How to Design Engaging Educational Solutions?

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Abstract

The aim of this white paper is to examine the key components in designing good educational solutions. In this paper, we define a framework to guide educational solution design processes from the viewpoint of educational psychology. More precisely, we present the key components in designing a quality educational solution, as well as a pedagogical model, that can be used as the framework in design. Well-designed educational solutions have the power to foster or even transform goal-oriented learning pursuits, but not without good pedagogical design. Therefore, the design process should take into account the research on learning and pedagogy and pursue to implement good practices in order to promote and support learning. This can be achieved by designing solutions to implement a pedagogical model such as the engaging learning model. We conclude that instead of developing the most popular product, learning solution design should focus on trying to identify the goals and find the best way to help students of all ages and levels reach them.

Keywords: engaging learning, educational solution, educational solution design, pedagogical practices, educational psychology, engaging learning model

How to design engaging educational solutions?

Each time new (media) technologies emerge, they are often declared to somehow revolutionize education. As we all know, this has hardly been the case. When summing up the effects of educational technology on learning compared to non-technology, we do see a positive effect, especially when used as a learning tool, instead of a presentation tool. However, the effects have been rather modest and not better than the effects of non-technology-related learning interventions (e.g. Tamim, Bernard, Borokhovski, Abrami & Schmid, 2011; Escueta, Quan, Nickow & Oreopoulos, 2017). Multiple explanations for the modest effects have been uncovered, such as practical reasons of lacking infrastructure and know-how, incompatibilities between schooling and information technologies (Collins & Harvelson, 2010), mainly using technology to replicate prevailing pedagogical practices (e.g. Hakkarainen, 2009) or the diffusion of innovations (Rogers, 2010), which suggests that as the technologies are being more widely accepted, the focus shifts from solving a specific problem to using the tools “just because”. Nevertheless, by reviewing the research from the last 40 years, it should be clear by now that the focus should shift towards exploring *how* and in which situations the benefits of novel technologies can be utilized (e.g. Higgins, Xiao & Katsipataki, 2012). In exploring the *how*, the focus should be on what we already know about learning and pedagogy, and we should pursue to implement good practices with the added layer of doing things in a new way, as made possible by novel digital tools. To that end, we should also focus on evaluating and developing good educational solutions, some of which have already shown promise (Escueta et al., 2017).

The aim of this paper is to examine good pedagogical practices from the viewpoint of educational solution design, i.e. define a framework for good educational solution design. As the market is buzzing with educational solutions of varying quality, it is crucial to be able to examine and evaluate the learning potential they provide to be able to choose the best tool for each job. Furthermore, we argue that the pedagogical practices should also be the key components in designing these solutions, and that combined with a good process design, an educational solution can support and foster an engaging learning process (Lonka & Ketonen, 2012).

We have built our framework across four conceptually separated but empirically intertwined pairs of concepts that are organized as being each other's counterparts on a spectrum. Which end of the spectrum is emphasized is determined by the learning goals. Learning goals are the glue that combines the means to an end. Thus, prior to evaluating or designing the pedagogical practices, the actual and sometimes rather detailed learning goals should be explicated. Further, the goals of learning skills should be separated from content.

In an educational design, the goals have a two-layer and somewhat contradictory structure. For a learner, the solution should support learning in a way that the goals should be as personal and autonomous as possible. Learning should preferably be directed towards mastery of the content/ skills, instead of mainly performing well (e.g. Senko, Hulleman, Harackiewicz, 2011); whereas from the viewpoint of educational design, the goals should be narrowed and clear in order to design the pedagogy accordingly and, most importantly, integrated into activities. A good educational solution not only provides the learner with a possibility to reach the goal (facilitative goals), but also offers didactic support for the learner(s) to actually reach the goals (didactic goals). For example: a learning game with a separate fun game to play after familiarization with some content knowledge presented in an infobox. In this case, the learner's personal goals are not attended, and the gameplay activity is separate from the content goals, which leaves the whole situation a mess. For the learner, it is a question of whether to learn how to play the game, to study the content, or both? In terms of design, learning goals might be clear, but they are not integrated into the activities, making it just a combination of a piece of content and a recreational digital game.

