the procedures set out for them. Savery's view on projects was arguably much narrower and more practice-oriented than Schmidt's. Schmidt placed project work further down the student-centered end of the learning spectrum, whereas Savery thought PBL was half-way between student-centered and teacher-centered learning, revealing some confusion around the notion of "projects." It is precisely this lack of a

clear definition that allowed scholars to argue for the merging of the PBL and project work models on the grounds that some projects could be interpreted as problem-based.

Arguing for merging PBL and problem-oriented project-work

In 1996, Kolmos proposed that problem-based learning and project work should not be compared on a level plane because project work concerned the organizational structure of the learning, whereas PBL concerned the educational structure of learning. Given this, three types of project work could be identified: assignment projects, which are teacher-driven, application-of-knowledge projects of the type described by Savery; subject projects, in which students are given a broad theme from which to derive a problem and then seek to resolve it; and problem projects, in which students have to direct every aspect of project from problem-formulation and methods to final product. Kolmos argued that whereas problem-based learning, being a set of student-centered learning principles, was not compatible with the first type of project, it could be superimposed onto the second and third. Therefore, according to Kolmos, the way in which McMaster and Maastricht organize their tutorials in month-long or week-long problem cycles may differ from the semester-long problem-cycles of Aalborg, but those are simply organizational issues. Whether one looks at medical problems in Maastricht or problem-projects in Aalborg, the educational principles of problem-orientation remain constant.

De Graaff refined this argument with Kolmos (2007). While reiterating the distinction between the three types of projects, the authors suggested that the difference in length of the problem cycle was caused by the nature of the discipline in question, namely medicine versus engineering, rather than by a difference in the education method. The core principles, they argued, remain the same and can be expressed along three axes: learning, contents, and the social aspect. Thus, according to these authors, the programs from McMaster, Maastricht, Roskilde, and Aalborg all feature a problem as the starting point of the learning process. This problem serves to trigger motivation in students, provides an authentic context for learning, and therefore provides justification for using the term PBL for all of them. Additionally, they argued, PBL is by nature interdisciplinary, and problems serve as examples of broader concepts and principles. Finally, self-direction and collaboration form the core of the social component of the learning. Thus, projects are not necessarily merely applications of knowledge but could also be the starting point of knowledge acquisition (see Table 1).

What emerges from this review of the literature is a difference between the position held by authors from Maastricht and Roskilde on the one hand (the separation position) and the position taken by authors from the Technical Faculty of Aalborg on the other (the merging position). However, the literature fails on several points. Firstly, it seems that the contributors to this debate are not arguing from comparable standpoints. Roskilde argues for a historical distinction, Maastricht for an organizational one, and Aalborg for a philosophical merging with disciplinary differences in application. Secondly, very little empirical evidence has been provided to support the points made. The arguments from both sides were mostly made without reference to concrete examples in past or current practice. This makes the outcome of the discussion harder to grasp given that it is never clear which sort of practice the authors are referring to. After all, there have seemingly been almost as many ways of implementing PBL as there are PBL-practicing schools, and the same is true for project work. This makes it very difficult to know exactly what educational practices the authors are talking about.

In answer to this problem, the following sections will present a historical institutional comparison between the original McMaster, Maastricht, Roskilde, and Aalborg models of problem-based and problem-oriented learning, leading to a discussion section on current practice. We will begin by analyzing three important themes: educational problems, the role of teachers, and the educational process.

Comparison of the Nature of Problems

We begin by looking at "problems" in the original McMaster PBL model. According to the founding Dean, the purpose of educational problems was to trigger students to examine

Table 1. Summary of Arguments from the Literature

Arguments against using "PBL" for both models	Arguments for using "PBL" for both models
Problems in project work are far more complex than in PBL	Common educational principles
Self-direction is much greater in project work than in PBL	Problems as starting point of learning in both
There is a crucial difference in who gets to write the problem: teachers (PBL) or students (project work).	Commitment to interdisciplinarity in both
Teaching role is different between a PBL tutor and a project supervisor.	Primacy of self-directed learning in both

underlying physical or behavioural mechanisms, acquire the skills necessary to define and manage these problems for their future patients, and develop the learning habits necessary to seek out relevant information to define and understand these problems on their own (Evans, 1966). Such problems, in the early years of McMaster, often looked something like this:

> A man aged 35 years suffers a compression fracture of his lumbar injury, he develops pain in his left calf. Clinical examination suggests a deep vein thrombosis (D.V.T.) 2 days after symptoms attributed to D.V.T. had become manifest the man experienced onset of sharp pain just below the right axilla and aggravated breathing (Pleuritic pain). Cough developed with altered blood present in sputum. Analyse the above events in terms of possible cellular, tissue, organ and whole body response. Suggest rational therapeutic approaches (Muckle, 1971).

