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A Scoping Review**

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ABSTRACT

It is often assumed that problem-based learning is an effective approach for fostering the development and/or improvement of students' critical thinking. To shed light on the connection between problem-based learning and critical thinking, this scoping review maps out how the notion of critical thinking is conceptualized in relation to problem-based learning in the literature about problem-based learning in the context of higher education. Eight academic databases were searched and a total of 66 peer-reviewed articles were identified as eligible for review. Our findings indicate that there is a plurality of positions regarding the meaning of critical thinking and the concept's relation to problem-based learning. What is more, more often than not, no explicit explanation for why this connection is thought to exist is presented.

Keywords: problem-based learning, critical thinking, higher education, scoping review

Critical thinking is high on the agenda these days: Politicians talk about it, industry demands it, and institutions of higher education try to teach it. Indeed, higher education, no matter the particular discipline, is expected to contribute positively to the development of students' abilities for critical thinking (Abrami et al., 2008; Bailin & Siegel, 2003; Johnston, Mitchell, Myles, & Ford, 2011; Kilby, 2004; Roth, 2010; Siegel, 1980; 1990; Winch, 2006). The focus on critical thinking raises interesting questions about how different pedagogical approaches may facilitate the development and/or improvement of students' critical thinking. One approach that is often assumed to effectively promote the development and/or improvement of students' critical thinking is problem-based learning.

Problem-based learning was developed by educators from McMaster University as an instructional approach to medical education in the 1960s in response to the problems they encountered with the traditional didactic approach used to prepare medical students for clinical practice. The educators from McMaster found that students were unable to apply the reasoning skills of experienced physicians and that students would often forget what they had been taught in the lecture hall (Hmelo-Silver, 2015). In an attempt to remedy this unfortunate situation, based on their own experiences,

these educators developed problem-based learning as a new instructional approach to promote student-centered, multidisciplinary education and lifelong learning in professional practice (Boud & Feletti, 1997). During the 1980s and 1990s problem-based learning spread to other institutions of higher education in North America and Europe (Savery, 2015). One of the outcomes expected by these institutions was that problem-based learning would facilitate the development and/or improvement of students' critical thinking, cf. e.g., Thammasitboon, Sukotjo, Howell, and Karimbux (2007) who describe the reasons for adopting a problem-based approach as stated by the Harvard School of Dental Medicine:

Problem-based learning (PBL) was implemented into the dental curriculum at the Harvard School of Dental Medicine (HSDM) in 1994 with an expectation that this pedagogy would enhance students' critical thinking and communication skills as well as general professional competencies (p. 1080).

Similar statements can be found on the websites of three other major American universities (Stanford University (n.d.), University of Illinois (n.d.), and Brown University (n.d.)) that encourage the use of problem-based learning.

All three of these institutions list the potential for enhancing students' critical thinking as one of the main reasons for the adoption of a problem-based approach to learning and teaching. Similarly, in Europe where problem-based learning has been adopted most notably perhaps by Maastricht University in the Netherlands and in Denmark by Roskilde University and Aalborg University, critical thinking also figures prominently among the reasons for adopting a problem-based approach to learning and teaching. Thus, on the website of Maastricht University, for example, critical thinking is listed as an advantage of problem-based learning (Maastricht University, n.d.), while in a brochure used to introduce new students to Roskilde University it says that "This [problem-based learning] is a working method that increases your ability to analyse and collaborate, to have a critical and independent view, and also to focus on what you find academically interesting" (Roskilde University, n.d.). The institutions mentioned here are merely three examples of universities that have encouraged a problem-based approach to teaching and learning. From the information available on their websites, it is not possible to ascertain to what extent problem-based learning is actually implemented. Rather, problem-based learning is listed as one of several possible approaches that teachers can employ to engage their students. In addition to the institutions mentioned here, there are numerous others around the world that have encouraged a problem-based approach to learning. However, the true prevalence of problem-based learning in institutions of higher education is unknown.

Having noticed that the claim that problem-based learning fosters critical thinking is quite prevalent, we initially set out to explore the underlying theoretical assumptions guiding this view. To that end, we set out to clarify the theoretical foundations guiding the understanding of the concept of critical thinking and to discuss how these relate to the ideas that inform problem-based learning.

In spite of the fact that a number of institutions of higher education seem to agree that problem-based learning may promote students' critical thinking, there continue to be many different understandings of what exactly problem-based learning is, so many in fact that Servant (2016) states that

Along the way, it [problem-based learning] has morphed into all manner of contraptions—some people adopting this or that aspect of PBL without the rest, others omitting one part and tacking others on to it (p. 1).

For example, a comparison of the kinds of problem-based approaches practiced at the institutions mentioned earlier would yield a number of highly heterogeneous descriptions

of what constitutes problem-based learning. Nevertheless, most researchers agree that all varieties of problem-based learning share the following four basic characteristics: (1) a focus on complex, real-world problems that have no one right solution, (2) students work in groups, (3) students gain new information through self-directed learning, and (4) teachers act as facilitators (Boud & Feletti, 1997; Hmelo-Silver, 2004; 2015; Savery, 2015). Moreover, problem-based learning is sometimes described as having a solid philosophical and epistemological foundation (Savery, 2015) that is based on an integrated approach to learning rooted firmly in John Dewey's educational theories, constructivist philosophies (McCaughan, 2015), and psychological theory (Hmelo-Silver, 2015). Thus, we imagined that because most researchers agree on the basic characteristics of problem-based learning and because problem-based learning is said to rest on a solid theoretical foundation, there would also be consensus about how and why this pedagogical approach fosters the development and/or improvement of students' critical thinking. As we began looking for explanations for why a connection between problem-based learning and critical thinking is said to exist, however, we were surprised to find that little research on this topic was available. To uncover what is already known about the assumed relation between problem-based learning and the development of critical thinking in students, we decided to conduct a scoping review and thus the research question we sought to answer was:

How is critical thinking conceptualized in research about problem-based learning in higher education in a sample of the research literature?