Overall, with regards to learning goals, the educational solution should be designed so that the goals are clear, the learner has the possibility to have a personal goal, and most importantly, the actual activities and mechanics of the solution should provide didactic support to reach the goals. Finally, the question of transfer should be addressed: are the goals aligned so that there would be real-life knowledge or skills that can be extracted and utilized outside of the solution?

Pedagogical components

The components we use to examine the pedagogical practices are organized as concept-pairs such as: 1) *individual vs. collaborative*, referring to whether the pedagogy is directed towards individual or collaborative learning; 2) *active vs. passive*, referring to the requirements of the learners participation in the process; 3) *rehearse vs. construct,* referring to whether the learning activities are designed to drill and rehearse certain skills or information-bits or to build new knowledge-networks; and 4) *linear vs. non-linear*, referring to the organisation of the learning process, that is, whether it is expected to develop gradually on a fixed learning curve or more dynamically, across various possible curves. In the following, we will further discuss the components of these concept-pairs and provide some key concepts useful in assessing these.

Learning individually or collaboratively

In consideration of the learning goals, the activities promoted by the learning solution can be situated somewhere on the spectrum between individual and collaborative. Individual learning is usually the default, whereas when aiming to also promote collaborative learning, more thought is usually required. This can be examined through components such as *interaction*, *responsibility* and *regulation* between the users (see Table 1). In general, even individual learning happens in social contexts (Vygotsky, 1978), i.e. learners interact with each other but also with artefacts (i.e. concepts, texts, tools) and in the process (adequate scaffolding provided) develop new skills and knowledge by gradually internalizing the externally manipulated learning objects such as texts, manipulatives etc.. This, when designing and developing educational software, is an important layer of learning that can be tapped into with a well-developed educational solution. More precisely, when discussing interaction, it is important to explore questions like *does the solution require socially shared manipulation of learning objects as part of the learning experience or does the solution allow learners to make (all) decisions independently?*. The solution may support and even require interaction between users (digitally or face-to-face) to increase collaboration and work on shared objects. If the solution aims to promote collaborative learning, the user's progress should also be dependent on the functionality of collaboration. If the learner acts independently, and the solution offers no community or no work on shared objects, the learning process is inherently individual.

In a collaborative learning process, the learners should have positive interdependence (Johnson & Johnson, 1999). Basically, this means that users are accountable to each other; they hold that shared goals and work is mutually beneficial and non-competitive. From this point of view, an educational solution aiming to foster collaboration through responsibility would need to ensure that, for instance, the success of the user depends on joint efforts, and users should be enabled or required to share their learning goals, outcomes and products. Thus, an important question to ask when aiming to foster shared responsibility is *are the users also accountable to others or only to themselves?* Allowing users to progress fully independently may foster competition instead of collaboration, rendering the users (positively) independent of each other, which makes the learning process lean towards more individual characteristics.

Regulation can be conceptualized as self-regulation, co-regulation or socially shared regulation (Hadwin, Järvelä & Miller, 2011). When taking regulation into consideration in a learning solution, it is important to ask questions like *do users set personal or shared learning goals?*, *do the users act independently or are they dependent on others?.* Self-regulation refers to the processes individual learners use to regulate their cognition and behaviour within social activities, co-regulation, on the other hand, means that learners regulate their own behaviour and emotions when interacting with others, and socially shared regulation refers to the social processes groups use to regulate their joint work on a task. Self-regulation is a crucial component in any learning process, and a solution aiming to cultivate collaborative learning processes also should allow and support practices of co- and shared regulation.

Table 1. Components of the concept pair individual vs. collaborative.

