TECHNOLOGY INTEGRATION EVALUATION AND CRITICAL SELF-REFLECTION USING THE PICRAT MODEL IN THE MATH AND IT CLASSROOMS

Ivan Shotlekov

Abstract. *Teaching technology integration models are invaluable tools for providing insights into effective and efficient pedagogical practices to both pre-service and in-service teachers pursuing training or professional development. Educators employ a set of criteria to evaluate these models and then use the product of their informed choice to gauge the effectiveness of integrating various technologies for the particular learning goals towards improved pedagogical performance. The aim of this study was to explore the potential of one of these models, PICRAT, for application in the Math and IT classrooms, grades 6–8. Specific software technologies were analyzed and mapped against the PICRAT matrix at activity level with specific apps and platforms implementing those technologies to explore some practical uses of this tool for encouraging teaching professionals' evaluation-based reflection on their current practices inspiring their endeavors for pedagogical improvement and innovations. It was found to be particularly useful for project-based learning, problem-based learning, collaborative learning, and active learning scenarios.*

Key words: technology integration, reflection, evaluation, interactive learning, creative learning, collaborative learning, PICRAT model.

1. Introduction

In the times of Industry 4.0, amidst a cornucopia of new technologies enabling a digitized world, with major catalytic phenomena such as the coronavirus pandemic, Math and IT teachers have a more pressing need for a compass to help them adopt and adapt new tools in an effective and efficient way with regard to achieving the learning goals. Although effective integration of technologies in the classroom may seem intuitive to some, this is more often than not a tough decision [1]. At the same time, such approaches are "technocentric, often omitting sufficient consideration of the dynamic and complex relationships among content, technology, pedagogy, and context." [2] An appropriate model can be a very useful enabler of technology integration in education provision in an effort for pedagogical reforms" [3].

Although a variety of theoretical models are applied to help teacher trainers, teachers and researchers with effective and efficient designing, analyzing, and implementing technology integration, the most widely spread as suggested in the literature are (in alphabetical order): LoTi (Levels of Technology Integration) [4], PICRAT (Passive, Interactive, Creative / Replaces, Amplifies, Transforms) [5], RAT (Replacement – Amplification – Transformation) [6], SAMR (Substitution – Augmentation – Modification – Redefinition) [7], TAM (Technology Acceptance Model) [8], TIM (Technology Integration Matrix) [9], TIP (Technology Integration Planning [10], TPACK (Technology, Pedagogy, and Content Knowledge) [11]. Each of these has its strengths and room for improvement. Educators and researchers alike can resort to a set of criteria to evaluate the merits of such models or rather their relevance to their own needs and in their particular contexts, through a formal or informal metanalysis. Six criteria, have been proposed by Kimmons and Hall [12] and are a meaningful evaluation tool for both inexperienced and seasoned adoptees: compatibility, scope, fruitfulness, role of technology, student outcomes, and, clarity.

Teachers' pedagogical, psychological and methodological professional training and further development involves reflexive competences [13] of both the reflection in action and reflection on action type [14]. "By far the most significant learning experience in adulthood involve critical self-reflection – reassessing the way we have posed problems and reassessing our own orientation to perceiving, knowing, believing, feeling and acting." [15].

Practitioners note that these days "students' … expectations are gaining knowledge and skills to happen in a dynamic, intriguing and interesting way." [16]. A very exciting, albeit, quite challenging to implement, scenario is "interdisciplinary lessons via videoconferencing involving two, three or more teachers at the same time." [17].

An indispensable aspect of technology integration is security. It is beyond the scope of this paper, but it is addressed in the literature. "The challenges of identifying new threats to the security of e-learning systems, as well as their elimination, will continue to be one of the key components in the daily implementation of e-learning." [18].

This paper presents a full set of scenarios we developed for each of the cells in the PICRAT matrix to illustrate possible avenues for critical self-reflection and evaluation of teaching technology integration by other Math and IT teachers. In a real-life situation, a practitioner will most probably not use all of them in one session, but nevertheless, this level of detail is expected to provide a more comprehensive demonstration of a practical implementation. We believe the suggested tetrads of Learning Activity – Integrated Technology – Sample Tool – Use Case will facilitate pre-service and in-service teachers who wish to explore new pedagogical horizons and tap into some of the good practices such as the six clusters of innovative pedagogies: Blended Learning, Computational Thinking, Experiential Learning, Embodied Learning, Multiliteracies and Discussion Based Teaching, and Gamification [19].

2. Methodology

The current investigation involved the use of the six criteria by Kimmons and Hall [12]: compatibility, scope, fruitfulness, role of technology, student outcomes, and, clarity, in order to select a theoretical model for evaluation and full understanding of teaching technology integration in classrooms teaching Mathematics and Information Technology. Based on these six criteria, we determined PICRAT, an activity-based model at unit level, to be the most suitable for our needs. We mapped sample activities referring to the taxonomies in [20] and [21] and the sample technologies to be integrated for each of them along with a sample tool and a possible use case against all the nine cells of the matrix. A total of 9 tetrads were analyzed altogether. The suggested scenarios were of the type teachers employ in their lesson plans, while the apps and platforms identified were those we considered teachers would find accessible and effective.

Two core questions are addressed by the model, viz.: "What are students' roles in the integrated technology learning experience?" (Passive, Interactive or Creative) and "What is the impact of the technology on the teacher's pedagogical practice?" (Replaces, Amplifies, Transforms) [5]. The concept underlying PICRAT promotes reflection by the teachers using it and ultimately leads them, where appropriate, to a paradigm shift from passive reception to interactive involvement and creativity, e.g. through project-based learning, problem-based learning, collaborative learning, etc. at the top levels of Bloom's revised taxonomy of learning [22].

