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Inspiring the Scientists of Tomorrow



**European
Schoolnet**



TEACHER TRAINING AND IBSE PRACTICE IN EUROPE

A European Schoolnet overview

ABOUT EUROPEAN SCHOOLNET

European Schoolnet (EUN, www.europeanschoolnet.org) is a network of 34 Ministries of Education whose mission is to support Ministries of Education, schools, teachers and any stakeholders in Europe in the transformation of education processes. EUN is positioned as an Ideas Lab that is able to help its Ministries develop policies to support the educational reform process at European level based on evidence and facts. The objectives of EUN are to:

- Provide services, content and tools based on ICT to members and partner networks
- Foster and support collaboration and cooperation among schools in Europe
- Support professional development of teachers, teacher trainers, school leaders and support staff
- Disseminate inspiring practice and investigate new models for schooling and learning
- Offer pedagogical and information services with European added value to schools in Europe
- Contribute to the development of technology-enhanced learning in schools

EUN works on three strategic areas:

- Providing usable evidence and data in the area of innovation in education to inform policy recommendations (via peer exchanges, policy experimentations, surveys and reports and through its various working groups)
- Supporting schools and teachers in their teaching practices (via the running of three European networks – eTwinning, Scientix and BIK)
- Developing and sustaining a network of schools engaged in innovative teaching and learning approaches (via the activities organised around the Future Classroom Lab and the FCL Ambassadors scheme).

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FOREWORD

One of the primary goals of the Amgen Foundation is to inspire the next generation of innovators. We prioritize two complementary strategies: providing students with excellent hands-on and virtual science learning experiences, and investing in professional development and learning for science teachers.

In 2008, we started to advance our science education goals in Europe. In addition to considering grant proposals from individual institutions we were motivated to explore pan-European endeavors. The question was how to do so in a manner that respected and celebrated each country's unique science curriculum, teacher education practices, languages, and cultures?

After deep study of the Rocard report, I was fortunate to connect with Marc Durando at European Schoolnet (EUN). We were thrilled to find in EUN an organization with experience in partnering with Ministries of Education across the continent, as well as a shared commitment to science educators and a firm belief that inquiry-based science education could play a transformational role in how science teachers engage their students and ultimately influence how students learn.

Teachers tell us that in order to be successful in the classroom, they need a way to learn from



their peers, continue to develop professionally and have access to the latest thinking to increase student learning. In the spirit of collaboration, I welcome the publication of this report and believe that by sharing insights from a number of key science education projects, including Amgen Teach, EUN is highlighting the need for continued teacher support and showing how educators play a vital role in fostering the innovators of the future.

Our hope is that this report will inform, inspire and encourage others. And we remain steadfastly committed to supporting science teachers - and organizations like EUN who support them - in continuing to make a difference in the lives of their students.

Eduardo Cetlin
President, Amgen Foundation

A handwritten signature in black ink that reads "Eduardo Cetlin". The signature is written in a cursive, flowing style.

1. INTRODUCTION

Since the 1990s there has been renewed interest in the improvement of science and technology awareness in society at large. Science literacy is a central concept in this context. As a first-step strategy towards that target, the improvement of Science Education in the educational system is a must.

The complex development, welfare and environmental problems that modern societies face can only be addressed through the powerful tools provided by science and technology. Informed opinion about any possible lines of action requires fundamental understanding of how science works and of the foreseeable consequences of the technological options available.

Moreover, the labour market demands more Science, Technology, Engineering and Mathematics (STEM)-literate – but also highly skilled – people to push forward the frontiers of science and technology and drive innovation. In addition, citizens at large need a basic command of key science and technology issues. Personal lifelong education, in that respect, starts at school level.

SCHOOL SCIENCE

STEM education or Science literacy starts at school. For this reason, School Science enjoys a prominent place in the EU's political and educational agenda, and in the educational projects of many private companies and foundations like Amgen, Cisco, EPCA, IBM, Lenovo, Shell, Transport Malta, and many others.¹

Initiatives towards School Science and Technology literacy feature the acronym STEM, which refers not only to the four subjects, Science, Technology, Engineering and Mathematics, but also to the strong relationship that exists among these four disciplines (and which therefore favours an interdisciplinary approach to education).

Within STEM education, an outstanding set of teaching strategies has gained prominence under the umbrella term of IBSE, for Inquiry-Based Science Education. Its aim is to engage students in active development and comprehension of fundamental scientific and technological concepts and investigative procedures.



STEM :
Science, technology,
engineering, mathematics

IBSE :
Inquiry-based, science,
education



Multiple European-scale initiatives on **STEM** Education and innovative **IBSE** strategies exist, within both the public and private sectors

¹These companies, plus Dassault Systems, GSMA, Johnson & Johnson, Lego Education, Microsoft, SISSA Medialab and Texas Instruments, are part of the STEM Alliance, to be discussed later in this report.



DOCUMENT OUTLINE

In this document, we share how IBSE has proven to be an effective tool in addressing the challenge of improving STEM learning and making STEM jobs more attractive. We also discuss the application and impact of IBSE in relation to varying learning goals, policy contexts, and timeframes.

We give selected examples of major European initiatives in STEM Teacher Training, in particular where inquiry-based strategies have been applied, originating both from public and private stakeholders: Amgen Teach, Next-Lab, Scientix and STEM Alliance.

After providing a synopsis of the lessons learned so far and possible paths forward in the quest for a society more knowledgeable about science and technology, a number of conclusions and recommendations are put forward.

