ASSUMPTION OF COGNITIVE GOALS IN SCIENCE LEARNING

Mihail Calalb
Tiraspol State University, Republic of Moldova
E-mail: mcalalb@hotmail.com

Abstract

A new didactical approach named "Learning by Being" (LBB) is proposed and its correlation with current educational paradigms in science teaching is analysed. The key idea in LBB is the assumption by the students of cognitive goals, and three components are mandatory in LBB: a) student's personal learning effort, b) student – teacher mutual feedback and c) metacognition. In other words, the ownership of cognitive goals and students' deep intrinsic motivation. Several didactic approaches, used within LBB, are analysed: independent research that has an impact factor on cognitive achievement equal to 83%; knowledge of success criteria (impact factor – 113%); ability to reveal similarities and patterns (impact factor – 132%). The core of LBB is guided learning effort that corresponds to the notion of teacher–student harmonic oscillator when both things – guidance from teacher and student's effort – are equally important.
Keywords: *conceptual understanding, learning by being, ownership of cognitive goals, science learning*.

Introduction

The problem of low students' motivation and interest for learning effort is one of most important in nowadays school. The majority of solutions for overcoming low motivation come from the constructivist area: learning by doing, active learning, learning by understanding, inquiry-based science education, problem– and project – based learning, etc. All these approaches differ in the degree of independence in learning. The higher is the degree the higher is impact of particular didactic strategy on academic achievement of school students (Hattie, 2017). In this way, increasing the students' independence degree in learning is the solution if we want to not only remove boredom but also achieve academic success of students.

This independence in learning should go until it will reach the student's ownership on learning goals. It means that the students both understand their way of learning and assume the didactic objectives as their own cognitive goals. It is about metacognition (Scharff et al., 2017). Thus, teachers' didactic goals should become students' learning objectives. This fact corresponds to the results of the theory of *visible teaching and learning* (Hattie, 2009). In order to obtain the assumption by the students of cognitive goals, the communication in the frame of the lesson should be based on mutual student – teacher feedback and the students' empowerment through metacognition (Millis, 2016).

In such a way, a modern didactic strategy contains three pillars: students' learning effort, enhanced student – teacher communication and metacognition (Calalb, 2020).

https://doi.org/10.33225/BalticSTE/2021.32

Considering these prerequisites, this short communication analyses several moments: the evolution of educational paradigms from *learning by doing* to *learning by being,* the correlation of students' learning effort with metacognition, the main features of multilateral student – teacher feedback (feedback from and to all students) and gives practical recommendations for applying learning by being concept in inquiry – based classroom.

From Learning by Doing to Learning by Being

The first step in the ladder of modern educational paradigms is *learning by doing* (LBD). For example, a form of LBD is *ludic education*. According to the results of the theory of *visible teaching and learning* (VTL), the impact factor on academic achievement of students for ludic education is 35% (Hattie, 2009). Compared with the benchmark level, which is equal to 40%, when an experienced teacher applies permanently the same conventional strategy during two academic years, LBD has a negative impact factor. These numbers demonstrate once again that school does not belong to entertainment industry and conventional teaching remains a solid option in modern times.

The second step in the mentioned ladder is *learning by understanding* (LBU). A well-known example of LBU is *inquiry-based science education* (IBSE) (Harlen, 2010), which has an impact factor equal to 77%. Thus, the effect of understanding is twice higher than the one of doing. The level or complexity degree of communication makes the difference between LBD and LBU. The communication should be seen as leverage for enhancing students' involvement degree in classroom activities.

The next step would be *learning by being* (LBB) when the students not only understand but also assume the learning objectives. In this way, within LBB, the students are the subjects of their learning process, construct their cognitive path, and form in class sustainable lifelong learning skills. It is about the students' *ownership on cognitive goals* (Calalb, 2019). Here we will present several characteristic features of LBB. For example:

- The ability of students to carry out *independent research*, in other words *guided self-scaffolding*, with an impact factor equal to 83%;
- *Knowledge of success criteria* or even more – assumption of success – the driving mechanism in learning, which is more than the knowledge by the students of evaluation criteria, impact factor on academic success is 113%. We have to emphasize that in order to achieve this level, students should be accustomed with IBSE. Years of permanent, daily IBSE implementation in classroom have to be seen as a mandatory prerequisite for this LBB approach.
- The ability of students for *revealing similarities and patterns*, which has an impact factor equal to 132%, is the ability to connect the new information with their previous knowledge "that is not forgotten". Thus, this approach relates to the formation of analytical and critical thinking skills, the basis for lifelong learning skills.

