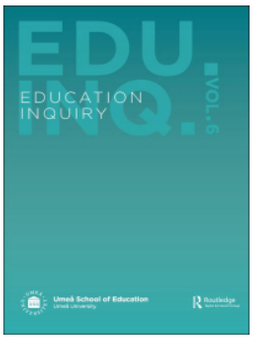

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DISCUSSION PAPER

The why, what and how of deep learning: critical analysis and additional concerns

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ABSTRACT

The concept of deep learning has become a popular and well recognised term in contemporary educational literature and international political documents. Deep learning typically induces positive connotations and represents the learning strategy that educational institutions should adopt in order to assure a sustainable future in modern societies. However, a major challenge with deep learning is the fact that the concept is used in many different scientific fields with a variety of definitions, understandings and applications. Thus, there is an imbalance between the quantity of governing documents in education that endorse the use of deep learning as a main learning strategy and the amount of academic theory and research examining its definitional clarity and related unresolved questions. The aim of the present theoretical analysis is threefold. First, we examine the concept of deep learning in light of the three fundamental questions "why", "what", and "how" and make assessments concerning its status in contemporary literature. Second, we discuss the compatibility between the idea of deep learning and the concepts of educational inclusion and adapted instruction. Finally, we make several recommendations for future development and application of the term deep learning in educational contexts.

KEYWORDS

Deep learning; definition; knowledge; education; inclusion

Introduction

There is a wide international consensus that educational systems in general and schools in particular should be visionary and foresee what kind of knowledge every new generation of learners needs to possess (OECD, 2015; Pellegrino & Hilton, 2012). It has been explicitly and repeatedly stated that appropriate learning strategies should be adopted to assure a sustainable future for the many various local and global communities around the world (Hermes & Rimanoczy, 2018; Lhiadi, Kaaouachi, & Jaddar, 2021; Warburton, 2003). This is not surprising considering that the organisation of life in many cultural contexts is based on the belief that specific and updated skills are necessary if we are to meet the challenges of the emerging complex knowledge society

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(2018; Theisens, Benavides, & Dumont, 2008; UNESCO, 2015). Indeed, some theorists have even declared that there is a crisis in the global education systems that calls for new approaches to teaching and learning (Fullan & Langworthy, 2013). This has led to the emergence of several concepts/ideas in the field of education over recent decades that have rapidly made their way into various national curricula and governing political documents in the guise of new pedagogies. Some examples of such prominent concepts in education are inclusion, democracy, adapted instruction, self-regulative learning, collaborative learning, critical thinking and lifelong learning. A common denominator among the majority of these concepts is that they jointly underline the importance of long-term future orientation and higher-order thinking. In other words, it is expected that these concepts should support each other and work in concert, thus elevating our ability to learn to think in abstract terms. The concept of deep learning represents one important part of this "new-pedagogies" assembly that over time has become popular, well recognised and frequently used in contemporary education and international political documents (Fullan & Langworthy, 2014). Deep learning is frequently presented as an overriding concept or learning approach that affects the entire educational system with respect to levels of understanding, in contrast to being an individual learning style (Tsingos, Bosnic-Anticevich, & Smith, 2015). As such, deep learning is frequently classified hierarchically above all other similar concepts, such as creative thinking and critical thinking (Fullan, Quinn, & McEachen, 2018). In general, there is explicit agreement on the idea that sustainable education logically necessitates a deep learning response in educational policy, thinking, content, and practice, again emphasising the importance of knowledge depth (Mohanty & Dash, 2018). A deep thinking approach is identified as one type of the new teaching or pedagogy that aims to preserve a sustainable future, but also represents "fun" education in terms of personal development (Quinn, McEachen, Fullan, Gardner, & Drummy, 2019).