2. IMPORTANCE OF IBSE IN STEM EDUCATION

Since the Rocard (2007) report, there has been a steady but perhaps slow increase in the motivational effects and positive observed outcomes of teachers' application of IBSE in order to improve School Education in STEM. Although there is still scope for improvement in teachers' pedagogical development, current international projects are already bearing fruit.



The Rocard Report

European Commission (2007). Science Education Now: A renewed pedagogy for the future of Europe (the Rocard Report), Brussels: European Commission, EC

In this section, after outlining the need for pedagogical innovation in STEM education, we will argue that IBSE is a powerful and complex methodology that provides a way of achieving the goals and overcoming the challenges spelled out in the Introduction. In support of this analysis, some data is presented from education research that provides insights and opens up lines of enquiry.

IBSE in STEM Education

- An integrated S+T+E+M is needed
- IBSE offers promise
- Education practices in Europe –
Current state of IBSE



2.a BROADER CONTEXT

Science permeates our lives: it lays the ground for the technological innovations that improve our social welfare and, just as importantly, it provides mind-sets and theoretical frameworks that help us conceptualise the Universe we inhabit.

Demographic trends in Europe show that its population is ageing, with many scientists, technicians and researchers drawing near to retirement (Kearney, 2016). This fact underlines the importance of having an adequate stock of researchers, innovators and entrepreneurs to ensure Europe's prosperity. However, all professional careers start at school level.

C. Kearney (2016).
Is there a shortage of STEM teachers in Europe?



The need for high-quality education systems that enable young Europeans to develop key competences - which include maths, science and technology – points up STEM's key role in developing adequate R&D capacity in Europe, ensuring economic and productivity growth, and supporting Europe's future competitive position.

These realities underline the important role that teachers and teacher training have for the future of Science and Technology in Europe.

SOMES FACTS

There are well-documented and persistent challenges faced by STEM teaching and learning (OECD, 2006):

- Attitudes towards STEM education and perceptions of careers strongly influence the number of STEM graduates.
- Students' lack of interest in studying science and technology, especially young women, frequently stems from the way these subjects are taught and learned.
- In the traditional science teaching model, the teacher provides facts and the students learn them in a passive mode which is usually disconnected from the students' reality.



OECD (2006)
[Evolution of Student Interest in Science and Technology Studies](#),
Policy Report from OECD's Global Science Forum.

THE WAY FORWARD – RENEWED PEDAGOGY

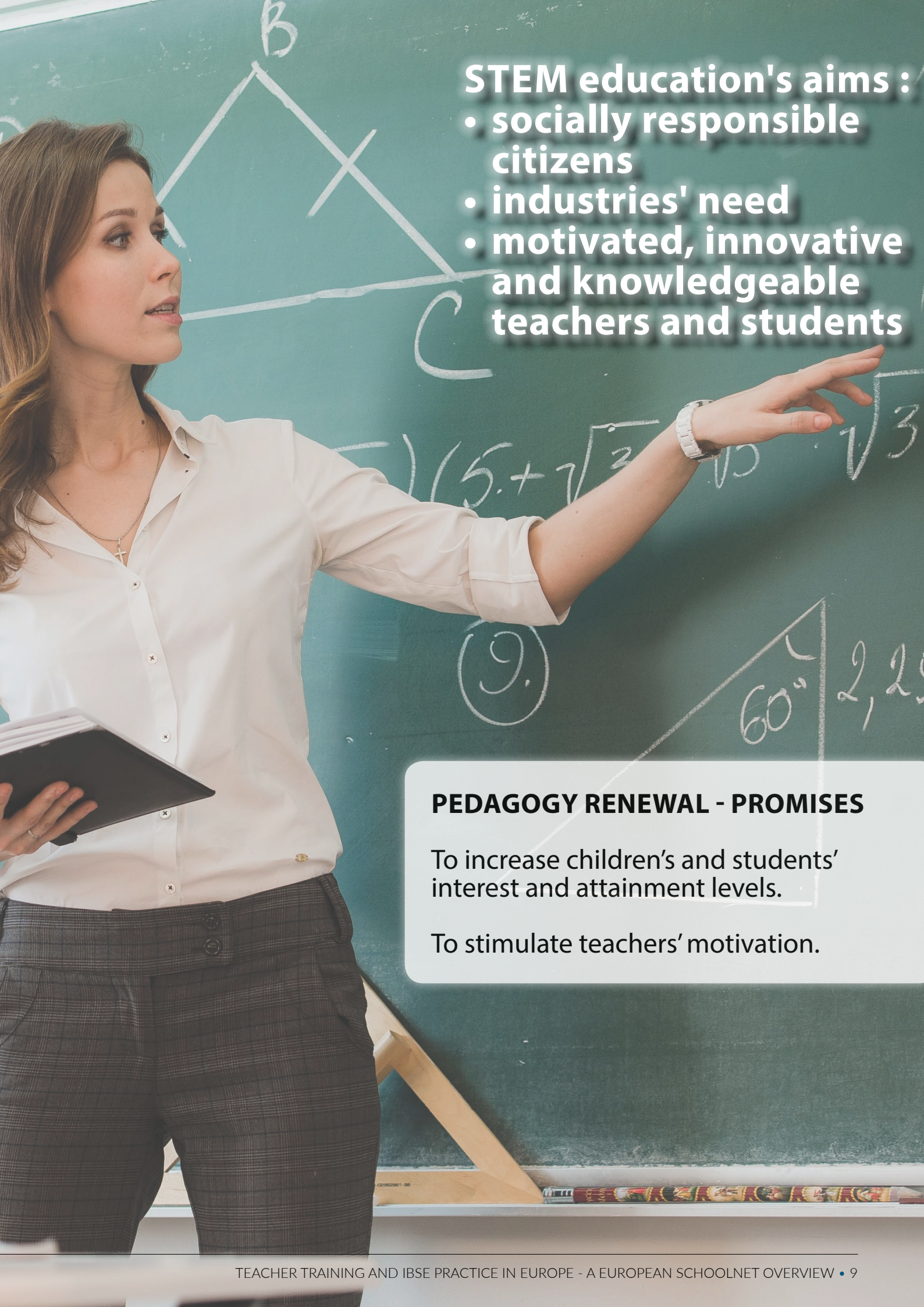
School science can be made much more attractive for students. It is mostly the teacher's responsibility to preserve and nurture the in-born enthusiasm, tireless activity and wide curiosity of youngsters, and direct it towards science and technology subjects. This demands major pedagogical renewal – and problem-based or inquiry-oriented approaches to STEM teaching stand out as strategies for improvement.