Insight into this relationship may help us build a foundation that can be used as a point of departure for an informed discussion about the potential inherent (or not) in problem-based learning to facilitate the development and/or improvement of students' critical thinking.

Method

A Scoping Review

According to Mays, Roberts, and Popay (2001), the aim of scoping reviews in general is "to map rapidly the key concepts underpinning a research area and the main sources and types of evidence available" (p. 194). The scoping review design suggested by Arksey and O'Malley (2005) was adopted for this study because it enables researchers to identify and summarize known literature on a given topic regardless of study design. Arksey and O'Malley (2005) list four potential reasons for conducting a scoping review: first, to examine the extent and nature of research activity; second, to summarize

and disseminate research findings; third, to identify whether there is a need for a systematic review; and finally fourth, to identify gaps in the existing research literature. All four of these reasons may be restated to describe our motivation for conducting the present study as we sought to investigate how the relation between problem-based learning and critical thinking has been articulated in current research literature.

The scoping review presented in this paper may be described in accordance with the framework suggested by Arksey and O'Malley (2005). According to Arksey and O'Malley, there are five stages that need to be completed when performing a scoping review: First, the research question must be formulated. Second, relevant studies must be identified. Third, studies must be selected to be included for review. Fourth, the data must be charted. Finally, the results must be collated, summarized, and reported. Although our study does not follow Arksey and O'Malley's guidelines for scoping reviews to the letter, we still consider this approach to be well-suited for our purposes since the objective of our study is in accordance with what has been described as the overall purpose of performing scoping reviews, that is, to identify and compare the conceptualization of common themes and constructs in and across individual studies in order to identify research gaps in the existing literature.

Keywords, Search String, and Screening

Based on our research question, the following keywords were identified to guide the literature search: problem-based learning, critical thinking, and higher education. These keywords, along with relevant synonyms, were combined to form the following search string that was used to search relevant databases:

((“problem-based learning” OR “problem based learning” OR PBL) AND “critical thinking” AND (“higher education” OR “tertiary education” OR university)).

Having consulted an information specialist, we chose to search the following eight databases and platforms, limiting our search to peer-reviewed journal articles written in English: Applied Social Sciences Index and Abstracts, Cambridge Companions Online, EbscoHost, Proquest, PsychInfo, Scopus, Web of Science, and Wiley Online Library. In keeping with the definition of scoping reviews provided by Arksey and O'Malley (2005), these databases and platforms were chosen for our scoping review to be able to accommodate our wish for breadth as well as depth.

Criteria for Inclusion and Exclusion

To best address the specific objective of our scoping review, we employed a number of criteria for inclusion as well as exclusion of studies. Studies were included for review if they

made explicit mention of problem-based learning/problem based learning/PBL in the title, abstract, or keywords; if they made explicit mention of critical thinking in the title, abstract, or keywords; and if they were performed in the context of higher education. Studies were excluded from review if by PBL they did not refer specifically to problem-based learning, if they were not published in a peer-reviewed journal (and thus, we deliberately excluded books, book chapters, conference proceedings, and grey literature in general from review), if they were not written in English, and if a full-text copy could not be procured by the university library in due time. We deliberately did not include studies for review if the term “PBL” referred specifically to project-based learning without mentioning problem-based learning. While this may be construed as a problem for the validity of our study, we feel that we made a reasonable decision in this regard nonetheless, since we did not notice any studies that mentioned project-based learning without also mentioning problem-based learning when we reviewed the literature. Of course, our failure to notice such studies in our review does not mean that such studies do not exist. It seems safe to assume, however, that even if a few studies of this kind should have been overlooked in the process, it does not matter much since a few studies of this kind would not have been able to change the overall pattern we saw in our findings. Also, while we are aware that different varieties of problem-based learning exist in different disciplines, we do not deal with these differences in this study because, given the particular purpose of the present study, we feel that it is more important to stress the similarities shared by different disciplines with regards to problem-based learning.

Having performed the initial search using the specific search string presented earlier, we proceeded to sort the articles by employing the criteria for exclusion and inclusion in the following five steps:

1. In the first step, we allowed Mendeley to identify and remove all duplicates.
2. In the second step, the abstracts of the remaining articles were sorted manually in the sense that titles, keywords, and abstracts of these articles were screened. At this point, all results in which the specific terms problem-based learning, problem based learning, or PBL and critical thinking were not explicitly mentioned in the title, keywords, or abstract were removed along with all studies that were not performed in the context of some form of higher education. Thus, articles that did not include these terms in the title, abstract, or keywords were excluded on the assumption that they

would not deal with the connection between problem-based learning and critical thinking in higher education as a significant part of the research.

3. In the third step of the procedure, we retrieved full-text versions of the remaining articles.
4. In the fourth step, we conducted in-depth inquiry of the full-text versions of the remaining articles. Articles that did not explore the relation between problem-based learning and critical thinking were excluded.
5. In the fifth and final step, we were left with the full-text articles to be included for in-depth analysis. These articles were subsequently categorized according to category, focus, and method. See Table 1 for details.

As illustrated in Table 1, the included articles were first grouped according to their overall approach, i.e., as either conceptual, empirical, descriptive, review, or some combination of these. By descriptive studies, we mean those studies that merely describe how the authors have put into practice a specific program or implemented an intervention. The studies that have been categorized as descriptive studies did not include evaluations of the effects of the interventions they describe.

