The Synergy Between Digital Tools and Modern Constructivist Pedagogies

Mihail CALALB*

Abstract

This article explores the correlation and the synergy between inquiry – based science education (IBSE) as an example of social constructivist pedagogy and digital learning environments. The main premises for an IBSE – type education are determined by the need of knowledge-based society in scientifically literate labor force. The main features of inquiry-based science education are examined and the formation of lifelong learning skills is presented as one of the main benefits brought by IBSE. Other outcomes of IBSE are: the need for permanent learning and research as a part of professional and intellectual growth of personality; the development of an active scientific vocabulary of students; enhanced motivation to learn and explore namely in a digital environment. Three pillars for building a modern educational system are presented: i) constructivist pedagogy; ii) a higher degree of student – student and student – teacher interaction; and iii) digital learning environment. The mandatory components of digital learning environment are presented and the main principles for embedding ICT in education are enumerated

Key words: constructivist pedagogy, inquiry – based science education, digital learning environment, lifelong learning skills.

1. Introduction

We are in a global, knowledge – based society where every serious country thinks of heightening the quality in its system of education, which has a many-sided aspect. For instance, the major challenge for educational system is to provide highly qualified labor force which (OECD, 2006):

- have a scientific view about the world,
- can use efficiently the technologies understanding what is behind them,
- can communicate in a globalised world and
- is civically active.

Thus, today's competitive labor market requires skills, which are beyond subject knowledge (European Commission, 2007). Nowadays there is a gap between the demand of knowledge-based society for highly qualified labor force and the offer of educational systems. Even for entry level on labor market there is a need for labor force with analytical thinking skills, familiar with epistemological principles (International Council for Science, 2011). Under these given conditions, the paradigm of memorization in education has to be replaced by the one of understanding. Here the technology has a word to say in education. In this way, nowadays, non-digital pedagogy is a non sense.

In the Sec. II the social constructivist pedagogies are described as a platform for realizing the switch from the paradigm of memorization to the one of understanding. It is demonstrated that the modern labor market requires lifelong learning skills which can be formed only in a constructivist pedagogical environment. The student – student and student – teacher communication is presented as a mandatory component of pedagogies targeting long – term

* Mihail Calalb, associated professor, Tiraspol State University
E-mail: mcalalb@hotmail.com

intellectual and professional development of personality. The democratic decision – making processes also are influenced by the level of scientific literacy (or illiteracy) of population.

In the Sec. III inquiry – based science education (IBSE) is presented as an example of constructivist pedagogy. IBSE has many similarities with project and problem – based learning, but brings a concept of “big scientific ideas”. Around these ideas the IBSE cycles or projects are built. Namely within these cycles the students come to new laws, scientific understanding of the world, assimilate new terms and form their own active scientific vocabulary. If IBSE is organized correctly, no students are lost for the learning process. Mainly it is due to the collaboration between students and high degree of freedom of students in their joint work on IBSE project.

In the Sec. IV the key principles for embedding ICT in teaching, learning and assessment are presented. Also the mandatory components of digitized learning environment are described. Three key components of educational process: constructivist pedagogy, social interaction and technology are seen as parts of the learning environment which doesn’t mean only infrastructure or technological components.

In the Sec. V the main conclusions are presented. Such as: inquiry –based science education contributes essentially to the formation of lifelong learning skills, social interaction in the frame of project – based learning develops active scientific vocabulary of students, digital learning environment is a strong motivator itself.

2. Constructivist pedagogies in the modern ICT context

First of all we have to emphasize that the modern pedagogical context isn’t only a digital one. There is an exponentially growing amount of information and educational systems fail to understand the relevancy of each particular piece of information. As a result, school curriculum suffers an inflation process which finally is reflected by low motivation of students to learn. The attempt to revitalize the teaching process by applying the concept of “learning by doing” gives partial, small improvements because it is demonstrated that students’ “doing” rarely is accompanied by their deep understanding of what they do (Alberts, 2000).