The above problem may have more than one angle of approach and several possible learning goals, but the subject matter is still carefully restricted to ensure that it does not exceed students' prior knowledge. Being thus restricted, the problem is suited for a short problem-cycle, typically one week. Problems at Maastricht were quite similar to those used at McMaster, except that these problems were often not patient cases but rather descriptions of interesting health sciences phenomena such as this:

> **Identical Twins**
>
> Jan and Erik, identical twins, lost their parents at the age of 7 from a car accident. Jan was fostered in the (3 children) family of a contract-labourer. Erik was fostered by the (also 3 children) family of a scientist. At the age of 6, both Jan and Erik were psychologically evaluated. Jan's IQ was measured as 111, that of Erik was 108. At the age of 12, both boys were evaluated again. Jan's IQ was now 93, and that of Erik 123. Explain the difference in the results (Schmidt & Bouhuijs, 1981).

An astute observer will note that the McMaster problem focused more on therapeutic approach, and therefore on professional practice, while the Maastricht problem focused more on explaining the phenomenon, and therefore on the acquisition of prior knowledge. This difference in approach has been elaborated upon elsewhere (Servant-Miklos, 2019b) and was resolved with McMaster aligning with Maastricht in 1991.

Let us now compare this with problems as they were as they were defined at Roskilde in the 1970s, at the apogee of its radical ambitions. In the ideal of critical theory, which defined the Roskilde model, problems emerged from the conditions of society, and implicitly, from class conflict. This ideal was reflected in the founding documents of the University (Interimstudienævnet for det Humanistiske Hovedomrade, 1972; Roskilde Universitetscenter, 1972) and applied in all three faculties, though most especially in Social Sciences. The description of problems in these documents leaves little doubt as to their centrality in the learning process. This is not, as Savery and Schmidt had assumed, a case of applying knowledge acquired through traditional course work. Instead, the objective was to deconstruct reality to access its hidden social structures, beyond existing disciplinary standpoints. In this sense, knowledge could not merely be applied, since the entire point was to deconstruct the accepted truths of disciplinary theorizations. Certainly, one must know the theories to deconstruct them, but in this model the theories were not fed to the students, they arose in confrontation with social reality. Looking at the problem-statements from Roskilde, we can see that they covered central themes of Marxism and critical theory (see Table 2).

Table 2. Sample list of social sciences problem statements at RUC 1972 - 1975

1972	1.	The Village School
	2.	Imperialism: the Asian Mode of Production
1973	n/a	
1974	1.	Brazil: a study of production and class structures from the early colonial period.
	2.	Social Security Benefits
	3.	On Workplace Accidents
	4.	The State Theories of Aristotle
1975	1.	Class analysis of clerks in the private sector.
	2.	State-industrial structure and capital building in Denmark
	3.	Female clerks: revisiting the class position of female clerks
	4.	Danish Capitalism in crisis: an analysis of the 1930s and 1970s
	5.	Trade Unions, the unity of action and the wave of strikes in 1974/75
	6.	The origins of a pauperization theory in the capital relation.

The social-critical dimension of these problems makes them different from McMaster and Maastricht problems in their underlying purpose. In that sense, one would do better to look at the Aalborg problems over the same period for a fairer comparison, given that Aalborg was never much swayed by critical theory (see Table 3).

These problems did not comprise any a priori social-revolutionary elements (although some could be interpreted as such). The science problems, more than the rest, focused on the resolution of practical problems, such as the construction of a swimming pool in a village outside Aalborg. From here on it becomes difficult to make statements about the "Aalborg Model" in general. A turf war seems to have erupted between some radicals led by Eva Hultengren at the social sciences and humanities departments, who believed that Aalborg should pursue Roskilde's commitment to critical problems (Hultengren, 1979), and those who believed that such problems were detrimental to real learning (Keldorff, 1981). Meanwhile, the Technical Faculty followed its own practice-oriented approach and published English-language books about the "Aalborg Model" in which only the Technical Faculty's pedagogy was expounded (Kjærsdam & Enemark, 1994), thus presenting engineering education as the face of the "Aalborg Model" to the world, and later the standard bearer of the shift to the "PBL" appellation. This explains why our analysis of the other faculties at Aalborg is sparser, and unless otherwise mentioned, the "Aalborg Model" refers to their practice of engineering education.

