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SCIENCE,

TECHNOLOGY,

ENGINEERING AND

MATHEMATICS

Education Practices in Europe

MAIN FINDINGS AND RECOMMENDATIONS

SCIENTIX OBSERVATORY EXECUTIVE REPORT

European Schoolnet

Texas Instruments

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The community for science education in Europe

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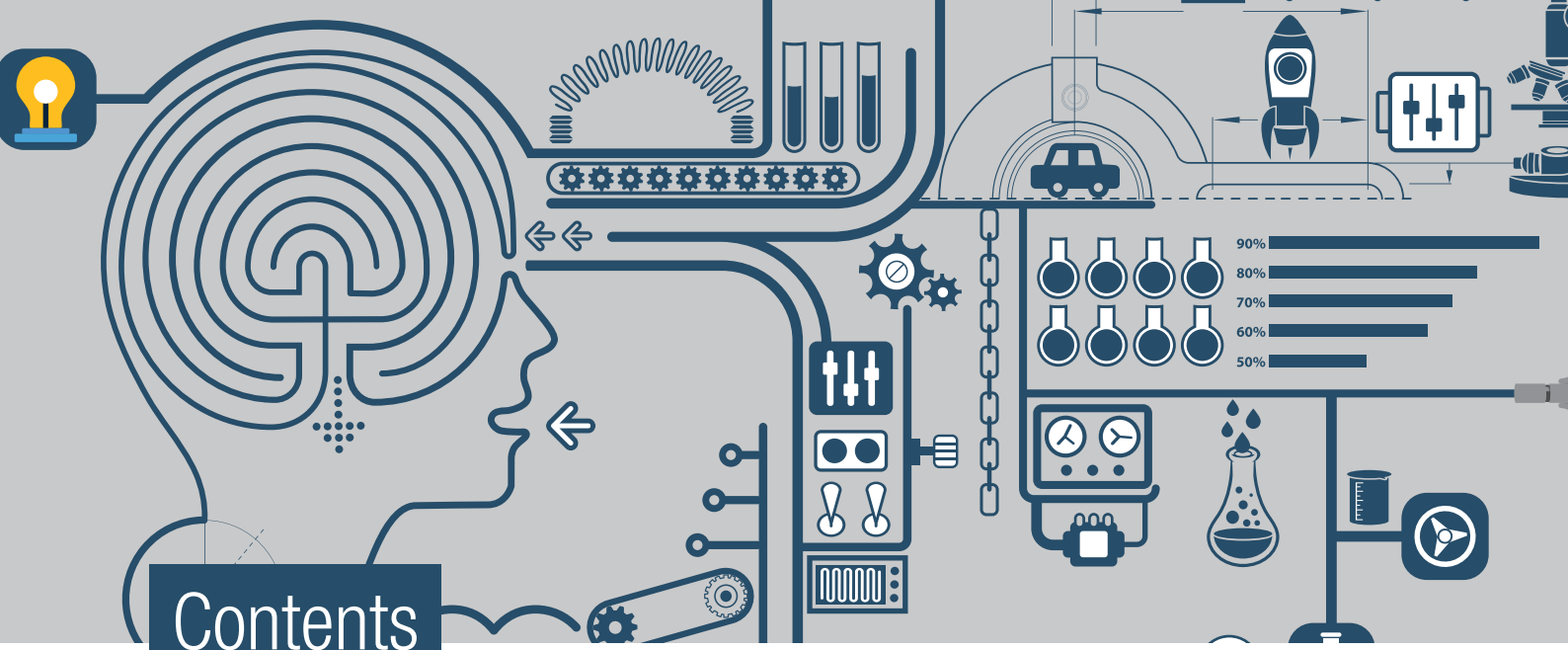

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Rationale

Studies funded by the European Commission or conducted by Science, Technology, Engineering and Mathematics (STEM) communities such as the STEM Alliance have highlighted major issues regarding the situation of STEM in European education systems: the low attractiveness of STEM studies and careers, or the unmet labour market needs in STEM-related sectors that are expected to grow in the future.

Many initiatives and programmes have been pursued to focus on improving the quality and relevance of STEM skills development, to promote STEM studies and careers and to support teachers' professional development. They are supplemented in some countries by national approaches to deal with STEM issues.

In this context, Scientix conducted a study on policies and practices in Europe regarding STEM education, which aims to nourish the European public debate by providing information on STEM policies and STEM teaching practices. The study was carried out in collaboration with Texas Instruments.