"Scientific practices"

– Alternative term to 'inquiry'.

It makes explicit that "doing science" is a process with many components.





- STEM education's aims :**
- socially responsible citizens
 - industries' need
 - motivated, innovative and knowledgeable teachers and students

PEDAGOGY RENEWAL - PROMISES

To increase children's and students' interest and attainment levels.

To stimulate teachers' motivation.

2.b IBSE DEFINED

Inquiry-based teaching or learning is the process in which not only are facts explained but also where questions, problems and scenarios are presented to the students for exploration and discussion.

This learning approach can include a wide range of activities, such as case studies, field-work, investigations or research projects, among others.

From the early 1990s the concepts of inquiry, doing experiments and active engagement have played an important role in renewed approaches to Science Education. The term Inquiry-Based Science Education (IBSE) has appeared in European policy documents since the Rocard Report (2007) and has become the basic ingredient in most initiatives and calls for funding in science education in Europe.

There is evidence that the objectives of renewed pedagogies are best achieved through opportunities for students to conduct extended investigative work and “hands-on” experimentation, which complements the traditional acquisition of canonical concepts.

IBSE pedagogy conveys

- Better and more motivated STEM learning
- More involvement, especially for girls
- Greater student interest in STEM than traditional teacher / textbook pedagogy
- More attractive science-related studies and occupations

THE IBSE STRATEGY

According to the European Commission, inquiry-based education includes “the development of questions, the formulation and testing of hypotheses based on existing knowledge and theories, and the analysis and presentation of results and conclusions – it means ‘minds-on’ and ‘hands-on’ activities.” (EC, 2004, p.125)

IBSE thus involves the progressive development of scientific ideas through conducting one’s own investigation while building knowledge, attitudes and understanding on the world around us. The rationale behind this approach is based on recognition that ideas are fully understood – and not only superficially known – if they are constructed by students through their own reflections regarding different experiences.



European Commission (2004). [Europe needs more scientists. Increasing human resources for science and technology in Europe.](#)

Report of the High Level Group on Human Resources for Science and Technology in Europe. Luxembourg: Office for Official Publications of the European Communities



IBSE vs Traditional Pedagogies

- Learning objectives and tests should be aligned
- Long-term attitudes and interest are more important than short-term recall and soft skills

IBSE – EXPECTATIONS

IBSE - active involvement in investigations, collaboration and discussions - is expected to lead to a number of consequences. The following six positive outcomes appear regularly in recommendations and policy documents. IBSE:

1. Provides an efficient way of teaching and learning science content, in line with the tenets of constructivist theories of learning.
2. Is instrumental for learning about the nature of Science.
3. Improves students' joy, interest and motivation towards science.
4. Has lasting effects on attitudes to science.
5. Helps reduce the gender gap.
6. Increases recruitment to science and technology-related studies and careers.

2.c RESEARCH ON IBSE

Policies and initiatives from the private and public sectors to promote social awareness of Science are informed by hard data and results from current programmes.

Research shows that there is still limited use of IBSE nowadays, in spite of the fact that IBSE practices, within an integrated approach to STEM, stand out as the most promising avenues to achieve Science and Technology Literacy at large, and clearly overcome unwanted side-effects of traditional pedagogies.



SCIENCE EDUCATION RESEARCH INTO IBSE

- Empirical studies
- Reviews
- Meta-studies (and books)



RESEARCH INTO IBSE IN COMPARISON WITH OTHER TEACHING METHODS:

- “Inquiry” has a spectrum of meanings
- IBSE also comprises a range of activities and thinking processes in which students might be engaged
- Attitudes to and interest in STEM are reinforced



PISA: Programme for International Student Assessment (OECD-Organisation for Economic, Co-operation and Development)

TIMSS: Trends in International Mathematics and Science Study (IEA - International Association for the Evaluation of Educational Achievement)

DIAGNOSTICS – CONCERNS?

International large-scale assessment of students’ achievements, such as TIMSS and PISA, include measures of the degree of student exposure to IBSE, and provide indicators for inquiry-based instruction. They find that:

1. The use of IBSE varies strongly among countries. Greater exposure to inquiry-based instruction does not always lead to higher scores in science.
2. Activities featuring experimental and laboratory work do not necessarily lead to better science performance in assessment tests.
3. IBSE results in greater interest in Science and motivation for science-oriented future careers.



