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Design principles and design patterns of TEL scenarios created by K-12 teachers

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Abstract

Although teaching is a design science, not much is know on how teachers spontaneously create their learning designs, especially in the technology enhanced learning area. The paper seeks to promote our understanding of teachers design work by critically examining twelve design scenarios that were spontaneously creating by active school teachers that are geographically dispersed in different European countries. The scenarios were freely available online as Open Educational Resources. The document analysis involved mapping the selected scenarios against already existing well-established design principles, meta-principles and patterns. The analysis revealed the main trends with respect to these three design elements as well as a new emerging design principle. The paper concludes with how the findings related to the premises of authentic learning, universal design for learning and the maker movement in education.

Keywords: teachers as designers, design patterns, design principles, intermediate design knowledge

Introduction

Latterly, there has been evolving interest and uptake in teaching as design in educational research and practice (Goodyear & Dimitriadis, 2013). However, this uptake is still not widespread as "the nature of teachers' inquiry processes when designing for learning remains largely unclear" (Alhadad, Thompson, Knight, Lewis, & Thomson, 2018, p. 428). According to Goodyear (2015), the knowledge that is needed to design in education is "actionable knowledge: that is knowledge that is sufficient to information action in the word" (p. 38). In contrast to researchers, teachers are faced with the fact that they must take relevant actions which would ultimately improve learning support and students' learning outcomes. Thus, this paper aims at not only researchers, but also at practitioners, i.e., teachers.

Competent and innovative teachers are the primary change agents of an educational system (Cobb, 2001; Villegas & Lucas, 2002; Mor, 2013; Vandeyar, 2017). Nowadays, teachers who act as change agents are expected to be competent in their teaching, including the possession of the necessary skills for collaboration with colleagues and enactment both as lifelong learners as well as innovative entrepreneurs (van der Heijden, Beijaard, Geldens, & Popeijus, 2018). Yet, we are amidst a gradual change in education involving teachers and learners alike embracing new digital technologies for learning and teaching (Laurillard, 2013). Hence, in this digital era, change agent teachers are called to design powerful learning experiences for their students, and to develop effective learning designs that harness meaningful use of information and communication technologies while anchoring their learning designs to formally defined goals and/or standards (ibid). Also, they try to document and share their innovative learning designs (ibid).

Previous research in the area of teachers as designers of technology enhanced learning (TEL) has showed that there are a number of benefits in teachers' involvement in the TEL design (Kali, McKenney, & Sagy, 2015), both for the teachers and the students. For instance, teachers

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learn through design; also, their involvement in the TEL design process can have a positive impact on the TEL designs created and in turn, on student learning. The problem is that, to date, the knowledge about teacher design work is limited. At the same time, this knowledge is expected to "definitely play a critical role in the future of instructional science" (Kali, McKenney, & Sagy, p. 173). This problem gets even more striking considering that recent technological developments have changed the nature of teacher design work (Kali, McKenney, & Sagy, 2015). A notable exception includes a special issue devoted to the topic at stake, which was published in the Instructional Science journal in 2015. One of the research orientations stemming from this research endeavour was focusing on analyzing the work of teacher designers (Kali, McKenney, & Sagy, 2015), which is in line with the focus of the work discussed herein.

More specifically, the purpose of this paper is to deepen our knowledge about teachers as designers of TEL by examining a number of learning scenarios - developed by K-12 teachers in Europe - in accordance with existing educational design patterns, design principles, as well as meta-principles and pedagogical approaches. Thus, the results of this study aim to help us to understand teachers as designers of TEL better by revealing the kind of choices, i.e., patterns, principles, and approaches that teachers make when they design TEL scenarios.

Intermediate level design knowledge: design patterns and design principles

The idea that learning design can be treated as a design science is not new. Laurillard (2012) argues about that with a focus on the role that digital technology can play. She also argues about the importance of building pedagogical design patterns as a means by which the teaching community can actively participate in TEL design. In relation to that, it has been recently suggested that the accumulation of '*intermediate level design knowledge*' in the TEL field is currently needed in order to further advance it, since it has reached a maturation point in which an abundance of design instances and theoretical frameworks exists, but not much design knowledge 'in the middle space' (Prieto et al., 2017; Sharma et al., 2017; Mavroudi, Divitini, Mora & Gianni, 2017) e.g., knowledge about design patterns and design principles.
In general, design patterns are used as a means to identify and describe solutions for design problems in a semi-formal way (Ecker, Müller, & Zylka, 2011). Typically, their key elements are: the context, the problem, and the solution. In the TEL domain, they are used as a means to represent good pedagogy, to describe best practices, and to capture teachers' experiences with learning designs (Ecker, Müller & Zylka, 2011; Laurillard, 2012).

