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Promoting Personalized Teaching and Learning of Physics accompanied by a Digital Environment (PeTeL)

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Abstract

Personalization of teaching and learning is an educational approach in which the basic concept of teaching and learning changes from the idea of one-way-fits-all to teaching personalized by each teacher to the needs of the student to promote his learning (Hattie, 2012; Dockterman, 2018). The recognition of the teacher's central role and the characterization of her actions in personating the teaching and learning are central to the realization of this educational vision. In this way of action, the teacher transforms from the source of knowledge and the main bridge to it, into a designer shaping, guiding and navigating the learning by adapting the teaching and learning to the level of the individual student. The teaching approach and content are tailored by the teacher to the needs of the students according to their prior knowledge and abilities through ongoing diagnostic and evaluation processes that shape the continuation of teaching and learning (Childress & Benson, 2014; Pane et al., 2015; Abbott et al., 2014).

Content has been developed over the years in many digital environments to promote personalized teaching and learning (Zhang & Basham, 2020). These environments emphasize the teachers' important role in digital learning processes and empower them with tools that enable to diagnose and evaluate the learners in order to customize further learning to the learners' needs (Csapo & Molnar, 2019). Although such digital and technological environments are abundant and have contributions to teaching and learning, many teachers encounter difficulties in integrating these environments into their teaching and in many cases, choose not to adopt them at all. There are varied reasons for this, mainly pedagogical views of teachers regarding learning and teaching processes that are not in line with the vision described, the complexity of choosing and adopting teaching and learning materials, and various systemic difficulties such as busy classrooms and limited time resources available to teachers (Dockterman, 2018; Inan & Lowther, 2010). These difficulties emphasize the need to deepen the knowledge about how digital environments can promote personalized teaching and learning.

The PeTeL environment (PeTeL - Personalized Teaching and Learning) was developed by the Department of Science Teaching at the Weizmann Institute of Science to promote personalized teaching and learning. The digital environment has been successfully implemented for 4 years among over 300 physics teachers who operate it among their 12,000 students. The environment has a unique architecture that uses sharing mechanisms to link between content repositories, which are shared among all physics teachers, and a Learning Management System (LMS) used by the teacher in the classroom (Bar-Yosef, 2019). The researcher and author of these lines led the effort to develop the PeTeL initiative in physics. The research described in this work has accompanied the development and the operation of the environment from its beginning and allows examining various aspects of content design as well as teacher development and use. The PeTeL environment served as the main operating and data mining arena in the study. The research, development and implementation program, on which this work focuses, began in 2016. The development and implementation was composed of three main phases:

a) In the first phase, a leading group of innovative teachers *(the development team)*, technological experts and researchers from the Department of Science Teaching at the Weizmann Institute was formed. The group worked on developing an initial repository of interactive activities that would be available to the teachers who would join PeTeL later.
b) In the second phase, which began the following year, the leading group led a professional learning community of early adopting teachers (*the operating group*). The environment was used in the classrooms while collecting data from teachers and students.
c) In the third phase, in 2018-19, the environment was opened to physics teachers from around the country. Teachers participated in workshop days which eventually gave them the opportunity to use the environment with their students. As of the beginning of 2019, the second year of operating the environment, about 180 physics teachers accompanied their teaching with PeTeL (*the user group*) among over 7000 students in ninth-twelfth grades.

Simultaneously with the development of the environment and the activation with teachers and students in physics, developments were made in the Biology and Chemistry with the aim of expanding to other scientific subjects (Bar-Yosef, 2020).

The research in this thesis examines the question of how to build and operate a dedicated digital environment to promote personalized teaching and learning by physics teachers? The answer to this complex question has been explored in several categories related to the functioning of teachers in digital environments in the context of teaching physics with the PeTeL environment in high schools.

In this research, we chose to organize the functional features of digital environments which were presented in leading studies in the last decade as 3 pedagogical dimensions that can be promoted while using digital environments in education: Data-Based Teaching, Personal Customization, and Interactivity of the Participants. Those dimensions will be called in this work the DPI dimensions and they will be used as a tool for examining the degree of personalization of teaching and learning through the environment.

Before starting the main study, several pilot studies were conducted. These studies highlighted the difficulties that teachers face using digital environments that aim to promote personalized teaching and learning. A central cause has been the need to function as producers of digital resources in using these environments. Despite the desire of teachers to shape their way of teaching, it has been found that many of these teachers lack the knowledge required to develop and customize digital content as well as lacking time for these actions. The findings of the pilot studies underscored the importance of digital mechanisms for sharing between teachers as a response to these difficulties and the desirability to empower the functioning of teachers in the environment as producers, consumers, and designers (Cviko et al., 2014).