It is easy to recognise that the main principles behind deep learning sound appealing, and consequently it is not surprising to discover the wide international consensus on recommending deep learning as an educational strategy that could help people to deal with the constantly growing complexities of a modern life in rapid change (Fullan, Quinn, & McEachen, 2018; Pellegrino & Hilton, 2012). However, one obvious challenge with deep learning is the fact that this concept is used in many different scientific fields with a variety of definitions, understandings and applications. Moreover, there is an apparent imbalance between the quantity of politically loaded texts and governing documents in education that use deep learning as a beacon guiding the learning approach for all learners and the quantity of academic theory and research examining its definitional clarity and other related unresolved questions. For instance, the findings from a recent systematic mapping review show only 71 publications that focus on definitions of deep learning in primary and secondary education from 1970 to 2018 (Winje & Løndal, 2020). Similarly, a systematic review of longitudinal research on how students' approaches to learning to develop during higher education identified only 43 studies that could be included in the final analysis, failing to provide clear empirical evidence for the assumption that students develop towards deeper approaches during higher education (Asikainen & Gijbels, 2017). Furthermore, a literature review with a critical discussion on the concepts of deep and surface processing concludes that inconsistencies in the findings from diverse studies may be attributable to the lack of conceptual clarity in

defining these concepts (Dinsmore & Alexander, 2012). Even though these reviews are limited to specific educational contexts or age brackets, several of these papers nevertheless have clearly urged researchers to pay special attention to how precisely deep and surface learning are conceptualised and measured. In other words, even though the number of studies included in any systematic literature review is certainly a product of inclusion/exclusion criteria, the number of these calls for attention nevertheless indicates that the current understanding of deep learning is insufficiently documented in the current literature, leaving us with several possibly unresolved questions. Hence, there is a discrepancy between the amount of research illuminating this concept under various conditions and the growing enthusiasm for embracing this concept in the field of education. It is important to note that even though this issue is under-researched, it is not entirely novel. A similar concern was raised several decades ago, contending that it is unrealistic to assume that a deep approach to learning is universally desirable and applicable in all situations (Beattie, Collins, & McInnes, 1997).

This apparent knowledge gap relating to the definitional clarity of deep learning as used in the field of education is the starting point for the present paper. We consider our rationale on this issue to be sound as the implementation and indiscriminate acceptance of ideas that seem ideological, appealing or simply popular contradicts with the scientific premise of critical thinking. Bearing this in mind, the aim of the present theoretical analysis and discussion is threefold. First, we attempt to examine the concept of deep learning in the light of three fundamental questions: (1) "why" (why deep learning should be implemented in praxis), (2) "what" (what deep learning is and what its theoretical clarifications and operationalisations are), and (3) "how" (how to implement deep learning in educational practice and how to measure learning or effect), and make assessments concerning its use and status in contemporary literature. Even though the main focus of the present paper is on educational contexts, we deliberately present a wide scope of various traditions, so we can convey the complexity of deep learning when it comes to its use in different fields and its conceptual origins. Second, by examining the content of the above questions, we discuss the compatibility between deep learning and other overarching processes in the field of education, such as the ideas of inclusion and adapted instruction. Third, we make several recommendations for future development and application of the term deep learning in educational contexts. Overall, our aim is to identify knowledge gaps relating to the concept of deep learning that are insufficiently examined in the current literature and discuss possible consequences for wider educational work. It is important to note that achieving these aims necessitates avoiding focusing on or favouring one particular theoretical perspective, at the expense of grasping the complexity of the term deep learning. Thus, the present theoretical approach avoids clear positioning in terms of specific theoretical perspectives or traditions, but rather aims to (1) present how different scientific fields in general perceive and currently use deep learning, and (2) to discuss the possible consequences of adopting deep learning without further advances in terms of theoretical and empirical analysis.

The "why" question

The "why" question starts with an examination of the foundations of the overall argument advocating that deep learning should be adopted as the guiding learning