Next, those studies that were categorized as empirical were sorted with reference to focus and methods used. Focus pertains to whether the studies were directly concerned with exploring the effect of problem-based learning on students' critical thinking or whether they were concerned with exploring students' self-reported perceptions of the effect of problem-based learning on their critical thinking; method on the other hand refers to whether qualitative or quantitative methods were used to generate the empirical material on which their conclusions were based.

Those empirical studies which employed quantitative measures and were concerned with measuring the effect of problem-based learning on the development and/or improvement of students' critical thinking were then categorized according to the specific instrument employed to test and evaluate students' critical thinking.

In a final step, in order to produce a more nuanced picture of how the different understandings of critical thinking were articulated in relation to problem-based learning across the sample of articles included for review, we sorted the articles identified as dealing with the connection between problem-based learning and critical thinking in two subsequent steps. First, we sorted the studies according to the kind of definition provided. Thus, we first identified those studies that provided explicit definitions of critical thinking. Second, we classified these studies according to the theoretical premises that informed them.

Table 1. Categorization of included studies

			Empirical				Conceptual	Descriptive	Review
Perception			Effect				17, 28, 30, 33, 40, 41, 45, 46, 49, 60, 64	9, 24, 35, 52, 58, 62	27, 32, 33, 41, 66
Qualitative	Quantitative	Qualitative	Quantitative						
3, 10, 12, 15, 17, 18, 19, 25, 31, 43, 61	1, 2, 4, 5, 7, 11, 16, 19, 21, 22, 25, 34, 35, 36, 37, 39, 44, 46, 50, 55, 56, 57, 59, 62, 63	6, 17, 42, 51	California	Cornell	Watson-Glaser	N B R C	Other		
		14, 59, 61, 64, 65		26	54	8	13, 16, 17, 20, 23, 28, 29, 34, 36, 37, 38, 39, 40, 42, 44, 45, 47, 48, 51, 53		

Findings

The search of Applied Social Sciences Index and Abstracts, Cambridge Companions Online, EbscoHost, Proquest, PsychInfo, Scopus, Web of Science, and Wiley Online Library yielded 5, 62, 316, 273, 73, 118, 82, and 28 articles, respectively. The process of literature searching and identification is presented in Figure 1.

The search was conducted on November 14, 2016. The initial search yielded 957 documents in total. Having performed the initial search using the specific search string presented earlier, we proceeded to sort the articles by employing the criteria for exclusion and inclusion. After the first step we were left with 656 articles. After the second step, 165 articles remained. We then excluded 72 articles that merely mentioned that problem-based learning fosters critical thinking as a matter of fact. While these studies were subsequently excluded, the fact that so many articles point to this connection testifies to the prevalence of this commonly held view. Having removed these articles, we were left with 93 articles. Finally, another 27 articles were excluded since they did not match our criteria for inclusion after all because they were not concerned with describing/investigating the relation between problem-based learning and critical thinking in the context of higher education. We were left with 66 full-text articles to be included for in-depth analysis. Since several articles contained both empirical as well as conceptual content, specific articles may appear more than once in the categorization.

Categorization of Studies Included for Review

Of the 66 articles, 54 articles contained empirical content utilizing either quantitative, qualitative, or a combination of the two approaches to investigate the relationship between problem-based learning and critical thinking. Five articles were categorized as reviews, while six were descriptive.

Eleven articles were classified as conceptual since they were either conceptual or somewhat conceptual, containing some conceptual content about the relation between problem-based learning and critical thinking in addition to reporting on empirical findings. Finally, the 54 empirical articles were categorized according to whether they investigated students' experiences of the effect of problem-based learning on critical thinking or whether they attempted to measure the actual effect of problem-based learning on critical thinking or both. Twenty-eight articles were found to measure the actual effect, while 37 articles looked into students' self-reported experiences of the effect of problem-based learning on critical thinking. Some articles purport to measure the actual effect of problem-based learning on critical thinking, but in reality what they measure is students' opinions about how problem-based learning has influenced their ability for critical thinking. These articles have been counted as part of the category of articles dealing with students' perceptions of the effect of problem-based learning on the development and/or improvement of their critical thinking skills. The numbers mentioned here do not add up in any straightforward sense simply because many of the studies included for review have been counted more than once, since many of them employ more than one method, have more than one focus, and/or belong to more than one category.

The 66 studies included for review might also be categorized according to how critical thinking was defined. Hence, we understand the definitions offered to be indications of the conceptual understandings of critical thinking. From this perspective, the studies may be classified according to how clearly the authors define critical thinking. Based on our findings, three distinct approaches to conceptualizing critical thinking may be discerned in the reviewed literature: The first category included those studies that offered no definition of critical thinking whatsoever. To the second category belonged those studies that contained what we may call an

