Artificial Intelligence in Education: Developing Competencies and Supporting Teachers in Implementing AI in School Learning Environments

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Abstract — **Implementing digital technology, and especially artificial intelligence, in schools is becoming an increasingly significant challenge for society. Digital services supported by artificial intelligence are becoming more prevalent in all aspects of social life, including schools. The project "Innovative Learning Environments Supported by Digital Technologies" aims to introduce artificial intelligence as a support for transforming teaching in a way that prepares learning opportunities for students, where they can acquire knowledge and develop digital competencies. Teachers need knowledge and tools to assess whether AI-supported activities are appropriate for achieving their goals and enabling the transformation of teaching.**

Within the project, we have tested three models to assist teachers in implementing digital technology and AI. Based on the analysis of submitted good practice cases, we found that the most suitable scale for teachers in the project "Innovative Learning Environments Supported by ICT" is the RAT scale.

Artificial intelligence; education; Innovative learning environment,

As one of the most important and crucial components of individual and societal development, the modern approach to education and training in the role of the employment and economic environment and the growing importance of knowledge reinforces the demand for forms, methods, and approaches to education supported by appropriate digital technology, both domestically and internationally [1]. Such approaches are no longer conceivable without the support of artificial intelligence (AI). Most experts now agree that a transformation in education is inevitable if schools are to meet the challenges of the 21st century [2]. The skills that formed the basis of progress in the 19th and 20th centuries are no longer enough, and it seems that competencies that enable lifelong learning and adaptation to rapidly changing circumstances should be the answer to the competitive struggle of individuals, and thus society, in a global world. Ken Robinson says: "We are the largest human population ever to inhabit the earth, and our numbers are rising fast. Digital technologies are transforming the way we work, play, think, feel, and relate to each other. And this revolution has only just begun. The old education systems were not designed with this world in mind. And if we improve them by raising conventional standards, we will not be able to meet the challenges that lie ahead" [3].

The field of AI is also increasingly present in education, although we are often unaware of it. AI is now present in all areas of modern society (business, medicine, agriculture, engineering, law, etc.), and education is no exception. Many experts and policymakers believe that the future of AI is bright and that upcoming technologies will improve access to education for all. Such approaches, supported by digital technology and modern working methods, could also ease the pressure on teacher shortages [4]. AI would allow teachers to spend more time on their noble tasks, while some of the routine tasks of a teacher are taken over by machines or devices. AI can be very helpful when used in an appropriate learning environment for selected tasks (at the teacher's discretion). Nowadays, more and more electronic services and applications are available to teachers to help them solve tasks or problems that they may not have had to deal with before. However, teachers must be trained and know how to integrate this technology into the classroom in a meaningful way. So when using AI in the classroom, the teacher must always know exactly what is happening and monitor the AI's performance. The most effective use of AI is when it empowers the teacher. If the teacher knows what the student is learning, good results will not fail to materialize.

There is another, more skeptical view of the introduction of AI in education that sees algorithms and AI as a major threat. In their view, the billions of dollars that relevant industries are willing to invest in the development of AI technologies are proof that education has now become a purely commercial activity. The warnings about the changing behavior of children, social norms, social and psycho-physical characteristics of children, and technology addiction caused by algorithms in social networks and beyond are certainly true.

In any case, the development, testing, and implementation of modern didactic concepts and models have been a constant

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feature of the school environment in Europe and Slovenia for quite some time. This is mainly related to the changing generations of children (millennials, zoomers, and already the alpha generation) and the adaptation to the demands of the digital age in which we live and for which we educate pupils, students, and undergraduates.

As a result, integrating AI and the digitization of education into teaching and learning is likely no longer an issue. These insights come from education experts, but the question is whether we teachers have the pedagogical knowledge to do so. One could argue that there will be two types of teachers - those who can meaningfully integrate digital technologies and AI into their teaching, and those who cannot.

Even the latest OECD study says: »advancing AI capabilities with respect to literacy and numeracy may have important implications for employment and education. Most workers use these skills every day at work. At the same time, these skills have not improved in most countries in the last decades. By contrast, AI capabilities in literacy and numeracy are developing quickly« [5].