The paradigm of memorization should be replaced by the one of understanding. Moreover, the modern students have to be endowed with lifelong learning skills, which will ensure for decades after graduation successful carrier and professional path. In this way, two big moments should be taken into account by the educational systems: a) formation of lifelong learning skills, and b) formation of big scientific ideas as a basis for further intellectual and professional growing of the personality (Harlen, 2010).

Let’s accustom the reader with the basic principles of constructivist pedagogies. The basic belief of constructivism is that knowledge is actively constructed by learners rather than transmitted by the teacher. The fact that the learners are not passive information receivers is very important namely for forming lifelong learning skills. There are two types of constructivism:

1) Cognitive constructivists believe learners construct knowledge individually based on their prior experience and new information. So, the knowledge is the result of individual effort. In this case, the pedagogical environment must support and satisfy the needs individual learners providing various learning resources and activities.

2) Social constructivists, argue knowledge is the outcome of collaborative construction and learning is an interactive process of information sharing, negotiation, and discussion between participants.

Anticipating the next section of this article, we have to state that namely the social constructivism is the basis for project based and group based learning. In addition, as teachers are facilitators in a constructivist learning environment, it must enable teachers to scaffold students during a learning process. Such a learning process requires important student’s effort – it is in flow with the basic didactical principles of well-known pedagogy of collaboration developed in ’70 of XX century (Calalb, 1989). Thus, the role of learning environment is very important in the case of constructivist pedagogy – it must be a safe and comfortable space, in which learners are willing to share information. Also, the learning environment must offer certain tools so that the students can easily communicate and collaborate with others.

Now we will enumerate the premises or the factors determining the demand for digital constructivist approach in today pedagogy. Firstly, it is the necessity for a cultural society with developed sense of civic duty. Here we have to underline that scientific understanding of the world by the majority of population directly influences the democratic decision-making process and finally – the quality of the life. Secondly, today, the motivation of students to learn and the relevance of taught knowledge is the stumbling block in pedagogy. It has a plenty of roots and the main one is the digital divide between teachers and students. I would say more: between educational system and students. Other factors are linked to the creation of favorable external environment for educational system like: appropriate awareness of population toward the science and encouragement of education for sustainable development.

3. Inquiry-based science education

An example of constructivist pedagogy is Inquiry-Based Science Education which recognizes the active role of the children in the formation of their ideas and conceptions about the world. Within IBSE the path of a new scientific idea is repeated in the frame of the lesson. There is a growing interest at international level for IBSE because here the accent is put on learning even the teaching within IBSE requires much more effort. The IBSE pedagogy is oriented toward development of understanding, formation of those competences and attitudes necessary for every personality for and active life within knowledge-based society. The IBSE projects developed in the classroom by groups of students help the teacher to guide students during the process of the formation of big scientific ideas which, further, will contribute to the understanding of phenomena in the nature, events in human society, and things in the created world (Harlen, 2010). In this way, IBSE puts the basis for analytical, reflection skills of students and forms models of learning strategies which will be permanently applied by students further after graduation.

IBSE is an empirical combination of several constructivist pedagogies such as: multiple intelligences, Bloom taxonomy, whole method, etc. Shortly, IBSE is a strategy which is based on:

- Practical work of students, which is only the first level of IBSE. It is about advanced involvement of students, active learning or learning by doing (LBD). But we have to emphasize that doing isn’t necessary equivalent with understanding. For example, in the frame of laboratory the students may repeat the manipulations of teacher without realizing the sense of these actions. It means that practical work of students doesn’t mean yet that it has intrinsic cognitive value.
- Accession of multiple learning paths. They often say: I saw – I forgot / I heard – I remember / I did – I understood. We have five feelings and for a whole learning with to use all of them. From one side, as there isn’t a panacea for all diseases, there aren’t universal pedagogical tools and approaches. Indeed, the modern teacher has to know a wide spectrum of approaches and methodologies oriented toward formation and keeping of cognitive and interrogative skills of students. From other side, accessing multiple intelligences we obtain that more students are actively involved into the knowledge process. Finally, it is mirrored by the academic success rate because every student may choose his/her own learning path depending on his/her intellectual profile. What is extremely important here that the deep scientific understanding of the world isn’t transmitted to the students; it is the result of their own intellectual effort.
- The learning process within IBSE is structured on two main levels. The first level supposes the organization of curriculum around big scientific ideas. Such a big idea is assimilated in the frame of a research project or cycle developed by students (organized mainly in groups). Implicitly the big ideas replace the accent from memorization to understanding, avoiding the dissipation of students’ attention by many small facts. The second level refers to the organization of the lessons around new three – four scientific terms. This type of learning ensures the assimilation of scientific terms by active vocabulary of students, training and accustoming them to use scientific speech. It develops the personality influencing lifelong learning skills.