FURTHERING OF IBSE STRATEGIES

- Laboratory work has to be more extensive
- All STEM subjects can increase practice in IBSE, particularly Maths
- End-of-cycle exams should align more with IBSE practice
- Teacher training and regular support is required
- STEM teachers welcome further collaboration with Industry, to enhance their practice and model students’ interests



“WHAT WORKS” IN EDUCATION

Assessing and measuring the claims and benefits of IBSE for STEM teaching is complex, but it is an established fact that the quality of teaching is a main predictor of students’ learning and students’ attitudes towards STEM.

The conclusions above from PISA have to be treated with caution since students’ tests should be aligned with teaching objectives. And these international tests have not so far incorporated IBSE elements. PISA tests are more focused on recall and repeated-drill exercises, which are standard teacher-directed and textbook-oriented instruction in Asian countries which score high in PISA.

Students within traditional pedagogies, in comparison with students who have enjoyed IBSE learning environments, experience unwanted “side-effects” that may be significant in the long run, with students in traditional settings having very low self-confidence and self-efficacy in relation to science and mathematics.

The clear outcomes from the deployment of IBSE strategies are more positive attitudes towards STEM careers, increased motivation, and the development of skills related to open-problem solving. This is beneficial for attitudes, interest and motivation in a longer-term perspective, especially for those students – who represent the majority in society - who do not see themselves

working in occupations related to science and technology.

A 2018 report from the Scientix Observatory on how STEM teachers throughout Europe organise their teaching practices shows that, although three out of four of the teachers surveyed share with their colleagues a positive vision of innovative STEM teaching, traditional direct instruction remains prevalent among the most highly reported pedagogical approaches. Furthermore, the study highlights the need for increased efforts in teachers’ professional development and initial teacher training in IBSE, and in increasing the availability of resources and materials that are aligned with IBSE pedagogies.

STEM Education Practices in Europe (2018)

Nistor, A., Gras-Velazquez, A., Billon, N. & Mihai, G. (2018). Science, Technology, Engineering and Mathematics Education Practices in Europe. Scientix Observatory Report. December 2018, European Schoolnet, Brussels



STEM EDUCATION PRACTICES IN EUROPE SCIENTIX OBSERVATORY SURVEY (2018)

3,780 RESPONSES

4,500 CLASSES

38 COUNTRIES



IBSE – THE WAY FORWARD

The single element that deserves more imaginative approaches in ISBE is laboratory work in STEM areas. Science and technology teachers are well aware of the insufficient access to experimental laboratories that shapes their present practice and they need an increased pool of resources and materials.

The necessity of greater support for teachers is also evident from the contrasting fact that teachers may use inquiry-directed collaboration pedagogy in their classroom, but in their own professional practice nearly 40% of the STEM teachers surveyed report having received little or no support, even from their colleagues. Support from local and online colleagues is a much-felt need (Nistor et al., 2018).

A distorting effect in efforts towards greater Science and Technology Literacy stems from national end-of-secondary-education-exams, as well as international-scale tests, which in effect perpetuate the place of more traditional teaching and deter the use of more diverse pedagogies, and IBSE in particular. One way out of this vicious circle would be for end-of-cycle exams to increasingly include investigative and open-ended questions and activities.

And, last but not least, teachers have a predisposition and openness to collaborating with STEM industries in order to enhance teaching and learning, and greater investment is needed to take advantage of their willingness.



Science research communities endorse IBSE

Umbrella organizations, science academies and unions, like [ALLEA](#), the European Federation of Academies of Sciences and Humanities, and ICSU (now [The International Science Council](#)) also support and recommend IBSE.

3. IBSE IN EUROPEAN INITIATIVES

The European Commission is making constant and significant efforts to strengthen the engagement of the science and technology community - and its relentless progress - with the rest of society. The aim is to make science more accessible to the public and increase science literacy and understanding of how science and technology affect us in our daily lives.

EU PROGRAMMES

WITH INCIDENCE ON STEM / IBSE

- **FP6** (Science and Society)
- **FP7** (Science in Society)
- **Horizon 2020** (Science with and for Society)

LARGE INCREASE IN THE EU BUDGET FOR THESE PROGRAMMES

From € 71.5 million to € 462 million, in the last two decades

THE PRIMARY TARGETS

The targets of the STEM/IBSE-related European actions are threefold:

- a) to motivate the whole of society through societal engagement;
- b) to encourage young people to pursue science studies; and
- c) to meet industry's needs for a workforce that is gender-balanced and equipped with scientific competences.

When it comes to STEM, innovative initiatives are supported to facilitate best practices in both formal and informal science education, teaching, and learning. This includes strengthening sustainable collaboration between the educational and scientific communities, and supporting the concept of scientific citizenship, in which science becomes an integral part of daily lives.



EXPECTED OUTCOMES FROM PEDAGOGICAL RENEWAL

- Address barriers to gender equality in science
- Improve understanding of the role of science in society
- Increase public participation in science policy-making processes
- Promote science ethics and increased access to science research

THE WAY FORWARD – COLLABORATIVE PROJECTS

Inquiry-based science education, IBSE, has become the basic ingredient in most initiatives in Science Education in Europe and in the majority of the projects funded, and should continue to be so.

Within these European frameworks, European Schoolnet (EUN) has developed a number of cooperation projects addressing the whole spectrum of STEM-related issues, so as to amass more evidence on which to base policy recommendations and develop model practices.