A. Innovative learning environments

The Innovative Learning Environment report defines the learning environment as an organic, holistic concept that encompasses both activities and learning outcomes and extends beyond the school in both time and space; it is the context in which learning takes place [6]. Microsoft's concept of transforming education or innovative learning is consistent with the OECD guidelines, the document EC "Innovating learning policy: key elements for developing Creative Classrooms in Europe", and the "21st Steps Transformation concept of the Ministry of Education Queensland" (Queensland Government, 2008).
Microsoft defines ICT-enabled innovative learning environments as high-quality learning opportunities that put learners at the center of the learning process and provide them with activities to build their knowledge and develop their skills [7].

In the Innovative Learning Environments Supported by Digital Technology project (2019-2023), innovative learning environments are understood as high-quality learning opportunities that put the learner at the center of the learning process and enable them to engage in activities that build their knowledge and develop their competencies.

The starting points for introducing flexible learning and innovative learning environments (supported by AI) that promote the development of competencies follow a multidimensional approach [8] and are summarised in eight areas that represent a comprehensive roadmap for change in the education system: Learning, Teaching, Assessment, Content and Curriculum, Organisation, Leadership and Values, Coherence, and Infrastructure, with at least the first three areas closely linked to teacher education and readiness to engage and empower teachers to implement change.

The quality of a teacher's work in the classroom is determined both by the knowledge and experience prospective teachers acquire during their studies and by ongoing professional development. At the same time, international research shows that the methods teachers use in the classroom depend more on the environment and teaching culture in which they grew up than on their training. Few teachers outgrow the teaching style they themselves were taught with [9].

Most teachers today are not yet part of the Millennial generation, so teaching with digital technology and artificial intelligence does not come naturally to them. This makes it all the more important that they reflectively explore their own practise, that they know their strengths and weaknesses in the areas of content, pedagogy, and technology use. The TPACK model (Teacher's Technological, Pedagogical, and Content Knowledge of the Teacher) is the foundation for teaching with technology and requires an understanding of the concept of technology use, the use of pedagogical techniques that incorporate technology for constructivist teaching methods, knowledge of how the teacher can help students, Overcome difficulties with technology and how to make learning more or less difficult, knowledge of students' prior knowledge and theories of epistemology, knowledge of how the teacher can use technology to build on students' existing knowledge, develop new epistemologies, or enhance existing ones [10].

Thus, the competencies a teacher needs to create innovative learning environments are many and varied:
- Knowledge of the 21st century skills domain in which teachers themselves must be well versed.
- Mastery of the curriculum of each subject to the extent that they are able to select content where they can prioritise the development of a particular competency.
- The ability to plan and collaborate with other faculty in the department to achieve synergy and avoid overlap or oversaturation with certain elements.
- Pedagogical and instructional skills that enable the teacher to organise student-centred instruction with constant assessment and feedback.
- Mastery of assistive devices and the ability to find and evaluate applications suitable for carrying out specific activities and achieving the general or specific objectives of the course.

The European Reference Framework for Teachers [11] proposes six areas of digital competences that teachers must master: professional engagement, digital resources, digital pedagogy, digital assessment, learner empowerment, and fostering the development of learners' digital competences.

B. *Using digital technology and artificial intelligence in teaching and learning*

Richard E. Mayer described technology-enhanced learning as "learning situations in which the learning experience is created through physical devices such as computers and the Internet" [12]. At the same time, he pointed out a fundamental difference between the two approaches to technology-enhanced learning:
- Technology-centered learning is understood as an activity that aims to use technology in instruction, and it is technology that provides access to instruction;
- a learner-centered approach to learning with technology is an approach that helps people learn and therefore aims to adapt technology to enhance learning.

Hattie also categorized some of the impacts associated with technology use in his list of 150 influences on student achievement, which he compiled based on a review of more than 800 meta-analyzes. While the use of technology may be hidden in some places (e.g., visual/audio methods at 110), it is explicitly mentioned in the following impacts: interactive video methods at 46 (with an above-average impact factor of 0.52), computer-assisted instruction at 77 (with a below-average impact factor of 0.37), programmed instruction at 105 (with an impact factor of 0.23), and online learning at 124 (with an impact factor of 0.18) [13].
Access to technology alone does not necessarily make learning more effective, although there is evidence that the use of technology in students' daily lives increases their motivation and engagement in the classroom [14, 15]. A recent survey of Slovenian secondary school students found that 50% of the students surveyed use ICT at school a few times a week and 21% use it every day. Less encouraging is the fact that 42% of this use is limited to only one or two school subjects, suggesting a very uneven integration of ICT use in the classroom.

