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SAMR Framework for Study Technology Integration in Science Education

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Abstract

The main changes in science education initiated by Information and Communication Technologies (ICT) are associated with advances in a number of educational technologies: Microcomputer Based Lab; Modeling and Simulation; Mobile Technology; Networked Learning; Mixed-Reality Technology. The advances define the changes in science education and, consequently, gained broad attention of educational researchers.

Despite the abundance of opinions, approaches, and interpretations of the changes in science education, two key alternative interpretations explain the ICT integration phenomenon. The first interpretation considers ICT as a tool for enhancing classical science education by providing different emerging technological means. In contrast, an alternative interpretation considers ICT much wider than a tool. Supporters of this interpretation perceive thus digital science class as a new phenomenon in education, since the mentioned technologies changed the class qualitatively, brought to it a new essence, which is not just a sum of the added technologies. In our research, we have chosen the second interpretation as our assumption.

We hypothesize that the changes of teachers' worldview are vital for their understanding the role of technology in science education in its transformative stage.

To check this hypothesis we propose a new conceptual framework for study and analysis the ICT integration phenomenon in science education. The proposed framework is a modification of SAMR (Substitution, Augmentation, Modification, and Redefinition) model for perception of technology. Our modified SAMR framework can be used for assessing the teachers' worldview regarding ICT integration in science education. Specifically, the teachers' awareness about such kind of assessment opens a way for their reflexing and improving their own teaching, which in turn affects their learners. An initial study of the proposed framework was conducted with a group of eighteen teachers in the School of Education at Tel Aviv University, who had undergone a specific training course. The initial study has confirmed our hypothesis and indicated the high efficiency of the proposed framework.

1. Introduction

Our society has transitioned into the Digital Age. This transition is considered a revolution in the history of mankind [3]. The digital revolution is based on unprecedented advances of Information and Communication Technologies (ICT) broadly connects humanity, whereby people perceive themselves as informational organisms that live and interact as connected agents in a world of information. This new role of individuals and such a new perception is significant for human society in general, and for education in particular.

In comparison with the great success of ICT in all spheres of the life, integration of ICT in education (also called informatisation of education) seems to remain modest and even incremental. While the majority of governmental systems have changed drastically during the last years, the education system has not changed significantly [6, 9, 15]. One can conclude that technology has had a little impact on instruction.

We argue that integration of ICT into education cannot be limited just to technological issues. Contemporary educators, being both witnesses of and active participants in the digital revolution, must be aware that the main significance of the digital revolution is not just the great technological advances but much more fundamental changes in the life of people. While many researchers tend to believe that the main bottleneck of ICT integration into education stems from teachers' lack of technological literacy [17], we assume that success of the informatisation cannot be achieved by technological enhancement alone. Rather, it also requires significant changes in teachers' worldview.

We propose a new conceptual framework for study and analysis the ICT integration phenomenon in science education. The proposed framework is a modification of SAMR (Substitution, Augmentation, Modification, and Redefinition) model for perception of technology. Our modified SAMR framework can be used for both assessing ICT integration in science education and assessing teachers' worldview. We assume that the proposed modified SAMR being used in teachers' training, will affect the teachers' professional growth. Specifically, the teachers' awareness about such kind of assessment opens a way for their reflexing and improving their own teaching, which in turn affects their learners.

2. Scientific Background

2.1. ICT in Science Education

The main changes in science education initiated by integration of ICT are associated with advances in the following main directions:

- Microcomputer Based Lab (MBL) is equipped with emerging probes and sensors provides a hands-on science learning by performing various lab experiments in the majority of science curriculum topics [13].
- Modeling and Simulation make it possible to learn about the many science concepts that are too small or too large or that happen on timescales too long or too short to examine directly in the classroom. Computational models and simulations allow students to see and manipulate the unobservable [16].
- Mobile Computing based on mobile devices have enough computing power to run complex simulations and have incorporated ever more probes and sensors as integrated parts of science learning activities. This paves the way to ubiquitous learning of science [18].
- Network Collaboration becomes an essential component of the process of learning, as students work in groups to arrive to new understandings, applying collaboration – an essential skill for today's interdisciplinary workplace [1].
- Mixed-Reality technology is identifying how learning changes when probeware and simulations are wired to each other for a multisensory experience. The transition from initial technology development to a new stage of mixed and high-level integration offer unprecedented opportunities for educational innovation [10].

The above directions define the changes in science education and, consequently, gained broad attention of educational researchers. Despite the abundance of opinions, approaches, and interpretations of the changes in science education, two key alternative interpretations explain the ICT integration phenomenon. The first interpretation considers ICT as a tool for enhancing classical science education by providing different emerging technological means. In contrast, an alternative interpretation considers ICT much wider than a tool. Supporters of this interpretation perceive thus digital science class as a new phenomenon in education, since the mentioned technologies changed the class qualitatively, brought to it a new essence, which is not just a sum of the added technologies. In our research, we have chosen the second interpretation as our assumption and propose the ontological model of ICT integration in science education.

2.2. Matrix model of the ontology of ICT integration in science education

Our model maps components of human's worldview in a context of constituent parts of education. We address four components of the worldview: self-conception, mutual interactors, conception of reality, and interactions with reality. We consider four components of the worldview as corresponding to transformations of the Digital society [4]. In our model, we represent the components of the worldview in the context of constituent parts education [12]. Thus the model has a matrix form. Rows of the matrix correspond to the four significant transformations of Digital Society: 1) the blurred distinction between reality and virtuality; 2) the blurred the distinctions between human, machine, and nature; 3) the reversal from information scarcity to information abundance; and 4) the shift from the primacy of entities to the primacy of interactions. Columns of the matrix correspond to the constituent parts of education [12]: Learner (learning and the role of student), Teacher (teaching and the role of teacher), Milieu (learning environment) and Curriculum. Table 1 summarizes our matrix model.

