CHALLENGES OF CONTEMPORARY EDUCATION AND HOW TO OVERCOME THEM

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Abstract. This paper explores the critical role of scientific literacy in addressing 21st-century challenges such as sustainable development and technological advancements. The "Ruka u testu" project in Serbia, inspired by the French "La main à la pâte" initiative, exemplifies this effort. The article details the project's international collaboration, which enhances its resources, methodologies, and impact through partnerships with the French Academy of Sciences and other institutions. The implementation of inquiry-based learning in Serbian schools, highlighting pilot programs, curriculum integration, teacher training, and continuous support is discussed. Also, this communication provides an overview of the inquiry-based learning modules, emphasizing hands-on experiments, interdisciplinary connections, and reflective discussions. These efforts aim to transform science education by fostering critical thinking and engagement among students. The "Ruka u testu" project's success is bolstered by ongoing professional development and international cooperation, ensuring that educators are equipped to provide high-quality science education.

Keywords: scientific literacy, inquiry-based learning, international collaboration, hands-on science education.

Rezumat. Această lucrare explorează rolul esențial al alfabetizării științifice în abordarea provocărilor secolului al XXI-lea, cum ar fi dezvoltarea durabilă și progresul tehnologic. Proiectul „Ruka u testu” din Serbia, inspirat de inițiativa franceză „La main à la pâte”, exemplifică acest efort. Articolul detaliază colaborarea internațională a proiectului, care îmbunătățește resursele, metodologiile și impactul acestuia prin parteneriate cu Academia Franceză de Științe și alte instituții. Este

prezentată implementarea învățării bazate pe cercetare în școlile din Serbia, evidențiind programele-pilot, integrarea în curriculum, pregătirea cadrelor didactice și sprijinul continuu. De asemenea, această comunicare oferă o privire de ansamblu asupra modulelor de învățare bazate pe cercetare, accentuând experimentele practice, conexiunile interdisciplinare și discuțiile reflexive. Aceste eforturi vizează transformarea educației științifice prin promovarea gândirii critice și implicarea elevilor. Succesul proiectului „Ruka u testu" este consolidat de dezvoltarea profesională continuă și de colaborarea internațională, asigurând echiparea metodologică adecvată a profesorilor pentru a furniza o educație științifică de înaltă calitate.

Cuvinte-cheie: alfabetizare științifică, învățare bazată pe cercetare, colaborare internațională, educație științifică prin practică.

Introduction

A society's attitude towards its heritage is most evident through its attitude towards the level of scientific literacy of every member of the young generation and the assistance provided to teachers and schools in achieving this goal. Because that's the only way the civilisation of the 21st century can competently confront the following challenges:

- The necessity for each individual's conduct to be harmonised with the concept of sustainable development;
- Existing development in which nature is to the fore and everything else is subservient, with which activities characteristic of the industrial revolution are reduced drastically;
- New technologies that are characterised by multi-disciplinarity, interdisciplinarity and trans-disciplinarity, coupled with a reliance on nanotech, cognitive technologies, information science and biotechnology;
- The teaching approach introduced by the ancient Greeks, which experienced significant transformation during the Renaissance, with the advent of the printing press, when Montaigne himself said that he would rather have a

guide with a well-made head than a well-filled one, and now it is set to undergo even more significant changes with the advent of digitalisation.

That's why every educator, tutor or subject teacher, of any educational institution at any level of the education system, is confronted by the following three questions:

Who are we addressing today? Young people whose education is provided through the use of book culture and screen culture; users of the results of the first quantum technological revolution, but contemporaries of current trends of the second quantum technological revolution, as well as a cultural, cognitive and psychological shift; youngsters who look at a picture for seven seconds and take 15 seconds to find an answer, who spend more than five hours in front of some kind of screen and will, in the next few decades, have a vocabulary that's about 30,000 new words richer... Nevertheless, the data shows that, on the basis of a survey of approximately 900,000 adolescents in France (data from the magazine CLEFS NO64, 2014, p.30), upon completing primary and secondary school, around 25% of pupils are unprepared for the challenges they face today! I don't have the data for Serbia!

What should we offer them? Perhaps curricula that, apart from taking a disciplinary approach, will also use an interdisciplinary one, with complex topics from everyday life. The possibility of providing greater freedom for teachers and the more active participation of pupils in the teaching process, with the use of non-formal and informal education, and more formative evaluation.

How can that be done? Try to apply teaching approaches based on research, projects, STEM and STEAM ((Science, Technology), Engineering/Art, Maths). These teaching approaches are coherent and attractive to all learners, because they respect not only their social, cultural and geographical differences, but also the specificities that are imposed on them by every school-centred situation.