There is a natural question: “What the teacher should know related to IBSE?” There are two aspects of inquiry: *a)* inquiry as a set of cognitive skills which determine the further educational path of students as autodidacts and *b)* inquiry as a complex of strategies which facilitate: understanding of scientific principles and concepts, development of research skills, and awareness about scientific research. Another aspect is that within IBSE class there are differentiated goals for all students. Thus, the teacher will structure the didactical aims in the following way:

For all students – the teacher will encourage them to:

- Explore why things / phenomena are as they are.
- Formulate adequate explanations on things / phenomena.

For the majority of students – they recognize that:

- Some scientific ideas may be useful for society and for them personally
- Scientists have research methods which may be used not only in science.

For some students – we may expect that they:

- Will replace their own naïve explanations with scientific concepts
- Are willing to advance in scientific understanding of the world.

IBSE approach supposes a higher freedom degree for students, without diminishing the guiding role of the teacher. The problem how to form the analytical skills of students, the ability to formulate and develop a thought is on the first plane. Further, inquiry-based education is an experimental one. The student’s own experience and the artifact of learning process influence the subliminal. In this context we present a list of more or less mandatory things for teachers in order to ensure successful guiding of students. Thus, during the IBSE-style lesson the teacher should:

- Formulate questions which require reasoning, explanation, reflection and answers of students showing their interest for the debated subject.
- Provide the opportunity for students to explore themselves the phenomenon.
- Allow development of experiment and its discussion within small groups of students.
- Sustain via his/her personal example the spirit of tolerance, mutual respect and objectivity during discussions both at group and class level.
- Ensure the access of students to alternative research and information means.
- Offer tasks to students requiring a more complex degree of knowledge then their actual knowledge – in order to respect a well-known principle of the pedagogy of collaboration which states that efficient learning supposes and essential effort of students.
- Encourage students, through his/her comments and questions, to verify if their ideas correspond to the reality and experiment results.
- Help students record and analyze in a systematic way the results of their observations along with other available information by using adequate terms and enrichment of scientific vocabulary.
- Stimulate critical thinking on newly learnt things and they may be applied in further studies.

But encouraging students to investigate isn’t enough because their curiosity is natural. This fact is reflected by their activism and ardent willingness in primary school and refractive boredom shown in middle classes. Thus, is very important to create the environment which will fuel and sustain this curiosity and endow them with skills necessary for a constant success in analysis and research. In other words, it is about meta-cognitive facilitation because, as it was stated above, investigation or research is a state of mind – from one side, and from other side – it is a habit that has to be learnt.

As a structure, IBSE is similar to project – based learning. The project in this case doesn’t coincide with the lesson, exciding it in time. The projects or the cycles are built around “big ideas” already mentioned. Every IBSE project has five stages (White and Frederiksen, 1998): question, hypothesis, experiment, model and application. This cycle is repeated every time when the students start learning a new “big idea” from the curriculum.

The structure of IBSE cycle:

1. Question. The inquiry process starts with a question like: “What will happen with the examined

body if there are no friction forces?"

2. Hypothesis. The students formulate hypotheses and theories trying to anticipate possible situations. Thus, at this stage the students develop imaginary experiments.

3. Experiment. After assumptions and hypotheses the students are split into groups for further elaboration and application of their theories. It may be done both on computer and with real objects.

4. Model. Here the students analyze the obtained data and check if there is law in the results of different groups. Namely the students have to formulate this law and draw the conclusions.