strategy at nearly all levels of educational practice. The origins of the distinction between deep and surface learning (see Richardson, 2015 for a discussion) are historically embedded in the work of Marton and Saljo (1976), who experimentally examined different levels of processing information among groups of university students. Based on this initial, and later subsequent, research, we find today a reasonably well accepted idea that high-quality learning outcomes are associated with deep-learning approaches, whereas low-quality results are associated with surface learning (Smith & Colby, 2007). This idea is embedded in part in a combination of progressive education and a sociocultural perspective on learning that focuses on how children learn, rather than on the content in the learning, that is, what they learn and their immediate performances (Abbott, Townsend, Johnston-Wilder, & Reynolds, 2009). Thus, in its origins, the idea of deep learning contrasts with test-score approaches that have a tendency to limit students' motivations by stimulating learning processes that occur on a superficial level. The argument is that students' potentials and learning abilities should be strengthened by letting them apply their own goals and obtain deeper understanding and meaning for the subjects in the process (Biggs & Tang, 2011). Indeed, in the contemporary literature, the deep processing of knowledge is also connected to autonomous motivation and self-regulated learning, thus facilitating the manner in which knowledge is acquired, organised, retained and above all experienced when it comes to motivation to learn (León, Núñez, & Liew, 2015). The reasons for advocating such holistic view of learning are compatible with humanistic and progressive education where the aim of learning exceeds instrumentality and includes education that stimulates the all-round person, the soul and the self (Stone, 1988). For example, Miller (1999) argues that educational systems need to adopt a broader vision of education that fosters the development of the all-round human being, including physical, emotional, aesthetic, moral and spiritual aspects, in contrast to pure intellectual development. This view is virtually identical to Bentz (1992), who points out that deep-learning experiences have many emotional, intellectual, mental, physical, social and personal processes that are inheritably intertwined and positively energised or charged. Other scholars similarly conceptualise deep learning as a sustainability mindset advocating for a holistic approach to learning by connecting the content of learning to a person's intellect, emotions, and values (Hermes & Rimanoczy, 2018). In these descriptions it is easy to identify a resemblance to the "flow" process where optimal peaks of involvement produce intense feelings of enjoyment and creativity (Csikszentmihalyi, 1988). In sum, even though it is certainly difficult to capture the prevalent discourses on deep learning in the international literature in any unbiased way, it seems that the "why" arguments could be categorised according to two main levels (Quinn, McEachen, Fullan, Gardner, & Drummy, 2019). The first could be cautiously labelled as the cognitive/personal approach. The argument is that the acquisition of knowledge through deep learning is a good way to understand meaning, learning is easier after the "dots have been connected", this increases efficiency, and long-term retention is facilitated. Such an educational approach focusing on a deeper understanding of teaching and learning is the ultimate goal that will improve the quality and effectiveness of the global educational process and stimulate the urge to understand on the personal level (Entwistle, 2001; Hermes & Rimanoczy, 2018). Hence, simply put, deep learning is good and useful for the person himself/herself, increases motivation, and is "fun".

The second approach refers to the structural and societal levels through which education is expected to provide guidance in terms of the knowledge required for a sustainable future. However, in many cases, the content of texts on this level tends to be politically loaded, highly normative and basically has very little critical thinking when it comes to specifying why exactly deep learning is recommended as a learning strategy. The language in these texts is also ambiguous, where expressions are used that could easily be connected to surface learning, such as cost-efficiency, outcomes, potentials, and similarities. Nevertheless, the argument for teaching deep learning across all educational structures is that this mode of acquiring knowledge is the best strategy to (1) respond to the rapidly changing modern global society, (2) process the large quantity of incoming new information, (3) deal with emergent new technologies, and (4) make sense of new forms of knowledge in a complex world. In other words, the general message is that the future requires deep learning if we are to solve the new modernity problem (Norwegian Directorate for Education and Training, 2021a).

The "what" question

The "what" question refers to the manner in which the term deep learning is filled with content in contemporary literature, and more importantly its further interpretation and use in the documents governing education. The origin of the concept itself is embedded in machine learning research from the mid-1940s and stretches from the earliest stages of cybernetics to the current research on artificial intelligence (Peters, 2018) and neural networks in the brain (Gillon et al., 2019; Richards et al., 2019). Both fields conceptualise deep learning as the establishment of learning paths that optimise cost functions during the attainment of new knowledge, leading to effectiveness (Marblestone, Wayne, & Kording, 2016). Initial understandings in the field of cybernetics and neuroscience were later, in historical terms, connected to artificial intelligence, focusing on learning methods with multiple levels of representation. The deeper levels are reached by composing non-linear modules of simple representations at one level (raw input) into a representation at a higher, slightly more abstract level (LeCun, Bengio, & Hinton, 2015). During this process, concrete knowledge and experiences are elevated to higher levels of abstraction or deeper levels of knowledge, depending on the perceiver's metaphoric perspective and point of view. Deep learning in this field refers to attempts to develop artificial intelligence by enabling machines to learn from experience and consequently operate in terms of a hierarchy of concepts (Goodfellow, Bengio, Courville, & Bengio, 2016). According to this reasoning, a multitude of singular experiences are linked logically together, revealing overreaching dimensions that were hidden behind these singularities. The net result is that machines get better and more efficient at performing their tasks just by connecting the dots and doing so repeatedly. As noted above, the basic reasoning behind artificial intelligence and machine deep learning is conceptually connected to knowledge acquired in neuroscience (Gillon et al., 2019; Richards et al., 2019). This implies that deep learning creates shortcuts between different fields of knowledge in a similar way as shortcuts between the neurons in the brain are created. Recently, attempts have been made to focus on relational understandings of artificial intelligence and to further connect these experiences to deep learning in various educational contexts (Perrotta & Selwyn, 2020).