What we can say about Aalborg across all of its faculties is that, like the problems at McMaster and Maastricht, its problems triggered the need for an explanatory theory. It is not the case that the students were simply applying principles and theories from lectures, a contrario to what Schmidt claimed about project work (Schmidt, 1986). However, unlike the more restricted medical problems above, the problems in the Roskilde and the Aalborg list could be approached from a very broad range of interdisciplinary angles, using a plethora of theoretical models, including empirical data collected by the students themselves as well as an understanding of relevant literature. It would be unfair to say that these problems were a free-for-all given that the themes within which the problems could be defined by students were selected by the faculty, providing some basic guidance for students. But ultimately whilst Maastricht students were confronted with a problematized situation from the outset, both Roskilde and Aalborg students from all faculties were required to

Table 3. Sample project themes and problems statements at AAU in 1974-1976

Language & Pedagogics (Humanities)	Theme: Education & Teaching	1. Children in Kindergartens 2. Relationship between language & cognitive development and attitudes about education. 3. Reading books & connection with reality, a research into 5th grade reading books. 4. Investigation of socially relevant radio programme for 7th graders. 5. Language and teaching in evening schools.
Social Sciences	Themes: Unemployment in relation to the crisis Violence in society Democracy, ideology reality	1. Criminal acts' influence of a family's situation. 2. Family and the public sphere's function as socialization factor. 3. Treatment possibilities in connection with different social events for low-income families. 4. Youth crime. 5. Disabled pensioners.
Technical & Natural Sciences	Theme: The house (building): its surroundings, form, function, constructive design	1. Sports hall at a school (South East Aalborg) 2. Technical, vocational school in Aalborg East 3. Swimming pool in school in a village outside Aalborg. [For each of these they have to propose an analysis of surroundings, form, function, and design]

problematize it themselves, and this was and remains to this day the single greatest difference between the McMaster and Maastricht approach to PBL and the Roskilde and Aalborg approach to problem-oriented project work. This difference gave the content experts a much larger control over the direction the students might take in McMaster and Maastricht than in Roskilde and Aalborg. At both McMaster and Maastricht, the belief was that students lacked the necessary background knowledge to know which problems were relevant to their studies—and it was particularly important that they did study the right problems because at the end of the day, people's lives depended on their proper training as doctors. In the both the Roskilde and the Aalborg models, students would get together in groups and decide, based on the theme, which problem they wanted to tackle for their project. The key to understanding the difference in problem formulation (experts versus students) could be found in Illeris' (1974) interpretation of Piaget as a justification for participant-direction at Roskilde. He claimed that unless a problem was truly a problem to the students, they would not be interested in addressing it, and would instead seek shortcuts to obtain the desired grades and please teachers. In this case, learning would be merely accumulative, or at best assimilative. This is a Piagetian shorthand to designate learning that fails to challenge the person's preconceptions. The only way to ensure true learning was to spur accommodative learning, or learning that forces mental representations of the world to change, which could only occur when the learner was truly invested in the problem at hand. Thus, for real learning to take place, the learner had to be allowed to formulate a problem that would interest him.

We can conclude that the nature of problems in the McMaster and Maastricht approaches differed quite markedly from those at Roskilde and Aalborg—in their purpose, their form, and their formulation (see Table 4). What this means is that if one does use the appellation "problem-based learning" for all of these approaches, one must do so with the understanding that the meaning of "problems" is quite different in each case. One might argue that this difference is purely down to disciplinary imperatives, but given that Donald Woods from McMaster's engineering department was more or less successfully using the McMaster method in his course in chemical engineering from the 1970s to the 1990s (Woods, 1991), and that the Faculty of Economics of Aalborg uses problem-oriented project-based learning whilst the Faculty of Economics of Maastricht University uses the method borrowed from the medical school, this is an unlikely explanation. Therefore, the difference in the understanding of problems probably lies in the models' historical path-dependency rather than the constraints of particular disciplines.

Comparison of the Role of Teachers

McMaster and Maastricht call them "tutors," while Roskilde and Aalborg call them "vejleders" [way leaders] in Danish or "supervisors" in English. Everyone agrees that when learning is based on problems, the teacher no longer teaches in the traditional sense of lecturing. But how does a problem/project supervisor compare with a tutor in the PBL tutorial setting?

The role of a vejleder was a rather fuzzy construction both at RUC and AAU, which meant that each faculty developed its own set of practices in this regard, and the practice of RUC differed from that of AAU. From the writings of Illeris (1974), from which both institutions drew inspiration, we gather that supervisors were considered one of the participants in the project work, alongside the students. What's more, teachers were expected to set the criteria (themes) for problems to ensure that these would meet the requirements for accommodative learning. More specifically, in the social sciences at RUC, the teacher was defined as a consultant to

Table 4. Matrix showing the combinations of the organization of learning with problems and nature of problems in the different institutions using problems

Organization of learning with problems/Nature of problems	**Tutorial groups (problem written by teachers)**	**Project work (problem written by students)**
Practice-oriented	McMaster (until 1991)	Aalborg (Technical)
Content-oriented	Maastricht McMaster (after 1991)	Aalborg (Social Sciences & Humanities)
Critique-oriented		Roskilde Aalborg (Social Sciences & Humanities)

be called upon as the need arose, whether for methodological or content support (Roskilde Universitetscenter, 1972). But pinpointing the pedagogical implications or precise function of this role at RUC was rendered problematic by the large influx of left-leaning teachers who saw their role from a social-revolutionary angle rather than from the perspective of progressive pedagogy. The problem with this revolutionary stance was that it actually lacked theoretical content and pedagogical depth (Hansen, 1997). This translated into political trouble-making instead of a concrete roadmap for rethinking teaching beyond disciplines.

