Towards Simplifying Learning Systems: A Critical Review

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ABSTRACT
The concept of learning itself involves a significant amount of complexity. Therefore there is a need to design and implement learning systems that are not complex, confusing or complicated. This paper discusses, based on a review of the literature, how we could simplify educational technology and learning systems by focusing on one of the most important user centered design principles, i.e. understanding learner's needs and establishing requirements. It is also important to consider the learning context before focusing on the characteristics and system requirements. In conclusion, nowadays, more than ever before, new and emerging technologies could make possible the design of powerful learning systems that could transform the quality of learning as long as they are easy to use, intuitive and provide an engaging user experience.

Categories and Subject Descriptors
K.3 **[Computers and Education]:** Computer Uses in Education **-** *Computer-assisted instruction (CAI), Computer-managed instruction (CMI).*

H.5 **[Information Interfaces and Presentation]:** User Interfaces **-** *User-centered design, Theory and methods.*

Keywords
Learning Systems, Educational Technology, Learning, User-centered Design.

1. INTRODUCTION
Interaction design involves designing interactive systems and products to support the way we communicate and interact in our everyday and working life [1]. Consequently, learning systems should be designed focusing on the above goal. In order to achieve this, there is a need to understand human capabilities, cognitive limitations, people's desires and motivation. This will help us identifying the learners' needs, establishing the system's requirements and translate these into an appropriate and optimized design that could enhance and facilitate learning. How could we simplify complexity of educational technology and learning systems?

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2. LEARNING
The concept of learning itself involves a significant amount of complexity both as a process as well as an outcome. According to Hodkinson and Macleod [2], "learning is a conceptual and linguistic construction that is widely used in many societies and cultures, but with very different meanings, which are fiercely contested and partly contradictory. Learning does not have a clear physical or reified identity in the world". As learning is complex enough, educational technology and learning systems should be particularly simple. We could simplify complexity of learning systems by focusing on the primary user of such systems i.e. the learner and the learning activity. As Norman [3] emphasizes, we need to start with an understanding of people i.e. learners: user needs first, technology last.

Over the last 20 years, psychologists are trying to understand the influence of the social and cultural environments that are involved in someone's learning and cognitive development [4] and more emphasis is now being placed on seeing learning as a very social process. This idea of learning as a collaborative and socially situated process has led to a number of researchers e.g. [5, 6, 45] nowadays focusing on how educational technology could act as powerful social resources in someone's learning context.

When learners acquire information in a meaningful context and are able to relate it to their prior knowledge and experiences, they could form connections between the new information and their prior knowledge to develop larger and better linked conceptual understanding [7].

3. LEARNER NEEDS AND CHARACTERISTICS
Numerous researchers, e.g. [8, 9, 10, 11, 12, 13] have emphasized the common idea that technology can create learning environments that would not otherwise be possible without technology. Hence how can we simplify the complexity of learning systems in order for them to facilitate and enhance learning? The key answer to this question is to know the users and their needs. Knowing and analyzing what is meaningful to the learners and their possible interactions with educational technology is fundamental. We need to study learners' preferences, desires and adopt their perspective. Understanding their needs as users means that we can design educational technology that makes the learning object meaningful and

provides learners with a context in which learning becomes a tangible need [14].

It is important to understand why and how learners differ because then educational technology could be designed and used in such way that learners could achieve their full potential and guided though the learning process. Intelligence, personality and cognitive styles contribute to variations among individuals. Cognitive style refers to "an individual's preferred and habitual approach to organizing and representing information" [15]. Although within the literature, the term "learning style" has been used in two ways: a) as "cognitive style" and b) as a term to indicate a wide description of rather consistent behaviors in relation to the way people learn, in both ways the term meant to cover "a range of concepts which have emerged from attempts to describe aspects of student learning" [16]. Research into the field of individual differences and learning styles is particularly significant in order to design instructional material through technology. In this way it is possible, if we adapt the instruction, to accommodate learners' differences in styles or preferences [17] and help them approach their learning in the best possible way. Riding and Rayner [15], argue that academic performance is related to the development of learning strategy, the learning process and individual differences.