It is therefore fair to say that the description of deep learning is filled with much more content in the social sciences and connected to basic human functioning compared to the use of deep learning in the fields of machine learning, artificial intelligence and neuroscience. For instance, the concept of meaning and meaning-making represents one prominent process, which is frequently associated with deep learning in the contemporary literature. Some theorists focus on the underlying meaning (Warburton, 2003), others concentrate on the intention to understand and impose meaning (Cleveland-Innes & Emes, 2005; Smith & Colby, 2007) and yet others emphasise the purpose of grasping a meaningful understanding and mastery of concepts (Biggs & Tang, 2011). Indeed, recent systematic mapping reviews have shown that 63 out of 71 publications explicitly connect deep learning to meaningful learning, making the notion of meaning a very prominent category in the collected data (Winje & Løndal, 2020). In addition to meaning, some other processes are repeatedly and frequently associated with deep learning in contemporary literature: analytic skills, cross-referencing, intrinsic motivation, imaginative reconstruction, independent thinking, holistic thinking, higher levels of cognitive abstraction and essentially many others. These terms comprise an assembly of interrelated, probably empirically highly intercorrelated concepts that are expected to work in concert and support each other. Deep learning, like any form of learning, is also theoretically linked to change and growth of general competence propelled by creativity (Ohlsson, 2011). Thus, change towards deeper levels of understanding is led by cognition where learners are able to adapt to new situations and experience cognitive transformation, thus overriding previous learning and experience. Furthermore, this type of change is connected to the broader idea of human flourishing that can be developed and achieved if purposive education systematically supports the development of such skills as character education, citizenship, communication, critical thinking, problem solving, collaboration, creativity and imagination (Fullan & Langworthy, 2013).

Yet another popular route in illuminating the "what" of deep learning is through contrast, i.e. emphasising the difference between deep learning and surface learning (e.g. Dolmans, Loyens, Marcq, & Gijbels, 2016; Smith & Colby, 2007). A surface approach to learning has traditionally been described as a transparent lack of interest in knowledge accompanied by a minimum amount of work invested in the required work (Biggs & Tang, 2011). This form of superficial learning is consistently portrayed as a negative process with the simple purpose of reaching the desired aim and evoking a series of negative states, such as boredom, anxiety and dread (Warburton, 2003). As expected, the emotional feedback that follows accomplishments of tasks using a deep approach to learning is characterised by such positive sentiments as intrinsic motivation, exhilaration, optimal challenge, meaning and similar (Biggs & Tang, 2011). Thus, deep learning is described as a learning journey where people tend to reveal links between various and seemingly unrelated bits of knowledge so the path towards discoveries will be rewarding in itself. In sum, it seems that deep learning is presented in the literature as a rather intuitive, easily comprehended process that aims to elevate human thinking to higher levels of cognitive abstractions by (1) seeking meaning and understanding, (2) revealing patterns that reduce the distance between seemingly unrelated pieces of knowledge, (3) transferring knowledge to other subject areas, and consequently (4) facilitating for a deep understanding of complex concepts. The result

