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Digital Tools Supporting Teachers as Learning Designers: The Case of iCPeLDs for Designing Personalized Learning

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Abstract

Educational research has been promoting teaching as a design science, accounting for various digital tools that support teachers as learning designers. Learning Design (LD) tooling has employed pedagogical frameworks and models to explicitly stimulate and advance teachers' design practices, such as inquiry-based, problem-based, blended, and collaborative learning. Remarkably, there seems to be a research gap concerning Personalized Learning (PL), as LD tools have implicitly addressed it by enabling teachers to design alternative sequences of learning activities. This paper presents the iCPeLDs tool, which focuses on supporting teachers in designing activities for PL. The tool's novelty lies in incorporating a design framework for PL to scaffold teachers. Concretely, based on this design framework, the iCPeLDs tool (i) facilitates teachers to describe the learning context for PL, (ii) provides guidance that triggers teachers to address characteristics of their students' profiles and apply personalization practices, and (iii) recommends peer-based practices by filtering and presenting how peers designed particular activities for PL. The paper also reports on a case study following a mixed-methods research design, which yields promising preliminary findings on the tool's utilization in a teacher education context. The findings showcase the tool's potential for supporting teachers as PL designers and provide valuable insights into LD tooling research.

Keywords: learning design, learning design tools, personalized learning, teacher support tools, teacher training

Introduction

Educational research emphasises the importance of transforming teachers' role from conductors of information to learning designers (Garreta-Domingo et al., 2017). Promoting teaching as a design science where teachers apply learner-centered design (Goodyear, 2015; Laurillard, 2018) has called for research that provides a notation system enabling teachers to present and document their design ideas coherently (Li et al., 2022). Traditional methods such as handwritten notes and lesson plans in generic technology tools, have inevitably evolved into various digital tools that support teachers in the Learning Design (LD) process (Asensio-Pérez et al., 2017).

Consequently, tools such as the Learning Designer (Laurillard et al., 2018) and PeerLAND (Papanikolaou et al., 2022), hereafter referred to as LD tools, have shifted the focus of educational research toward a new perspective for more methodologically sound and effective LD practice (Prieto et al., 2014). Indeed, the teachers participating in studies that

utilized LD tools estimated that LD tools facilitated them in planning their practice more efficiently (Laurillard, 2018). They felt that utilizing an LD tool shifted their focus from overloading students with content towards teaching approaches that prioritized an authentic learning experience (Garreta-Domingo et al., 2017).

Notably, LD tooling research encompasses various approaches to scaffolding teachers in applying particular pedagogical models or frameworks (Zalavra et al., 2023). Some tools are associated with a specific pedagogical approach or theory, while others were developed to be theory-independent, allowing teachers to determine their own pedagogy (Dagnino et al., 2018). Research findings indicated that applying a pedagogical model advanced the traditional lecture-based teaching models and triggered creative LD practices (Katsamani & Retalis, 2013). Furthermore, teachers valued LD tools incorporating design patterns as a means to apply formalism and structure in the LD process to (i) embed pedagogical approaches, (ii) situate the learning context, and (iii) tackle particular learning outcomes (Hernández-Leo et al., 2010; Law et al., 2017).

Although supporting teachers in applying, e.g., blended, problem-based, inquiry-based, and active learning has been explored, there seems to be a research gap in LD tools supporting teachers in designing Personalized Learning (PL). Remarkably, PL is increasingly becoming an aspirational standard in educational settings, challenging the "one-size-fits-all" approaches and addressing student variability and individuality (Zhang et al., 2020). From the teachers' perspective, personalizing learning imposes a significant pedagogical and procedural burden on making critical pedagogical decisions (Gunawardena et al., 2024). Nevertheless, LD tooling has merely facilitated teachers in designing PL through alternative learning paths, i.e., alternative sequences of learning activities to be carried out by students (e.g., Dalziel, 2011; Linn et al., 2010; Pozzi et al., 2020).

Arguing that teachers need scaffolding for the pedagogical perspective of PL, our research goal is to develop an LD tool that explicitly supports teachers by incorporating a design framework for PL. This paper exhibits the potential of such an LD tool. It describes the design rationale of iCPeLDs, an LD tool aiming to support teachers as PL designers by incorporating (i) contextualization, (ii) guidance, and (iii) recommendations based on a design framework for PL. Additionally, we present a pilot study employing a mixed-methods research design, along with preliminary findings regarding the tool's utilization in teacher education.

Relative work

LD tooling research details several tools supporting teachers in authoring learning designs based on pedagogical models or frameworks.