In addition, it is important to study the relation between educational technology and certain processes that learners employ in their learning, i.e. their learning strategies. Mayer [18] defines learning strategies as "the behaviors of the learners that are intended to influence how the learners process information". Investigating the learning strategies that students are engaged in when learning from and with certain computer applications could be beneficial. It could provide an assessment of the way computer-based learning strategies differ from the strategies used in the traditional learning environment within the school (lectures, tutorials, use of textbooks). Although the use of computer applications in the classroom becomes greater there is a dearth of research (particularly in primary education) regarding the kind of learning strategies students use when working with technology. The use of certain learning strategies in the course of learning could affect the encoding process and consequently, the learning outcome and performance [19].

Adaptive learning environments through the use of educational technology could also play an important role on enhancing the learning process. Adapting content and instruction to particular learner characteristics, needs and abilities is a particular important area of research, e.g. [20], nowadays especially since the recent advances in technology have created a number of exciting opportunities for personalized learning and instruction. However, as Mavrikis et al [21] highlight, computational analysis and reasoning in supporting learning with and from exploratory environments will be of little benefit when designing these exploratory environments without subtle understanding of the interaction between the learner and the system and the types of support they need.

4. LEARNING CONTEXT

It is important to increase our understanding regarding the relationship between learning and context so that we could specify the requirements for the design of learner activity and technology. The nature of context is crucial for someone's development, Luckin [22] concludes that different contexts will lead to different social interactions and consequently to the development of different mental processes within the individual. Luckin [5] defines a learning context as "an Ecology of Resources: a set of inter-related things/elements that provide a particular context". Past research has confirmed the importance of exploring the learner's context but has been largely limited to specific environmental locations. Nowadays, the capacity to create learning context is widely available and the challenge is to develop ways in which technology can support learners to effectively create their own learning contexts [22].

Luckin [23] argues that we need a framework which helps us design educational experiences that match the available resources to each learner's needs. According to Luckin's Ecology of Resources framework, there are four different types of resources: a) Tools: learning materials, b) People: teachers, peers and adults, c) Knowledge and Skills: the teachers' expertise and d) Environment: the setting in which learning is taking place.

In addition to the issues discussed above regarding the learning context, it is also significant to consider the overall power of contexts in educational research which makes the need for qualitative approach necessary in trying to understand school life and particularly designing successful learning systems for use in formal learning.

5. CHARACTERISTICS OF SUCCESSFUL LEARNING SYSTEMS

Sinclair et al [24] analyzed a range of digital technology implementation projects with focus on mathematics and which have been implemented at a national scale in various parts of the world. The researchers highlighted that although early work with digital technologies mainly focused on individual learners or school-based groups, these large-scale projects that they analyzed demanded a much more systemic approach that considered issues such as teacher adoption and curriculum integration. Sinclair et al [24] noticed a shift in focus towards the teacher's role and participation that was emerging across these projects. Furthermore, it appeared that the majority of these projects were focusing on the use of one "multi-purpose digital technology". The majority of digital technology implementation projects that have been undertaken at a national scale in different parts of the world are still focusing nowadays on a mandated curriculum. Nevertheless, there are some exceptions where certain projects encourage new content or new variations of curriculum content [24]. For example, by offering different ways of approaching primary school mathematical ideas, they focus on scaffolding learning. For instance, the use of a visual animation could enhance understanding of a difficult mathematical idea, or an abstract mathematical idea.

Nowadays, innovative technology and open-ended environments afford new forms of interaction that offer great opportunities for exploratory learning as well as personalization. Nevertheless, in the classroom there is a need to obtain a balance between allowing students to express their own ideas and follow their own paths, and at the same time steering them towards the activities and ideas that are concerned with the curriculum material [25]. A potential solution to this problem could be to equip the teacher with tools that could provide the latter with valuable insights as to how the students progress so that the teacher could still orchestrate the classroom but without becoming intrusive as this would almost certainly lead to the elimination of any exploratory learning opportunities.

Exploratory learning seems to have great potential nowadays through information visualizations, online environments, powerful

simulations and augmented reality. Nevertheless, there are not enough examples of innovation [26] and this type of learning appears to be underused and undervalued within the school classroom. Possible reasons for this could be the obvious limited amount of time that teachers have to use such environments, the complexity of designing such environments and also, the difficulty of assessing and effectively evaluating what needs to be learned at school through such exploratory environments.