Education is a discipline of intervention, because the teacher has to react in an appropriate way at a given moment. That's why they need resources, first and foremost! Under the scope of the Hands in the Dough (Ruka u testu / Hands-on)

project, over the course of 20-odd years, teachers had at their disposal 20 books (mostly translated from French and English), 15 books in digital format available to be downloaded for free, around a dozen types of inexpensive experimental boxes that can be made in every school, the YouTube channel Informatika i nauka za sve [Informatics & Science for Everyone] (40,000 views), the website Ruka u testu [Hand in the dough / Hands-on] (containing more than 3,000 pages), around a dozen exhibition-workshops, multiple seminars, lectures etc. These resources were created within the framework of: the contract between the French Academy of Sciences, the Serbian Academy of Sciences and Arts - SANU and the University of Belgrade; international cooperation under the scope of EU projects SUSTAIN and FIBONACCI; cooperation among the collaborators in the Ruka u testu project and foundation La main à la pâte, the global network of science academies InterAcademy Partnership - IAP and the French Institute in Belgrade, with which we are also implementing this exhibition-workshop “Science and informatics for every child”.

I. Origin and Support for "Ruka u testu" project from "La main à la pâte"

The "Ruka u testu" project in Serbia is part of a broader international initiative known as "La main à la pâte," which originated in France. This international collaboration plays a crucial role in enhancing the project's resources, methodologies, and overall impact. Here are the key aspects of this international collaboration.

Foundation and philosophy - "La main à la pâte" was founded in 1996 by the French Academy of Sciences. It aims to improve science education through hands-on, inquiry-based learning. The philosophy and pedagogical principles of "La main à la pâte" serve as the foundation for "Ruka u testu."

Adoption and adaptation - The Serbian project adopts and adapts the pedagogical approaches and teaching materials developed by "La main à la pâte." This includes translating resources into Serbian and modifying them to fit the local educational context.

International workshops and seminars - Serbian educators participate in international workshops and seminars organized by "La main à la pâte". These events provide training in inquiry-based science education and offer opportunities to learn from experts and peers from other countries.

Exchange programs - There are exchange programs where Serbian teachers and educators visit schools and institutions in other countries to observe and learn from their implementations of inquiry-based science education. Similarly, educators from other countries visit Serbian schools to share their experiences and insights.

Access to a global repository - "Ruka u testu" benefits from access to a rich repository of educational resources, including lesson plans, teaching modules, and multimedia materials developed by "La main à la pâte" and its international partners.

Collaborative development: - Serbian educators collaborate with their international counterparts to develop new teaching materials and resources. This collaborative development ensures that the materials are culturally relevant and pedagogically sound.

Joint research projects - The project participates in joint research initiatives with international partners to study the effectiveness of inquiry-based science education. These research projects help to evaluate and refine the teaching methods and materials used in the project.

Publication and dissemination - Findings from these research projects are published in international journals and presented at conferences, contributing to the global body of knowledge on science education. Serbian educators and researchers actively participate in these dissemination efforts.

Global educator networks - The project is part of a global network of educators and institutions committed to improving science education. This network facilitates the exchange of ideas, best practices, and support among educators from different countries.

International conferences - Educators and coordinators from "Ruka u testu" participate in international conferences and symposiums on science education. These events provide platforms for presenting their work, learning from others, and building professional relationships.

International grants and funding - The project receives funding and support from international organizations and foundations dedicated to education and science. This financial support is crucial for sustaining and expanding the project's activities.

Collaborative grant applications - Serbian educators collaborate with their international counterparts to apply for grants and funding opportunities. These collaborations increase the chances of securing funding and enhance the project's capacity to achieve its goals.

Promoting global citizenship - Through its international collaborations, the project promotes global citizenship and intercultural understanding among students and educators. It helps students appreciate the global nature of scientific inquiry and the importance of international cooperation in addressing scientific and societal challenges.

Diverse international perspectives - Exposure to diverse educational practices and perspectives enriches the teaching and learning experiences in Serbian schools. It encourages educators to innovate and adopt new approaches that have been successful in other contexts.

By leveraging these international collaborations, the "Ruka u testu" project in Serbia is able to enhance the quality and reach of its inquiry-based science education initiatives. The collaboration brings in valuable resources, expertise, and perspectives, making the project a dynamic and impactful educational endeavor.

II. Implementation of "Ruka u testu" in schools

Selection of pilot schools - Initially, the project selects a number of pilot schools to implement its programs. These schools serve as testbeds for developing and refining the project’s methods and materials.

Integration into curriculum - The project works closely with these schools to integrate inquiry-based science modules into their existing curricula. This involves adapting teaching materials to align with national education standards and school-specific needs.