Several LD tools supported teachers in designing for inquiry-based learning. For example, WISE (Linn et al., 2010) and Learning Design Studio (Law et al. 2017) which integrated design patterns and technological components. Likewise, the Go-Lab platform's authoring tool, Grasp, supported teachers in creating inquiry learning spaces through ready-made structures (de Jong et al., 2021).

Regarding collaborative learning, CeLS provided structured online collaboration scripts (Kohen-Vacs et al., 2011), and WebCollage provided predefined design templates as pedagogical patterns for applying collaborative learning (Villasclaras-Fernández et al., 2013).

Regarding technology-enhanced learning, the Learning Designer (Laurillard et al., 2018) has incorporated the Conversational Framework (Laurillard, 2013) into its representation. In line with the theoretical underpinnings of the TPACK framework (Mishra & Koehler, 2006), the PeerLAND tool adopted a modular design approach to support teachers in explicitly

representing their design ideas starting from pedagogical content knowledge and gradually cultivating all the TPACK knowledge domains (Papanikolaou et al., 2022).

Regarding other pedagogical models or frameworks supported by LD tools, we noted blended, problem-based, and active learning. Although blended learning has gained tremendous popularity recently, to our knowledge, only edCrumble has provided a representational format of a timeline that supports teachers in designing blended learning contexts (Albo & Hernandez-Leo, 2021). Regarding problem-based learning, the PLATE authoring tool scaffolded organizing model-based phases with their corresponding learning activities (Wang et al., 2016). The EDIT tool was developed to facilitate the design of projects that sequence educational activities according to student groups (Artola et al., 2023). Additionally, recent calls for increased student active learning have been noted by the developers of CourseFlow. The Courseflow mapped out activities promoting active learning as flowcharts and reified orchestration workflows (Law et al., 2024).

Although educational policies and practitioners have advocated for PL, we noted limited research on LD tools that support designing for PL. Reviewing LD tools, we identified some that implicitly supported personalization by enabling teachers to design alternative learning paths. For example, the Pedagogical Planner did not support any specific learning theory, but it facilitated the design of sequential or random activity flows that could include multiple pathways (Pozzi et al., 2020). As indicated by its developers, this feature allowed for a certain degree of personalization, i.e., the designer could propose different activities to different learners (or groups of learners) pursuing the same set of objectives. Likewise, WISE provided a graphical interface facilitating alternative learning paths while designing inquiry science units (Linn et al., 2010). A similar approach was the one of LAMS, which enabled teachers to design multiple pathways in the form of "branched activities" (Dalziel, 2011).

Considering all these implicit approaches, it appears that no LD tool explicitly supports teachers in designing PL, which triggered our research in developing such a tool.

Designing for personalized learning in the iCPeLDs tool

This section presents the iCPeLDs tool, a web-based tool available at https://bit.ly/icpelds, featuring a bilingual interface (English and Greek). First, it outlines the design framework for PL incorporated into the tool to scaffold teachers in conceptualizing learning activities for PL. Then, it presents how, based on the design framework, the LD tool:

i. facilitates contextualization, i.e., facilitates describing the learning context for PL,
ii. provides guidance, i.e., triggers teachers to address characteristics of their students' profiles and apply personalization practices,
iii. recommends peer-based practices, i.e., filters and presents how peers designed particular learning activities.

Notably, the tool's development followed a four-year-long Design-Based Research (DBR) approach (Plomp, 2013) which employed participatory processes with in-service and pre-service teachers.

Design Framework for Personalized Learning activities

Aiming to alleviate the challenging task of designing for PL, we synthesized a framework for designing PL activities called CPeLDs (*C*oherent *Pe*rsonalized *L*earning *D*esign) (Zalavra et al., 2022) and named the iCPeLDs tool after it. Due to space limitations, we provide a brief overview of the CPeLDs framework in this paper.

As shown in Figure 1, the CPeLDs framework comprises the elements *Learner Profile* and *Personalization Practices*. *Learner profile* involves accommodating student characteristics related

to *Interests, Needs,* and *Strengths. Personalization practices* originated from transforming and augmenting the guidelines of Universal Design for Learning v2.2 (UDL), a widely accepted framework for addressing learner variability in special education (CAST, 2018) and differentiated instruction (Tomlinson, 2000). Concretely, the iCPeLDs framework encompasses nine personalization practices grouped under the overarching principles of *Perception and Comprehension*, *Engagement,* and *Action and Expression.* Designing learning activities for PL involves considering student profiles to apply personalization practices by providing alternative resources, technologies and assessments and allowing students to choose the one(s) they prefer. Employing learner choice promotes engagement, therefore practices for engagement are ultimately seen as interrelated with other practices.