The portfolio of EUN STEM-related projects, in various collaboration schemes, ranges from teacher training (Amgen Teach), to technology-enhanced learning (Next-Lab), science awareness for schools (Scientix), and collaboration with industry on STEM issues (STEM Alliance).

In that respect, EUN is leading the work of two strategic initiatives in science and mathematics education in Europe: the public-private initiative STEM Alliance and the European Commission-funded Scientix programme, which includes IBSE actions related to STEM education.



OTHER H2020 FRAMEWORK LINES INTERSECT WITH STEM

- Industrial leadership
- Societal challenges
- ICT and advanced materials

3.a AMGEN TEACH

Amgen | Teach
Engaging Science Educators



Amgen Teach is funded by the Amgen Foundation

An initiative of the Amgen Foundation, coordinated by EUN, the Amgen Teach programme is a very fruitful six-year-old collaboration to provide professional development opportunities for life-science teachers at secondary level, especially by strengthening the ability of those teachers to use IBSE in their practice.

SUCCESSFUL OUTREACH

Amgen Teach is a combined effort between teacher training providers at national level and the international community. Centred on the life sciences, it offers webinars, face-to-face workshops, online activities, national ambassador networks, repository tools supporting IBSE education, and other forms of support for teachers.

Amgen Teach successfully reaches large numbers of teachers across Europe primarily through face-to-face training. Additionally, a recent open online course attracted hundreds of teachers with an enormous spread of national backgrounds.

AMGEN TEACH - OUTREACH



218
WORKSHOPS



+4,000
TEACHERS ACROSS



10 EUROPEAN
COUNTRIES



BENEFITING
+530,000
STUDENTS

ONLINE COURSES



590
TEACHERS ACROSS



44
COUNTRIES

Furthermore, in collaboration with EUN, Amgen Teach will select teachers for essential roles: Amgen Teach Expert Teachers, who will act as IBSE school representatives and collaborate with the training providers, and Amgen Teach Ambassadors, who will become national representatives for the project.

PROJECT EVALUATION

Data on the benefits and challenges of the Amgen Teach initiative, extracted from pre and post questionnaires, interviews, and focus group discussions during Amgen Teach International Workshops, show that:

- 99% of the teachers would recommend the courses to their colleagues and 83% state that they have increased their knowledge of IBSE methodology.
- Teacher expectations as regards increasing their confidence in teaching IBSE and networking with other teachers interested in IBSE have been largely exceeded. Reflective networking and collaboration with their peers have been identified as one of the main takeaways of the programme.
- Before the course only 30% of the teachers used IBSE in the classroom but, after the course, 79% stated that they would definitely use the IBSE approaches learned and the materials provided.
- 81% of the students surveyed say that their teachers now link the science and technology lessons to real-life scenarios and 71% can now see how scientific research can contribute to a better society and world.
- The impact on students' motivation to participate in science activities, to study science, to better understand what is being taught in science lessons, and achieving better results for science subjects are significantly greater among younger students.

PRESENT AND FUTURE OF THE PROJECT

The sustained and strengthened Amgen Teach activities reinforce the essential role played by teachers and IBSE, and provide invaluable resources and opportunities for teacher training and continuous professional development which results in tangible effects on the school student population.

3.b GO-LAB ECOSYSTEM



The Go-Lab Ecosystem is partially funded by the European Union in the context of the Go-Lab project (Grant Agreement 317601) under the Information and Communication Technologies (ICT) theme of the 7th Framework Programme for R&D (FP7) and by the Next-Lab innovation action (Grant Agreement 731685) under the Industrial Leadership - Leadership in enabling and industrial technologies—Information and Communication Technologies (ICT) theme of the H2020 Framework

Under the umbrella of the Horizon 2020 European Programme, the Go-Lab Ecosystem focuses on introducing IBSE in European schools and promoting innovative teaching methods in primary and secondary schools.

The Go-Lab ecosystem provides access to online labs worldwide and trains teachers in the use of innovative teaching technologies.

THE APPROACH

Go-Lab addresses both in-service and pre-service teachers and facilitates the use of online laboratories and inquiry learning applications for science education in schools. It provides the Go-Lab Ecosystem for teachers, where various online labs can be found and used to create customised Inquired Learning Spaces.

Important elements of the project are its summer and winter schools and training workshops for Go-Lab ambassadors, which complement a free online course, "Using online labs in the classroom: an introductory course for teachers."

The common core curriculum for the project training activities is broadly defined within a competence framework which includes IBSE pedagogy, the use of the Go-Lab facility, and networking and enlargement of the community of users.

NEXT-LAB COMPETENCE FRAMEWORK

- Pedagogy / IBSE
- Use of the Go-Lab ecosystem
- 21st century skills
- Learning Assessment in Go-Lab
- Multiplication (enlarging the community of users) / communication

The overall approach to training in Go-Lab is based on the principle of subsidiarity: the National Expertise Centres and Go-Lab Ambassadors have established close links with the teachers and the Go-Lab communities in their countries, and are therefore best equipped to define and choose the training topics, as well as the type and duration of events and workshops.

Each partner identifies the needs of their own teacher community and the thematic areas that are most appropriate in teacher training to facilitate the use and uptake of Go-Lab in schools.

The educational resources created within the project blend science and technology education. They allow teachers to effectively and efficiently implement practices that address various STEM areas. Numerous learning materials have been developed and extensively tested.