Interaction	Responsibility	Regulation
Interaction	*Accountability*	*Self / co-regulation*
Fostering collaboration	*Peer support*	*Personal / shared learning goals*
Content sharing	*Information sharing*	*Independency / co-dependency*

Users' active or passive role during learning

Regarding the role of the student, the learning solution can promote learners to be active or passive in the learning process, often referred to by the concept of student engagement (Fredricks, Blumenfeld, & Paris, 2004). Despite the fact that most goal-oriented learning efforts require conscious active behaviour on the part of the learner, there might be some educational goals that can be reached better with a seemingly more passive role, such as if the solution was aiming to foster, e.g., relaxation or mindfulness. Mostly, however, for a learning solution designer, the crucial issue is *how to make sure that the learner takes an active role, becomes engaged and learns something new during the learning process* (i.e. achieves the set learning goals). The concept-pair active vs. passive can be elaborated through components of *agency*, *behavioural engagement* and *emotional engagement* (Table 2).

With *agency,* we refer to the learners' psychosocial resources of taking action, regulating their behaviour and emotions, acting with purpose, planning to achieve goals (see Emirbayer & Mische, 1998; Bandura, 2006) and utilizing available tools in a situation (Edwards, 2009). In general, most learners elect to engage in tasks and activities when they feel competent and confident and avoid those in which they do not (Bandura, 1997). Decisions like *how the user is instructed to take responsibility of his/her learning* and *how the learning materials or tools are presented to the user in the educational software* are essential to promoting and supporting users' agency; whereas taking action and proceeding only through active behaviour should be required always (instead of, e.g., mainly automated procession). To take an active role in the learning process, the user should be required to engage actively in the task. Engagement can be observed through *behavioural engagement* and *emotional engagement* (Fredricks et al., 2004).

Behavioural engagement can be viewed through learners' participation and involvement (are they willing to invest time to make progress?) and also persistence and effort (how much are they willing to invest?). When aiming to foster behavioural engagement, the following questions should be explored: *Does the solution require active engagement (doing things) to progress or does the solution allow user to pass through the content with no/low engagement*? In short, mandatory interaction between the solution and the user (solution responds to user's activity) supports behavioural engagement should be pursued.

To promote emotional engagement, a solution should somehow activate and provoke learners’ interest and motivate them to solve problems and progress. Interest and curiosity can emerge in many ways, usually situationally (see Hidi & Renninger, 2006). Through carefully designed scaffolding (a solution providing support to guide the user in overcoming hard or challenging obstacles), engagement can be supported. A solution which allows the user to skip hard or challenging content does not adequately support behavioural engagement, i.e. the learner’s role becomes more passive. Instead, motivation and interest can be maintained with various activating methods (Tsai et al., 2008). To keep the user continuously willing to invest effort into progressing through learning tasks, the solution should be able to activate academic emotions such as enjoyment of learning, hope for success or pride of achievement, sometimes even anxiety, which are crucial for effective learning (Pekrun, 2012). Further, the solution should provide structured (and personalized) motivational support and feedback aimed at keeping the user actively engaged.

Feedback and personalized messages are important when praising and maintaining emotional engagement. Feedback should always be constructive and valid (data-based and targeted), and it is beneficial to view it as *feed forward*. This means that when a user makes a mistake or has a lack of knowledge, feed forward should not focus on the mistakes but instead help the learner to proceed further (Goldsmith, 2003). The learner needs to know what was done right and how to learn more and progress.

Table 2. *Components of the concept-pair active vs. passive.*

Agency	Behavioural engagement	Emotional engagement
Autonomy	*Interactivity*	*Activating motivation*
Self-regulation	*Engagement*	*Sustaining motivation*
Intentionality	*Scaffolding*	*Feed forward*

To rehearse or to construct knowledge

Depending on the goals, the most effective way of reaching them might require countless hours of drill and practice or careful, deep, constructive exploration of a certain topic. The components (see Table 3) in our evaluation framework related to this spectrum are *interest*, *building of knowledge* and *reflection*. If the goal is mainly to engage the user in a drill-and-practice session, the pedagogical approach is much simpler – just make it work; whereas if the goal is to actually to learn a complex topic and construct knowledge, the above-mentioned components should be aligned. To that end, it is important to assess how the role of information in the solution is perceived and aligned with the learning goals. Is the goal achieved by knowledge acquisition with learning based on memorizing and repeating things or through knowledge building, with learning being based on constructing novel information and artefacts through creative and more complex activities (Paavola & Hakkarainen, 2014)?