5. Application. Once the class has formulated the laws and the best models have been selected, the students analyze the application limits for the models and try to apply the models to real situations. Here new questions arise which are the starting point for a new IBSE cycle.

We have to underline a crucial aspect within IBSE – the collaboration between students. It aims to build the understanding of investigated phenomena through the conversation among students which may be developed at class or group level within the lesson or exceeding the time boundaries of the lesson. During this collaborative conversation the students come to the understanding of new scientific terms, assimilate adequate scientific vocabulary, form for them cognitive values and become aware of the essence of scientific research – in general and what they did – in particular. A rigid structuring of students groups in the frame of the lessons is not so important. What we seek is enhanced scientific understanding of phenomena and events through ideas sharing. In this sense we have to recall the idea of peer instruction, which was developed in '70s of XX century in URSS by Shatalov V. F. and in XXI century by Eric Mazur from Harvard University, USA (Calab, 1989) and (Crouch et al., 2007).

In this way, shortly IBSE is about advanced involvement of students which means that the knowledge resulted from the own research of students are much more relevant and meaningful rather than those delivered by teacher in the form of rigid and undeniable truths. And such an involvement may be reached through enhanced student – student collaboration, because the work on joint project amplifies the assimilation of knowledge and student – teacher collaboration which forms those research skills which will be applied long time after school graduation. Thus, IBSE is an adequate term for denominating collaborative learning. Namely collaborative learning has to be emphasized because it enhances the achievement because students see learning as dependent on thinking and understanding.

6. Key principles for embedding ICT in education

The student – teacher communication gets a two-way character and turns into interactivity namely in ICT-based classrooms when the teacher facilitates learning by:

- working with small groups,
- directing them to useful resources, and
- helping with problem solving activities.

In this way, the students are motivated to learn by digital environment itself. Thus, there are three key components of educational process: constructivist pedagogy, social interaction and technology. All these components may be seen as parts of learning environment which doesn't mean only infrastructure or technological components. A case study from the Organization for Economic Co-operation and Development, which examined the hypothesis that technology is a strong catalyst for educational innovation, found that ICT was only partly included into school development process, ICT was seen merely as an innovation and served in the main:

- as a search instrument for information,
- media illustration of subject matter,
- for learning computer science and
- for text creation.

Moreover, a report on digital technologies from the charity Nesta in the UK notes, "What is clear is that no technology has an impact on learning in its own right; rather, its impact depends upon the way in which it is used". So, the technology doesn't replace the pedagogy. Despite this, our teachers dream of a magic soft with all lessons plans incorporated. For such teachers, teaching begins with authority. Conversely, for the digital pedagogue teaching begins with inquiry, and this attitude can be formed nowadays only within digital pedagogy.

In this section we will focus on digital learning environment which ought to support and satisfy the needs and learning intentions of students with different backgrounds. Namely the digital learning environment ensures self-paced learning of all students. In other words, it is about the democratization of learning process by using various learning tools, resources and activities which both support students' learning and allow teachers to facilitate learning. In conclusion, the constructivist pedagogy, social interaction among all participants of educational process (student – student and student – teacher) and technology are critical components of a digitalized learning environment. It means that ICT has to be seen as a mandatory background for implementing IBSE and vice versa. Nowadays the efficiency of pedagogy is determined mainly by the degree of social interaction and technological support provided during the learning process. We have to note here that we avoided saying "during classroom hours" because there is a permanently growing experience of international learning projects when tens of classrooms work jointly on the same topic. See, for instance, e-Twinning projects which form in the same time communication, language and research skills of partnering classes (Istrate, 2013).

Further UNESCO ICT Competency Framework for Teachers is provided. We have to state that this framework was developed for teachers around the globe and there is a need to localize it for the national context.