NEXT-LAB OUTREACH

- More than 12,000 teachers
- >100 yearly training activities
- 30 countries over all Europe
- A subsidiarity principle underlies the project's actions

INQUIRY LEARNING SPACES (ILS) AND SCENARIOS

A number of resources for teachers are created in the form of high-end Inquiry Learning Spaces (ILS) for in-class use. A technical team is continuously developing new tools and integrating functionalities that make it easier for teachers to communicate with one another and even seek help directly from the project team. The project is therefore developing and disseminating Inquiry Learning Spaces and integrated online labs as open educational resources.

An interesting outcome of Go-Lab is the definition of scenarios that can be used to shape the didactical structure of an ILS. This scenario idea may be applicable in other teacher training projects, and is defined by a number of considerations (see box). Advanced scenario versions are being developed, building on the introductory basic scenario.

SCENARIOS SHAPING THE DIDACTICAL STRUCTURE OF INQUIRY LEARNING SPACES CONSIDER

- Educational objectives involved
- Characteristics of the students
- Students' prior knowledge level and the inquiry skills the students possess
- Local organizational issues.

THE WAY FORWARD – SHARING, AUTHORIZING AND LEARNING PLATFORMS

The technical Go-Lab ecosystem combines cloud services and platforms. The golabz.eu sharing platform is a repository offering online labs, scaffolding apps, and Inquiry Learning Spaces created by teachers for teachers. As a suitable complement, the graasp.eu authoring and learning platform enables collaborative creation, agile personalisation, and secure exploitation at school, as well as exchange of best practices among teachers.



golabz.eu sharing platform & graasp.eu authoring and learning platform

Gillet, D., Rodríguez-Triana, M. J., De Jong, T., Bollen, L., & Dikke, D. (2017, June). Cloud ecosystem for supporting inquiry learning with online labs: Creation, personalization, and exploitation. In Experiment@ International Conference (exp. at'17), 2017 4th (pp. 208-213). IEEE

As we repeatedly point out in this document, sharing of resources and networking for cross consultation are essential ingredients for IBSE propagation within the teacher community and for fully gaining the benefits of IBSE in the student community.

3.c SCIENTIX



Scientix is currently supported by the European Commission's H2020 programme – project Scientix 3 (Grant agreement N. 730009), and coordinated by European Schoolnet (EUN)

European Schoolnet is at the forefront of the debate on how to attract more people to science and technology to address the future skills gaps that Europe is facing, and STEM is one of its major thematic domains. EUN has been involved in more than 30 STEM education initiatives, financed through EUN's Ministry of Education members and industry partners, or by the European Union's funding programmes.

EUN's key initiative in STEM education is the EC H2020-funded Scientix, the Community for Science Education in Europe.

THE SCIENTIX PROJECT

One of the major STEM-related projects in EUN is Scientix. Scientix is a flagship within the EU programmes for Science with Society and Science for Society. Since 2010 Scientix has promoted and supported European-wide collaboration among STEM teachers, education researchers, policy-makers and other STEM education professionals.

A 2015 study conducted by EUN within the Scientix project on national measures taken by 30 countries to increase students' interest in pursuing STEM studies and careers, found that:

- STEM education policies and initiatives continue to receive political and financial

support to tackle underachievement and a lack of student interest in STEM studies and careers.

- The majority of countries pay greater attention to improving development for in-service STEM teachers than investing in STEM-specific initial teacher training.
- The need to recruit more STEM teachers is an issue which faces various countries, with almost 40% reporting that initiatives are planned or in place to address the shortage of STEM teachers, particularly at secondary level.
- The Responsible Research and Innovation (RRI) agenda has recently gained prominence at European level, and could play a role in motivating students to pursue STEM studies and careers, by bringing the societal aspects of STEM to the forefront. However, RRI mostly is a concern of academia and has yet to be fully embedded within school education systems.

SCIENTIX OUTREACH

- An online portal (>375,000 visitors)
- 600+ projects in STEM education
- 2,600+ teaching materials
- Almost 500 Scientix ambassadors in 44 countries
- Thousands of attendees in workshops, conferences & MOOCs
- A network of >20 Ministries of Education STEM representatives
- Over 4 Million students impacted

IBSE/STEM – THE WAY FORWARD

STEM teachers do try their hand at new pedagogies and use a diversity of resources and materials, but there is still a need for support in order to advance effective STEM education at the European level.

3.d STEM ALLIANCE

Innovative STEM teaching practices and networks based on IBSE and other student-centred pedagogies have to be further developed and promoted.

The data suggests that there is still little confidence among STEM teachers in approaching IBSE pedagogies, particularly amongst less experienced teachers.

Furthermore, actions to support European networks of exchange and assistance for STEM teachers to build expertise in approaching innovative teaching inside and outside the classroom are fundamental. The fact that teachers tend to turn primarily to their peers for professional support shows the important impact teacher networks can have.

EUROPEAN STEM INITIATIVES – SCIENTIX REPORT

- Sustained political and financial support for education
- Innovative teaching and learning strategies are pursued
- Initial teacher training should receive as much attention as in-service development
- Addressing the shortage of STEM teachers is a priority

FURTHER NEEDS – SCIENTIX REPORT

- Teachers innovate but want further support
- IBSE pedagogies have to be promoted more intensively
- Confidence in using IBSE should be reinforced
- Deeper networking and exchange are fundamental tools for dissemination and consolidation of IBSE



The STEM Alliance is currently co-funded by EUN and a number of industry partners, including Amgen, Cisco, EPCA, IBM, Lenovo, Shell, Transport Malta, Dassault Systems, GSMA, Johnson & Johnson, Lego Education, Microsoft, SISSA Medialab and Texas Instruments

European Schoolnet is leading the work of two strategic initiatives in science and mathematics education in Europe: Scientix, discussed in the previous section, and the STEM Alliance.