Classroom activities - Teachers use the provided modules to conduct hands-on science activities. These activities encourage students to engage in scientific

inquiry by forming hypotheses, conducting experiments, observing results, and drawing conclusions.

Workshops and training sessions - The project organizes workshops and training sessions for teachers. These sessions cover the principles of inquiry-based learning, the use of specific teaching modules, and strategies for fostering student engagement and curiosity in science.

Continuous support - Teachers receive ongoing support through mentoring and coaching. Experienced educators and project coordinators provide guidance on effectively implementing the modules and addressing any challenges that arise.

Resource provision - Schools are provided with resources such as teaching guides, experiment kits, and digital tools that support inquiry-based science education.

Teacher networks - The project fosters the creation of networks where teachers can share their experiences, exchange best practices, and collaborate on developing new teaching strategies. These networks often operate both in-person and online.

Professional learning communities - Schools participating in the project often form professional learning communities (PLCs). Within these PLCs, teachers collaborate to plan lessons, reflect on their teaching practices, and assess student outcomes.

Science clubs and camps - The project encourages the formation of science clubs and the organization of science camps where students can further explore scientific concepts through extracurricular activities.

Competitions and exhibitions - Students have opportunities to participate in science fairs and competitions, showcasing their projects and experiments. These events celebrate student achievements and foster a culture of scientific inquiry and innovation.

Monitoring student progress - The project includes mechanisms for monitoring student progress and assessing the impact of inquiry-based learning on their understanding of scientific concepts. This involves both formative and summative assessments.

Teacher feedback - Teachers provide feedback on the effectiveness of the

modules and the training they receive. This feedback is used to continuously improve the project's resources and support mechanisms.

Research partnerships - The project collaborates with educational researchers to study its impact and effectiveness. Findings from these studies help refine the project and contribute to the broader field of science education.

Expansion to more schools - Based on the successes and lessons learned from pilot schools, the project gradually expands to include more schools across Serbia. This scaling process is carefully managed to ensure the quality and sustainability of the program.

Publications and sharing best practices - The project disseminates its findings, teaching materials, and best practices through publications, conferences, and online platforms. This helps spread the inquiry-based learning approach to a wider audience of educators and policymakers.

Through these collaborative efforts, the "Ruka u testu" project aims to transform science education in Serbia by making it more engaging, interactive, and effective in fostering scientific literacy and critical thinking skills among students.

III. Inquiry-based learning modules

Inquiry-based learning modules provided by the "Ruka u testu" project are designed to foster a hands-on, student-centered approach to science education. These modules encourage students to engage actively with scientific concepts through questioning, experimentation, and critical thinking. Here's a detailed description of the key components and structure of these modules:

Introduction and Context:

- **Topic overview:** Each module begins with an introduction to the scientific topic. This includes background information, relevance to everyday life, and the key concepts that will be explored.
- **Learning objectives:** Clear objectives are outlined, detailing what students should understand and be able to do by the end of the module.

Engagement and Question Formulation:

- **Hook activities:** Initial activities designed to spark curiosity and interest in the topic. This might include intriguing questions, demonstrations, or real-world problems.
- **Formulating questions:** Students are encouraged to ask questions about the topic, fostering a sense of ownership and curiosity. Teachers guide students in refining their questions to make them investigable.

Exploration and Investigation:

- **Hands-on experiments:** Detailed instructions for experiments that allow students to explore the topic actively. This section includes lists of required materials, step-by-step procedures, and safety guidelines.
- **Data collection:** Students collect data during their experiments. The modules provide templates or guidelines for recording observations, measurements, and other relevant information.

Explanation and Concept Development:

- **Analyzing data:** Students analyze the data they have collected to identify patterns, make connections, and draw conclusions. This involves using charts, graphs, and other analytical tools.
- **Developing explanations:** Based on their analysis, students develop explanations for their findings. The modules provide guiding questions to help students articulate their understanding.

Elaboration and Application:

- **Extended activities:** Additional activities that extend the learning experience, allowing students to apply their knowledge in new contexts or explore related topics. This might include projects, further experiments, or real-world applications.
- **Interdisciplinary connections:** Suggestions for connecting the scientific concepts to other subjects, such as math, technology, engineering, and even social studies or art.

Evaluation and Reflection:

- **Assessment tools:** Various assessment tools are included to evaluate student understanding and skills. This may consist of quizzes, rubrics, peer assessments, and self-assessment checklists.
- **Reflective discussions:** Prompts for reflective discussions where students can share what they learned, discuss challenges they faced, and consider what they might do differently in future investigations.