is that knowledge acquired through deep learning is easy to retain, difficult to forget, intrinsically motivating and efficient. It seems that the main principle in deep learning is the progression from simple, concrete surface knowledge towards higher levels of a hierarchy of concepts where more abstract experiences residing on the deeper level are adopted. Bearing this description in mind, it is not surprising to find that deep learning is conceptually connected to other popular learning processes, such as self-regulation (Panadero et al., 2021) and goal orientation (Geitz, Brinke, & Kirschner, 2015; Leenknecht, Hompus, & van der Schaaf, 2019). In summary, the prevalent idea in the contemporary literature, expressed at various levels of explicitness, is that complex understanding cannot be acquired by employing surface approaches, instrumental learning or other strategic yet relatively simple approaches to knowledge acquisition. However, even though there is a rather high degree of consensus regarding the definitional components of deep learning, it is fair to point out that the quality of the content of the current literature on the "what" question is unsettling. Thus, the understanding of deep learning has a wide definitional span, including both "soft" concepts, such as intrinsic motivation and meaning making, and more instrumental concepts from machine learning, such as cost-effectiveness. Indeed, some researchers have pointed out the need for more precise conceptualisations, and more importantly, operationalisations of all processes that are measured and consequently generically called deep learning (e.g. Asikainen & Gijbels, 2017).

The "how" question

The "how" question refers to the manner in which deep learning is implemented and used by educators in everyday practice, and how it is ultimately adopted by students as a preferable learning strategy. The "how" question is also connected to the identification of the processes that support the development of the deep-learning approach. We can start the present analysis by again drawing a parallel to the field of artificial intelligence and machine learning where the aim is to instruct mechanical devices to "learn" without being programmed in advance, thus simulating the ability to perform intelligent thinking. In these cases, computer-like machines artificially recognise inputs, create patterns based on those inputs and develop algorithms that in many ways mimic human logic and intelligence. This means that the "how" of machine deep learning is a relatively static input–output process where data are fed into the computer, which then provides or creates algorithms that result in improved quality of thinking by the machines. The ultimate goal is to produce autonomous and adaptable response patterns and agents that are able to learn in complex and uncertain environments (Mousavi, Schukat, & Howley, 2018). Obviously, human beings are not machines, and hence it is expected that processes that are applicable to machine learning are not directly transferable to human learning and behaviour. For instance, machine deep learning is based on a rather straightforward process of feeding large amounts of data into a computer and expecting processing on deeper levels, without interference from such processes as initial motivation, social interaction and other possible contextual and personal influencing features. On the other hand, human deep learning is influenced by many additional, interfering or not, characteristics, such as personal motivation, perception of meaning, task features, teacher–learner interaction, learner–learner

interaction, nature of feedback, learning environment and essentially many others (Smith & Colby, 2007). The review of the current literature on "why" and "what" suggests that this parallel with machine learning is nevertheless deeply embedded in the visions of "how" to teach and "how" to adopt the deep-learning approach to improve knowledge acquisition in education. For instance, deep-learning techniques are used with learning analytics to predict academic performances in terms of identifying successful and at-risk students (Waheed et al., 2020).

However, the specific "instructions" for the acquisition of human deep learning through teaching that can be found in the educational literature are indeed very few, and the content is frequently very general. All this research basically suggests that deep learning aims to develop students' bits of knowledge gradually by forming a larger interrelated insight, as opposed to cramming bits and pieces automatically without creating links between them. This description and a number of variations of it which intermix all three main questions addressed in the present analysis, is the closest we have come to detailed instructions on how to employ deep learning in educational practice. However, a relatively large number of studies identify key processes that support or are empirically associated with the development of deep learning. For example, several studies state directly that formative assessment, in contrast to summative assessment, are a key to deep learning where the role of feedback is promoted as a tool for modifying teaching and learning activities in which students are engaged (Rushton, 2005). A similar line of research reports that the formative structure of instruction, which incorporates self- and peer-assessment and feedback, results in higher quality learning outcomes and enhances critical thinking skills (Lynch, McNamara, & Seery, 2012). A deep-learning approach was also found to be a mediator in the relationship between goal orientation and feedback-seeking behaviour (Leenknecht, Hompus, & van der Schaaf, 2019). More specifically, learning goal orientation that fosters mastery focus is to a higher degree associated with deep learning, in comparison to goal orientation that has a performance orientation in focus (Geitz, Brinke, & Kirschner, 2015). Other research findings also point to the relationship between the learning environment/nature of interaction and deep learning (Cleveland-Innes & Emes, 2005). In addition to these specific factors, the literature review investigating the effects of specific learning strategies found that problem-based learning (PBL) enhances deep learning (Dolmans, Loyens, Marcq, & Gijbels, 2016; Geitz, Joosten-ten Brinke, & Kirschner, 2016). Moreover, other studies report that the practice of the flipped classroom also increases deep learning (Kevser, 2020), where students in the flipped classes are found to relate new ideas to previous knowledge, are involved in their own learning, apply learned knowledge in their own projects and show a tendency to apply learned knowledge to situations in the real world (Danker, 2015). The list of these alternative teaching methods that are supposed to increase deep learning is relatively long, and also includes different theoretical models (e.McPhail, 2020), taxonomies (e.g. Smith & Colby, 2007), use of video (Mitra, Lewin-jones, Barrett, & Williamson, 2010), digital storytelling (Barrett, 2006) and various social processes, such as peer interaction, faculty interaction and features of the learning environment (e.g. Cleveland-Innes & Emes, 2005). However, all these approaches are embedded in specific educational traditions, rarely transcending the frames of the given national context.