The STEM Alliance builds on the success of the inGenious project funded by the Commission (2011-2014) to increase the links between STEM education and careers, by involving schools throughout Europe.

The STEM Alliance – inGenious Education and industry initiative brings together industries, Ministries of Education and other education stakeholders to promote STEM education and careers to young Europeans and address anticipated future skills gaps within the European Union.

STEM Alliance actions include:

- 1) Bringing Professionals Back to School
- 2) Teacher Discovery Placements
- 3) Knowledge building and professional development

With the support of 14 major companies and private partners, the STEM Alliance activities promote STEM jobs in all industrial sectors and contribute to building a STEM-skilled workforce. The STEM Alliance improves and promotes existing industry-education STEM initiatives (both national and European or global) and contributes to innovation in STEM teaching at all levels of education. It is precisely here that the STEM Alliance stands out with regard to STEM/IBSE, because it provides industry-level contextualisation of STEM teaching.



CONTEXTUALISATION OF STEM TEACHING

Contextualisation in IBSE practice is important for at least two reasons (Fazio, 2016): because reflective teaching is based on teacher judgement, informed by evidence-based enquiry; and because it is a component for an approach to Responsible Research and Innovation (RRI), an important ingredient of STEM subjects in relation to society.



Fazio, C.,
Inquiry Based Science Education &
Responsible Research and Innovation in
the classroom, 2016

The STEM Alliance Observatory is currently producing research materials on key issues such as the shortage of STEM teachers and the innovative use of Information and Communications Technologies (ICT) in STEM education. The findings are based on surveys and state-of-the-art analysis carried out by the Knowledge Centre/Observatory of STEM Trends in Education, with additional consultation with both Ministries of Education and industry partners.

The main aim of these publications is to further a debate on key issues in STEM education and to support calls for action at both national and European levels.



ICT: Information and Communications Technologies

ICT are essential tools in many of the implementations of IBSE. One of the reports tries to answer the question of what are the impacts and challenges of ICT in STEM education from the teachers' viewpoint. In particular, the report analyses the areas of teachers' skills and competencies, digital backpacks, attitudes and beliefs, innovation and pedagogy, gender effects, and the risks and limitations involved in the use of ICT. The report deals with teachers from three perspectives: pre-service, in-service, and in-training. Conclusions from this report include the following:

- Teachers' networks should be promoted for the exchange of problems, suggestions and teaching materials, to make young teachers "agents of change."



- A unified approach to the use of ICT (and IBSE, for that matter) should be devised for teaching & learning to accommodate various instructional designs. In general, achievements and motivation are excellent when the topics selected are rich in digital resources and close to the students' interests. It is also desirable to work with teams in interdisciplinary fields.
- As regards teacher training, training in the new ICT tools and, more importantly, pedagogical training in how to integrate them into existing or renewed practices is constantly advocated, but favourable conditions for pedagogical change have to be generated. Ongoing professional development has to include several dimensions: personal (beliefs), subject-related (contents) and social (support), ideally in a context that promotes the creation of communities of practice to share best practice.

THE WAY FORWARD – SAMPLE INITIATIVES

The STEM Alliance has a broad agenda of activities for supporting STEM teachers. For example, two outstanding projects contribute to giving responses to STEM teachers' recurrent demands for more Continuous Professional Development (CPD) and for more contact with STEM-related industries.

- First, the STEM Alliance has developed the Teacher Discovery Placement Scheme, an initiative in collaboration with the SYSTEMIC project that highlights existing placement programmes and helps ensure the success, promotion and development of these placements.
- And secondly, the STEM Alliance has developed the Professionals Go Back to School programme. This is an initiative that supports representatives from industry visiting schools and participating in collaborative activities for one hour to half a day. The school organises an exchange session and prepares the visit of the STEM professional.



ICT in STEM Education - Impacts and challenges on teachers.

A STEM Alliance Literature Review,
June 2017

4. CONCLUSIONS AND RECOMMENDATIONS

We have stressed the importance of IBSE in STEM education, and showcased some of the large-scale European initiatives in STEM Teacher Training in the application of IBSE strategies, originating from both public and private stakeholders.

In the light of comprehensive reports and analysis of multiple initiatives in the public, EU and private sectors, science education and the significance of public understanding of science justifiably take up a clear place on the political agenda in Europe.

However, there is a long way to go towards achieving STEM basic literacy even at school level. Consequently, current IBSE outreach initiatives and efforts should receive sustained support and financing, particularly in the field of teacher training.

IBSE/STEM - FACTS

- IBSE is a central priority
- IBSE and integrated STEM should be further promoted and adopted in teaching practices
- IBSE innovation requires good foundation, evaluation, persistence and fuelling
- Performance in international tests is not a good measure of IBSE
- STEM role models, resources and toolsets for IBSE pedagogies are needed

IBSE has become a central priority in STEM education. The introduction of inquiry-based pedagogy can be a vehicle to deepen the close relationship among the four subjects that the term STEM suggests. But, as seen in the recent 2018 Scientix STEM Practices Report, fewer than 40% of teachers at least occasionally use some form of IBSE pedagogy.