Despite its more pragmatic orientation, AAU did scarcely better in defining the supervisor role in its early days. With an influx of teachers from pre-existing teaching institutions, it had to contend with experienced teachers attached to their traditional ways, a few new radicals of the Roskilde caliber, and young recruits with no idea about project work. By the time the university opened, the planning body still had not decided on the extent to which the project should be framed by the teachers or students, on the distribution of teacher-centered and student-centered activities, and on the qualifications expected of incoming teachers. During the 1970s, pamphlets emerged explaining that the role of the supervisor was that of a participatory co-worker in the project, but in practice, in the first ten years at least, the role of the supervisor tended to emerge in each faculty as a construction negotiated between teachers, their students, colleagues, and the institutes in which they operated (Servant-Miklos & Spliid, 2017). As such, in some programs supervisors were more directive and content-oriented, while in others they were more passive and methodology-oriented.

Given the blurred nature of the vejleder role, what can we say to offer a fair comparison with the McMaster and Maastricht tutor? The most important point is that the scope of the supervisor role could be much broader than that of the tutor. Indeed, much has been written about role of the tutor at both McMaster and Maastricht, who acts as a process guide who uses his content expertise sparingly and only in a bid to enhance his cognitive congruence in group meetings (Chng, Yew, & Schmidt, 2011; Maudsley, 1999). The literature makes it clear that the role of the tutor is limited to his interaction with the students in the tutorial group setting, usually two to three hours, once or twice a week, for the duration of the learning unit. Within that setting, the McMaster tutor had a freer hand to steer the group in his preferred direction, whereas the Maastricht tutor was constrained by the seven-step method in which the role of guiding the group process was largely left to a student chair. The tutor's role was, from the outset and to this day, principally to probe students to go deeper into the subject matter using "scaffolding" techniques (a constructivist method of helping students structure and expand their mental representations of reality) and to step in when the group process was malfunctioning (De Grave, Dolmans, & van der Vleuten, 1999). The PBL tutor was never considered a co-participant in the problem-analysis process. Outside of the group meeting, students were expected to reach out to resource persons rather than their tutors if they needed extra guidance, although they rarely did so.

In summary, the role of the tutor and supervisor are similar in the sense that they are focused on student guidance and support rather than knowledge transfer, authority, and process-direction, but there is a major difference in the scope of the roles. The role of the tutor is far narrower and with a smaller margin of interpretation than the role of the project supervisor. It must however be remembered that while students at McMaster and Maastricht generally had little contact with professors and lecturers other than as tutors, half of the students' contact time at Roskilde and Aalborg was with lecturers in a lecture setting, which gives a rather different dynamic to the learning process.

Comparison of the Educational Process

The comparison of the learning process in PBL and problem-oriented project work has two components, which we shall call external and internal. By external, we mean the process that takes place in the classroom—the arrangement of students in groups, the study materials, self-study, etc. By internal, we mean the process that takes place in the head of the student, thus, from a cognitive psychological perspective. While the first is of organizational importance and therefore answers to Schmidt's argument for separation, the second answers to Kolmos' claims that the learning principles are comparable.

Comparing the "external" educational process

Small groups

The idea for the new forms of education at RUC, AAU, McMaster, and Maastricht all began with the same complaints about the traditional education process. Under the old ways, students would be bored stiff by pontificating professors in large lecture halls, and this was simply inadequate for the twentieth century. The answer was to strip the professor of his lecture hall and hand power to small groups of students who would learn not by being told but by experiencing problems first hand. In all four programs, the physical representation of this change was in the shaping of learning spaces as small group rooms, rather than massive halls. At Roskilde, this idea was transposed into a "house" system, which in Aalborg was called the "storgruppe" [Large Group], and featured as a centerpiece of both student life and the physical

structure of the campus (Illeris, 1992). Each House or storgruppe comprised 96 students, 8 teachers, and a secretary, divided into a number of project groups of usually 6-8 students, each with their own room equipped with a typewriter, printer, and other necessary group-work facilities (Aalborg Universitetscenter, 1976).