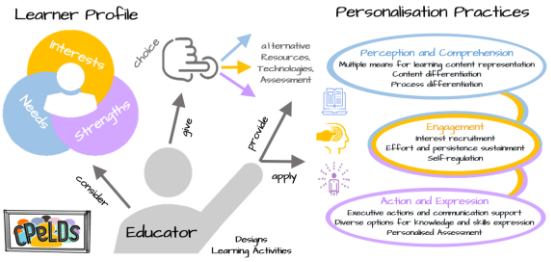

Figure 1. CPeLDs: a design framework for Personalized Learning activities

Contextualization

The iCPeLDs tool employs a visual representation of a learning design, enabling teachers to create sequences of learning activities organized into learning units. The screenshot of an indicative learning activity, shown in Figure 2, allows identifying its two parts. Part A includes the general context of the learning activity, while Part B refers to the context for PL. Focusing on Part B in Figure 2 enables spotting the F1 and F2 features incorporated into the iCPeLDs tool, which support designing the learning context based on the CPeLDs framework.

Feature F1 involves defining the learning context through the elements of the CPeLDs framework, with structured fields for the learner profile addressed and the personalization practices applied. Feature F2 complements the description of the learning context with an open field that allows designers to freely elaborate on the learning experience designed and the choices given to students.

Guidance

Figure 3 depicts a screenshot focusing on the context for PL while a teacher is designing a learning activity. Teachers are prompted to consider the characteristics of their students' profiles and apply personalization practices through two features that provide guidance on utilizing the CPeLDs framework. As shown in Figure 3, feature F3 involves three buttons with question marks (?), which provide online explanations (visual and text-based presentations of theory and examples) for designing PL based on the design framework.

Feature F4 involves getting theory-based suggestions and/or limitations for applying PL. Based on the elements of the PL design framework selected, the tool provides guidance through (i) pop-up containers with recommendations on exemplary applications of those elements, and (ii) restrictions by deactivating fields to prevent considering particular elements (seen in faded grey color).

Recommendation

During the LD process, teachers are supported in designing for PL by receiving peer-based recommendations. Feature F5 involves a recommender system integrated into the iCPeLDs tool, which filters and ranks learning activities available in the tool's repository. Based on the elements of the CPeLDs framework selected by the teacher, the tool filters its repository and creates a list of learning activities. The recommended activities correspond to activities designed by other teachers in the tool, which applied the selected elements.

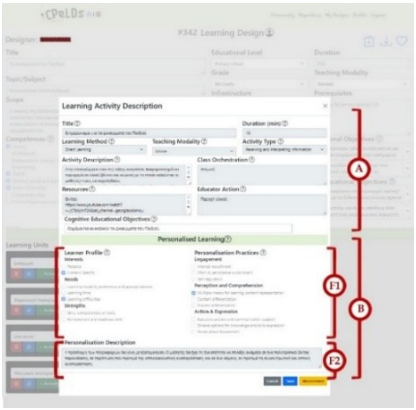

Figure 2. Screenshot of a learning activity in the iCPeLDs tool

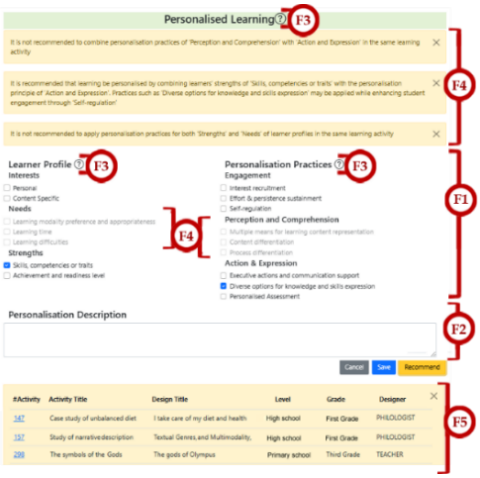

Figure 3. Screenshot of guidance and recommendation for PL while designing a learning activity in the iCPeLDs tool

Methods

Research scope

Aiming for a formative evaluation of the iCPeLDs tool, we explored its potential to support teachers in designing for PL, addressing the research question: *What are teachers' perceptions of the iCPeLDs tool supporting them to design for personalized learning?*

Adopting research practices in LD tools' evaluations (e.g., in Albo & Hernandez-Leo, 2021; Hernández-Leo et al., 2018; Pozzi et al., 2020), we set top-level indicators to formulate participants' feedback. Specifically, we employed the four indicators (effectiveness, satisfaction, efficiency, and ease of use) from the UMUX model (Finstad, 2010) to consider participants' perceptions of the iCPeLDs tool regarding three forms of support in designing PL through the features outlined in the previous section: (i) contextualization (Features F1 and F2), (ii) guidance (Features F3 and F4), and (iii) recommendation based on the PL design framework (Feature F5).