C. *Research problem: When and how to use digital technology and artificial intelligence in the classroom?*

The impact of digital technology and artificial intelligence on the effectiveness of learning depends mainly on how they are used. There are several models that teachers can use to test the usefulness and effectiveness of technology use. One of the simplest models that can guide teachers in this process is the decision tree (Figure 1), which helps teachers think about how to implement technology in the classroom [16].

The decision tree alone does not tell us much about how technology is used in the classroom. For more than a decade, teachers have been encouraged by various models to create high-quality learning opportunities through the use of technology.

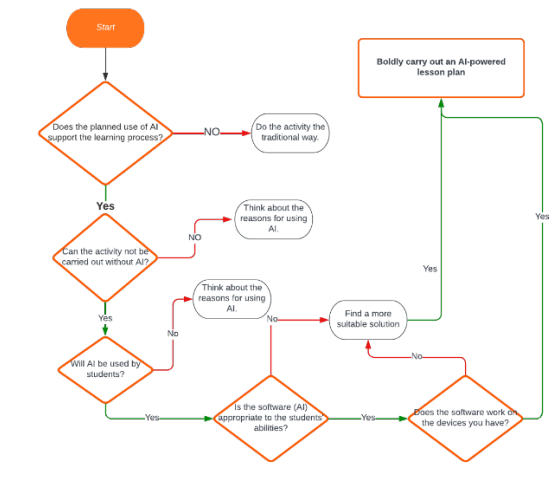

Figure 1. Decision model of using technology in the classroom.

Many other models have evolved from the three-point scale RAT (Replacement - Reinforcement - Amplification - Transformation), which considered the impact of technology not only on student activities but also on the teacher's role and learning objectives [17]. Probably the most widely used online model is the four-step SAMR model (Substitution/Replacement, Augmentation/Enrichment, Modification/Modification, Redefinition/Redefinition) [18]. Teachers also use the ITL rubrics developed by Microsoft program »Microsoft-Partners in Learning«, in which the levels of AI use are arranged slightly differently: technology facilitates the learning of basic skills, reproduction - technology supports the construction of knowledge - ICT facilitates the construction of knowledge - Learners are the designers of the ICT solution.

Thus, the introduction of digital technology and artificial intelligence into the classroom is not an end in itself but serves to achieve the goals of both the individual learning unit and the subject itself. Categorization helps to identify the consistency or lack of consistency in how the goals of a unit are articulated, how it is taught, and how knowledge is assessed [19].

The research question is, which model is the most suitable for integrating digital technology and AI in the school, does the model depend on the subject area and the age level of the children?

D. Methodology

In the first year of the project, 20 schools were involved in the Innovative Learning Environments Supported by Digital Technology project, and their teachers participated in regular monthly training sessions within their schools and also within the project. The first phase of training was an introduction to AI, basic concepts, and a historical overview of the impact of technology and AI on education. This was followed by basic training on the use of the Orange tool, explaining the basic concepts of machine learning and demonstrating its applicability to specific subject areas. In the third step, we conducted training on the use of AI in specific subject areas. In doing so, we, the trainers, found that many people attribute the use of digital technology and artificial intelligence in teaching and learning mainly to a motivational function, without the deeper conviction that the use of technology can support the learning process and enable greater student activity, thereby developing competencies and knowledge acquisition.

E. Instrument

After the initial training on AI in education, we offered training to selected teachers on lesson planning with digital technology and AI. We focused on Orange, a free and open-source tool developed by researchers from the Faculty of Computer Science at the University of Ljubljana. Orange is an open-source data visualization, machine learning and data mining toolkit. It features a visual programming front-end for explorative qualitative data analysis and interactive data visualization.

With the Orange tool, we wanted to introduce teachers and students to the field of machine learning, which is one of the important areas of AI. The training was planned in three parts, and 71 of the 133 participants in the first meeting submitted an example of AI-based lesson planning. These examples were used to analyze the quality of the planned activities. Participants were not informed of the analysis in advance, so we assume that the examples submitted are a true reflection of the teachers' activities. The following questions was intended to guide them in planning and linking goals and activities.

- What do I want my students to know? (Objectives - verb according to Bloom's or other taxonomies)
- How will students achieve this (activity)?
- Which tool function will be used as a preventive measure?
- How will we verify and measure the achievement of the objectives (success criteria)?
- Challenges, evaluation.