At McMaster and Maastricht, the Faculty was built to include a large number of small group rooms for tutorials as well as a "Home Base" (McMaster) or "Study Landscape" (Maastricht) for groups to conduct their self-study. Groups at McMaster initially comprised 5 students, and at Maastricht 6-8 students. That ideal is long gone due to financial constraints, with the norm in tutorial groups at both institutions now at 8-12 students per group, with some groups of up to 15 or 20 students (Moust, Berkel, & Schmidt, 2005).

One notable difference in the format of small-group work is that on the one hand McMaster, Roskilde, and Aalborg did not tend to structure the times at which the groups would meet, whereas on the other hand Maastricht provided a fixed schedule for tutorials. At Maastricht, the group could meet outside of those hours amongst themselves, but the tutor would not be present, whereas the McMaster tutorial meeting was organized with the tutor at the request of students, much like in the Roskilde ideal (Spaulding, 1991). This said, even though all four schools studied here featured small group work as a core component of their educational process from the outset, the two Danish institutions took this principle one step further by turning the end-of-project examinations into a group affair too (Klemmensen, 1997). Indeed, students at both RUC and AAU would have to hand in their project report and then present their findings together, thus obtaining one grade (pass or fail) for their work as a group (Aalborg Universitetscenter, 1976). These group exams came under fire in recent years from a right-wing government coalition in Denmark claiming that they stifled individual merit (Krogh & Rasmussen, 2007), but after a brief period of being discontinued, they were reinstated (Ministry of Higher Education and Science, 2011).

In conclusion, the organization of learning into small groups is one of the features that brings the four models closest together. This is not surprising, as these models were constituted as a 1970s rebellion against the patriarchal authority of professors. However, if small group work was the constituting feature of PBL, by that token all small-group activities should be considered PBL, including team-based learning, case-based learning, the jigsaw method, and so forth. Since this suggestion is absurd from a historical, philosophical, and organizational perspective, then small-group work can at best only be considered a necessary but not sufficient condition of PBL.

Courses and lectures

One of the key principles of the McMaster program was that lecturing would only be done in exceptional circumstances. McMaster's Education Committee noted of lectures: "Large group—reserved for a few important occasions a) a useful visitor who has much to offer but no other method of communication b) the presentation of organized information in concise form on a complex subject. Time saving is the goal. c) a change of pace when other techniques are wearing thin" (Education Programme Committee, 1968). Therefore, lectures were a very limited part of the program, which was centered on tutorial discussions and self-study. Neither McMaster nor Maastricht ran any traditional courses alongside their problem-based program: whatever students had to find out should be available from the study materials or experienced in the skills lab and other sources of applied knowledge.

In its earliest days, Roskilde offered a similar model, with problem-oriented project work as the default mode of study and courses as "auxiliaries" to the projects as and when students required them. But from the outset, natural sciences, being deemed too difficult to handle without supporting theoretical instruction, was offered an exemption to this principle and project work was reduced to 50% of study time, with the rest filled by traditional courses (Hansen, 1997). It was still the case in the early 70s that lecturing was a marginal activity reserved for cases where students felt some theoretical explanations might help: "teachers at Roskilde do not lecture and are used as references by students when they feel it necessary" (Astroth, 1973, p. 11). However, around 1975, as pressure mounted and tensions between the university management and the ministry of education rose, a compromise was forced according to which disciplinary inputs were reinstated alongside project work (Hansen, 1997). By the 1980s, a 50/50 share of project work and regular courses had emerged that is still practiced today.

The 50/50 debate was never an issue at Aalborg, where the division was accepted from the outset and included in the university planning proposal. Half of the course time was allocated to courses specific to the projects and the other half to general theory courses. It seems this approach has been quite popular, since, as Kjærsdam and Enemark (1994) noted from a student evaluation, "the balance with 50% project work, 25% project-oriented courses, and 25% general courses was assessed as perfect." Despite this positive assessment, Aalborg reformed its curriculum in 2010 such that all traditional courses are now independent from the project, thereby moving the emphasis farther away from the problem-projects and closer to disciplinary knowledge transfer (Dahl, Holgaard, Hüttel, & Kolmos, 2016).

What we can conclude from this is that while the Roskilde study format would originally have been closer to the modus operandi of McMaster and Maastricht in their commitment to problem-orientation as the sole guide to learning, the later Roskilde and the Aalborg model veered decisively in the direction of a more strongly teacher-guided process with the insertion of the 50% courses rule. Thus, if the ratio of lectures to small-group problem-work were to determine the sort of PBL that one ends up with, then according to Kwan and Tam's (2003) classification of PBL curricula, in which type I contains the least PBL and type IV contains the most, the pre-2010 Aalborg would best fit the "type III Hybrid PBL" model, while the post-2010 Aalborg moves a step closer to a "type II Hybrid PBL." That said, Kwan's typology was designed to describe PBL programs of the medical variety; therefore the fit with Aalborg is far from perfect and provides an unsatisfactory description of a program with such a long, rounded history of using problem-oriented projects.