Teacher Resources and Support:

- **Teacher guides:** Comprehensive guides that provide additional background information, tips for facilitating inquiry-based learning, and answers to common questions.
- **Professional development:** Resources for ongoing professional development, including links to workshops, seminars, and online communities where teachers can share experiences and strategies.

Here are two examples of typical inquiry-based learning modules that are be provided by the "Ruka u testu" project in Serbian schools:

Example Module 1: **The Water Cycle**

Introduction and Context:

- Topic Overview: Understanding the water cycle and its importance to life on Earth.
- Learning Objectives: Students will understand the processes of evaporation, condensation, and precipitation.

Engagement and Question Formulation:

- Hook Activity: Demonstration of water evaporating from a heated container and condensing on a cold surface.
- Formulating Questions: Why does water evaporate? How does it form clouds? Where does rain come from?

Exploration and Investigation:

- Hands-On Experiment: Creating a mini water cycle in a closed container.
- Data Collection: Observing and recording the changes in water state over time.

Explanation and Concept Development:

- Analyzing Data: Discussing observations and linking them to the stages of the water cycle.
- Developing Explanations: Explaining how water moves through the environment in a continuous cycle.

Elaboration and Application:

- Extended Activities: Exploring how human activities affect the water cycle.
- Interdisciplinary Connections: Linking to geography by mapping the water cycle in different climates.

Evaluation and Reflection:

- Assessment Tools: Quiz on the stages of the water cycle.
- Reflective Discussions: Discussing the importance of the water cycle for agriculture and water conservation.

Example Module 2: **Electricity and Circuits**

Introduction and Context:

- Topic Overview: Basics of electricity, simple circuits, and their applications.
- Learning Objectives: Students will learn how to build and understand simple electrical circuits.

Engagement and Question Formulation:

- Hook Activity: Demonstration of a simple circuit lighting up a bulb.
- Formulating Questions: How does electricity flow? What materials conduct electricity?

Exploration and Investigation:

- Hands-On Experiment: Building circuits using batteries, wires, bulbs, and switches.
- Data Collection: Testing different materials for conductivity and recording results.

Explanation and Concept Development:

- Analysing Data: Comparing the conductivity of various materials and understanding circuit components.
- Developing Explanations: Explaining why certain materials conduct electricity while others do not.

Elaboration and Application:

- Extended Activities: Designing a simple electrical device or game.
- Interdisciplinary Connections: Linking to physics (energy transfer) and technology (modern uses of electricity).

Evaluation and Reflection:

- Assessment Tools: Peer assessment of circuit designs.
- Reflective Discussions: Discussing the role of electricity in everyday life and its environmental impact.

In this way, the inquiry-based learning modules provided by the "Ruka u testu" project emphasize active student participation, critical thinking, and real-world applications. These modules are designed to make science education engaging and meaningful, helping students develop a deep understanding of scientific concepts and the skills to explore them further.

IV. Conclusions

Importance of scientific literacy: A society's commitment to scientific literacy is critical for preparing the younger generation to face the challenges of the 21st century, including sustainable development and technological advancements.

Role of education in sustainable development: Harmonizing individual conduct with sustainable development principles is essential, and education plays a pivotal role in achieving this alignment.

Interdisciplinary approach to education: Modern education needs to incorporate multidisciplinary, interdisciplinary, and transdisciplinary approaches, leveraging advancements in nanotechnology, cognitive technologies, information science, and biotechnology.

Evolution of teaching methods: The evolution of teaching methods, from ancient Greek approaches to Renaissance transformations, continues with digitalization, emphasizing the need for adaptable and forward-thinking educational strategies.

Challenges for educators: Educators face the challenge of addressing the needs of a generation influenced by both book and screen cultures, and who are experiencing rapid technological and cognitive shifts.

Curriculum innovation: There is a need for curricula that combine disciplinary and interdisciplinary approaches, promote active student participation, and integrate non-formal and informal education along with formative evaluation.

Inquiry-Based learning: Implementing teaching approaches based on inquiry, projects, STEM, and STEAM is crucial for engaging students and respecting their diverse social, cultural, and geographical backgrounds.

Resource availability: Teachers require access to resources such as translated books, digital materials, inexpensive experimental kits, and online platforms to effectively implement inquiry-based learning.

International collaboration: The success of the "Ruka u testu" project is significantly bolstered by international collaborations, including partnerships with the French Academy of Sciences, the Serbian Academy of Sciences and Arts, and the University of Belgrade.

Ongoing professional development: Continuous professional development through workshops, seminars, and participation in international

networks and conferences is essential for educators to stay updated with the latest methodologies and resources in science education.

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