There is little doubt that interactivity facilitates learner's exploration of the learning environment and as Salomon [27] underlines, interactivity adds a completely different value to the learner's engagement in the activity. In addition, it makes possible the testing of ideas and receiving guidance and informative feedback.

Guidance and feedback is another characteristic of successful learning systems. In contrast to other mediums of learning (e.g. books), a well-designed interactive learning system can provide important guidance and informative feedback [27]. In fact, it could be said that it creates for the learner a "Zone of Proximal Development", the distance between the learner's actual developmental level and their potential level of development under guidance and help [28]. However, it is obvious that different kind or amount of feedback can have different effects on learning. For example, when the students start an interactive activity the amount of guidance and feedback is greater in comparison with what they receive as they move on and complete a number of activities and acquire certain skills.

New and emerging technologies require reconsidering the concept of scaffolding within software. Luckin [23] introduced the "Zone of Available Assistance" (ZAA) and the "Zone of Proximal Adjustment" (ZPA) in an attempt to clarify the relationship between the ZPD and educational technology. Luckin used ZAA to describe the types of resources, both human and artifact, available within a particular context to help a more able partner to offer appropriate help to a less able learner. The ZPA represents a selected subset of the ZAA that are the resources which are the most appropriate form of help for a specific learner at a particular moment in time. However, Luckin argues that the existence of a rich set of resources within the ZAA is not sufficient to ensure the required interactions in order to create a ZPD for the learner.

The computer-based learning environments should not only present information but also provide guidance for how to process the presented information (i.e. determine where to focus, how to mentally organize it and how to relate it to prior knowledge) [29].

Learning systems should be designed in such way that [44] a) cognitive processing which does not facilitate the instructional goal (i.e. extraneous processing) is reduced while b) cognitive processing that is needed to represent the material in working memory (i.e. essential processing) is managed and c) cognitive processing that is needed for deeper understanding (i.e. generative processing) is supported. This is, according to Mayer [44], the triarchic model of cognitive load.

Research, e.g. [30, 42, 43] emphasizes that there is a need to develop educational computer environments that will foster meaningful learning and that this could be achieved through active learning. However, we need to consider what we actually mean when we refer to active learning. Is the latter related to the learner's physical behavior (e.g. the level of hands-on activity) or to what is going on in the learner's mind (e.g. the level of integrative cognitive processing)? As Mayer [29] highlights: "Research on learning shows that meaningful learning depends on the learner's cognitive activity during learning rather than on the learner's behavioral activity during learning... My point is that well-designed multimedia instructional messages can promote active cognitive processing in learners, even when learners seem to be behaviorally inactive".

In successful educational games, difficult concepts could be explored through gaming that motivates and engages students. In addition to this, students' interactions with a game could be logged and then analyzed in order to acquire valuable information regarding their learning, for example, what section they found difficult or easy etc. Such data-mining in a school environment could reveal which curriculum areas lead to achieving the required learning outcomes, which as Noss [8] explains is particular difficult information to collect traditionally.

Furthermore, educational games or other technology enhanced learning systems could help learners apply their knowledge in real life. Simulation authoring tools such as SimQuest [31] enable students to explore the physics of motion in a real life context. Immersive virtual environments such as EcoMUVE [32] teach secondary school students about ecosystems and causal patterns [34]. Simulation tools and micro-world environments such as ThinkerTools [33] allow primary and secondary school students to run simulations of objects moving and observe the affects of various forces such as impulses, gravity and friction. Gee [45] argues that good computer game design can help us understand how to design good learning because good games are mainly learning and problem-solving experiences.

There is also a need for better understanding whether and how specific characteristics of a particular type of educational technology could be effective in promoting learning since by expanding our knowledge in this area we create the foundation for further research that could lead to the implementation of systems capable of making a real difference in schooling."Technology by itself cannot be expected to revolutionize education, but rather should be seen as one of a collection of tools that might spark and facilitate innovative thinking" [35].