"In creative learning activities, students may directly drive the learning as they produce artifacts (giving form to their own conceptual constructs) and iteratively solve problems by applying the technology to refine their content understanding." [5]. The process of promoting "digital creativity in students should begin as early as in primary school and be upgraded and developed in each subsequent stage of learning." [23]. Self-reflection on technology integration need not be limited to the teachers, but can also involve students where appropriate to increase their involvement and awareness of the learning process. Teachers should "undertake the formation of reflective skills, thanks to which students learn to self-assess, self-educate and develop their personality" [24].

To determine the RAT profile of an instance of technology integration in Math and IT classrooms, we followed the flowchart in Figure 4 in [5]. The first vault line / indicator was the achieved learning outcomes of the activity: if inferior to a scenario without using the technology, it was Replacement; if student learning was better, the second indicator was whether that effect could have been plausible without the technology or by resorting to lower tech (Amplification for positive and Transformation if negative). Self-reflective practitioners' aspirations to move from bottom left to top right should not be an end in itself, though, as effective teaching is about aligning teaching and learning activities with the learning goals for a particular unit. PICRAT was found to have the potential to encourage teachers to look for pedagogical changes and innovative practices.

The model has its room for improvement, e.g. creative and transformative allow differences in interpretation. Also, the flowchart used to identify a classroom use of technology as Replacement, Amplification, or Transformation uses "learning outcomes" which rules out assessment activities. We would suggest to add "or teacher's empowerment". For instance, students' performance would be similar regardless if the final test is administered using Google Forms, or using a more sophisticated platform, offering teachers deeper understanding of the test results.

By traditional practice we understand the model adopter's context similar to the prevailing state of play in Bulgarian secondary schools. For instance, PPT is traditionally used for presenting subject content, although in some parts of the world it may be whiteboard and pen or even chalkboard. In other schools, on the other hand, pathfinding teachers go for Intelligent Learning Environments and tools because they have found that the use of multi-agent learning platforms provides adaptability, interactivity and personalization of the learning process." [25].

At transformative level, team work on projects can successfully take place in distance learning settings because of the unique experience offered by "simulations such as TinkerCAD, Wokwi, Fritzing, Diagrams, Arduino.cc, Webminal for Linux, VMWare virtual machines", for training application programmers [26].

3. Results and discussion

In a condensed form, for each of the nine cells in the PICRAT matrix by RAT tiers, we present the tetrads systematizing Learning activity (Activity), Integrated technology (Tech), Sample tool (Tool) and Use case (Use). Because of space limitations, we had to discard the rationale and details for the suggested tetrads below.

It is worth noting that there are numerous apps and platforms, e.g. Whiteboard.chat, whose abundant features make them eligible for a number of cells across the PICRAT matrix depending on what particular settings and tools a teacher will select to use for certain pedagogical purposes.

We intended to suggest tools that are not too trivial, but at the same time are accessible, being aware of "the disruptive use of technologies as an opportunity to enhance learning and teaching" [27] and that "the AR revolution will happen – and it will be amazing – but not until later in the 2020s". [28]. To maximize the pedagogic effect using some comprehensive environments, e.g. DisPeL (Distributed Platform for e-Learning), adoptees need the right methodology, e.g. for "the appropriate provision and subsequent verification of practical knowledge and skills acquired by students using the tools of the distributed platform DisPeL ... – an integrated software system for automation of management and learning" [29].

Future developments may involve designing a platform to pool resources by contributing teachers by a large body of teaching professionals, such as TIM's tools [9].

1.1 Passive * Replacement	
Activity	Reading materials
Tech	Online textbooks
Tool	Digital version of the printed textbooks
Use	Similar to using the paper versions
1.2 Interactive * Replacement	
Activity	Memory activities
Tech	Online crossword generators
Tool	Crossword Labs
Use	Knowledge reinforcement
1.3 Creative * Replacement	
Activity	Create presentations
Tech	Online formula editor
Tool	Mathcha editor
Use	Student-generated materials
2.1 Passive * Amplification	
Activity	Watching presentations and videos
Tech	Online video editors
Tool	Kawping
Use	Introduce new subject content or reinforce knowledge
2.2 Interactive * Amplification	
Activity	Problem solving tasks
Tech	Interactive presentation software
Tool	Mentimeter
Use	Guided practice: review and prepare for an exam
2.3 Creative * Amplification	
Activity	Creating presentations
Tech	Online presentation software
Tool	Canva
Use	Transfer of knowledge to new contexts
3.1 Passive * Transformation	
Activity	Discussions
Tech	Webinar platforms
Tool	Demio
Use	Webinar with an expert or a panel of experts on a particular topic or career awareness
3.2 Interactive * Transformation	
Activity	Demonstrations
Tech	Interactive simulations
Tool	PhET
Use	Explore real-life use of acquired knowledge
3.3 Creative * Transformation	
Activity	Design project
Tech	Image search engines
Tool	Google Lens
Use	Photo puzzle project, e.g. geometric architecture

Table 1. Tetrads based on the PICRAT matrix

4. Conclusion

Applying the PICRAT model, we developed Learning Activity – Integrated Technology – Sample Tool – Use Case tetrads which are not meant to be prescriptive but to instigate critical reflection. This model can be employed in both face-to-face and online modes, for both on-site and distance learning environments. We hope our effort will encourage other professionals to avoid technocentric approaches, reflect on technology integration, and enhance their current teaching practices by giving certain technologies a try as we have provided specific sample tools to facilitate the process.

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Ivan Shotlekov[1,*]
[1] Paisii Hilendarski University of Plovdiv,
Faculty of Mathematics and Informatics,
236 Bulgaria Blvd., 4003 Plovdiv, Bulgaria
[*] Corresponding author: shotlekov@uni-plovdiv.bg