The research topics in this work stemmed from a literature review and the findings of the pilot studies and dealt with several key aspects that help shed light on the ways to build and operate digital environments that promote personalized teaching and learning among physics teachers.

I. **Content development** - This topic has been researched in the context of converting activities into interactive digital versions by the teachers of the *development team* to include them in PeTeL's repositories. The purpose of this research is to investigate the characteristics of planning the conversion of content to PeTeL by the teachers and how one can scaffold the design process in order to advance unique opportunities enabled by digital environments.

II. **Sharing mechanisms between teachers** - This topic has dealt with the connection between PeTeL's architecture and the various roles of teachers in the environment. The research emphasis in this category is focused on exploring the role of sharing between the teachers using the environment on the promotion of personalized teaching and learning.

III. **Classroom practice** - This topic focuses on how physics teachers used the PeTeL environment in their classrooms and examines whether and how they promoted personalized teaching and learning through it.

The data collection in this research was conducted by a variety of research tools including recordings of teachers' meetings, documentation of teachers' meetings by a researcher diary, interviews with teachers, questionnaires and data from PeTeL that enables automatic data collection on the teachers' and students' work. In the study, the researcher wore 2 hats - one as a researcher and the other as a facilitator, thus functioning as a "participant observer". At all stages of the study the researcher was in close contact with the study population and served as a facilitator in both *the development team* and *the operating group*.

The research on **content development** focused on the design of digital activities in the PeTeL environment by a team of three innovative physics teachers. The study followed the design process from the initial stages to the completion of developing the initial repository of activities. The team's goals were to convert existing paper and pencil activities to digital activities in PeTeL and formulate design principles for this process. Discourse analysis of the development process used a methodology based on the DPI dimensions. This methodology made it possible to examine the techno-pedagogical considerations of the team and follow what the team planned to achieve through the digital activity. The findings showed that the teachers' considerations in converting the activities to digital included an attempt to add value to the activities by advancing them on the DPI dimensions. Since the DPI dimensions involve an ordinal structure in which higher levels refer to more advanced degrees of personalization, these findings suggest that the development team aimed to promote, through the digital version, personalized teaching and learning. Moreover, the results show a "jump" in the teachers' considerations, from initial digital designs constrained by the goals and features of the original activities to designs that go beyond *mere amplification* towards a completely *new approach* that could not be achieved in the paper and pencil version thus utilizing the unique opportunities availed in digital versions (Arcavi, 2019). The scaffolding strategy which led to this jump in designs involved structuring of the design process by requiring the team to explicitly discuss collaboratively content and skill goals referring to benefits and challenges of alternative ways to achieve these goals. These understandings of digital content development processes by teachers are of great importance in

light of the transition of many digital professional content developers, evidenced in recent years, from mainly developing digital content themselves to supporting and mentoring teachers in developing processes focusing on the pedagogical and not just technical aspects (Pepin et-al, 2017; Brown, 2007).

The second research topic focused on studying collaboration processes among teachers using PeTeL and characterizing the **sharing mechanisms between teachers in the environment**. The architecture of the PeTeL environment involves content repositories that are integrated into a LMS through a variety of sharing mechanisms. Those repositories include a *Shared Repository* of teaching items that are tagged and cataloged according to the curriculum. Another repository is the *Peer Environment* that allows teachers to share, view and copy content from courses developed by their peers. The sharing mechanisms consist of many elements taken from the world of social networks that encourage the creation of convenient and fast connectivity between teachers scattered throughout the country. Underlying the design of these mechanisms is the assumption that they may allow teachers who take different roles while using the environment (producers, consumers, and designers), to better tailor their teaching to their needs and the needs of their students. This hypothesis was tested with a focus on the use of the environment's sharing mechanisms by the 15 teachers in the *operating group* and the 180 teachers in the *user group*. Findings show that one or more of the three roles indeed characterized the method of operation of the groups of teachers. Mutual fertilization was evident between the teachers' role as consumers and as producers. The architecture of the environment encouraged teachers to share created content and at the same time gave them tools to choose and use the shared content. In using the content repositories for designing their teaching sequences, they combined interactive items from the content repositories with items they created on their own. Despite this similar pattern of action and the same curriculum, teachers were found to design their teaching sequences in very diverse ways. Conclusions that emerge from these findings suggest that the combination of content repositories, sharing mechanisms, and a LMS allowed teachers with different characteristics to act in different ways in PeTeL and shape their teaching sequences in diverse ways that are tailored to their teaching needs.