In this way in order to maximize the academic achievement of students, we should increase the independence degree of their learning. In other words, teaching should be seen as couching in sport when the athlete not only knows what the couch wants from him/her, but also assumes these tasks as own goal and has all physical, technical, tactical, and emotional means for achieving the goal set initially by the couch.

https://doi.org/10.33225/BalticSTE/2021.32

Learning Effort and Metacognition

The main goal of contemporary education is the scientific understanding of the world by the majority of population. Despite many and various efforts for identifying adequate strategies for this goal, it remains Fata Morgana in education. The cause is minimisation of the importance of the learning effort or the search for royal ways in science. Learning through intellectual effort is a well-known didactical principle that reflects the fact that the ascension is only uphill. It suits to Vygotsky's concept of the *zone of proximal development*. Namely because of this ludic education has a negative impact factor. Intrinsic intellectual effort is the base for conceptual, scientific understanding of phenomena and things. There can be no understanding without student's intellectual effort in the atmosphere of empathy in classroom that encourages verbalisation and fosters communication. We should speak about education centred on student's learning effort rather than student centred education. Constructivist approach without learning effort is non-sense. Research suggests that constructivist teaching approach is not necessarily reflected in higher test scores but students familiar with constructivist classrooms scored much higher when they were asked to explain scientific phenomena, than students in traditional classrooms (Berube, 2001). Other results of pilot studies suggest that teaching programs based on 5E constructivist approach (engage, explore, explain, elaborate, and evaluate) increase motivation and remove boredom by creating positive impression to the learners (Arioder et al., 2020). Indeed, motivation and students' interest have to be seen as the first bricks in the foundation of any LBB approach when students' ownership of cognitive goals is targeted.

Learning by being concept is about not only students' assumption of learning process but also requires that students themselves are aware and understand their way of thinking in the case of learning, which is more than the application (or replication) of a learning activity taken from the teacher. It is about metacognition when students: a) are able for and analyse what type of strategy they will use to accomplish a particular task; b) estimate their possible result; c) analyse their result and decide if it is necessary to change the strategy to accomplish the task (Kirschner, 2006). Thus, the metacognition closely relates with the didactical principle of consciousness of learning.

Student – Teacher Mutual Feedback

Two-way communication channel is the mandatory component of any constructivist didactic strategy. According to VTL theory, teaching and learning should not be with closed eyes – the teacher doesn't know how the students have received his/her message, and students don't know and don't understand what the didactic objectives of the lesson are (Hattie & Donoghue, 2016). VTL analyses and measures the influence of more than 250 factors on academic achievement of school students. From these factors, several factors that directly influence the feedback have been selected. For example:

- Teacher's a *priory assumption* about the student's potential and aptitudes – with an impact factor equal to 162%
- Teacher's *instant knowledge on students' response* to his/her didactic action – impact factor equals to 129% (in other words teacher knows immediately what students think about his/her action).

- Teacher's ability to *coordinate classroom debates* within and among groups – 82%.
- Peer instruction – 74%.
- Formative evaluation – 48%.
- Student centred teaching – 36%.
- Problem – based learning – 26%.

The last two strategies are below the benchmark level of 40% mentioned above because in the case of student-centred teaching we have the student as the passive object of teacher's action and because the majority of teachers don't apply permanently PBL in their classes. These results are confirmed by PISA results in the Republic of Moldova where in three – four classes there is only one student with high depth of knowledge, compared with South Korea where there are three -four such students in one classroom (PISA, 2017).