Design principles in TEL are empirically tested guidelines that refer to a learning situation with a focus on its characteristics or its procedure, i.e. how it can be developed and are expressed in a way that can inform practice (Herrington, Herrington & Mantei, 2009). They emerge from, and connect to, theories of instructional science and learning design (Herrington, Herrington & Mantei, 2009). One of the most well-known set of design principles in TEL, originally suggested by Mayer and Moreno (2003), stems from the educational psychology field and proposes a theory of multimedia learning which reduces students' cognitive load. Other examples include design principles that stem from the instructional design field; for instance, design principles for mobile learning (Herrington, Herrington & Mantei, 2009; Kukulska-Hulme & Traxler, 2013), and design principles for authentic learning environments (Herrington, Reeves & Oliver, 2010).

Method

The method adopted involves document analysis (Bowen, 2009) of twelve TEL scenarios that were developed and shared by K-12 school teachers. These scenarios are freely available online as Open Educational Resources (OERs) in the portal of the project "Open Discovery Space" (Athanasiadis, Sotiriou, Zervas, & Sampson, 2014), a large project with a three-year duration (2012-2015) which was funded by the European Commission. The portal (ODS portal website, n.d.) is still available targeting primarily school teachers and integrates a large number of a) different OERs (e.g., learning scenarios and learning objects), b) online teachers' communities, c) associated schools and teachers and d) online academies (for teachers, educational policymakers, eLearning developers, and parents) (Clements et al., 2013).

The learning scenarios were purposefully selected in the sense that they were all created by active school teachers geographically dispersed in different European countries. This is known due to the fact in the scenarios the name of the school of the teacher was completed. In addition, in order to achieve a wide coverage in terms of subject matters taught in schools, different scenarios target different subject matters while some of the scenarios are interdisciplinary. Six learning scenarios are exemplars, i.e., they were the winning scenarios in their respective countries in the context of national learning scenario contests. Furthermore, they were chosen for the participation in a pan-European learning scenario contest that was organised in the context of the Open Discovery Space project, and took place during the school year 2014-2015 (ODS scenario contest website, n.d.). Finally, the selected scenarios were written either in Greek and/or in English. The remaining six scenarios did not participate at all in the ODS scenario contest.

The selected scenarios were subsequently mapped by the authors against the design principles and the design patterns of the Design Principles Database (DPD, n.d; Kali, 2008). This database was developed as an "infrastructure for designers to publish, connect, discuss and review design ideas" and was created with the intent to "bridge research and design in a communicable and systematic manner" (Kali, Spitulnik & Linn, 2004, p. 294). The DPD provides complete descriptions of a several dozen design principles relevant to TEL. The description includes a general rationale, the theoretical underpinning, and other important considerations e.g,. pitfalls, tradeoffs and limits of practical use (Kali, Levin-Peled & Dori, 2009). Each design principle is associated to one or two design meta-principles which represent a cluster of design principles. There are four design meta-principles: 1) help students learn from each other, 2) make contents accessible, 3) make thinking visible, and 4) promote autonomous lifelong learning. Similarly, the DPD provides descriptions for ten design patterns. They are standalone in the way that they are not associated to any design principles. Finally, we reflected in terms of any recurring new design principles and patterns (i.e. not existing in the DPD) emerging from the scenarios.

Results

In the Appendix, a list of the selected scenarios is presented, analysed with respect to associated design principles, design meta-principles and design patterns. The second half of the table involves the exemplar scenarios. Interestingly, although the D.P.D. contains dozens of design principles, the analysis revealed that there are some recurring and dominating design principles (while some others are not represented at all). More specifically, the following design principles appear in 3 (out of 12) scenarios:

- Connect to personally relevant contexts
- Create a clear and engaging flow of activities

- Employ multiple social activity structures
- Promote productive interactions
- Communicate the rich diversity of inquiry
- Enable virtual navigation for exploring complex physical systems

Less dominating are the following design principles, which appear in 2 (out of 12) scenarios:

- Design prompts for planning and monitoring
- Use multiple representations
- Provide dynamic visual aids for the perception of 3D phenomena

With respect to design meta-principles and design patterns, the figures below depict their distribution across the selected scenarios, respectively. The number at the end of the horizontal bar indicates the number of occurrences of a specific design meta-principle in Figure 1 and the number of scenarios that abide in a specific design pattern in Figure 2.

