

# COLLABORATIVE, ICTS SUPPORTED LEARNING SOLUTIONS FOR SCIENCE EDUCATION BASED ON THE SSIBL FRAMEWORK

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## ABSTRACT

*PARRISE ("Promoting Attainment of Responsible Research and Innovation in Science Education", 2014-17) is a project of the 7th Framework of the European Union, involving a transnational community of science teachers, trainers, communicators, and curriculum experts from 18 institutions in 11 countries. Its major objective is to engage young people in learning science through experiencing its societal impact. The paper introduces the educational framework for socio-scientific inquiry-based learning (SSIBL) and shows results of its implementation in a teacher professional development course series at ELTE University, Faculty of Science, to enhance the pedagogical repertoire and increase affective components of science literacy of teachers.*

## INTRODUCTION

In Hungary, student performance in national as well as international science surveys keeps declining while best students still excel at International Student Olympics and other competitions. Educational efforts seem mainly to target high performers and transmits knowledge and skills necessary to embark on a scientific or technological career. We hope to modify this situation through developing an awareness in science teachers towards socially relevant issues – an aspect that is emphasized as increasingly important all over Europe, according to a recent study by the European Commission [1]. When engaging in socially relevant topics, a wider range of students may be motivated to learn science and eventually become a better informed and more engaged citizen.

We joined the EU-supported *Promoting Attainment of Responsible Research and Innovation in Science Education (PARRISE)* project to take part in the development and adaptation of its new framework in collaborative, ICTs-supported learning environments for use for establishing new in-service training programs for Physics teachers. Our major objective is to provide alternatives for traditionally hierarchical, driven by methods transmission in-service training and create a network of knowledge-builders –a community of teachers supported by resources shared through digital technology (the Moodle e-learning environment and social computing tools). A training course for experienced and innovative teacher communities like those applying for admission to one of Hungary's leading research universities, seem to the best environment for presenting and adapting new models through networked learning methods [2]. In this paper, we introduce the SSIBL concept and show how it is being used for the professional development of Hungarian teachers.

## THE SSIBL FRAMEWORK: A NEW MODEL FOR INTRODUCING RESPONSIBLE RESEARCH SCIENCE EDUCATION

The SSIBL Framework is being developed by the PARRISE project, a European community of science teachers, teacher trainers and educational researchers whose activities centre on integrating current issues of science and society at school. Through experiencing the societal impact of research and innovation, this approach intends to increase the agency and motivation of young people for pursuing studies in science. By becoming more scientifically literate, young citizens are better equipped to participate in the process of science innovation. PARRISE also intends to improve pre- and in-service science teacher education through sharing best practices of professional development for primary and secondary teachers in Europe.

The project objectives are as follows (cf. [3] for details and publications):

1. Provide an overall educational framework for socio-scientific inquiry-based learning (SSIBL) in formal and informal learning environments;
2. Identify examples of best practice;
3. Build transnational communities consisting of science teachers, science teacher educators, science communicators, and curriculum and citizenship education experts to implement good practices of SSIBL;
4. Develop the SSIBL competencies among European primary and secondary science teachers and teacher educators;
5. Disseminate resources and best practice through PARRISE website, digital and print-based publications online and face to face courses authored by national and international networks;
6. Evaluate the educators' success using the improved SSIBL materials with pre-service and in-service teachers.

The project team collects and shares existing best practices in European science education and develops learning tools, materials and professional development courses for based on the SSIBL approach. *Socio-Scientific Inquiry-Based Learning* (SSIBL) is meant to address the need for a heightened awareness of the role of research in contemporary society through expanding teachers' perceptions about the aims and objectives of science education. The model is based on the concept of Responsible Research and Innovation (RRI).

*“At the moment, Europe faces a shortfall in science-knowledgeable people at all levels of society and the economy. Over the last decades, there has been an increase in the numbers of students leaving formal education with science qualifications. But, there has not been a parallel rise in the numbers interested in pursuing science related careers nor have we witnessed enhanced science-based innovation or any increase in entrepreneurship. Science education research, innovation and practices must become more responsive to the needs and ambitions of society and reflect its values. They should reflect the science that citizens and society need and support people of all ages and talents in developing positive attitudes to science. We must find better ways to nurture the curiosity and cognitive resources of children. We need to enhance the educational process to better equip future researchers and other actors with the necessary knowledge, motivation and sense of societal responsibility to participate actively in the innovation process” [4].*

The SSIBL framework [5], [6] connects RRI with three pedagogical concepts. *Inquiry-based Science Education* (IBSE): this model has always been at the core of Hungarian Physics education, and is being gradually adapted by other science disciplines as well. It focuses on empowering students to act as researchers and them not only facts also problems and solution scenarios to experiment with. Case studies, field-work, investigations in the school laboratory or even complex or research projects can be involved in this educational approach. Teachers who employ it believe that ideas are fully understood only if they are constructed by students through reflections on their own experiences. For STEM (Science,

Technology, Engineering and Mathematics), this approach is especially important, but may be successfully used in the arts and humanities as well (EC-FP7 projects promoting an IBSE approach are, for example, PROFILES, SAILS, Pathways, PRIMAS or Fibonacci) [7]. This model has proven useful also in teacher professional development [8].