Table 3. Components of the concept-pair rehearse vs. construct.

Interest	Knowledge building	Reflection
Activating interest	*Defining problems*	*Reflection*
Activating prior experiences	*Assimilation - accommodation*	*Decision-making*
Personification	*Knowledge creation*	*Forwardness*

Interest is a rather powerful mechanism in making learning happen (Edelson & Joseph, 2001). Therefore, a good learning solution should aim to capitalize on this by taking the user's prior knowledge and interests into account, triggering the user's situational interest by activating prior thoughts and experiences on the topic and maintaining and deepening interest during the process by allowing for personalized choices, autonomy and customisation (see e.g. Hidi & Renninger, 2006). To this end, a good guiding question for a pedagogical designer would be: *How does the solution take into account prior knowledge and interests?* Or *what kinds of functionalities are designed to specifically activate learner interest*? Further, personalized learning solutions provide better learning outcomes by curating and targeting the activities and content according to the learners' prior competence and needs (Escueta et al., 2017).

By *knowledge building,* we refer to learning as construction of knowledge (knowledge *of* in contrast to knowledge *about* (Scardamalia & Bereiter, 2006)) instead of mainly memorizing things. To be able to build new coherent knowledge, the prior state needs to be assessed and the "gaps" identified, i.e. by defining the problems. The importance of activating or mapping prior knowledge stems from Piaget's theory of assimilation and accommodation (e.g. Berger, 2014). More precisely, besides assimilating new information on a prior schema, a well-developed educational solution can depend on a continuous cycle of cognitive disequilibrium and accommodation (Van Eck, 2006) and, thus, be able to expand the learning outcomes towards conceptual change (Vosniadou, 1994) and new constructs of knowledge. Moreover, besides assimilating and accommodating knowledge on prior schemas, a crucial part of learning is to create something new, an externalized object that can be shared and re-visited by the learners. The crucial question to be explored would be: *What are the main learning goals, and what are the functionalities that support acquiring, assimilating, accommodating or creating knowledge?*

Being able to engage in metacognitive *reflection* of one's own learning process is crucial in developing "adaptive expertise" needed to solve ill-defined, dynamic problems (Bransford, Brown & Cocking, 2000). Good educational application or a game aiming to foster expertise can push the user to enhance these metacognitive capabilities in terms of providing structures that guide the user to reflect on what has been learned, as well as require informed decision-making and planned progression, i.e. how the learner should progress to deepen the understanding on the topic (Grossman, 2009). Therefore, for the designer, it is important to reflect on the following question: *What are the different ways in which the solutions help the learner recognize what has been learnt and what guides the learner in navigating forward in their own learning trajectory?*

Learning process as linear or non-linear

Regarding the learning process, we characterize the learning solution as promoting learning that is situated somewhere on the scale between linear and non-linear. We used *procession* and *predictability* as key components in determining the characteristics of the solution on this scale.

Procession in linear–non-linear terms refers to the elements through which the solutions carry the user in the learning process. It ranges from a fixed, linear learning path to a random combination of activities. Depending on the goals, a linear process sometimes fits the best. For instance, if the content or skill that is the object of learning activities is explicitly defined and develops gradually, then a linear learning process following pre-determined steps is well justified. However, this is often not the entire picture. For instance, in learning that is centred on creative problem-solving of ill-defined problems (Treffinger, Isaksen & Stead-Dorval, 2006), a non-linear and dynamic learning process is often needed. By this we refer to a process in which the learner can follow multiple paths to the same outcome. In this case, however, appropriate scaffolding should be employed by the solution to ensure learners with different capabilities and preferences are able to proceed (Chen, 2002).