6. ISSUES OF ASSESSMENT

In order to be able to design simple and effective learning systems an investigation is required from a number of different perspectives (e.g. types of assessment, relevant measures of learning) and an understanding of the difficulty of evaluating the system's effectiveness on learning. Lee (cited in [36]) argues that there are several questions about evaluating educational technology as well as some serious problems in using more authentic assessments (e.g. performance assessments) to measure change over time such as low reliability. In school education it is quite difficult to assess long-term change (such as learning) due to changes in classroom conditions for example, change of a teacher. Lee argues that outcomes such as performance assessments, engagement, academic self-concept or aspirations are more complex to measure than the assessment scores (e.g. standardized tests) therefore, there is concern regarding the reliability and validity of other measures (that could be used in order to measure the impact of technology).

Ridgway and McCusker [37] agree that educational technology raises important questions about "what is worth learning in an ICT-rich environment, what can be taught, given new pedagogic tools and how assessment systems can be designed which put pressure on educational systems to help students achieve these new goals" [37].

In addition, as Jonassen [38] underlines, the most important reason for assessment and evaluation is to provide learners with feedback that facilitates their comprehension of how much they have learned in order to "better direct their learning". Jonassen embraces the opinion that technology should be used to support meaningful learning and engage students in critical thinking but at the same time he highlights the fact that critical thinking is difficult to assess because, apart from all the other reasons, it is quite complex to define.

Assessing the process of learning as opposed to simply the result is crucial. Being able to assess competencies such as students' ability to a) analyze and solve complex problems, b) synthesize information and c) apply knowledge to new situations. At present, assessment in school is designed to simply indicate if students have learned but it is not sophisticated enough to assess student inquiry learning or students' thinking during learning. Educational technology has the potential to engage students in immersive, meaningful and challenging learning activities that could provide the teachers as well as the students themselves with rich insights into their reasoning and knowledge [39].

In order to assess the simplicity and consequently effectiveness of educational technology and learning systems there is a need to determine the purpose of the assessment and to identify the best ways to measure the key (and usually multiple) outcomes. For example, are we measuring the learning outcome or creativity or higher order thinking or any changes in learning attitudes? According to Rutter, "the long term educational benefits stem not from what children are specifically taught but from the effects on children's attitudes to learning, on their self-esteem, and on their task orientation" (cited in [40]).

A learning system that supports and facilitates learning activities could gather valuable data while the learning activity is taking place. While the learners are working their inputs are captured and their learning paths are documented as well as the amount of time spent in each activity. This process needs to be straight forward and the recorded results appropriately collected and with various options of analysis and presentation. If such process is complex, confusing and time-consuming or if the collected data is overwhelming and the system does not offer a simple and easy way to analyze it then all the great system's functionality and powerful features do not serve their purpose i.e. to provide teachers and facilitators (or even learners themselves) with a simple and easy way to enhance their classroom learning through better control and awareness of classroom's performance that could consequently lead to opportunities for formative assessment.

7. CONCLUSIONS

This paper has attempted to discuss briefly the need to consider the learner's characteristics and needs as well as the learning context before focusing on system requirements and specifications. There is a need to consider how we can design non complex learning systems that could enhance learning and how we can measure that enhancement [39].

Further research is required on the way games, simulations, virtual words and collaborative environments could be implemented to motivate students while assessing complex skills and aspects of thinking in different situations. For example, a research project in Sweden [41] focused on kinesthetic learning (i.e. how we learn and acquire understanding through bodily interactions and through moving into a large space setting). Researchers explored how abstract notions of energy and energy consumption could become something that could be experienced and interacted with in a physical manner using our body and movement. They argued that: "by adapting the interchange needed between the different spaces, it is possible to build activities and learning environments that allow for both a rich experience of small details in the personal space to a joint understanding of concepts in the larger whole, through both system and real world feedback and interaction" [41]. This seems quite an interesting approach to design for alternative pedagogical practices.

Learning systems could enable both learners and teachers to reflect upon activities and keep track of the learning process as well as present the information and learning material in rich and interactive ways.

Nowadays, more than ever before, new and emerging technologies could make possible the design and development of powerful learning systems that could transform the quality of learning, teaching and assessment through unique opportunities of individual and appropriate feedback and personalized learning as long as such systems are easy to use, intuitive and provide a positive, immersive and engaging user experience. Our focus should always be first in better understanding how people learn, what are the requirements of education and learning and then following a user-centered design approach implement systems for learning.

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