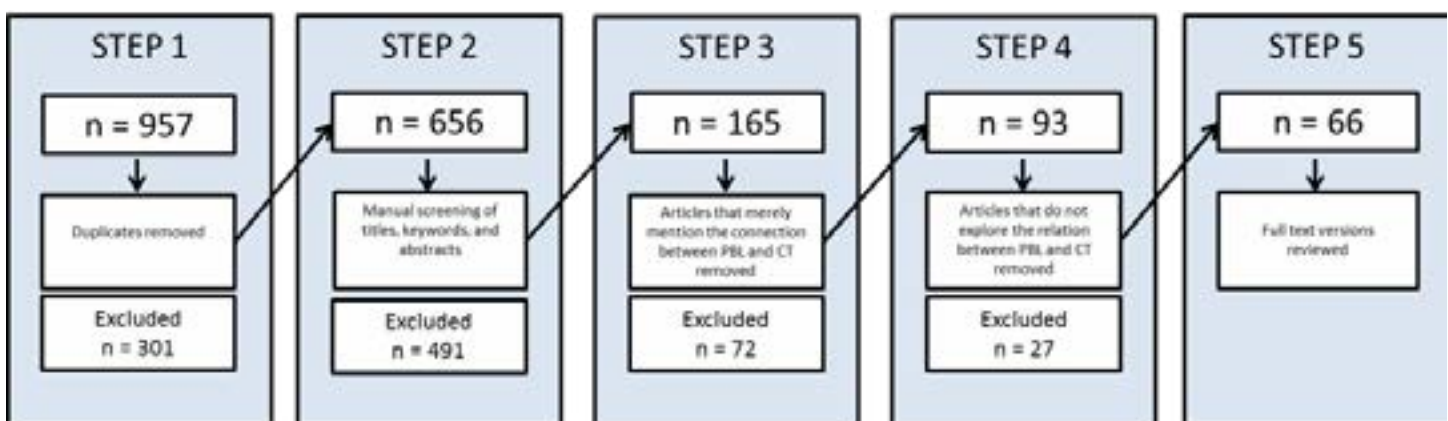


Figure 1. Search decision flowchart

implicit definition of critical thinking in the sense that the authors hinted at an understanding of critical thinking, e.g., by employing specific instruments for measuring students' critical thinking. The last category included those studies in which the authors made deliberate efforts to explain how they understood the concept of critical thinking (see Table 2, Appendix A). Finally, we identified the theoretical premises on which each of the definitions was based in order to be able to determine if one set of premises can be said to be prevalent among studies dealing with the relation between problem-based learning and critical thinking.

Of the 66 studies included for review, sixteen studies were found in which the authors made deliberate efforts to explicitly present and explain their understanding of critical thinking. In the following section, we compare and contrast the specific understandings of critical thinking provided in those sixteen articles. We do this in order to illustrate how understandings of critical thinking overlap and differ according to the particular perspective and point of departure of individual researchers. It is clear from our findings that critical thinking was only rarely explicitly defined in the studies reviewed, leaving readers to the task of inferring the meaning of the term by themselves based on hints provided in the texts.

According to Lai (2011), different definitions of critical thinking are inspired by three different academic disciplines. While some are inspired by philosophy, others are inspired by cognitive psychology, and others still by educational science. Based on Lai's (2011) claim that philosophers have criticized the cognitive psychological approach for being reductionist because it reduces "a complex orchestration of knowledge and skills into a collection of disconnected steps or procedures" (p. 8), one would expect that the empirical studies would be inspired by cognitive psychology or educational science whereas the conceptual studies would be inspired by philosophy. Indeed, according to Lai (2011), some philosophers contend that "it is a fundamental misconception to view critical thinking as a series of discrete steps or skills, and that this misconception stems from the behaviorist's need to define constructs in ways that are directly observable" (p. 8). This trend is evident to some extent, but there are also exceptions.

When looking at the premises informing the definitions provided, we found that seven studies (14, 30, 32, 42, 53, 60, 66) based their definitions on the philosophical thinking about critical thinking, while six studies (17, 20, 38, 47, 54, 63) based their definitions on cognitive psychology, and the remaining three (26, 40, 59) based their definitions on educational science. We were not able to detect a pattern that could be used as a framework to explain the categorization of different studies. It was evident that to some extent those

studies that were categorized as conceptual were more likely to be inspired by philosophical thinking about critical thinking while studies that were empirical in nature were more likely to be inspired by one of the other two disciplines, psychology and education.

Discussion

Troublesome Findings

Although we were well aware of the fact that there is a plethora of different understandings of the concept of critical thinking, what initially led us to conduct this scoping review was an interest in uncovering the underlying theoretical principles of problem-based learning and critical thinking that are responsible for the claim made by many authors that problem-based learning fosters critical thinking in university students. Clearly, definitions of critical thinking will vary with intended goals and settings. But since problem-based learning would seem to constitute one particular setting, however, it did not seem unreasonable to expect a certain level of uniformity in the definitions given in the literature specifically concerned with exploring how problem-based learning affects or relates to critical thinking. We imagined that because most researchers agree on the basic characteristics of problem-based learning, there would also be consensus about how and why this pedagogical approach is said to foster the development and/or improvement of students' critical thinking.

Indeed, the reason why problem-based learning is said to foster critical thinking is often stated in ways similar to that put forth by Kek and Huijser (2011), who contend that problem-based learning "explicitly and actively engages students in a learning and teaching system, characterised by reiterative and reflective cycles of learning domain-specific knowledge and doing the thinking themselves" (p. 329). Therefore, when we first embarked on our study, we expected that we would be able to locate a (large) number of studies delineating the conceptual basis for the common claim that problem-based learning fosters the development and/or improvement of students' critical thinking, just as we expected that those studies dealing with this connection empirically would also touch upon the issue. Much to our surprise, however, our search of the literature did not yield a great many studies dealing explicitly with the question we were out to answer either conceptually or empirically. What we discovered was that while the claim that problem-based learning fosters critical thinking was common, there does not seem to be any theoretically informed agreement about why this should be so. The significance of critical thinking remained unquestioned with research findings indicating that the contention

that problem-based learning fosters critical thinking continues to be prevalent, but as Bailin, Case, Coombs, and Daniels (2010) point out:

as soon as they begin to spell out in more concrete terms what critical thinking consists in, what educational attainments are required if one is to be a critical thinker, and what means are likely to be efficacious in teaching persons to think critically, that is to say, as soon as they interpret the term in such a way as to provide a clear conception of critical thinking, agreement evaporates (p. 285).