*Socio-scientific Issues (SSI)* are open-ended science problems which may have multiple solutions. Most of them involve controversial social issues as well, which are closely connected to research and innovation in science. SSI may be successfully utilised in science education to enhance the ability to apply both scientific and moral argumentation and develop solutions in relation to real-world situations like climate change, genetic engineering, advertisements for increased consumption of unhealthy food, animal testing for cosmetic purposes, or the use of nuclear power as cheap and clean energy resource. SSI is highly efficient in promoting scientific literacy and increasing students' understanding of science in various contexts. Involvement with controversial scientific issues also enhances argumentation skills and, through developing empathy, contributes to the acquisition of moral reasoning.

*Citizenship Education (CE)*: “can be defined as educating children, from early childhood, to become clear-thinking and enlightened citizens who participate in decisions concerning society. ‘Society’ is here understood in the special sense of a nation with a circumscribed territory which is recognized as a state” [9]. It involves an awareness of the rules of law and other regulations that concern social and human relationships. CE also provides an orientation for the individual on ethics the rights inherent in the human condition (human rights); and those that are related to being the citizen of his country, civil and political rights recognized by the national constitution of the country concerned. Recent research on citizenship education in science shows that focusing on civil rights and responsibilities can be efficiently integrated with teaching about responsible research and innovation [1]. The interrelations of these four pillars of the model are represented in Fig.1.

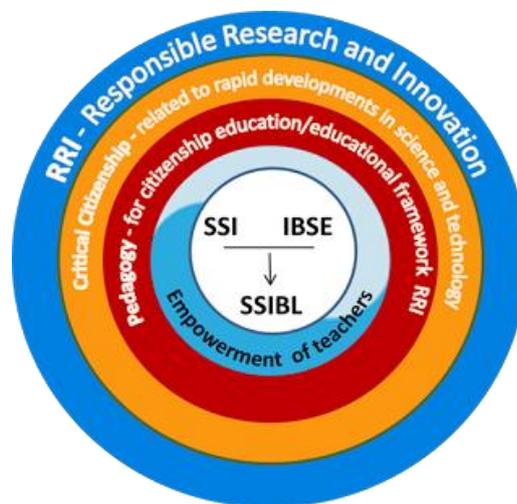


Fig.1. The Socio-Scientific Inquiry-Based Learning (SSIBL). Source: [6]

## METHODOLOGY

In our first teacher professional development (TPD) course for teachers of Physics, based on the SSIBL framework and delivered in the second half of the academic year 2014-15, we organised a networked system of learners who developed active, collaborative agency around shared knowledge objects, according to the triological model of learning [10]. Teachers as knowledge builders worked and learnt together in a mentored innovation setting [11]. This setting is meant to introduce teachers new methods through investigating their pedagogical

needs and offering new strategies that suit them best. The learning triangle involves the teacher as learner and peer tutor at the same time, a mentor who also acts as role model for teaching and research, and a knowledge object: in our case, a new learning unit to be developed (Fig.2.).

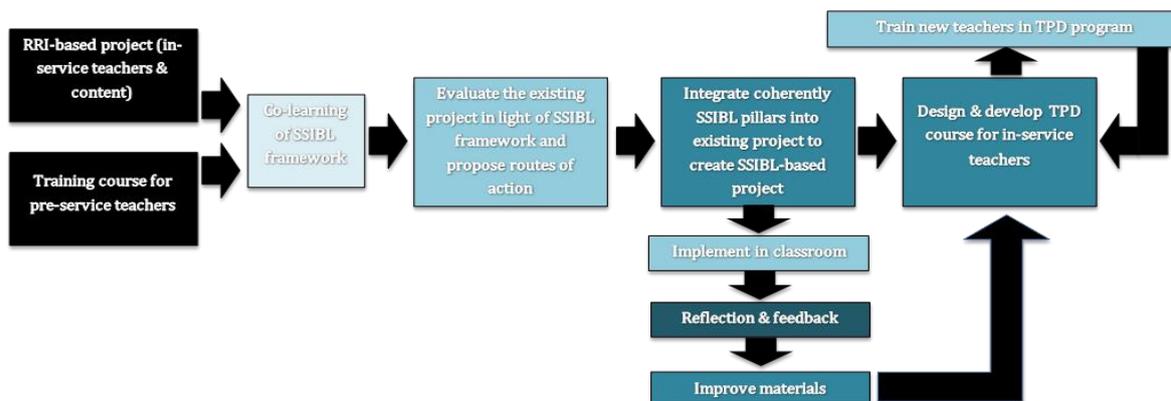


Fig.2. Model for the Hungarian in-service teacher training program based on the SSIBL framework