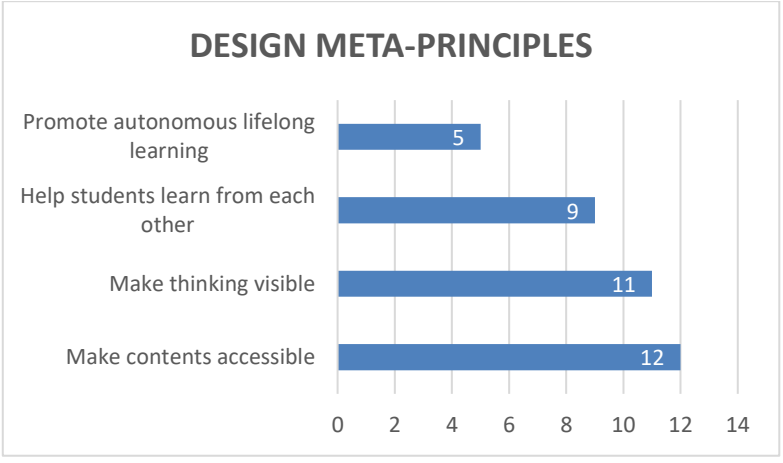

Figure 1. Scenario distribution across design meta-principles

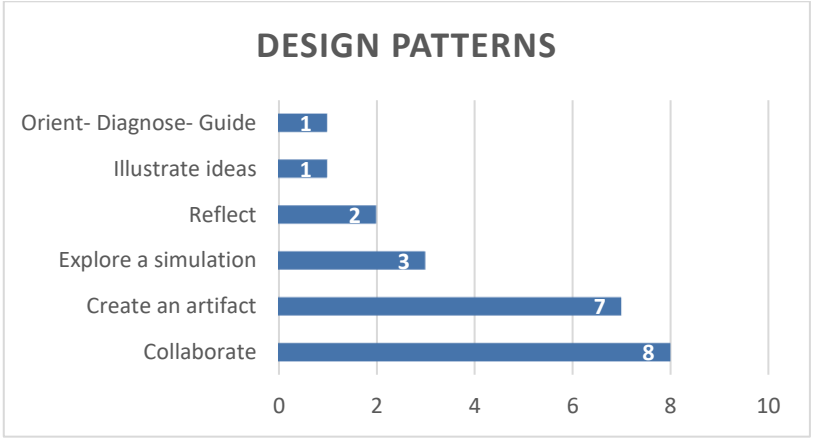

Figure 2. Occurrences of design patterns in the selected scenarios

Figure 1 indicates that making contents accessible, making thinking visible and helping students learning from each other are harnessed almost at the same extent, while the promotion of autonomous lifelong learning is slightly falling behind.

Figure 2 shows that student collaboration and creation of student artifacts are emerging as dominant design patterns. It should be noted that 5 (out of 8) times, the student collaboration design principle appears in tandem with the creation of artifacts design principle in the same scenario, which indicates a clear trend. Finally, it seems that five scenarios involve students interacting with external stakeholders in order to better facilitate authentic and situated learning, like experts and professional, refugees, parents and grandparents. Thus, a new design principle is emerging from the present scenario analysis. An example includes inviting refugees-parents of the students in a scenario about acceptance and integration of refugees in the social system. Another example ('Waternews' scenario) involves students visiting a beach to measure the purity of water and select information from experts. Finally, it should be noted that the six exemplar scenarios and the six remaining scenarios were similar in terms of the occurrences of the three design elements studied.

Discussion and conclusions

The aim of the paper is to reveal design principles, design meta-principles and design patterns used by school teachers when they spontaneously design TEL scenarios. The contribution pertains to a better understanding of their preferences when they create and share TEL designs, with a focus on best practice which is well-documented in intermediate design knowledge formats in the DPD. The fact that the exemplar scenarios were similar to the remaining scenarios indicates that all the selected scenarios were quality scenarios (provided that the exemplar scenarios can be safely considered as a benchmark for the remaining ones). The document analysis of the TEL scenarios shows that there is a small number of dominating design principles. Some of them pinpoint to the design elements of authentic TEL environments as discussed in the seminal work of Herrington Reeves and Oliver (2010). They argued that authentic learning designs are those that can provide (among others): authentic contexts and activities that reflect the ways that knowledge can be used in real life settings, support of social knowledge construction and situated learning opportunities. Regarding the latter, some of the selected scenarios promoted situated learning (among others) by inviting to the school external stakeholders to interact with the students about the topic at stake.

Some of the dominating design principles and meta-principles (e.g. provide multiple representations, create a clear and engaging flow of activities) are also in line with the "Universal Design for Learning" (UDL, n.d.) framework which suggests a set of design guidelines for the creation of inclusive learning environments that optimise learning (Rose, Gravel & Gordon, 2013). It is anchored in three pillars: 1) facilitate student engagement, 2) provide multiple representations, and 3) give diverse opportunities to learners for action and expression. Furthermore, the emerging combination of collaboration and creation of artifacts by students in seven scenarios, pinpoints to a paradigm that combines constructionism and social learning, in which students are learning by doing during groupwork. This paradigm is similar to the one which emerges from the maker movement in education (Taylor, 2016). This is important also due to the fact that the maker movement has been mostly associated to K-12 STEM education- see Taylor (2016), for example- whereas 3 (out of 5) of the scenarios that incorporate this combination in our analysis do not involve STEM. In these scenarios, the maker movement aims at helping to transform pedagogies of individual educators through immersion in the context and the support of an educative community. The social-constructive

model emphasises the notion that knowledge is socially constructed and the importance of others in developing understanding, through, for example group work (Fleming, 2015).