This statement resonated with what we were able to deduce based on the studies we found. Aside from that, however, it proved hard to specify in a more detailed fashion the theoretical basis guiding the notion that problem-based learning fosters the development and/or improvement of students' critical thinking.

To add insult to injury, the premises on which different definitions of critical thinking are based are not diametrically opposed. Rather, each of the three disciplines, philosophy, cognitive psychology, and educational science, emphasizes different aspects of the concept of critical thinking. Consequently, it was hard to compare different studies to one another. Furthermore, there also appeared to be quite a bit of mixing going on in the sense that it was not uncommon for studies to define critical thinking in accordance with the definition provided by Ennis, i.e., philosophy, while simultaneously listing a number of skills as proof of the ability for critical thinking, which is an idea inspired by cognitive psychology (Lai, 2011). For example, according to Du, Emmersen, Toft, and Sun (2013), critical thinking is "purposeful, self-regulatory judgment [philosophy], which results in interpretation, analysis, evaluation, and inference [cognitive psychology]" (p. 73). Another example comes from Temel (2014), who defined critical thinking in accordance with a definition provided by Jeeva-nantham (2005), who stated that critical thinking may be defined as a "higher order thinking skill [educational science] and it has properties such as analysing, evaluating, being reasonable and thinking deeply [cognitive psychology], which all enable the individual to make judgements about the world [philosophy]" (p. 2). This kind of mixing might prove problematic because the epistemological and theoretical premises that inspire different disciplines might not necessarily be compatible. As a final example, Semerci (2006) also referred to Ennis' philosophically inspired definition of critical thinking, stating that it is "reflective and reasonable thinking that is focused on deciding what to believe or do" (p. 1130). Later

on in the same article, however, the author implicitly advocated another type of understanding that would seem to be inspired by cognitive psychology when he stated that:

critical thinking involves the use of focused, self-regulatory judgment to assist with identification of a problem and its associated assumptions: clarifying and focusing the problem; analysing, understanding, and making inferences; inductive and deductive logic; and judging the validity and reliability of the assumptions and available data (p. 1133).

While we can hardly expect experts from different fields of research to come to a consensus on this matter, we call attention to the plurality of understandings that exists in order to encourage researchers to explicitly state how they understand the concept of critical thinking when employing it in their research and writings so that it might become possible for others to compare and evaluate the validity of results of different studies.

Thinking Critically About Critical Thinking and Problem-Based Learning

In addition to the problem described earlier that affects all studies dealing with the concept of critical thinking, the majority of studies dealing with the connection between problem-based learning and critical thinking seemed to be affected by one of three additional problems. The first of these problems follows directly from the overall problem described earlier in the sense that many studies make no attempt whatsoever at defining critical thinking. Since the omission of definitions was rarely construed as a problem, the researchers behind these studies seem to assume that readers will somehow know how to understand the concept of critical thinking in accordance with the particular perspective taken up by the researchers themselves, even if they have not been provided with any clues as to how they are meant to understand this concept.

As previously mentioned, in our study we found that 72 of 165 articles, cf. Figure 1, merely mentioned the connection between problem-based learning and critical thinking as if it were a well-known fact. We found that only sixteen of 66 studies provided explicit definitions of the concept of critical thinking. Even though this finding does not aid in clarifying the theoretical premises that inform the idea that problem-based learning fosters critical thinking, nor in providing a better understanding of whether or how problem-based learning can be used to develop and/or improve students' abilities for critical thinking, it directs attention to another pertinent problem in parts of the research literature: If researchers make no effort to define what they mean by contested terms such as critical thinking and problem-based

learning in their studies, it is impossible for readers to evaluate the conclusions reached as well as the usefulness of their findings.

Many of the studies assessing students' perceptions about the ability of problem-based learning to contribute to the development and/or improvement of students' critical thinking also failed to provide a clear definition of the concept of critical thinking, cf. Table 2 in Appendix A. As a result, some further issues arise: First, there was no way for readers to know what the authors meant by the term critical thinking. Because no definition was provided for the readers, it does not seem unreasonable to assume that the students in the study had also not been instructed on how they should understand the term critical thinking when taking the test. This causes the second issue: there was no way for students to know what was meant by the term critical thinking. This leads directly to the third issue, namely the fact that there was no way for either authors or readers to know how students understood the term critical thinking.

Due to the existence of these problems, the internal validity of the tests used to test students' perceptions about the ability of problem-based learning to contribute positively to the development and/or improvement of their critical thinking decreased significantly because it was hard to know exactly what was measured.

The next problem facing studies intent on exploring the connection between problem-based learning and critical thinking has to do with the fact that there continue to be many different definitions of critical thinking in use, which made it difficult to compare and contrast the findings of different studies. Of course, this was not a problem for each individual study as such. Rather, it only becomes a problem once a researcher tries to synthesize the results of different studies such as when trying to conduct a literature review. Finally, the fact that the definitions of critical thinking available in the literature were often themselves quite elusive constitutes a problem. Indeed, it was not always clear which theoretical premises informed them. Thus, sometimes it was not so much the differences between different definitions of critical thinking that caused the most significant problems. Rather, it was the elusive nature of the definitions themselves that caused problems because such definitions made it difficult to evaluate how sensibly these theoretical constructs were operationalized to enable the empirical study of certain phenomena.