1. Namely the constructivist pedagogy underpins the embedding of ICT in schools. Here we have to underline an important issue. The majority of teachers comes from pre-digital age and therefore ICT only replaces the old tools: chalk and whiteboard. It is the first level or step. Further, we have to realize that new technology requires new methodology and the basis for this is social constructivism in general and IBSE in particular.
2. The use of ICT in teaching, learning and assessment can enhance the learning experiences of all students. – It means that ICT plays an important role in supporting inclusion. As it was mentioned above, ICT democratizes the educational process. Moreover, it responds to the stringent necessity for having scientific literate population.
3. The use of ICT in teaching, learning and assessment should be reflected by school curricula (organized around "big scientific ideas"), ministry policies (which have to take into account that the learning process exceeds the time and space boundaries of the classroom – for example) and teacher education system (where the accent should be on lifelong learning skills of future teachers).
4. ICT is used in an ethical and responsible way.
5. When we design a digitized learning environment we have to ensure ICT integration in teaching, learning and assessment. It means that digital tools and resources should be provided for these three components. Here there are two approaches: the first states that the elaboration of teaching / evaluation resources is the duty of the teacher and the second one underlines that complete ICT educational packages should be provided.

These five principles are designed to ensure that the ministry, school authorities, school leaders and all key stakeholders play a proactive role in enhancing our education system by integrating ICT more effectively.

In this way, we come to the necessity to define digitized learning environment. Shortly, the digitized classroom means the following moments (which are more or less mandatory):

1. Use of digital tools such as interactive whiteboards (IWB) and electronic response systems (ERS). Here we have to underline that many IWB and ERS are designed for other purposes than educational.
2. Use of interactive projector with tablet or laptop for teacher and a set of tablets/laptops for students.

3. Use of Virtual Learning Objects as digital educational resources available for free (paid by ministry, local authorities or school authorities) both for teachers and students.
4. Teacher – collected or teacher – created resources. Such resources usually are shared within teacher communities and networks. In terms of professional growth, the valued of the communication within these networks is appreciated by teachers themselves much higher than conferences, workshops or presentations.
5. Inquiry, Project & Problem-Based Learning. In a digital learning environment there is only one approach – the constructivist one. This constructivist approach should be taught both within initial and continuous education of teachers.
6. Student work is published for a wider audience – on the didactical blog, and remains there for years. It strongly motivates.
7. Digital and Multimedia Literacy of all participants.

7. Conclusions

This article explores the synergy between social constructivist pedagogy and digitized learning environment. The author emphasizes that the main premises for a digital, inquiry-based education are determined by the major need of knowledge-based society in highly qualified labor force which have a scientific point of view on nature and society. At a large, this work draws the framework for educational systems which targets to deter or alleviate widely spread among population scientific illiteracy. In this sense, the main features of inquiry-based science education are examined. The benefits of IBSE are multiple but the main one the formation of lifelong learning skills. The need for permanent learning and research as a part of professional and intellectual growth of personality is formed namely within IBSE.

Another important conclusion is related to the social interaction student – student and student – teacher type. It is shown that the social interaction should be a part of project – based learning when students work in groups and their interaction often exceeds time and space boundaries of usual lessons. An important outcome of social interaction in the frame of project – based learning is the development of an active scientific vocabulary of students.

In the case of IBSE the school curriculum is built around the concept of "big scientific ideas". Each idea corresponds to a project or an IBSE cycle. This approach is seen by many authors as a solution for curriculum inflation process. Also, the switch from the paradigm of memorization to the one of deep scientific understanding of the world should be realized only in and IBSE context.

The main problem of contemporary education is the motivation of students to learn. Digital learning environment is a strong motivator itself. Considering this fact, the author gives three pillars for building a modern educational system: *i*) constructivist pedagogy (for instance – IBSE); *ii*) social interaction within project – based learning; and *iii*) technology as didactical environment.

Nowadays the technology shouldn't be seen as an innovation. Digital tools and resources are the mandatory components of the Digitized Learning Environment which requires a certain level of digital and media literacy both for teachers and students.

Finally, the main principles for embedding ICT in education are enumerated. All of them underline the idea that ICT tools have to be used in parallel at three different but inseparable levels: teaching, learning and assessment. In order to reach this objective, the system of teacher education (both initial and continuous) should be redesigned because ICT in education means democracy – science and culture for wide population.

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