Predictability, in turn, broadens the scope by assessing elements related to how the learning process can be predicted in terms of outcomes or progress from an accurately predictable path to an undefined complex exploration in an unlimited problem space. A linear learning process can lead to a fixed number of outcomes, which can be predicted in terms of performance of steps, and further, the learners can be compared in terms of progress and performance; whereas a solution aiming to foster a creative problem-solving process cannot predict the outcomes, as there would be a very large or even an unlimited number of outcomes. Both have their benefits and setbacks in terms of evaluation. These decisions are heavily based on the characteristics of the learning content. Overall, when designing the learning solution, it should from early on be decided *whether the achievement of the core learning goals would be best supported by a linear and predictable process or an open-ended explorative process.*

Table 3. Components of the concept-pair linear vs. non-linear.

Process	Predictability
User progression	*Predictability of outcomes*
UX optimisation	*UX limitations*

Evaluation and Assessment

Evaluation should be seen as a supporting part of the learning process, as it aims to support the learner to do better and learn more, and not only as a summative or final assessment. An evaluation that supports the learning process consists of at least one of these approaches: *self-evaluation, teacher evaluation* or *peer-evaluation*. In some learning solutions, all of the evaluation approaches should be taken into consideration. Depending on the goals of the solution, it is important to gather information about progress, collaboration (functionality, amount), the learner's position in relation to age group, goals, other users and the applicability of what is learned (transfer).

It is typical for people to relate their own cognitive behaviour and skills to others (Hakkarainen, Lonka & Lipponen, 2004). That is why a learning solution should ask or encourage the learner to think about what the learner can already do well, what kind of things could be studied more and probably understand where the learner stands in relation to the learning goals. This self-evaluation data can be useful for the teachers as well.

From the teachers' point of view, it is helpful if the solution provides information about the learners' progress: *from what knowledge or skill level did the learner start? What has she/he learned?* And *what are the knowledge or skill levels at the end?* Data can help teachers to pinpoint what issues students are struggling during the learning process and where they are. For teachers, it is important to provide tools for both evaluation and assessment, because it is the teachers' obligation to support learning processes and also assess what was learned.

Especially if the solution aims to promote a collaborative learning process, it should provide *peer-evaluation.* This means that users give feed forward to each other. In this case, it is important to notice users' age and skills and make sure that the peer-evaluation is factual. The solution can provide a controlled format for peer-evaluation or at least teach users to give valid and supportive feedback to others.

To sum up, concerning evaluation approaches from the point of view of designers or developers, it is important to remember these aspects: 1) evaluation should support the learning process and can be viewed from three different approaches: self-evaluation, teacher evaluation and peer-evaluation, 2) evaluation should always be based on data or observed practices and, finally, 3) in any case, feed forward is necessary for the learner.

Discussion

All in all, well-designed learning solutions have the power to support both the learner and the teacher in their pursuits or even transform education. However, badly designed educational solutions or educational technology have very little or even a negative effect.

To sum up, the key components in designing a quality educational solution are, first and foremost, the learning goals; they should be explicated and reflected on carefully. Something is always learnt, but without goals, it is arbitrary and impossible to evaluate. There is an unlimited number of paths from the starting point to the goal, but none, if there is no goal. When the goals are clear, the design of the functionalities becomes simpler, as all the pedagogical functionalities should be aligned with the goals. With a good alignment with the goals, it is also possible to evaluate the process from the point of view of the learner, the buyer and the designer.