Comparing the "internal" educational process

The effect of McMaster and Maastricht models on the psychology of learning have been well documented by Norman and Schmidt (Norman & Schmidt, 1992; Schmidt, 1993), and their findings will be used to illustrate our analysis. By contrast, very little empirical research has been done to examine the cognitive processes that learners studying under the problem-based project model go through.

The foremost benefit of PBL at McMaster and Maastricht is its ability to activate prior knowledge, in line with cognitive psychology's findings that this enhances deep learning. In "problem-projects," students are confronted with a real-life or realistic situation that they are to investigate. In order to resolve the problem, they are given courses related to the project, but not before they consider the problem. This means that in the first instance, students would only have their prior knowledge with which to handle the problem. Does this mean that the projects work as effectively as the problem-triggers of Maastricht in activating prior knowledge? The absence of studies makes this a difficult point to conclude on, though we surmise that this depends very much on whether relevant cues are included in the project brief (hard scaffolding, meaning physical learning tools to help structure learning) and how much scaffolding students get from supervisors (soft scaffolding, meaning verbal cues to help structure learning).

The second important benefit of McMaster / Maastricht PBL to student cognition is its ability to contextualize knowledge. Schmidt argued that "the problem serves as a scaffold for storing cues that may support retrieval of relevant knowledge when needed for similar problems" (1993, p. 428). Given that the project problems are and always have been as realistic (if not more) than the problem triggers of the McMaster and Maastricht, we have an a priori reason to believe that this model would enable contextualization and later retrieval of relevant knowledge effectively, but this has not been tested empirically.

The third benefit of PBL is its ability to enable encoding of knowledge into long-term memory through elaboration. Schmidt (1993) linked this to the "reporting phase" of the Maastricht model, which allows students to explain their self-study findings. In the Aalborg model, the existence of group examinations based on the project work and the requirement that students hand in a group report would a priori satisfy the active processing of new information through elaboration, although once again, this should be empirically verified.

Finally, one of the biggest advantages of the McMaster and Maastricht models according to Norman and Schmidt (1992) is their ability to motivate students. Comparing this with the two problem-project models, the confrontation with an unfamiliar real-life problem in a project context would be a priori as likely (if not more) to spur student motivation as problem triggers in the medical PBL context. There is some empirical evidence to suggest that this is indeed the case with the model as it is applied today in engineering: Zhou, Kolmos, and Nielsen (2012) showed the multiple ways in which the Aalborg model could stimulate motivation in an engineering group.

What can we conclude from this? In the absence of data, simply that a priori, there is no reason to believe that a curriculum that handles educational problems in a project format should not be able to trigger the same learning processes as a curriculum that handles problems with shorter, teacher-formulated triggers. This a priori statement should not come as a surprise given that both of the Danish models were supported originally in part by the same constructivist arguments (Illeris, 1974) as those used by Schmidt to support the Maastricht model (Schmidt, 1983). In this sense, Kolmos may well have been right in claiming that there are common educational principles underlying PBL and the project work model. But is the similarity of educational principles enough to justify joining the models under one roof? We shall consider this argument in our final section.

Comparison of the Educational Principles

The first conclusion one can draw from an extended study of historical materials from all four programs is that there was, in the beginning, no overarching philosophical reference employed by all four programs. The second conclusion is that each program did have at least one intellectual influence in common with one of the others, and the third conclusion is that all programs latched onto constructivist

education theory in their later years. What this says is that all four models are children of the same generation, possibly even the same extended family, but not of the same parents (see figure 2 for the influences of the four original programs).

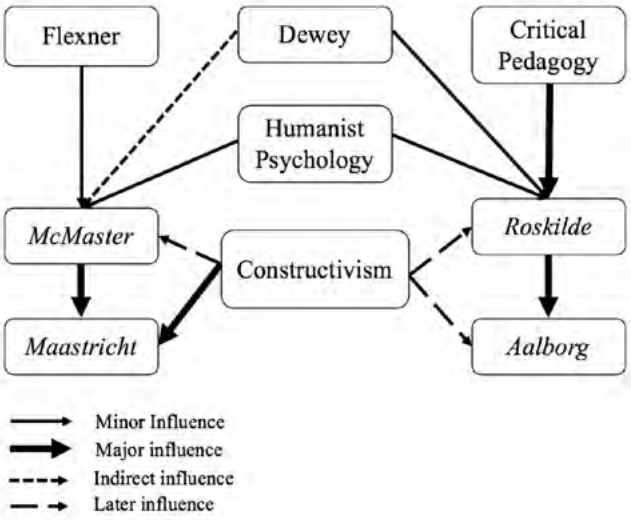

Figure 2. Intellectual influences behind the four original problem-based programs