Norway can serve as an example of the national context where the idea of deep learning has made a rapid journey towards pedagogic practice. In accordance with a wide-ranging political and student-association agreement, Norway started to implement deep learning in the national curriculum for primary and secondary education in 2017. According to the Norwegian Directorate for Education and Training (2018), deep learning occurs when students (1) gradually take a more active role in their learning processes, (2) practise what they have learned in unfamiliar situations, (3) see relevance and contexts, think in new ways, wonder and are creative and curious, (4) transfer what they have learned in one context to new situations to find solutions, (5) see connections across subjects and actively maintain reflection over their own and other students' learning processes, and (6) need to formulate questions and seek their answers through collaborative efforts. Furthermore, the basic principles underlying deep learning are connected to values embedded in the national core curriculum, such as human dignity, identity, cultural diversity, critical thinking, ethical awareness, the joy of creating, engagement and the urge to explore, respect for nature, environmental awareness, democracy and participation in society (Norwegian Directorate for Education and Training, 2021b). The impulses originating from international movements in the field of education are clear in a number of recent political documents in Norway (NOU, 2015; Meld. St.,). Based on the combination of international influences and domestic traditions, Norwegian education is in a state of constant reform adjustments where the concept of deep learning plays a central role. It is also easy to detect that the descriptive approach in terms of listing expected (inter)related attributes of deep learning in Norway is similar to dominant views in international literature where it is difficult to identify precise instructions or directions for practitioners as to how exactly to implement deep learning in their everyday practice. Indeed, some authors in Norway have raised several important questions concerning the use and implementation of deep learning in the Norwegian educational context (Gilje, Landfald, & Ludvigsen, 2018; Hjardemaal, 2021).

In sum, although a relatively large number of empirical studies address to varying degrees of explicitness the question of "how", it is nevertheless fair to say that there are apparent inconsistencies and inaccuracies connected to measuring, conceptualising, operationalising and choosing an appropriate level of specificity (task as opposed to context) in empirical approaches to deep learning. Moreover, it seems that deep learning is an umbrella concept for a variety of different approaches that are supposedly associated with deep insights, as mentioned in the text above. Bearing this in mind, it would be not surprising to discover that the dominant teaching approaches in many cultural contexts are still firmly embedded in the mechanical reproduction of the learned material (Smith & Colby, 2007). Indeed, a systematic review of longitudinal research on how students' approaches to learning to develop during higher education reveals that there is no empirical evidence to support the assumption that deep learning evolves during higher education (Asikainen & Gijbels, 2017). Furthermore, this review shows that a variety of different theoretical frameworks conceptualise this term somewhat differently, using terms such as deep motive, deep strategy, intention to understand, holistic teaching, relating ideas and so on.

Discussion

The present analysis of the "why, what and how" of deep learning leads to the following conclusions and interrelated issues that need to be discussed. First, it seems that deep learning represents a continuation of progressive education where the emphasis is on the learner's development in terms of collaboration, teacher approach, insights and deeper understandings of the subject matter (Kohn, 2008). As such, deep learning stands in stark contrast to the testing tradition where rapid and frequent assessments are undertaken with the aim of pinpointing developmental stages and making hierarchical selections between members of the given population without assessing the "real learning". Indeed, educational research indicates poor correspondence between student achievements, in terms of grades, and deep learning (Campbell & Cabrera, 2014), but it is important to note that this connection depends on the subject area and other contextual factors (Laird, Shoup, & Kuh, 2005). Thus, it appears that the association between learning achievements and the deep approach is influenced by the nature of the interaction between the student and the course structure, curriculum content and methods of teaching and assessment (Laird, Shoup, Kuh, & Schwarz, 2008).