One of the goals set for the teacher network was to investigate a socially sensitive scientific domain, namely, the use of nuclear energy. We used the Moodle e-learning environment for sharing good practice and discuss issues of adaptation, and also employ social computing (Web 2.0) tools like science blogs and interactive science portals – a format especially important to meet changes of science media consumption [12].

Teachers were expected to introduce the SSIBL framework in their teaching as they felt most appropriate (in the form of an interdisciplinary lesson, a project week, an informal learning opportunity in a science centre or museum, or in a lesson sequence addressing socially sensitive research issues). TPD participants delivered a pedagogical essay and digital teaching materials on strategies of teaching about one of the four main subject areas of the course: modern physics, microphysics, astronomy, and chaotic dynamics and manifest how they adapted the educational framework explained in this paper. Community driven inquiry learning based on progressive inquiry and collaboration was especially suitable for involving students in disputed, social issues related to science [13]. The four pillars of SSIBL were employed in structuring course content:

1. RRI: traditionally, scientific discoveries are described as a final product of research. In this course, they were presented as *an interrelated complex of research endeavours and relevant social processes*. First, the conception of the research idea and (potential) social needs manifest in it was presented, then phases of the research where social issues were at stake were highlighted. Finally, a discussion of related innovations that raised social issues.
2. IBSE: *presentations were followed by experimentation*, where teachers acquired new scientific investigation skills. For example, they learnt how to apply information and communication technology (ICTs) tools for modelling processes and exploration of data. Teachers were also informed about still unresolved issues and encouraged to enhance student skills to develop different explanations.
3. SSI: most of the topics included in this course have *high social relevance for Hungary* (e.g. the generation and use of nuclear energy, “Big Bang” and Creation “theories”, the butterfly effect and other naïve beliefs and scientific explanations, etc.). Media

coverage of these issues were discussed and the moral implications of science communication – a field bordering on science education – was revealed.

4. CE: teachers were expected to act like responsible citizens (and trainers of such) and identify connections among current research in the field of Physics, critically reflect on curricula and propose means for future improvement, involving the inclusion of the results of New Physics.

## CONCLUSIONS

The first iteration of the course, with nuclear energy and related social issues in focus, suggests improved social skills and heightened interest in the public understanding of science and research based policy making – both necessary for developing responsible researchers and citizens as well. We hope to have *introduced social and ethical concepts* that promote teachers' reconceptualization of their teaching content and do beyond teaching, towards the education of morally responsible, ethics-driven citizens [14]. Teachers have retooled their teaching processes through the *employment of ICTs solutions* as simulations, measuring tools or communication devices that facilitated the creation of an interactive science education environment. ICTs solutions should not replace real life experiments, but are inevitable for widening access and also for introducing experiments that were impossible to deliver otherwise in a classroom setting.

A second iteration currently undertaken centres around climate change – another crucial issue for Hungary where agriculture is a major factor in national economy. In this iteration, we intend to *increase the collaborative aspects* of our TPD. Collaborative knowledge building in teacher education is planned to relate to learning that occurs partially in an informal setting, the Moodle virtual learning environment that supports situated cognition and situated learning in knowledge building communities. In its ideal form, such a collaboration involves the mutual engagement of learners in a coordinated effort to solve a problem together or to acquire new knowledge together [15]. We intend to use cooperative learning methods based on cognitive apprenticeship that result in knowledge-building communities that offer peer tutoring and support [11]. In these collaborative learning models, mature communities of practitioners participate in inquiries at the frontiers of knowledge. Their activities with their mentors during the TPD process will be characterised as a transformative communication for learning.

Through collaborative methods [16], we hope to embed social issues relating to science in Physics education while retaining its major merit: its hands-on, experiment-based character. We also hope to empower Physics teachers to realise the goals of *The Framework for Science Education for Responsible Citizenship*. Its 5<sup>th</sup> objective: “Greater attention should be given to promoting Responsible Research and Innovation (RRI) and enhancing public understanding of scientific findings including the capabilities to discuss their benefits and consequences”, Its 6<sup>th</sup> objective: “Emphasis should be placed on connecting innovation and science education strategies, at local, regional, national, European and international levels, taking into account societal needs and global developments” [1]. Both are in line with the SSIBL Framework and the methodological repertoire currently under development by an international team with the membership of the authors of this paper.

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