Maastricht was most strongly influenced by constructivist psychology, in particular the psychologists in the tradition of Piaget. Roskilde was most strongly influenced by critical philosophy, in particular the Frankfurt School philosopher Negt, and McMaster and Aalborg by a broader scope of influences ranging from Rogers' humanist psychology to Dewey's education philosophy. McMaster was also to some extent influenced by the discussions surrounding the Flexner report on medical education in the early twentieth century (Flexner, 1910). The influence of Negt's critical philosophy was exclusive to the Roskilde and the early days of Aalborg and did not transpire at all in McMaster or Maastricht. Thanks to the work of Illeris (1974), Roskilde shared Deweyan and Rogerian inspirations that were also present at McMaster, though these were ignored at Maastricht. These influences were limited at Roskilde in the days when critical theory still held sway, but grew stronger as the latter fell out of favor in the late 1970s. At Aalborg, where critical theory failed to find a strong anchor point, Illeris' work on education psychology exerted a more powerful pull on teachers in search of an explanatory paradigm, and therefore the influence Piagetian ideas was stronger. As the decades passed and collaborations between McMaster and Maastricht intensified, McMaster also embraced constructivist psychology as a research avenue to support the development of medical education and PBL. This is hardly surprising, given the almost complete triumph of constructivist psychology over other alternative scientific interpretations of learning from the 1980s onwards (Ohlsson, 2012). It is therefore safe to say that today, all four programs and many of their "offspring" have been touched to some extent by the principles of constructivism, and to that extent, Kolmos is indeed right to claim that there are common learning principles behind PBL and problem-projects. Given that this is the case, then perhaps all educational innovations which claim some Piagetian ancestry should also be considered as potential candidates to the title "problem-based learning." However, such a broad sweep brings us no closer to understanding what PBL is in practice. To leave it at that would sow confusion about the generalizability of scientific research done on PBL that is based on specific educational practices, rather than principles.

Discussion

Looking at a cross-section of the four curricula as they were in 1975, the students' experience at McMaster and Maastricht would have been nothing like their experience at Roskilde or Aalborg, because the learning was organized so differently. Let's take, for example, a student at Maastricht in 1975. They would have attended pre-scheduled tutorials twice a week, a Skillslab session once per week, and perhaps a two-hour lecture if required, while the rest of their time would have been dedicated to self-study based on the learning objectives of the tutorial session. A student at the Technical Faculty of Aalborg, on the other hand, would have attended a significant number of lectures (some independent of project content and others bound to the project content) and then divided their time between self-organized project meetings with their teammates, and if necessary, the project supervisor. The amount of time they spent on the project per week would have depended on how close to the deadline the student was, with more time spent on courses in the beginning of a semester than in the second half. Our Maastricht student would be covering one to two problems per week, resulting in an end-of-block examination after only six weeks, whilst our Aalborg engineering student would be laboring away on a lengthy, complex problem for which they would need the support of technical lectures. As a comparison of a cross-section from 1975, then, it would be hard to argue that there are sufficient similarities between the organization of PBL and the organization of project work to merge them under one conceptual banner.

However, the curricular organization of PBL and project work has become somewhat more confusing since 1975. On the one hand, a large split in the interpretation of the purpose of PBL in the McMaster-Maastricht model emerged in the late 1970s, pitting those who believed that PBL was best used as a tool to develop problem-solving skills and clinical reasoning against those who believed that PBL should

be seen as a vehicle for knowledge acquisition. This dispute has been written about at length elsewhere (Servant-Miklos, 2019b), and therefore will not be developed here. However, as argued by Servant-Miklos, the continuing popularity of the "problem-solving skills" approach allowed for the proliferation of "PBL Hybrids" in medical education. Certainly, PBL Hybrids still offer a variable amount of time spent in tutorial groups with a tutor who acts as a process-guide. But since students are not provided with sufficient time to study on their own, these hybrids compensate with traditional knowledge-transfer lectures and focus PBL tutorials instead on elusive "collaboration skills" and "problem-solving skills." These developments have cast a shadow on many of the core tenets of the McMaster and Maastricht models, namely the availability of ample time for self-study, the reduction of lecture hours, and the primacy of problems over knowledge-transfer. One might dismiss these programs by simply stating that they are not PBL at all, but since even Maastricht fails to abide by its own PBL standards these days, it becomes very difficult to sort the wheat from the chaff (Moust, van Berkel & Schmidt, 2005). If the ideal model of PBL exists only on paper in the scientific literature, can it justifiably be used as a benchmark for practice? On the other hand, Aalborg itself has begun adopting some of the educational format of the McMaster-Maastricht model. In 2013, Aalborg opened a new medical school that combines the medical case-based approach to PBL with project work (Stentoft, Duroux, Fink, & Emmersen, 2014). Add to this the emergence of programs, particularly in Asia, that propose a cocktail of many progressive approaches, including PBL and project work, and providing clear-cut demarcations becomes almost impossible.