The general limitation of this study pertains to the relatively small number of scenarios selected, even though this can be compensated by the selection methodology at some extent (e.g. teachers that are geographically dispersed in different European countries). Also, the fact that the scenarios were created 3 or 4 years ago. Yet, after the completion of the ODS project no other project focused on the creation and sharing of TEL scenarios created by active school teachers. Future plans include enriching our knowledge of teachers' design work. We would recommend to look for more recent TEL scenarios, through, for instance through a closer collaboration with practitioners, and compare them to this study's findings. Furthermore, to deeper understand the identified design principles and patterns, other qualitative methods, such as interviews with teachers, students and even external stakeholders, as well as field observations, are needed to be employed.

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Appendix: Analysis of scenarios

Learning Scenario title	Design principles	Design meta-principles	Design patterns
CARBON FOOTPRINT: participate-calculate-compare-connect	Connect to personally relevant contexts	Make Contents Accessible	Collaborate
	Enable students to relate between micro and macro levels of phenomena	Make Thinking Visible	Orient, Diagnose, and Guide
	Communicate the rich diversity of inquiry	Make Contents Accessible	
«Φως σημαίνει γνώση και επικοινωνία» (in Greek)	Scaffold the development of classroom norms	Help Students Learn from Each Other	Create an artifact
	Visual representation of data collected by students	Make Thinking Visible	Collaborate
	Engage learners in complex projects	Promote Autonomous Life Long Learning	
Modern methods of introducing basic Physics concepts: The coordinates and the GPS	Enable virtual navigation for exploring complex physical systems	Make Thinking Visible	Create an artifact
	Provide dynamic visual aids for the perception of 3D phenomena	Make Thinking Visible	Explore a simulation
	Enable manipulation of factors in models and simulation	Make Thinking Visible	
WaterNews	Design prompts for planning and monitoring	Promote Autonomous Life Long Learning	Create an artifact
	Employ multiple social activity structures	Help Students Learn from Each Other	Collaborate
	Build on student ideas	Make Contents Accessible	
3d printing of a minoic vase	Provide dynamic visual aids for the perception of 3D phenomena	Make Thinking Visible	Create an artifact
	Design prompts for planning and monitoring	Promote Autonomous Life Long Learning	Collaborate
	Reuse student artifacts as resource for learning	Make Contents Accessible & Help Students Learn from Each Other	
	Connect to personally relevant contexts	Make Contents Accessible	Explore a simulation

Acceptance and integration of refugees through a game based learning scenario	Create a clear and engaging flow of activities	Make Thinking Visible & Make Contents Accessible	
	Promote productive interactions	Help Students Learn from Each Other	
Comparing the surface of terrestrial planets	Communicate the rich diversity of inquiry	Make Contents Accessible	Experiment
	Enable virtual navigation for exploring complex physical systems	Make Thinking Visible	Explore a simulation
	Provide knowledge representation and organization tools	Make Contents Accessible	Reflect
Let's Learn English together!	Promote productive interactions	Promote Autonomous Life Long Learning	Illustrate ideas
	Create a clear and engaging flow of activities	Make Contents Accessible	Collaborate
	Use multiple representations	Make Contents Accessible	
Rollercoaster Energy Transfers	Communicate the rich diversity of inquiry	Make Contents Accessible	Collaborate
	Integrate online with offline activities	Make Thinking Visible	Create an artifact
	Enable virtual navigation for exploring complex physical systems	Make Thinking Visible	
Let’s make our school breaks more enjoyable!	Connect to personally relevant contexts	Make Contents Accessible	Collaborate
	Engage learners as critics	Promote Autonomous Life Long Learning	Create an artifact
	Integrate online with offline activities	Help Students Learn from Each Other	
Multimedia - 6th grade Computer science through Footloose Musical	Use multiple representations	Make Thinking Visible	Create an artifact
	Employ multiple social activity structures	Help Students Learn from Each Other	
	Promote productive interactions	Help Students Learn from Each Other	
Space Travel	Create a clear and engaging flow of activities	Make Thinking Visible	Collaborate
	Encourage learners to learn from others	Help Students Learn from Each Other	Reflect
	Employ multiple social activity structures	Help Students Learn from Each Other	