Although Kahlke and Eva (2018) suggested that there might be value in the variability that can be observed with regards to understandings of critical thinking when they contend that "multiple conceptions of critical thinking likely offer educators the ability to express diverse beliefs about what 'good thinking' means in variable contexts" (Kahlke &

Eva, 2018, p. 1), there can be no doubt that providing detailed and careful definitions of the terms and concepts most significant to one's research is always essential. When dealing with a subject matter infested with ambiguous terms or contested concepts, however, explicitly articulating the meaning one attributes to such terms and concepts becomes nothing short of crucial. In this case, it is essential that researchers define what they mean when they refer to the concept of critical thinking. If they do not, readers are effectively denied the opportunity to assess the real value of the research presented since they have no way of knowing which of the many possible understandings of critical thinking that are currently in use the authors are alluding to. Thus, if readers are not informed about the authors' understanding of critical thinking, it may also be hard for readers to determine whether the authors' claims about the ability/inability of problem-based learning to contribute to the development and/or improvement of students' critical thinking are fair and valid.

Implications

Perhaps the most important implication of our review is that we need a better understanding of what critical thinking looks like "in situ" to be able to recognize it in students' written work as well as in their discussions. At the moment, research on this issue has focused almost exclusively on trying to measure critical thinking via standardized tests, but if we really want to know about students' abilities for critical thinking, we would do better to study their actual assignments and projects, cf. e.g., Szenes, Tilakaratna, and Mason (2015), who contend that as of yet, there is relatively little analysis of what could be called "actually existing 'critical thinking' in higher education" (p. 573), or the knowledge practices that teachers and researchers consider to be educational evidence of this activity. The nature of the knowledge in, e.g., what students write in their papers aimed at eliciting critical thinking, and what teachers reward in the assessment of such papers as evidence of critical thinking, remain underexplored.

Furthermore, if students are not able to apply critical thinking in their assignments, it does not matter much whether or not they score well on a test designed specifically to evaluate their level of critical thinking. In other words, it is critical that students develop the ability to apply critical thinking in practice and independently. Otherwise, the effort to teach them how to think critically is in vain. This is one reason why ethnographic research focusing on how students apply critical thinking when doing independent assignments could improve our understanding of critical thinking by adding valuable, new insights on students' abilities for critical thinking.

Even though ethnographic research might be able to advance the scientific thinking about how critical thinking relates to problem-based learning, the fundamental problem that haunts this field of research cannot be escaped. Indeed, without a clear understanding of what critical thinking is, it remains impossible to identify signs of it in students' written assignments or in the discussions students have with facilitators and amongst themselves.

Another implication that should be addressed is that all of the articles reviewed in this study described critical thinking as an individualistic, cognitive activity with the responsibility placed solely on the individual student. Perhaps it would be useful to begin thinking differently about critical thinking by thinking of it as a kind of practice taking place in a complex culture of teaching and learning instead of merely a concept describing a particular type of thinking. If critical thinking was conceptualized instead as a practice, that is, as something embedded in and resulting from the sociocultural context of which we are always already a part, our understanding of this phenomenon would dramatically change, as would our understanding of where and how it may be evident and how it may be taught. Thus, in our opinion, there is a need to reconceptualize critical thinking in terms of moving away from a focus on individual student accountability to a focus on generating a sense of collective responsibility for creating conducive environments for student learning and thinking. This means moving away from a narrow definition of critical thinking as an isolated, individualized, technical, cognition-focused activity, towards a definition of critical thinking as a sociocultural practice that occurs between people in specific situations. Adopting this conceptualization means that critical thinking is a reciprocal, agentic, and shared responsibility, which is not solely dependent on individual abilities but which is also influenced by collective, institutional, and organizational circumstances.

Conclusion

In this paper, we have presented a scoping review of a sample of the literature about problem-based learning. More specifically, we have tried to answer the following research question:

How is critical thinking conceptualized in research about problem-based learning in higher education in a sample of the research literature?

As it turned out, there was very little evidence in the sample of literature on problem-based learning we reviewed that could be used to elucidate how critical thinking is conceptualized in relation to problem-based learning. We found that sixteen of the 66 articles explicitly defined the concept of critical thinking, but even within this small number of studies,

we could find no pattern or common ground that could be used to provide an adequate unifying picture of how critical thinking is conceptualized in the literature about problem-based learning, as the definitions provided by different studies were informed by different academic disciplines. Thus, while some studies were inspired by philosophy, others were inspired by cognitive psychology, while still others were inspired by educational science.

The most important conclusion that can be drawn based on the findings we have been able to produce is that it is imperative that researchers explain what they mean by the term critical thinking. Otherwise, it is impossible for readers to assess the results and conclusions, just as it is impossible to evaluate whether the choice of instrument used to measure the extent to which problem-based learning fosters critical thinking is likely to produce valid results.

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Appendix A

Table 2.

#	Author	Title	Year	Category	Definition	Focus	Method
1	Al-Shaikh, Al Mussaed, Alnamini, Elmorsheby, Syed, & Habib	Perception of medical students regarding problem based learning	2015	Empirical	Not defined.	Perception	Quantitative
2	Assad, Iqbal, & Sabir	Effectiveness of problem based learning as a strategy to foster problem solving and critical reasoning skills among medical students	2015	Empirical	Not defined.	Perception	Quantitative
3	Asyari, Al Muhdhar, Susilo, & Ibrohim	Improving critical thinking skills through the integration of problem based learning and group investigation	2016	Descriptive and empirical	Implicitly defined.	Perception	Qualitative
4	Blackburn	Innovative eLearning: technology shaping contemporary problem based learning: A cross-case analysis	2015	Empirical	Not defined.	Perception	Quantitative
5	Carpenter & Fairhurst	Delivering quality and value in the classroom: The use of problem-based learning in retail merchandising courses	2005	Empirical	Not defined.	Perception	Quantitative
6	Carriger	What is the best way to develop new managers? Problem-based learning vs. lecture-based instruction	2016	Empirical	Implicitly defined.	Effect	Qualitative
7	Carvalho	The impact of PBL on transferable skills development in management education	2016	Empirical	Not defined.	Perception	Quantitative
8	Ceconni, Holt, Zipp, Olson, & Beckett	Influence of problem-based learning instruction on decision-making skills in respiratory therapy students	2008	Empirical	Not defined.	Effect	Quantitative
9	Chamblee & Morgan	Utilization of problem-based learning in a capstone poultry science course	2009	Descriptive	Implicitly defined.	-	-
10	Chan	Exploring creativity and critical thinking in traditional and innovative problem-based learning groups	2013	Empirical	Not defined.	Perception	Qualitative
11	Connor-Greene & Greene	Science or snake oil? Teaching critical evaluation of "research" reports on the Internet	2002	Empirical	Implicitly defined.	Perception	Quantitative