Second, deep learning is associated with several interrelated educational traditions, all representing an alternative to instrumental and surface learning. For instance, there exist

an empirical and theoretical connection between deeper and informed understandings of the societal world and educational movements supporting democratic behaviour, character education, citizenship competencies and awareness of individual civic obligations/rights in society (Wood, Taylor, Atkins, & Johnston, 2018). Similarly, deep learning has some components from the Scandinavian and German "Bildung" tradition where emphasis is placed on broader approaches to learning and all-round development of young people, as opposed to learning isolated, specific or instrumental skills that might be severely limited in scope (Wagenschein, 2000). Additional connections in the educational literature can also be found between deep learning and constructivist theories of learning, where emphasis is on the learning process in interaction with others (Abbott, Townsend, Johnston-Wilder, & Reynolds, 2009). All these points taken together, originating from different traditions, clearly advocate that deep learning represents a diverse learning approach that aims to improve the quality of learning and stimulate long-term thinking, leading to a sustainable future.

The third issue that needs to be discussed here is that our analysis clearly shows that there presently exist several parallel and even competitive understandings of what deep learning is. In the same way as in other intuitive or self-explanatory educational concepts (i.e. inclusion), it is not clear what exactly deep learning is, and equally important what deep learning is not, in terms of definitional boundaries. Contemporary literature offers a superfluity of interrelated processes that are descriptively associated with deep learning, thus creating a "goulash" situation where different ingredients can be arbitrarily added to or subtracted from the pot depending on situational, contextual or individual preferences. Our conclusion is that the present situation requires advances in empirical research, combining sound theoretical perspectives with reliable appraisals of the content of the concept. Indeed, this somewhat blurred situation relating to definitional understanding is inevitably transferred to the

"how" question and uncertainties associated with its implementation in educational contexts. Thus, it is evident that currently there is little guidance on how to exactly practise or stimulate deep learning (1) in everyday educational life, (2) for different age groups, (3) in different contexts, (4) across different epistemological traditions, and (5) for specific vocational tendencies and ambitions that are embedded in individual learners. At present, it seems that deep learning is a side-effect of a number of specific approaches that use alternative teaching methods (e.g. PBL, flipped classroom, formative assessment, peer instruction) and not a primary didactic instrument or instructional goal.

There is, however, one obvious but nevertheless potentially overlooked issue that is rarely explicitly discussed in the contemporary literature: To whom is deep learning recommended as a twenty-first-century skill? This is somewhat surprising considering that this issue is collectively produced by the synergy of all the three above-presented questions, and more importantly has major consequences for the future direction of any given educational system. This question is relevant, remembering that one of the main unifying processes in modern international education is the concept of inclusion. Although it is difficult to provide a comprehensive and all-encompassing definition of inclusion, it is fair to say that it comes in degrees embedded in various social communities and levels that provide flexible learning settings (Qvortrup & Qvortrup, 2018). Thus, inclusion is about perceiving diversity as a normal state of affairs where everybody feels that they are part of the given context and learning environment. In short, people share social space together on equal terms when it comes to common human respect and human rights. On the surface, deep learning does not stand in contradiction to the basic premises of inclusive education, especially when small groups are employed (Dzemidzic Kristiansen, Burner, Johnsen, & Yates, 2019; Tal & Tsaushu, 2018) and where specific technological assistance is linked to the education of children with special needs (Srivastava, Varshney, Katyal, Kaur, & Gaur, 2021). Nonetheless, on a larger scale, the basic question/concern that should be discussed remains: are all children, including children with special needs, able or motivated to cope with knowledge on higher levels of abstraction? As mentioned above, deep learning is about conceptual interrelations, analytic skills, cross-referencing, intrinsic motivation, imaginative reconstruction, independent thinking, critical thinking, and higher levels of cognitive abstraction. Overall, deep learning includes several aspects of meaning construction and is presented as a learning strategy that surpasses concrete instrumental levels and encompasses changes in the current world picture of learners. For example, deep learning is linked to a strong sense of identity around a purpose or passion and is further connected to creativity and mastery in relation to a valued pursuit, thus leading above all to connectedness with the world and people in that world (Fullan, Quinn, & McEachen, 2018). However, in addition to these "soft" values, deep learning is also linked to cost-effectiveness, i.e. high outcome with low cost.