Further, the pedagogical functionalities should be based on what we already know about learning from different educational or technological solutions. To that end, it is advisable to build functionality and educational activities, so that they follow a coherent educational model such as the engaging learning model (Lonka & Ketonen, 2012; Lonka, 2012). In the engaging learning model (Figure 1), the learning process and the activities are designed so that they follow an iterative and cyclic process of knowledge advancement, tapping into various concepts presented above. The components outlined earlier can be operationalized through various learning activities across different parts of the learning process. A well-designed and engaging learning process would start with activating prior knowledge and capture interest, then moving onto fostering learning through various individual and collaborative activities, wrapping up the process and preparing the start of the next learning cycle through reflection and feed forward. A good educational solution would support all of these phases, with different activities tapping into various components of learning, or focus on providing tools to get the best out of a specific part of the process with specialized activities.

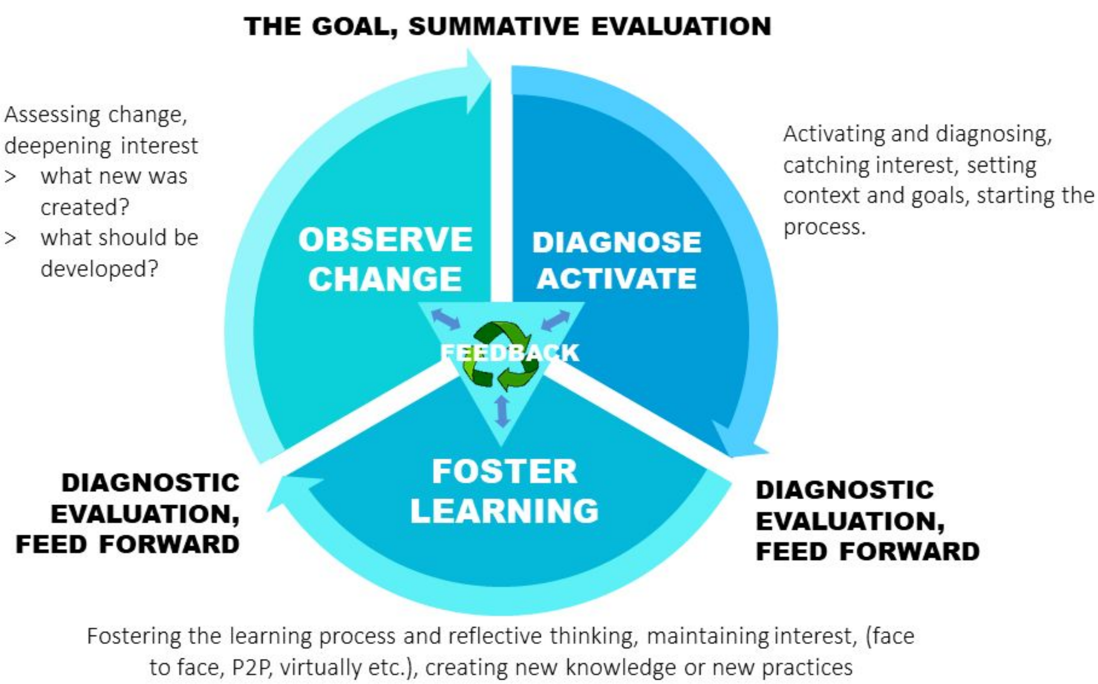

Figure 1. Engaging Learning Model (Lonka, 2012).

Less is more, distractions are distractions, and bells and whistles are not needed to support learning. Designing educational solutions should not be about the most popular product or the solution itself, but about the best way to help students of all ages and levels to learn (Escueta et al., 2017). Interdisciplinary know-how can be beneficial, and fostering goal-oriented learning should always be the leading ambition in learning solution design. Instead of just doing things that are “nice to have”, we recommend that learning solution designers and developers think how it all appears to the learner, what he/she should be able to learn and what kinds of practices the solution supports. Because in the end, it is all about the learners and their teachers. Their efforts and behaviour make learning happen (with or without technology). The key is to acknowledge that learning is an emergent, dynamic and cyclic process, and a good solution can spark up and support the cognitive, social and creative efforts of the learners moving through the various parts of the cycle.

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