The technical solution for instant feedback is digital classroom response system. Having such a system, the teacher will not "advance" to the next topic until at least 70% of students will understand the new notion or law. In this way, the instant teacher's knowledge of the effect of his/her didactic action on the students' understanding is three times more valuable than the assumption that the student would have retained something (knowledge of the effect – 129%, assumption – 40% (Nicol & Boyle, 2003).

Learning by Being within Inquiry-Based Science Education

Further, we will present the main steps to be followed by the teacher in the classroom, in order to achieve the assumption of the cognitive objectives by the students. In other words, how to put into practice the LBB concept in the frame of an inquiry-based science education (IBSE) project carried out by students. Here we present separately the teacher's role within IBSE lesson (namely teacher – student interaction, and students' group activities. Related to teacher we will analyse three moments: a) formation of students' ideas (this fact determines to what extent the students will assume the cognitive goals); b) guidance of students' own research activity, developed in groups; c) facilitation of analysis and drawing of conclusions (within debates at group and class level). Related to students' action we will describe: a) students' mandatory steps within IBSE classroom; b) development of group work; c) recording and analysis of measurement and/or research results, etc.

Teacher – student interaction

1. Formation of students' ideas

In order to reveal students' initial ideas, the teacher asks open questions and gives positive feedback to let students realize the necessity for the revision or development of their initial ideas.

2. Supporting students' own research

The teacher helps students to formulate productive questions such as "What is the shortest path, convenient form, etc. ...?" - which will form the basis for further research and guides the students in the planning of their further research. The teacher facilitates the planning process, providing a possible structure of the research plan. In addition, the teacher helps the students to record the measured data and to organize them in tables.

https://doi.org/10.33225/BalticSTE/2021.32

3. Guidance of students within analysis process and formulation of conclusions
The teacher asks the students to formulate as concisely as possible their conclusions, not only to say what the result of the measurements is, but what its meaning is. The teacher asks the students to check if the conclusions formulated by them correspond to the results of the measurements or observations. The teacher encourages students to reflect on what they have done and what conclusion they have reached.
Student activities
4. Conducting research
Based on their ideas, students formulate and explain their hypotheses. Students participate in planning the experience by discussing the details. Students do not create the research plan, but at least they understand and accept it. Here, in fact, we are talking about assuming the objectives of learning – according to the concept of LBB. Students analyse, compare, and explain the data obtained in relation to their hypotheses.
5. Group work
Students collaborate and share tasks being in the same group. Avoid individual work. Students report the results of group work in front of the whole class. Students – rapporteurs answer the asked questions, others approve, reject, or debate the results of the given group.
6. Recording the results
Students record what they have measured and what they have identified. All collected data are organized in the form of a table, i.e., any register must contain a table, so that students are familiar with the organization of the data collected in a table. Students note in the register if their results correspond to their hypothesis. The conclusion reached by the group is written in the register. Students also make their own notes, informal, with ideas or data, which they consider appropriate. Although informal in their content, these notes should be mandatory in order to form lifelong learning skills through inquiry-based learning.

Conclusions

This short communication presents the evolution of educational constructivist paradigms from the concept of *learning by doing* to the one of *learning by being* in terms of their impact on academic achievement of school students. The author emphasizes that active learning is not yet understanding, and its impact factor could be lower than conventional teaching. Moreover, apparent understanding is not equivalent to the formation of lifelong learning skills, or to the formation of that knowledge "which is not forgotten".

In order to achieve its main goal, namely scientific understanding of the world by the majority of population, the modern education should be based on students' learning effort and make them assume the ownership on learning goals. More simply, for students the desire and effort for knowledge should come intrinsically – the core idea of learning by being concept. Students' intrinsic intellectual effort is the base for their conceptual, scientific understanding of the world of things and phenomena.

https://doi.org/10.33225/BalticSTE/2021.32

Along with intellectual effort, learning by being is based on metacognition, which relates with the didactical principle of consciousness of learning. It means that students not only understand what they do but understand their own way of thinking. In these given conditions, the teacher turns into a coach who must provide the emotional environment for *guided self-scaffolding*.