Context, participants, and procedure

We conducted a pilot study in the context of teacher education. In particular, in the context of the inter-institutional postgraduate programme "Digital Transformation and Educational Practice" offered by three Greek universities. The participants were 10 teachers who attended the "Distance and Online Learning" course during the 2023-2024 academic year and consented to participate in the study. The participants' demographics are included in Table 1.

First, we assigned the participants to design individually in the WebCollage tool (Villasclaras-Fernández et al., 2013) due to its open-access and availability. These initial learning designs did not have to follow a particular pedagogical perspective. Then, we presented the iCPeLDs tool and the CPeLDs framework it incorporates. We asked them to redesign their initial learning designs in the iCPeLDs tool. We prompted them to utilize the tool's support for designing PL and consider modifying some of the learning activities they have already developed into PL activities.

Table 1. The participants' demographics

Characteristic	Sample (N = 10)
Sex	4 (40%) Male / 6 (60%) Female
Teaching Experience	4 (40%) Inservice / 6 (60%) Pre-service
Level of Expertise in LD	4 (40%) Low / 6 (60%) Moderate / 0 (0%) High
Academic Disciplines	3 (30%) Primary education 3 (30%) Engineering (ICT, Mechanical, etc.) 4 (40%) Greek/English language & Literature

Instruments, Data Collection, and Analysis

We employed a mixed-methods sequential explanatory research (Creswell & Plano Clark, 2017). First, we collected quantitative data through an online questionnaire to explore trends. Then, we conducted structured interviews to collect qualitative data that interpreted those trends and provided insights into the participants' perceptions.

As elaborated in the research scope, this paper presents the data around five features of the iCPeLDs tool. We explored each feature as four unidimensional statements corresponding to the UMUX indicators. The first and third statements were positive-toned, while the second and fourth statements were negative-toned as follows:

1) "… meets my requirements" to indicate perceived effectiveness,
2) "Using … is a frustrating experience" to indicate perceived satisfaction,
3) "… is easy to use" to indicate perceived ease of use,
4) "I have to spend too much time designing with …" to indicate perceived efficiency.

Additionally, following the typical UMUX model requirements, we scored each statement on a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree).

We performed quantitative data analysis in SPSS v29. We determined Cronbach's alpha to be 0.92, which indicates excellent internal consistency in measuring participants' feedback (Hulin et al., 2001). After transcribing the interviews, we performed content analysis in NVivo v15, following a deductive coding process, to gain insights into the perceived value of each feature and the participants' suggestions.

Results and Discussion

Table 2 presents the quantitative results, on a 7-point scale, of the participants' perceptions. In what follows, we complement these trends with qualitative results providing relevant quotes from participants' interviews (labelled as Pxx) and discuss them.

Table 2. The participants' perceptions of designing PL in the iCPeLDs tool. Results in *Mean* (scale 1-7) and *SD*

Feature / Indicator	Effectiveness	(No) Satisfaction	Ease of Use	(No) Efficiency
Contextualization (articulate personalized learning context)				
F1. Define the learning context with structured fields for the learner profile addressed and the personalization practices applied.	*6.70 (0.48)*	*1.70 (1.25)*	*5.40 (2.50)*	*2.90 (2.02)*
F2. Describe the learning context with an open field to elaborate freely on the choices given to students.	*5.50 (2.12)*	*1.50 (0.85)*	*5.70 (1.63)*	*3.20 (2.25)*
Guidance (conceptualize personalized learning)				
F3. Get online explanations (visual & text-based presentations of theory and examples) for designing PL based on the design framework.	*5.50 (0.22)*	*1.40 (0.84)*	*6.00 (1.63)*	*2.60 (2.17)*
F4. Get theory-based suggestions and/or limitations for combining the elements of the design framework.	*5.60 (2.06)*	*1.50 (0.85)*	*5.90 (2.07)*	*2.80 (2.04)*
Recommendation (consider the design practices of peers)				
F5. Get peer-based recommendations for applying the design framework by filtering the learning activities designed by peers.	*4.80 (2.57)*	*2.80 (2.34)*	*5.90 (2.80)*	*2.80 (2.53)*

Contextualization

The participants valued describing the learning context for PL, reporting a highly perceived effectiveness (M = 6.70/SD = 0.48) for the structured fields and a moderate for the open field (M=5.50/SD=2.12). They were highly satisfied (M = 1.70/SD = 1.25, M = 1.50/SD = 0.85) with these features for enabling them to articulate their design ideas. Nevertheless, the perceived ease of use (M = 5.54/SD = 2.50, M = 5.70/SD = 1.63) and efficiency (M = 2.90/SD = 2.02, M = 3.20/ SD = 2.25), although favorable, did not score high.