When teachers entered more than one example in the template or divided the activity into multiple parts, the one that showed the most meaningful and justified use of AI and the greatest added value was considered.

We excluded from the sample one case that related to a university program and two cases from IT, which were about learning to use software, but we included cases from computer science and other vocational modules that used applications to achieve other goals, for a total of 68 cases, 39 from elementary school and 29 from secondary school. Because of the small sample size in core schools, we did not distinguish between high schools and vocational secondary schools, and we grouped subjects into subject areas, as shown in Graph 1.

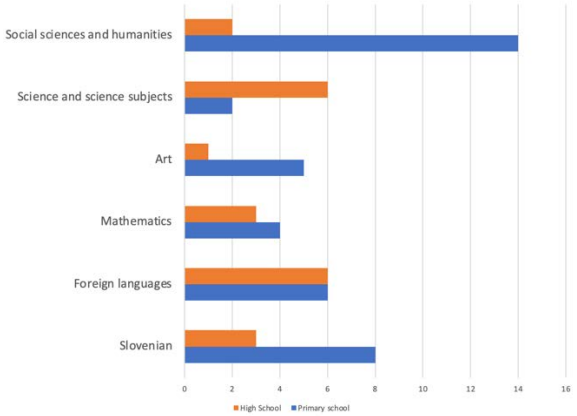

Figure 2. Structure of the sample of good use cases.

In analyzing the submitted cases, we applied three criteria in three stages

- Criterion 1: The planned activities enable, support, and achieve the objectives, where we scored the observed case 0 points if the activities were not related to the objectives and 3 points if the objectives and activities were fully aligned.
- Criterion 2 (RAT model): The planned activity is a replacement (1 point), an enrichment (2 points), or a transformation of a traditional activity (3 points).
- Criterion 3 (aligned ITL rubrics): The ICT activity can teach or reproduce basic skills (1 point) - it supports or enables the construction of knowledge (2 points), and students create an ICT solution (3 points).

When analysing and assigning the levels achieved according to the rubrics RAT or ITL, it was sometimes difficult to accurately determine the level of technology use from the records without giving precise instructions to the learners. In this determination, we were helped by the written objectives, i.e., what the teachers wanted to achieve with the planned activity, regardless of the actual implementation, which we have no insight into.

II. RESULTS

The results of the analysis are presented in Table 2, which shows that 61% of the analysed cases reach the highest level according to the first criterion, while when we apply the second and third criteria, we find that the majority reach the second level (51% and 59%, respectively).

TABLE 1. DISTRIBUTION OF THE ANALYZED CASES ACCORDING TO THE CRITERIA.

		Matching the activities with the planned goals, the use of ICT supports the set goals				RAT model			Adapted ITL rubrics		
	Subject area	Objectives are written in the students' activity outline, the distinction between an objective and an activity is not clear	The objectives are still partly written in the form of actions, their realisation is possible through the proposed action	The goals are clearly written, the proposed activity at least partially supports their realization	The objectives are clearly stated and the proposed action supports at least part of their realisation	Substitution	Augmentation	Transformation	Learning basic skills, reproduction	Supports, enables the construction of knowledge	Students create an digital solution
PS	Slovenian	1	4	2	11	5	9	4	13	5	/
SS	Slovenian	1	2	/	/	1	1	1	1	2	/
SS	Foreign languages	1	/	1	4	5	1	/	4	2	/
SS	Foreign languages	/	/	/	6	1	4	1	2	4	/
PS	Mathematics	/	/	1	3	2	2	/	1	3	/
SS	Mathematics	/	/	2	1	/	1	2	1	2	/
PS	Science	/	1	/	1	/	1	1	/	1	1
SS	Science	/	1	1	4	1	4	1	2	4	/
PS	Social sciences and humanities	1	1	2	/	/	4	/	/	4	/
SS	Social sciences and humanities	/	/	1	1	1	1	/	1	1	/
PS	Art	/	/	/	6	/	2	4	/	6	/
SS	Specialised subjects	/	1	2	5	2	5	1	2	6	/
	Total	4	10	12	42	18	35	15	27	40	1

When comparing the three criteria used, the highest level of meaningful digital technology and AI use was found in the category of aligning activities with goals, while the lowest was found in the use of Customized ITL rubrics, as shown in Figure 3.