The concept of learning by being changes the format of teacher – student communication. For a fruitful learning process, we should have a permanent student – teacher mutual feedback. It is according with the *theory of visible teaching and learning* when both the student and the teacher have the same cognitive/didactic goals. In this sense, the author emphasizes that feedback – based strategies have the biggest impact factors. However, the most valuable strategies are those focused on the management of multilateral feedback or teacher's ability to coordinate the group work within inquiry-based classroom activities.

In order to give practical solutions for application of the concept of learning by being, the author structures both teacher and students' activity in classroom on the example of inquiry – based science education project. Thus, in the development of fruitful teacher – student interaction the teacher will focus on the following aspects: the formation of students' ideas; supporting students' research; guidance within analysis and drawing conclusions. Related to students, the most important for teacher is to focus on making students assume the objectives of the research, to manage their group work, and get them familiar with discussions and debates.

References

Arioder, L. J. Q., Arioder, V. Q., Quintana, V. V., & Dagamac, N. H. (2020). Application of constructivist teaching approach in introducing new environmental concepts to young elementary students in the Philippines: A small class sized experience from slime moulds modelling. *Interdisciplinary Journal of Environmental and Science Education*, *16*(2), Article e2214. https://doi.org/10.29333/ijese/7818

Berube, C. T. (2001). *A study of the effects of constructivist based vs. traditional direct instruction on 8th grade science comprehension,* Doctor of Philosophy (PhD), dissertation, Old Dominion University, https://doi.org//10.25777/0abc-wf06

Calalb, M. (2019). Correlation between visible teaching and inquiry-based learning. In *Proceedings of the World Conference on Teaching and Education* (18–20 October, 2019) (pp. 81-88). Budapest. https://www.dpublication.com/wp-content/uploads/2019/10/55-CTE.pdf

Calalb, M. (2020). Learning by being or assumption of cognitive goals. *Studia Universitatis Moldaviae (Seria Ştiinţe ale Educaţiei)*, *5*(135), 49-54. https://doi.org/10.5281/zenodo.3967033

Harlen, W. (2010). *Principles and big ideas of science education*. ASE.

Hattie, J. A. C., & Donoghue, G. M., (2016). Learning strategies: A synthesis and conceptual model. *npj Science of Learning*, *1*, Article 16013. https://doi.org/10.1038/npjscilearn.2016.13

Hattie, J. A. C. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement* (1st Ed.). Routledge.

Hattie, J. A. C. (2017). *Hattie's 2017 updated list of factors influencing student achievement*. https://apsuperintendent.edublogs.org/2017/11/18/hatties-2017-updated-list-of-factors-influencing-student-achievement/

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. Educational Psychologist, *41*(2), 75-86, https://doi.org/10.1207/s15326985ep4102_1

Millis, B. J., (2016). Using metacognition to promote learning. *IDEA Paper #63*, December 2016, https://www.ideaedu.org/Portals/0/Uploads/Documents/IDEA%20Papers/IDEA%20Papers/PaperIDEA_63.pdf

Nicol, D. J., & Boyle, J. T. (2003). Peer instruction versus class-wide discussion in the large classes: A comparison of two interaction methods in the wired classroom. *Studies in Higher Education*, *28*(4), 458-473. https://doi.org/10.1080/0307507032000122297

PISA, (2017). *PISA 2015 assessment and analytical framework. Science, reading, mathematic, financial literacy and collaborative problem solving* (Revised ed.). OECD Publishing.

Scharff, L., Draeger, J., Verpoorten, D., Devlin, M., Dvorakova, L. S., Lodge, J. M., & Smith, S. (2017). Exploring metacognition as support for learning transfer. *Teaching & Learning Inquiry*, *5*(1), 78-91. http://dx.doi.org/10.20343/teachlearninqu.5.1.7

Received: *May 29, 2021* Accepted: *August 02, 2021*

Cite as: Calalb, M. (2021). Assumption of cognitive goals in science learning. In. V. Lamanauskas (Ed.), *Science and technology education: Developing a global perspective. Proceedings of the 4th International Baltic Symposium on Science and Technology Education (BalticSTE2021)* (pp. 32-38). Scientia Socialis Press. https://doi.org/10.33225/BalticSTE/2021.32