The Impact of Inquiry Based Science Education on the Formation of Lifelong Learning Skills

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Abstract

The pedagogy of inquiry-based science education (IBSE) is examined as an appropriate response to the main challenge of educational systems in knowledge-based society: increased demand for scientifically literate labour force with analytical thinking skills. Being widely applied, IBSE contributes to the fact that the majority of population understands the natural phenomena and societal events and is aware how science operates and how technology shapes the material and intellectual world. Bringing the intellectual challenge into the classroom and putting the accent on the satisfaction of child's natural curiosity, IBSE forms the basis for a profoundly scientific understanding of the world and, in the long run, determines the success of personality's lifelong learning path. IBSE is a constructivist pedagogy which, through its cyclical structure, correlates with project-based learning. All deliverables of an IBSE project belong exclusively to students, and in this sense, inquiry-based learning is an active learning. IBSE offers to the groups of students a higher degree of freedom enabling them formulate hypotheses, to build and further test models and formulate the laws. IBSE is about actively acquired knowledge. The essence of IBSE is to shape those skills which are necessary for lifelong learning. The skills could be structured into few categories: a) Social interaction and group collaboration skills meaning the inclusion of the student with his/her ideas and capacities, attention to the peers' ideas, ability to analyze the situation from several points of view; b) Skills related to the interaction and exploration of material world – observation, measuring, questioning, researching. These skills form the attention to details, teach students use measuring devices and understand the sense of collected data; c) Reasoning skills – when IBSE is applied permanently students come gradually to the scientific understanding of phenomena. Thus, the learning process developed in an IBSE way forms students' scientific vision and conception about the world – an objective which is practically at the horizon of school education; d) Communication skills –the ability to present in public the results of the research of the own group is a valuable because, along with oratory skills, the active scientific vocabulary rich in notions, terms, definitions is formed.

Keywords: inquiry-based science education, scientific literacy, lifelong learning

1. Many-sided context of IBSE

Demand for scientifically literate population

According to the report of Rocard commission there is a discrepancy between the demand of knowledge-based society in qualified labor force and the offer of educational systems. Even initial, entry level positions require analytical thinking, familiar with epistemological principles [1]. Thus, the way we teach science is crucial for the scientific alphabetization of all citizens. A positive attitude toward science has to be formed in school. The definition of scientific literacy has four indispensably linked key aspects [2]:

- Ability to apply scientific knowledge for acquiring another new knowledge.
- Understanding the particular features of the science as a distinct form of human knowledge.
- Awareness of how science and technology shape the material, intellectual and cultural world.
- Readiness to get involved as active citizen in science-related topics.

In this way, inquiry-based learning offers opportunities for cumulative development of students' knowledge, understanding and interest in science. On long run, the basic scientific knowledge obtained in school along with interest in science formed in early school years are the basis for personal and professional growth of the personality.

The teacher within IBSE pedagogy

There are several ways to prepare teachers for applying inquiry in their classes [3]:

- Initial and continuous education of teachers in IBSE pedagogy.

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- Development of networks of teachers as the best way for experience and information sharing.
- Mentoring as a mean for practical knowledge transfer and guidance.

Also professional development programs for school and preschool teachers are required. Such programs could be structured on four levels:

i. Scientific formation which includes: *a)* teachers' scientific knowledge and understanding of taught content; *b)* participation of teachers in research projects – the base for correctly taking into account the feedback and designing interactive learning environment.
ii. Methodological formation: *a)* learning and implementing best teaching practices; *b)* training in involving students into inquiry projects.
iii. Continuous professional development: *a)* allocation of time, resources and long – term support for teachers in order to enable them elaborate and integrate in their practices new content and teaching approaches; *b)* sharing of successful methods and didactical materials among teachers.
iv. Favorable external environment: a) awareness of population toward science; b) rallying to educational standards, programs and policies accepted in other developed countries.

Students' motivation

The name of the teaching-learning process reflects the mechanistic approach of transmitting knowledge from the teacher to the pupil. The failure of this act lies in the discrepancy between what adults see as relevant and how students look at the things. Born in the digital age, they realize that today knowledge will become outdated and useless. From this point of view, the inquiry-based learning contrasts with the majority of science lessons. We have to emphasize that a laboratory work performed in group isn't necessarily an active learning crowned with deep understanding of studied phenomenon or event. Because even if students practice in groups, they only repeat the teacher's precise instructions, such "research" excludes wondering, satisfaction of curiosity, question, student's mistake, or, generally speaking, the absence of intellectual challenge. The fact that namely the students have the main role in the identification of alternative ways for the explanation of phenomena, and in interpretation of collected data is the essence of inquiry-based learning. Thus, the way we teach has the central role in ensuring the relevance of learning. Implementation of IBSE would require series of fundamental changes which are related to:

- Curricula content
- Teaching approach
- Correlation of the content with modern science
- The form and the aim of evaluations.

These changes can't take place without a clear and broad understanding of IBSE paradigm and how it should be correlated with desirable students' knowledge and skills. Thus, the changes go far beyond the scope of solitary teachers or schools which can't change the requirements of the curriculum or the form of the assessment.

2. IBSE and problem-based learning

Nature of IBSE

IBSE is based on children's active role in the formation of their ideas about the world due to their natural curiosity, imagination and willingness to explore and research. In fact, IBSE reflects the long and laborious chain of discussions, argumentations, tests and modifications of scientific hypothesis. IBSE combines several theories, such as: Bloom's taxonomy, multiple intelligences, whole method, etc. Thus, it is a strategy which is based on:

- Advanced involvement of students –obtained knowledge is the result of their own intellectual effort.
- Accession of multiple learning ways, self-paced learning.
- Sequential structuring of learning process around "big scientific ideas".