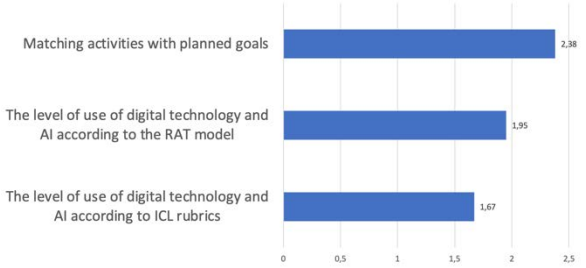

Figure 3. Comparison of results according to the criteria used.

Out of a possible 9 points, the analysed cases averaged 5.91, with no significant differences between the average scores of primary and secondary schools, as shown in Figure 4:

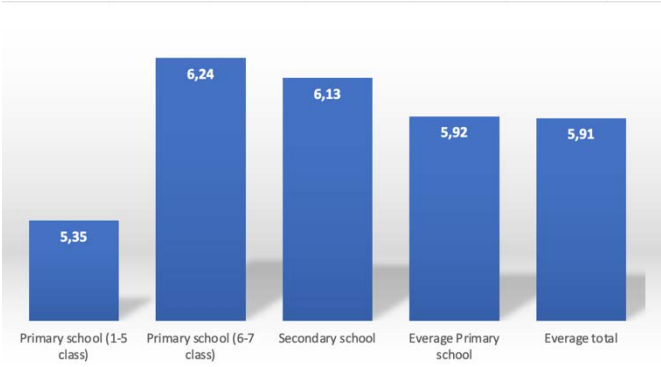

Figure 4. Average achieved values.

Due to the specificity of the students and the lower grades of elementary school, 14 cases were excluded from the calculation of average grades by subject area and grade in Graph 4:

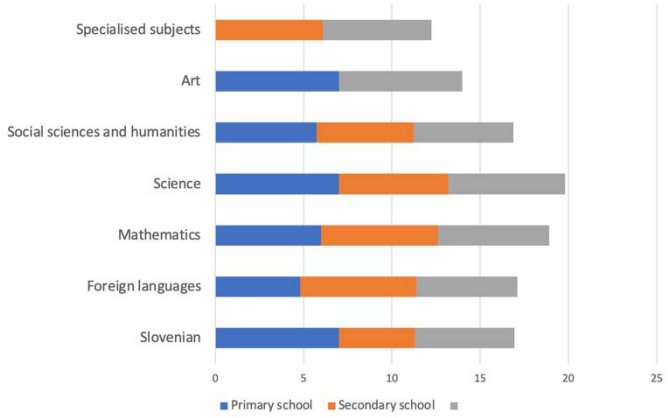

Figure 5. Transversal achieved values according to subject areas.

III. DISCUSSION

From a project perspective, we found that the use of customized ITL rubrics was less appropriate for assessing the use of technology in the classroom, as only one case analyzed reached the highest level, designing a technical solution for a target audience in which students worked in pairs to design, independently conduct, record, and publish a physics experiment to demonstrate the application of their physics knowledge.

Using the RAT model, the transformational stage was achieved by several teachers who succeeded in using technology to organize learning opportunities in ways that would not have been possible without the use of technology. Interestingly, all of the examples from the physics classroom reached this level, and close examination revealed that it was a matter of recording and video analyzing certain elements to perform them more correctly. The weakness of the RAT model was the relatively low differentiation at the second level (reinforcement/enrichment), as this category (mainly due to the added value of automated feedback, learning analysis, or learning analytics) was not included in the RAT model. The ICL rubrics also showed a large number of cases that only reached the first level, i.e., basic skill learning and reproduction, without any significant change in the way they were taught (e.g., use of flashcards for memorization, quizzes for reinforcement and review, etc.).

This element was particularly pronounced in foreign language teaching (especially in elementary school) and various subjects in the first two years of elementary school, although even here there are examples of good use that differ significantly from the average use of technology in teaching. The cases in Slovenian in secondary education are below average, but the

three cases analyzed, whose predominant feature is the use of the presenta

IV. CONCLUSIONS

Social change and living in a global, rapidly changing world present many challenges to individual teachers and society that cannot be solved with established patterns. For education, this means a shift away from knowledge transfer to innovation using digital technology and AI. The question of using artificial intelligence in education therefore no longer arises, because the answer is obvious. The judicious use of modern digital technology and artificial intelligence, supported by collaborative approaches to teaching and learning, adds value to education.
While most teachers do not have major problems with the use of digital technology and artificial intelligence in lesson preparation, it's a different story when it comes to using technology to support the learning process. Creating learning opportunities where students can easily acquire new knowledge and develop their skills requires a new mindset on the part of teachers. This starts with planning, and teachers need a tool to verify that the planned use of digital technology is appropriate and pedagogically justified.