Following the lessons of the Amgen Teach and other EUN-coordinated programmes, in order to enhance the quality of STEM education and the pervasive use of IBSE strategies, and thereby increase the interest and motivation of pupils for STEM subjects and possible careers, the following should be further promoted:

- Co-creating courses involving STEM educators and researchers in university research institutes and companies.
- Developing active and creative learning that promotes personalised learning where teachers are trained in how to customise teaching for each student's unique ability and interest.
- Fostering cooperation between formal, informal and non-formal science education as key characteristics of a school as a learning organisation.
- Enhancing the links and cooperation between educational stakeholders and industry.
- Training the trainers, with a key (common) focus of the training from a European perspective continuing to be on Problem-Based Learning (PBL), IBSE, co-creation of CPD and the follow-up of CPD.
- Developing regional and national STEM strategies.
- Strengthening cooperation between pre-service, CPD and induction science teacher education.

These guidelines for action lead to the following recommendations.

PROMOTION OF IBSE

It is important to continue promoting IBSE in the form of organised professional development of teachers (e.g. Amgen Teach) and providing the necessary tools (e.g. Go-Lab ecosystem).

Renewal of pedagogies for school science is not a one-off effort. It is a slow, long-term, continuously redirected process that needs constant fuelling from the private, public and EU levels. More efforts are needed to convince today's youth that STEM-oriented careers can resonate with their values and concerns, so they are willing to study and work in these areas. Along these lines, EUN's three key factors (see box) for implementing sustainable changes in STEM education are touchstones for further action.

RECOMMENDATIONS FOR IBSE / STEM

- Promotion
- Collaboration
- Community
- Resources
- Training
- STE(A)M Integration

CONTEXTUALISATION OF STEM PRACTICES – COLLABORATION

The importance of contextualisation of STEM practices (e.g. by supporting school–industry cross-industry initiatives like the STEM Alliance) must be stressed. Collected data shows that educators are open to school–industry collaboration.

This is a very positive sign, as such exchanges can provide valuable opportunities for teachers to develop professionally. Indeed, the STEM Education Policies in Europe report highlighted

that STEM industries are increasingly involved in actions that support teachers in producing educational content. However, use of industry-based educational materials is still rare among STEM teachers, indicating that their general openness towards collaborating with STEM industries is not being met with an appropriate response. Strengthening school–industry collaboration is a much-felt need and, together with relevant professional development opportunities, is essential to ensure that teachers are in a good position to help their students develop relevant skills. This collaboration also helps companies to support the improvement of the labour force of tomorrow.

EUN'S KEY FACTORS IN IMPLEMENTING CHANGES IN STEM

1. Highly qualified, motivated and recognised teachers
2. Innovative pedagogy and a creative curriculum
3. Better role models in STEM career opportunities.

RESOURCES AND COMMUNITY SUPPORT

It is also essential to ensure that all teachers are supported by their peers: through peer-support networks, by innovative teaching materials and other resources, and by a large-scale STEM community (e.g. Scientix). However, STEM education, and IBSE in particular as a main pedagogical strategy, cannot be isolated within a school or an educational system. STEM education has to be based on a whole school approach designed to achieve quality education and well-being for all children and contribute to preparing them as active and responsible citizens. Science education contributes greatly to children's acquiring, alongside scientific or technological knowledge, a wide range of skills (such as soft skills) useful for their personal and professional lives.

While education policy-makers strive to obtain high attainment levels in STEM, driven by the need to increase comparative performance (TIMSS, PISA), high STEM performance in a country does not necessarily lead to higher levels of interest in STEM in the short or longer term. Therefore, appropriate mechanisms to recognise and support teachers' efforts to improve their teaching should be put in place. With this in mind, the STEM Education Policies report has proposed the development of a common European framework of reference for STEM education to help evaluate and integrate curriculum and pedagogical innovations.

TEACHER TRAINING

While the core objectives of science education have common acceptance, students' personalities, interests and skills are fortunately quite diverse. As a consequence, there should be no single pedagogy but rather a multiple-front approach to science education. This requires from teachers

a solid pedagogical foundation and an ever-increasing toolset of resources and model best practices. IBSE combined with, for example, problem-based learning, is an example of such open and diversifiable pedagogical approaches.

Another challenge is for STEM teachers to be innovative in adopting new ways of teaching science and bringing science closer to students. It is essential to provide practising STEM teachers with innovative tools and approaches to make STEM teaching more attractive for young students.

Initiatives in STEM Teacher Training (both face to face and online) derive from multiple public and private analyses of the situation and the needs of Science in Society. Upstream, actions are also needed to improve the pre-service training of teachers so as to equip future STEM teachers with the appropriate pedagogical skills and tools to support them in their teaching.

STEM AND STE(A)M INTEGRATION

Finally, stakeholders should ensure that STEM is not taught in isolation, but integrated not only across the four subjects themselves but with all other disciplines (the (A) in STE(A)M). In this regard, the STE(A)M approach may bring a new dimension to teaching and learning via IBSE, since it highlights the creativity dimension by supporting the concept being investigated through interaction between STEM and non-STEM subjects.



TEACHERS' IBSE SUPPORT

- Digital and paper-based resources
- Best Practices
- In-training and in-service professional development
- Networking
- Encouragement by all stakeholders

In spite of the decades that IBSE has been around in STEM education, and the numerous initiatives from institutions and other stakeholders, further intensified efforts are needed. There is still much room for improvement in teachers' pedagogical renewal and continued dissemination of innovative pedagogy approaches like IBSE. Initiatives in these areas, exemplified by Amgen Teach, the Go-Lab ecosystem, Scientix and STEM Alliance, are essential.



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