The knowledge obtained within student's own research is much more relevant than the one provided by the teacher in the form of undeniable and rigid truths. This approach should be found both in the structure of curricula and in the organization of learning process which have to lead to a meaningful knowledge and not to the "acquisition" by students of information provided by teacher. From other

side, involving multiple intelligences of students, we get more students actively involved into the learning process. Thus, the knowledge obtained through personal research and involvement of the student has a profound character reaching the level that contributes to the proper understanding of the world and to the formation of his/her cognitive personality. Also student – student collaboration within IBSE amplifies the assimilation of the obtained knowledge, while student – teacher collaboration forms research, inquiry kills which will be applied long after school graduation.

IBSE projects

IBSE is similar to project-based learning having the following main features:

- IBSE lesson starts with an open question or a demonstration avoiding ready-made definitions and explanations.
- The teacher collects students' answers and directs them to "correct" questions or hypotheses.
- The collaboration between students within teams in planning the experiment or research methods.
- Based on the accumulated data, the question is reformulated and a new set of data is collected.
- The students present and debate with colleagues the results of their research.

Inquiry-based learning is useful where it is important to develop understanding. IBSE takes into account how pupils learn best - namely through their mental and physical activity. The ideas can be understood, not learned superficially, only if the students come to them through their own reasoning about the experiments they themselves have carried out. This learning modality includes: the formation of observation skills, the formulation of proper research questions, the planning and conducting the research, the examination of data obtained in the context of what is already known, the formulation of conclusions and the communication of results [4].
IBSE is similar to problem-based learning, but has its distinctive elements: the main accent is on the way science is taught, as this is the main cause for the decline of interest in science; the shift from deductive methods to inquiry-based learning is a way to raise interest in science. It means that the science should be learned in a scientific way.
IBSE pedagogy extends the boundaries of the educational act beyond the lesson and class, combining formal and informal learning, and offering opportunities for interconnection in a single network of all educational stakeholders: from universities and researchers to local authorities and companies. But the teacher plays the main role within these networks. The participation in such a network increases the quality of the teacher's work and is the source of his/her professional development.

3. IBSE and lifelong learning skills

The starting point in the construction of the IBSE concept was the lack of motivation determined by the fact that students don’t see the meaning for storing in their head of pieces of information from randomly selected domains. Thus, following the traditional paradigm, we lose the opportunity for teaching science in a way which forms to students such valuable skills like communication, analysis, problem solving which enable them become active citizens in knowledge-based society. Within IBSE classes the students obtain reasoning and action skills as researchers and understand the nature of science as a distinct part of human activity [5]. After all, understanding how science studies the world enlightens the person with a strategy for solving many problems in everyday live. We may conclude that IBSE method gives pupils the basic inquiry and scientific research skills:

- Planning and development of scientific research. Formulation of verifiable hypotheses, identification of logical connections between hypotheses.
- Usage of technologies and mathematics for improving research, data collection and interpretation.
- Formulation and revision of explanations or elaborated scientific models based on logic and data.
- Presenting and publicly debating a model. Recognition of alternative models or explanations. As a whole, it is about communication.

The formation of those research skills which will further allow efficient lifelong learning is the essence and the primary goal of IBSE. In this context is important to identify the set of the skills which will ensure continuous development of personality. These skills could be structured in the following way:

- Research skills linked to social interaction and collaboration: team work with colleagues, public reporting when each member of the group brings his/her distinct contribution to the final product. The formation of cognitive skills should be based on social education. Learning from others is a necessary ability throughout life and includes sharing ideas, building attention to colleagues' ideas, and taking responsibility for the common outcome. Another aspect of collaboration – children realize that the outcome of joint work is more valuable than in a solitary case.
- Skills related to the collection of information about the world. These skills form the attention to details, familiarize with the concept of fairness of the experiment, teach students to use measuring tools and devices and understand the meaning of what they measure.
- Analytical and reasoning skills: testing of hypotheses, drawing conclusions, explanations of results. It is about understanding the meaning of collected data. Constantly applied, IBSE leads students to the scientific understanding of things. The accumulation of chaotic facts cannot contribute to the formation of scientific vision about the world.
- Communication skills: writing, speaking, listening, argumentation, evaluation. They relate to the ability to present and defend the own results, to have a critical point of view. Efficient communication necessarily implies a rich vocabulary, knowledge of scientific terms, definitions, symbols.

References

[1] International Council for Science. “Report of the ICSU Ad-hoc Review Panel on Science Education”, Paris, ICSU, 2011, pp. 7-8, ISBN: 978-0-930357-83-2.
[2] PISA 2006: “Science Competencies for Tomorrow's World”, Volume 1: Analysis, OECD Publishing, Paris. OECD, 2007), pp. 34-35, ISBN 978-92-64-04000-7.
[3] Istrate O. et al., “Învățarea prin proiecte eTwinning: compendiu de practici didactice inovative realizate prin activități de parteneriat cu școli europene”, [in Romanian], București: Ed. Universitară, 2013.
[4] Harlen W., “Taking Inquiry-Based Science Education into Secondary Education”, Reports of IAP Science Education Program, York, United Kingdom, October 27 – 29, 2010, p. 5.
[5] Alberts B., “Some Thoughts of a Scientist On Inquiry” in: Inquiring into Inquiry Learning and Teaching in Science, ISBN 0-87168-641-4 AAAS Publication 00-1S, 2000, p. 8.