Although machine learning is one of the more challenging areas of AI application in education, it is safe to say that it adds a lot of value to both students and teachers in terms of achieving higher levels of taxonomic competence. Artificial intelligence programmes such as ChatGpt have created a buzz in the education community as they are widely used by students in the field, even for texting and solving certain tasks.

Based on our research, we conclude that the RAT scale is the most appropriate scale for teachers to use when deciding whether to integrate and use digital technologies and AI in education. We must constantly question what added value the technology used brings to the teaching and learning process. The real challenge is to enable teachers to understand the basic concepts of how modern digital technologies work and to integrate them meaningfully into the educational process. This represents added value for society, because without these skills our children will not be competitive in the job market.

V. REFERENCES

[1] Flogie, A., Aberšek B. (2019). Innovative learning environments - the role of ICT. Maribor: Institute of Anton Martin Slomšek, 2019. ISBN 978-961-92190-7-2.
[2] Gartner, S., Krašna, M. (2023). Artificial Intelligence in Education – Ethical framework (to be publishged) in *MECO 2023*, Budva, Montenegro, 2023.
[3] Robinson, K., Aronica, L. (2015). Creative Schools: A Mass Revolution Transforming Education. Nova Gorica: Eno, 2015.
[4] FLOGIE, A., ABERŠEK, Boris. (2022). Artificial intelligence in education. V: LUTSENKO, Olena (ur.). Active learning - theory and practice. London: IntechOpen, 97-117.
[5] OECD (2023). Is Education Losing the Race with Technology?: AI's Progress in Maths and Reading, Educational Research and Innovation, OECD Publishing, Paris, https://doi.org/10.1787/73105f99-en.
[6] OECD (2013). Innovative Learning Environments, Educational Research and Innovation. Paris : OECD Publishing.
[7] Microsoft. (2019). Education Transformation Framework - Microsoft K-12 Education Transformation Framework. https://www.microsoft.com/en-us/education/school-leaders/k-12-microsoft-education-transformation-framework
[8] Bocconi, S., Kampylis, P., Punie, Y. (2012). Innovating Learning: Key Elements for Developing Creative Classroms in Europa. European Comissio. http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=5181.
[9] Stigler, W. J., Hiebert, J. (2009). The Teaching Gap: Best Ideas from World's Teachers for improving education in classroom. New York : Free Press.
[10] Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. Teachers College Record, 108(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x
[11] Redecker, C. (2017). European Framework for the Digital Competence of Educators. Luxemburg : Publications Office of the European Union.
[12] Mayer, R. (2010), "Learning with technology", in Dumont, H., D. Istance and F. Benavides (eds.), The Nature of Learning: Using Research to Inspire Practice, OECD Publishing, Paris,https://doi.org/10.1787/9789264086487-10-en.
[13] Hattie, J. (2012). Visible learning for teachers: Maximizing impact onlearning. Routledge/Taylor & Francis Group.
[14] Francis, James. 2017. The Effe cts Of Technology On Student Motivation And Engagement In Classroom-Based Learning. University of New England. DUNE: DigitalUNE. Retrieved from http://dune.une.edu/theses/121.
[15] Godzicki, L. (2013). Increasing motivation and engagement in elementary and Middle school students through Technology-Supported learning environments . Chicago : Sant Xavier University.
[16] Lyon-Jones, S. (2011). Teaching Eth Technology - A Basic Checklist. The Edtech Hub. https://www.edtech-hub.com/resources/techteachchecklist.html.
[17] Hughes, J., Thomas, R., Schaber, C. (2006). Assesing Technology Integration: The RAT Framework. Society for Information Technology & Teacher Education .
[18] Puentedura, R. (2014). Technology In Education: An Integrated Approach. Retrieved from http://www.hippasus.com.
[19] Anderson, L. W. and Krathwohl, D. R. (2001) A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives. Allyn & Bacon. Boston, MA (Pearson Education Group).