The third research topic focused on the **operation of the digital environment in classrooms** by the *operating group* teachers. While the previous two research topics relate to the environment's content and architecture, this topic focused on the ways physics teachers used PeTeL in their classrooms and examined if and how personalized teaching and learning were in fact promoted through the environment. The main research tools were teacher reports on the integration of the environment in their teaching, their views on this matter and the digital traces left by teachers in the environment during classroom activity. These traces were cross-referenced with the teachers' reports and opinions. This data was characterized through the DPI dimensions, thus referring to the personalization of the teaching and learning. The findings show that teachers' views on operating PeTeL were that the environment promotes teaching and personalized learning better than general technology integration. At the methodological level, the DPI dimensions made it possible to analyze the actions of teachers in the digital environment and compare different uses

of teachers in it. Many teachers used the environment while interactively engaging their students and based their teaching on data accumulated from their students' activities. However, no digital traces were found that the teachers adapted the teaching sequences to specific students or groups of students. This finding is inconsistent with the reports of teachers who reported that operating the environment has helped them tailor their teaching to specific students. A possible explanation for this gap is that the environment provided teachers with the information they needed to tailor their teaching to individual students, but didn't give the tools to do so in the environment.

A main contribution of the research, rising from integrating insights from the research on the three topics, is the characterization of the connection between the architecture of digital environments and the roles of teachers in them, in a way that promotes personalized teaching and learning. Despite the variety of digital environments and the diverse use of technological means, teachers' roles in these environments are often monotonous. In many cases attempts to assimilate the environments lead to opposition on the part of teachers to the point of choosing not to adopt them at all (Dockterman, 2018; Larkin and Milford, 2017). Around the world, many professional development programs of teachers are moving to frameworks that encourage collaboration between teachers (such as professional learning communities) (Jaworski et al., 2017) and the contribution of teacher sharing mechanisms to the roles taken by teachers in general, has been well researched in the literature (Wenger-Trayner E. & Wenger-Trayner B., 2013). Yet, knowledge of ways to integrate these mechanisms in digital environments is still partial and there are many voices calling for increased collaboration between teachers in digital environments (Okada 2012; Pirkkalainen 2014; Schlager et al., 2009; Van Acker, 2014). The findings of this study show that the combination of content repositories, sharing mechanisms, and a LMS in PeTeL, encouraged teachers with different characteristics to function in a variety of roles in the environment and thus enabled them to personalize their teaching to their needs. Beyond that, the teachers' voice can be heard through the broad expressions of teachers' roles in the environment: personal teaching sequences, content creation and sharing, consumption based on the usage habits of other teachers and many more examples are evident. As professional development frameworks have changed from top-down approaches to ones that give great expression to the practical and unique knowledge of teachers this research points that this trend should also be implemented in the design and development of digital environments.

The methodological contribution of this study is expressed in the use of the DPI dimensions as a research tool for analyzing the degree of teaching and learning personalization carried out with the digital environment. The DPI dimensions have made it possible to analyze two aspects related to the first and third research questions- teachers' development of activities and the actual operation of the environment by teachers. The methodology made it possible to answer the first research question by using the DPI dimensions to interpret the considerations raised by teachers in planning to convert activities to digital. The teachers' consideration were marked as points on the dimensional system thus enabling to track the added value teachers planned to pour into digital activities during the planning group. The DPI dimensions have also been used as a tool that allows examining the teachers' activation of the environment by analyzing their digital

traces and cross-referencing them with their activation reports. The premise underlying these analyzes is that operating the environment through actions and opinions that advance the DPI dimensions, can attest to the course of action of a teacher who personally tailors his teaching to his students. This methodology can be used by researchers, developers, and teachers when they would want to examine how digital environments can promote personalized teaching and learning.

In examining the practical implications for the field of education, it is of great importance that the findings arise from a broad group of teachers. PeTeL has expanded in recent years and is operated by a more than a third of physics teachers in Israel who accompany the teaching of physics in the environment as a daily tool for personalizing their teaching. The expansion raised the natural difficulty in maintaining the quality of operation while addressing a wide range of needs of teachers and learners (Dokterman, 2019). In light of these findings, it can be pointed out that the operation of PeTeL has promoted the teaching and learning of physics in high schools in Israel towards personalized teaching and learning.