Concluding Comments on the Boundaries of PBL

It seems that the actors in this debate are not merely figuring out how they compare to a hypothetical "original" PBL model that would come complete with an instruction manual, but have instead been engaged over a period of time in a process of defining and redefining what exactly is covered by the appellation "PBL." To do this, they have called into play arguments from the disciplines of psychology, history, and philosophy, in an attempt to perform some kind of "boundary work" around PBL, to borrow a term from the sociologist Gieryn (1983). The intellectual confrontation is principally taking place at present between a small gathering of scholars of PBL in medical education, principally from the Netherlands, whose strength lies in the production of high-impact scientific research on PBL (Pinho, et al., 2015), and a group of engineering educators whose strength resides in outreach and reputation-building around their model. The former group is attempting to enclose the PBL debate around principles researched and discussed in the scientific literature in the field of cognitive psychology, and dismiss everything else as a side issue. The latter wants to see the definition of PBL expanded to encompass the project form of problem-oriented education. The two opposing groups have used different strategies to strengthen their case: the former through scientific publications in high-impact journals, the latter through rallying to their cause high-prestige institutions such as UNESCO and the European Society for Engineering Education (SEFI), organizing conferences in which they invite speakers from both models, and the development of outreach tools such as an online Masters program in PBL and The Journal of Problem-Based Learning in Higher Education. Both parties have understood the fundamental importance of international visibility for their cause, and have developed professionalized international outreach strategies through networks and training centers for their models as a result. Meanwhile, Roskilde has gone its own way, clearly separating itself from the PBL debate and nurturing its own international network based on a revival of critical pedagogy, the Critical Edge Alliance.

This situation has generated a non-negligible amount of confusion for practitioners. The culture of consulting high-impact scientific publications on education is far from normalized amongst the majority of academics, who are first and foremost experts in their disciplines and only incidentally educators. As a consequence, the average PBL novice will invariably seize one of the innumerable books written on the subject, very few of which deal with the historical, philosophical, or psychological underpinnings of PBL to a serious extent but tend instead to reflect specific examples of practice. As a consequence, there is a tendency for the novice practitioner to concoct her own educational alchemy from various sources of inspiration and call it PBL. The author has witnessed this phenomenon across a large selection of universities in Pacific Asian countries, with the unfortunate result that PBL often ends up either generating resentment among students and staff who don't understand what they are doing or why they are doing it, or ends up being considered ineffective because it is applied in educationally dubious constructions, or sometimes ends up being merely instrumentalized for accreditation purposes with no real intention to promote self-directed learning or accommodative learning following constructivist principles. In the end, there are curricula with less than 10% of student time spent in tutorials being labelled "problem-based learning" (Kwan & Tam, 2003).

Ultimately, we submit that there are three possible resolutions to this conundrum. Firstly, the scientific community could rebel against the use of "PBL" as a hold-all name for active education methods, either by issuing a series of high-impact articles to that effect, or by co-opting heavy-weight

education scholars in new PBL-adopting institutions into the exclusionary perspective. This scenario will only take place if the scientific community finds a way to make their point intelligible to the wider audience of novice educators, which means translating the findings of high-impact publications into easy-access books and multimedia content that can be considered authoritative, since this is what educators use. In the second possibility, the adoption of "PBL" to describe all programs which contain a problem-oriented small-group component succeeds due the superior communication capabilities of the proponents of this approach. This will happen if the heavy-weight contributors in the scientific field retire, retreat from their position, or cease to care about the distinction. Thirdly, and most likely, confusion will remain, with the scientific community dominated by medical educators from the Netherlands and North America meaning one thing with PBL and the educational practice increasingly meaning two or more things at once. The split in this scenario could last until either the debate becomes irrelevant because all forms of problem-orientation are replaced by something new, or because a significant shift occurs that tips the balance in favor of the first or second scenario, for instance if PBL spreads en masse to other disciplines like social sciences or humanities and they join the debate in favor of one position or the other.

This article has shown that there is no clear-cut answer to the question of whether problem-projects should be subsumed under the label "PBL." The proponents of the separation position are correct to point out that the two bear little practical and organizational resemblance. The proponents of the merging position are correct to point out that they share common principles. Neither of these two assertions is sufficient to arbitrate on the matter, and an answer which would have been historically clear-cut has been blurred by an increasingly fragmented practice. The purpose of this article is not to advocate for one position or another, but it is the viewpoint of the author that this issue needs to be addressed for the sake of safeguarding the benefits of PBL as an education method. The findings of this paper should encourage the parties in this debate to discuss this situation openly. The risk of not doing so is fomenting further confusion and fragmentation in the practice of PBL until PBL means nothing and everything.

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