Looking for insights into these trends, we noted positive appraisals for "*the super convenient way to tick the intended personalization*" (P03). Nevertheless, the participants expressed a

concern that "*designing in a digital tool takes more time than sketching a lesson plan on paper*" (P04), confirming previous research which reports teachers' mindset as an impending issue for promoting teaching as a design science and the high need to cultivate an LD mindset both in teacher education and in professional development programs (Asensio-Pérez et al., 2017). Notably, one participant reported being perplexed about "*the difference between the open-ended field for the personalization and the one for the general context of the activity in case the learning activity applies PL*" (P02). In response, we intend to provide tooltips when hovering over those fields and extend this practice to all the fields included in the tool.

Guidance

The participants appreciated the guidance provided through online explanations across all indicators: effectiveness: $M = 6.07/SD = 1.15$, satisfaction: $M = 1.40/\text{SD} = 0.84$, ease of use: $M = 6.00/SD = 1.63$, and efficiency: $M = 2.60/SD = 2.17$. The prevalent rationale for this appreciation was "*being very helpful to have available the theory for PL*" (P03). Remarkably, similar to previous research reporting the need for an LD tool to provide online explanations of its elements (Prieto et al., 2014) all the participants asked for extending/augmenting this form of guidance. Future development will heed the requests to "*include extensive examples regarding the application of the personalization practices*" (P06) and to "*provide extra guidance for each characteristic of the student profile and personalization practices separately*" (P01).

The participants were positively inclined to get guidance through suggestions in pop-up containers and restrictions through deactivated fields. There were mildly positive perceptions across all indicators: effectiveness: $M = 5.60/SD = 2.06$, satisfaction: $M = 1.50/SD = 0.85$, ease of use: $M = 5.90/SD = 2.07$, and efficiency: $M = 2.80/SD = 2.04$. Their feedback indicated that they appreciated the suggestions for "*inspiring*" (P04), "*stimulating*" (P01), and "*uplifting*" (P08) their design ideas. Likewise, having low to moderate expertise in LD, the tool deactivating fields for applying particular personalization made them "*feel more confident in the applicability of PL design ideas*" (P01). Nevertheless, the participants' feedback in the interviews revealed the need to address a procedural burden caused by a technicality of this feature, as "*experimenting with several elements and clicking on them caused several containers to pop up, and it was hard to follow which suggestion was actually applicable*" (P01).

Recommendation

The feature that involved peer-based recommendations, i.e., filtering and listing learning activities available in the tool's repository that applied particular personalization, was the least esteemed by the participants. It scored somewhat positively across all indicators: effectiveness: $M = 4.80/SD = 2.57$, satisfaction: $M = 2.80/SD = 2.34$, ease of use: $M = 5.90/SD = 2.80$, and efficiency: $M = 2.80/SD = 2.53$. A common explanation given in interviews was: "*I've tried the recommendation a couple of times, but either got no recommendations or just a few. So, I was discouraged from using it further*." (P06). This finding was expected as the tool was still a prototype under development, and its repository contained only three exemplar learning designs developed by the researchers. Consequently, when the participants were developing their learning designs, the limited number of learning activities for PL available in the tool's repository resulted in the typical cold-start problem reported for recommender systems (Karga & Satratzemi, 2019). We anticipate that the tool's further utilization will increase the availability of recommendation items and improve teachers' perceptions accordingly.

Conclusions

This paper presented the iCPeLDs tool, which aims to support teachers in designing activities for PL by incorporating the CPeLDs framework. A case study conducted in a teacher education context for its formative evaluation addressed teachers' perceptions of its effectiveness, satisfaction, efficiency, and ease of use regarding (i) describing the learning context for PL, (ii) getting guidance to address characteristics of their students' profiles and apply personalization practices, and (iii) receiving peer-based recommendations on designing particular personalization. The positive preliminary findings showcase the tool's potential for teachers as learning designers. The feedback from teachers informed the progress of the DBR approach adopted by our research team for the tool's development, and may provide valuable insights into LD tooling research.

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