#	Author	Title	Year	Category	Definition	Focus	Method
12	Cooke & Moyle	Students' evaluation of problem-based learning	2002	Empirical	Implicitly defined.	Perception	Qualitative
13	Cowden & Santiago	Interdisciplinary explorations: Promoting critical thinking via problem-based learning in an advanced biochemistry class	2015	Empirical	Not defined.	Effect	Quantitative
14	Du, Emmersen, Tofl, & Sun	PBL and critical thinking disposition in Chinese medical students—A randomized cross-sectional study	2013	Empirical	Explicitly defined.	Effect	Quantitative
15	Duncan, Lyons, & Al-Nakeeb	'You have to do it rather than being in a class and just listening': The impact of problem-based learning on the student experience in sports and exercise biomechanics	2007	Empirical	Not defined.	Perception	Qualitative
16	Fujinuma & Wendling	Repeating knowledge application practice to improve student performance in a large, introductory science course	2015	Empirical	Implicitly defined.	Perception and effect	Quantitative
17	Guerra & Holgaard	Enhancing critical thinking in a PBL environment	2016	Conceptual and empirical	Explicitly defined.	Perception and effect	Qualitative and quantitative
18	Gürses, Acikyildiz, Dogar, & Sözbilir	An investigation into the effectiveness of problem-based learning in a physical chemistry laboratory course	2007	Empirical	Implicitly defined.	Perception	Qualitative and quantitative
19	Halvorson & Wescoat	Problem-based inquiry on world water problems in large undergraduate classes	2002	Descriptive and empirical	Not defined.	Perception	Quantitative and qualitative
20	Hamdan, Kwan, Khan, Ghafar, & Sihes	Implementation of problem based learning among nursing students	2014	Empirical	Explicitly defined.	Perception and effect	Quantitative
21	Harris & Kloubec	Assessment of student experience in a problem-based learning course using the Course Experience Questionnaire	2014	Empirical	Not defined.	Perception	Quantitative
22	Hays & Vincent	Students' evaluation of problem-based learning in graduate psychology courses	2004	Empirical	Not defined.	Perception	Quantitative
23	He, Tang, Dai, Li, & Jiang	Problem-, team- and evidence-based learning	2012	Empirical	Not defined.	Effect	Quantitative

#	Author	Title	Year	Category	Definition	Focus	Method
24	Hogue, Kapralos, & Desjardins	The role of project-based learning in IT: A case study in a game development and entrepreneurship program	2011	Descriptive	Not defined.	-	-
25	Hou	Integrating problem-based learning with community-engaged learning in teaching program development and implementation	2014	Empirical	Not defined.	Perception	Quantitative and qualitative
26	Iwaoka, Li, & Rhee	Measuring gains in critical thinking in food science and human nutrition courses: The Cornell Critical Thinking Test, problem-based learning activities, and student journal entries	2010	Empirical	Explicitly defined.	Effect	Quantitative
27	Jayasekara, Schultz, & McCutcheon	A comprehensive systematic review of evidence on the effectiveness and appropriateness of undergraduate nursing curricula	2006	Review	Not defined.	-	-
28	Kamin, O'Sullivan, Younger, & Deterding	Measuring critical thinking in problem-based learning discourse	2001	Conceptual and empirical	Implicitly defined.	Effect	Quantitative
29	Kamin, O'Sullivan, Deterding, & Younger	A comparison of critical thinking in groups of third-year medical students in text, video, and virtual PBL case modalities	2003	Empirical	Implicitly defined.	Effect	Quantitative
30	Kek & Huijser	The power of problem-based learning in developing critical thinking skills: Preparing students for tomorrow's digital futures in today's classrooms	2011	Conceptual and empirical	Explicitly defined.	Perception	Qualitative
31	Kong	Students' perceptions of using problem-based learning (PBL) in teaching cognitive communicative disorders	2014	Empirical	Implicitly defined.	Perception	Qualitative
32	Kong, Qin, Zhou, Mou, & Gao	The effectiveness of problem-based learning on development of nursing students' critical thinking: A systematic review and meta-analysis	2014	Review	Explicitly defined.	-	-
33	Leibiger	"Google reigns triumphant"?: Stemming the tide of googlitis via collaborative, situated information literacy instruction	2011	Conceptual and review	Implicitly defined.	-	-
34	Lian & He	Improved performance of students instructed in a hybrid PBL format	2013	Empirical	Not defined.	Perception and effect	Quantitative
35	Lim & Chen	Challenges and relevance of problem-based learning in dental education	1999	Descriptive and empirical	Implicitly defined.	Perception	Quantitative