All these descriptions taken together appear to be demanding when it comes to learning. Furthermore, they collectively appeal to higher achievers and could easily be used in an advertisement for private schools where the emphasis is on the strategic development of special skills or talents in a select number of privileged children, and much less applicable to inclusive education. Thus, our point is that an indiscriminate insistence on categorical and strong conceptualisations of deep learning has an elitist

connotation that might be experienced as exclusive, and as such might be at odds with other global educational principles, such as inclusive education or adapted instruction. Indeed, deep learning includes aspects of the internationalisation and globalisation of knowledge that might collide, not only with the learners' interests or abilities on the individual level but also with national and local priorities (Haigh, 2002). At present, very little empirical knowledge and theoretically based arguments show that our concerns are groundless in the sense that deep learning can indeed be implemented in contemporary schooling without creating challenges for children who, for any number of reasons, are not able or motivated to elevate their own thinking to higher levels of cognitive abstraction. It is important to note that we are describing a slowly developing trend that might not be easily detected over the course of only a few years. The possible consequences of adopting a rigid or uniform approach to deep learning might be a gradual, and as such concealed, exclusion of those children who are not motivated or able to work with knowledge on deeper levels. Agreeing with other researchers, we maintain that empirical investigations on these issues, combined with sound theoretical reasoning and discussions, should precede intuitive enthusiasm or ideological positions advocating the implementation of any given process that fundamentally alters the way the new generations of learners are shaped or influenced (Beattie, Collins, & McInnes, 1997).

This leads us to speculate that a term such as "deeper learning" or some similar "softer" terms that explicitly come in degrees without a sharp distinction between depth levels, might be more suitable, and more importantly might provide inclusive foundations on which to base educational instruction. The idea of exercising caution in the use and implementation of deep learning as an overall and exclusive learning strategy has also been acknowledged by others, where it has been recommended that a flexible use of appropriate strategies, or a combination of strategies with various depth levels, might be more advantageous to learners in many situations (Dinsmore & Alexander, 2012; Grauerholz, 2001). Indeed, several authors have argued that the description "deeper learning", as an attempt to avoid complete separation between levels of knowledge, is a better term that promotes the idea that the approach to learning should be flexible, strategic and multi-sourced (Lynch, McNamara, & Seery, 2012; Pellegrino & Hilton, 2012).

Conclusions and further theoretical clarifications

Discussions such as the one here might directly contribute to advances concerning educational praxis and as such do not represent an academic theorisation divorced from consequences. The paths of global education are regulated by dominant, consensually reached concepts that govern the direction in which the desired development of learners is planned to progress. There is a price to be paid down the line if one indiscriminately accepts the promotion of new perspectives that are based on uncritical acceptance, authority, ideology or simply because they sound right or good. The attentive reader hopefully understands that our aim is not to discredit the concept of deep learning. We are actually convinced that the overall idea of deep learning is highly valuable and represents probably one of the main reasons for human progress throughout history. Nevertheless, there might be negative

consequences if this learning approach is adopted totally, exclusively and most importantly blindly when it comes to specific content, aims or the transfer to particular situations and contexts (Hattie & Donoghue, 2016). Even more alarming is if the insistence on deep learning is viewed in terms of costs and benefits (i.e. recognising costs but valuing benefits), again touching on the issue of inclusive education. We maintain that the points we raise here are valid and should be kept in mind if one chooses to romanticise the concept and downplay or completely ignore the effects that an indiscriminate practice and acceptance of novel concepts might have. There is a relatively simple solution to this problem. One could develop critical empirical research based on sound theoretical reasoning that specifies conditions and circumstances for where, when, to whom, and most importantly, how deep learning should be practised. Thus, one could still embrace the general notion of deep learning but accumulate nuanced knowledge showing how it is most efficiently combined with other existing traditional learning approaches, such as surface learning, memorisation, testing, and automatisation that have gradually taken on negative connotations (Hattie & Donoghue, 2016).

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