Table 1. Matrix model of the ontology of ICT integration in science education

Worldview	Transformations	Teacher	Learner	Environment	Curriculum
Self-conception	Reality/virtuality	Perceptions about informational organisms	Perceptions about informational organisms	Mixed-reality technology	Integration the digital inquiry methods
		Self-recognition as informational organism	Self-recognition as informational organism		
Mutual interactions	People/nature/artifacts	Perception of digital artifacts as socially behaving entities	Perception of digital artifacts as socially behaving entities	Cyber-physical systems, emerging probes and sensors technologies	Integration artifacts as objects of inquiry
		Utilizing ICT in scientific inquiry teaching	Utilizing ICT in scientific inquiry learning		
		Perception artifacts as objects of inquiry	Perception artifacts as objects of inquiry		
Conception of reality	Information abundance	Perception of Data Intensive Science as the new science paradigm	Perception of Data Intensive Science as the new science paradigm	Informational redundancy	Personalization of curriculum
		Teacher as a leader and not a driver in the class	Student as a co-learner with the teacher in the class		
		Teaching in digital space	Learning in digital space		
Interactions with reality	Primacy of interactions	Teachers' self-recognition as partners in the educational communications	Intensive interaction between learners	Collaborative learning environment	Attention to relations and to interactions in curriculum
		Teachers' awareness about the domination of networked learning	Collaborative inquiry based learning		

The table reflects interrelation between the four worldview's components and the transformations of Digital Society. Each cell of the matrix corresponds to a certain transformation and a certain constituent part of education. We believe that each such cell comprises a specific emerging educational phenomenon of science education in Digital Age. We formulate a number of hypotheses for the phenomena marked in the cells. The hypotheses are formulated according to a number of sources: [1, 7, 8, 13, 14]. For example, the matrix cell being intersection of the row of virtuality-reality blurring and the column of educational environment, presents the phenomenon of mixed-reality technology.

In our research, we utilize the ontological matrix model in order to map teachers' worldview regarding the ICT integration in science education. In turn, we use the SAMR framework to assess of the teachers' worldview.

2.3. SAMR Framework for Assessing ICT Integration in Science Education

A remarkable approach for studying changes of education initiated by ICT was offered by Puentedura [11]. The approach is based on a model of educational technology integration. It comprises four levels of perception of technology: Substitution, Augmentation, Modification, and Redefinition (SAMR). SAMR represents the evolution of the new technology in education: beginning with replicating a current practice (substitution), utilizing technology to provide an improvement (augmentation), application technology for significant task redesign (modification), through to appearance new technological phenomena that were previously impossible with pre-existing technologies (redefinition) [2]. The majority of studies compare educational activities mediated by old and new technologies, leading to the no significant improvements. The lack of new outcomes can be explained by the fact

that these comparative studies do not represent redesign of educational processes or activities, but focus upon substitution of known practice. A different results are presented by Hockly [5], where the author applies the SAMR model to distinguish between mobile learning activities designed to focus upon consumption of content (substitution) and those that create new learning experiences (transformation).

We consider the Redefinition as the supreme, creative form of the understanding of technology in education. Thus, the goal of teachers' training is to enable teachers to reach the Redefinition stage. Such an ability to understand the essence of the new phenomenon must be considered as an advanced and significant ability among educators. We believe that in the close future this ability will be formulated as one of the main goals of education. The principal question that arises is whether and how can we provide teachers with the ability to understand and to promote the transformative (modification and redefinition) stage of technologies. We hypothesize that the changes of teachers' worldview are vital for their understanding the role of technology in science education in its transformative stage.

3. Preliminary study

The preliminary study was conducted with a group of eighteen in-service teachers who had undergone a specially developed training course in the School of Education at Tel Aviv University. The study was based of our ontological matrix model. The goal of the preliminary inquiry was to examine the science teachers' worldview regarding the ICT integration in their professional life. The research questions were: 1) whether science teachers perceive digital technologies just as a tool, or as a more general cultural phenomenon; and 2) whether and how the specially developed training course affects the teachers' worldview. We used semi-structured interviews that were conducted before and after the course. The questions of the interviews were formulated according to the matrix model. The data were analyzed by using the SAMR framework.

We found that the completion of the course resulted in significant changes in the teachers' worldview. We further found that following the course the traditional teachers' perception of technology as just a tool for enhancing the teaching was changed. Over the half of the group of participants were able to percept technology as not just a tool (SAMR level of substitution). Some of them even achieved the SAMR level of redefinition in their perception of technology.

4. Conclusions

We have presented a new conceptual framework for (1) studying and analyzing the ICT integration phenomenon in science education; (2) examining and assessing worldview of teachers about the essence of technology and its role in education. The framework is based on the SAMR approach.

We used the proposed model as a research tool in our study, which assessing changing teachers' worldview as a result of passing a specially developed teacher training course. The worldview of the teachers who participated in the course were mapped according to a newly proposed matrix model that represent the ontology of ICT integration in education.

Results of the preliminary study are promising from the following points of view.

1. Conducting a specially developed training course allowed to change the teachers' worldview toward the deeper understanding of the role of ICT in science education.
2. The proposed SAMR framework approved its effectiveness as a research tool for assessing teachers' worldview.
3. A pretty good part of the teachers were able to achieve the so-called redefinition level of perception, which is the highest level of understanding technology.

The study shows that the SAMR framework has not only the simple instrumental significance. We also realized that teachers' awareness about the SAMR-based assessment is important for their professional growth. Summarizing, we believe that the proposed approach has a high potential in teachers' training.

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