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36	Lin, Lu, Chung, & Yang	A comparison of problem-based learning and conventional teaching in nursing ethics education	2010	Empirical	Not defined.	Perception and effect	Quantitative
37	Lohse, Nitzke, & Ney	Introducing a problem-based unit into a lifespan nutrition class using a randomized design produces equivocal outcomes	2003	Empirical	Implicitly defined.	Perception and effect	Quantitative
38	Lyons	Examining the effect of problem-based learning and NCLEX-RN scores on the critical thinking skills of associate degree nursing students in a southeastern community college	2008	Empirical	Explicitly defined.	Effect	Quantitative
39	Mandeville & Stoner	Assessing the effect of problem-based learning on undergraduate student learning in biomechanics	2015	Empirical	Implicitly defined.	Perception and effect	Quantitative
40	Martyn, Terwijn, Kek, & Huijser	Exploring the relationships between teaching, approaches to learning and critical thinking in a problem-based learning foundation nursing course	2014	Conceptual and empirical	Explicitly defined.	Effect	Quantitative
41	Mok, Whitehill, & Dodd	Problem-based learning, critical thinking and concept mapping in speech-language pathology education: A review	2008	Conceptual and review	Implicitly defined.	-	-
42	Mok, Whitehill, & Dodd	Concept map analysis in the assessment of speech-language pathology students' learning in a problem-based learning curriculum: A longitudinal study	2014	Empirical	Explicitly defined.	Effect	Qualitative
43	Morales-Mann & Kaitell	Problem-based learning in a new Canadian curriculum	2001	Empirical	Implicitly defined.	Perception	Qualitative
44	Muehlenkamp, Weiss, & Hansen	Problem-based learning for introductory psychology: Preliminary supporting evidence	2015	Empirical	Implicitly defined.	Perception and effect	Quantitative
45	Nargundkar, Samaddar, & Mukhopadhyay	A guided problem-based learning (PBL) approach: Impact on critical thinking	2014	Conceptual and empirical	Not defined.	Effect	Quantitative
46	Neo & Neo	A multimedia-enhanced problem-based learning experience in the Malaysian classroom	2005	Conceptual and empirical	Not defined.	Perception	Quantitative

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47	Pardamean	Measuring change in critical thinking skills of dental students educated in a PBL curriculum	2012	Empirical	Explicitly defined.	Effect	Quantitative
48	Park & Choi	Effect of applying a problem-based learning an approach to nursing education	2015	Empirical	Implicitly defined.	Effect	Quantitative
49	Parton & Bailey	Problem-based learning: A critical rationalist perspective	2008	Conceptual	Not defined.	-	-
50	Saalu, Abraham, & Aina	Quantitative evaluation of third year medical students' perception and satisfaction from problem based learning in anatomy: A pilot study of the introduction of problem based learning into the traditional didactic medical curriculum in Nigeria	2010	Empirical	Not defined.	Perception	Quantitative
51	Schell & Kaufman	Critical thinking in a collaborative online PBL tutorial	2009	Empirical	Implicitly defined.	Effect	Qualitative and quantitative
52	Selnow & Ahlfeldt	Fostering critical thinking and teamwork skills via a problem-based learning (PBL) approach to public speaking fundamentals	2005	Descriptive	Not defined.	-	-
53	Semerci	The effect of problem-based learning on the critical thinking of students in the intellectual and ethical development unit	2006	Empirical	Explicitly defined.	Effect	Quantitative
54	Sendag & Ferhan Odabasi	Effects of an online problem based learning course on content knowledge acquisition and critical thinking skills	2009	Empirical	Explicitly defined.	Effect	Quantitative
55	Senocak, Taskesenligil, & Sozbilir	A study on teaching gases to prospective primary science teachers through problem-based learning	2007	Empirical	Not defined.	Perception	Quantitative
56	Shafi, Quadri, Ahmed, Mahmud, & Iqbal	Experience with a theme-based integrated renal module for a second-year MBBS class	2010	Empirical	Not defined.	Perception	Quantitative
57	Stefanou, Stolk, Prince, Chen, & Lord	Self-regulation and autonomy in problem- and project-based learning environments	2013	Empirical	Implicitly defined.	Perception	Quantitative
58	Stewart	Problem-based learning in counsellor education	1998	Descriptive	Not defined.	-	-

#	Author	Title	Year	Category	Definition	Focus	Method
59	Temel	The effects of problem-based learning on pre-service teachers' critical thinking dispositions and perceptions of problem-solving ability	2014	Empirical	Explicitly defined.	Perception and effect	Quantitative
60	Thomas	Critical thinking, transformative learning, sustainable education, and problem-based learning in universities	2009	Conceptual	Explicitly defined.	-	-
61	Tiwari, Lai, So, & Yuen	A comparison of the effect of problem-based learning and lecturing on the development of students' critical thinking	2006	Empirical	Implicitly defined.	Perception and effect	Qualitative
62	Uden & Dix	Lifelong learning for software engineers	2004	Descriptive and empirical	Not defined.	Perception	Quantitative
63	Wheeler	Experiential learning: Impact of two instructional methods on student-instructor interaction, student critical thinking, and student course evaluations	2008	Empirical	Explicitly defined.	Perception	Quantitative
64	Yu, Lin, Ho, & Wang	Technology facilitated PBL pedagogy and its impact on nursing students' academic achievement and critical thinking dispositions	2015	Conceptual and empirical	Implicitly defined.	Effect	Quantitative
65	Yuan, Kunaviktikul, Klunk- lin, & Williams	Improvement of nursing students' critical thinking skills through problem-based learning in the People's Republic of China: A quasi-experimental study	2008	Empirical	Implicitly defined.	Effect	Quantitative
66	Zabit	Problem-based learning on students' critical thinking skills in teaching business education in Malaysia: A literature review	2010	Review	Explicitly defined.	-	-