The first part of the study, the "Science, Technology, Engineering and Mathematics Education *Policies* in Europe" report highlights the main trends of public education STEM policies in Europe and proposes general observations and synthetic recommendations. Representatives of 14 Ministries of Education provided information about the state of STEM education in their countries, and their insights were enhanced by interviews with industry and university stakeholders.

To complete the findings of this first report, Scientix launched, with the support of Texas Instruments, the STEM Education Practices Survey, looking to collect information about how STEM teachers throughout Europe organise their teaching practices. The "Science, Technology, Engineering and Mathematics Education *Practices* in Europe" report draws on the analysis of 3,780 responses (representing over 4,500 classes) to the STEM Education Practices Survey, answered by educators in 38 European countries. Its aim is to provide a grassroots, European-wide perspective on how STEM teachers organise their teaching, in terms of resources and pedagogical approaches used, on the current state of teachers' professional development and support, and on their opinions and attitudes, particularly in relation to their school environment and their openness to cooperation with STEM industries.

The present document summarises key findings and recommendations drawn from these two reports.

STEM Education Policies in Europe

MAIN FINDINGS

1. STEM education in general

The prevalence of Mathematics in the "STEM mix" of subjects in all national curricula surveyed makes it a key lever in consolidating student perceptions and interest in STEM education in general. To open the door of Mathematics to students is to open the door of STEM.

Some countries are taking steps in improving teaching methodologies in Mathematics. However, the perception is that more should be done to bring new types of teaching and learning to this subject.

Mathematics teachers could benefit from collaborating with science teachers, who tend to use more project-based, inquiry-based and research-based approaches in their classrooms. Often, there are few relations between Mathematics as a subject and other science subjects at the secondary level. This silo split carries on at university levels.

Science, Technology and Engineering are usually taught more innovatively. However, university and private company stakeholders point to the mismatch between students' skills and what they are expected to do in higher education or as engineers. A project-based and problem-based approach is important to secure student motivation. It is important to move beyond the "how to" state of mind – applying "recipes" to already known problems – and adopt a "why?" state of mind, inquiring about problems that are not yet documented.

A large number of initiatives at national and international level are aimed at increasing student motivation towards STEM. The advantage is that creativity and innovation are in the spotlight. However, often these initiatives do not appear to be part of integrated strategies, and their overall impact is difficult to estimate.

2. Main motivations regarding STEM reforms

There are two main motivators pushing national reforms in STEM education:

- the rise of the digital economy, the pace of technological change, and the need to prepare the citizens of the future, and
- labour market demands predicting STEM skills shortages in various sectors (particularly Engineering and ICT).

Addressing the shortage of STEM skills needs an integrated and holistic approach: focusing on ICT engineers and overlooking analog design engineers, and reforming curricula without analysing student orientation patterns are faults that governments with maturity on STEM reforms are trying to avoid.

3. Supporting STEM teachers

National authorities are mobilising universities and collaborating with companies to develop the skills of STEM teachers, but the commitment of universities or companies seems uneven from one country to another.

Most European countries are facing shortages of STEM teachers, although they vary among European sub-regions or countries. If governments are not able to hire and train

good STEM teachers, the chances of getting STEM graduates will be scarcer and scarcer: promoting STEM teaching careers and finding incentives to address this issue is urgent. Collaboration with the private sector could help to recruit the needed profiles: for now, the potential of initiatives proposing hybrid career paths, from engineering positions in private companies towards teaching positions, seems to be underexploited.

Teachers have access to flexible training programmes, often through a mix of online and face-to-face courses. In addition to the new teaching methodologies for teachers, a pool of innovative material is available either online (for virtual material) or in universities and science centres.

In some cases, on-the-job skills development is encouraged, by involving teachers in demanding projects with their students and experts to develop their pedagogical STEM skills on the job.

4. Teaching resources

Many teachers develop pedagogical content themselves, and various platforms exist to encourage exchange and curation of resources at the national and international level. However, the human and financial resources to support these activities are lacking. The life cycle of productions, including quality assurance or the gratification of authors, is rarely considered, leading to unequal quality of resources and the exhaustion of the most committed teachers. To enhance this "crowdsourced" content and respond to the problems it generates, most European states do significant work in classifying and qualifying resources. This work may remain hidden, and teachers can feel lost in the labyrinth of STEM resources.

Non-governmental organisations and private companies establish partnerships with governments to take action on STEM education challenges. The creation of educational resources for teaching STEM no longer relies solely on the activity of traditional publishers or publicly funded publishers operated by ministries. This transition to a free supply of resources is observable in several European countries and to some extent encouraged by European Commission funded programmes.

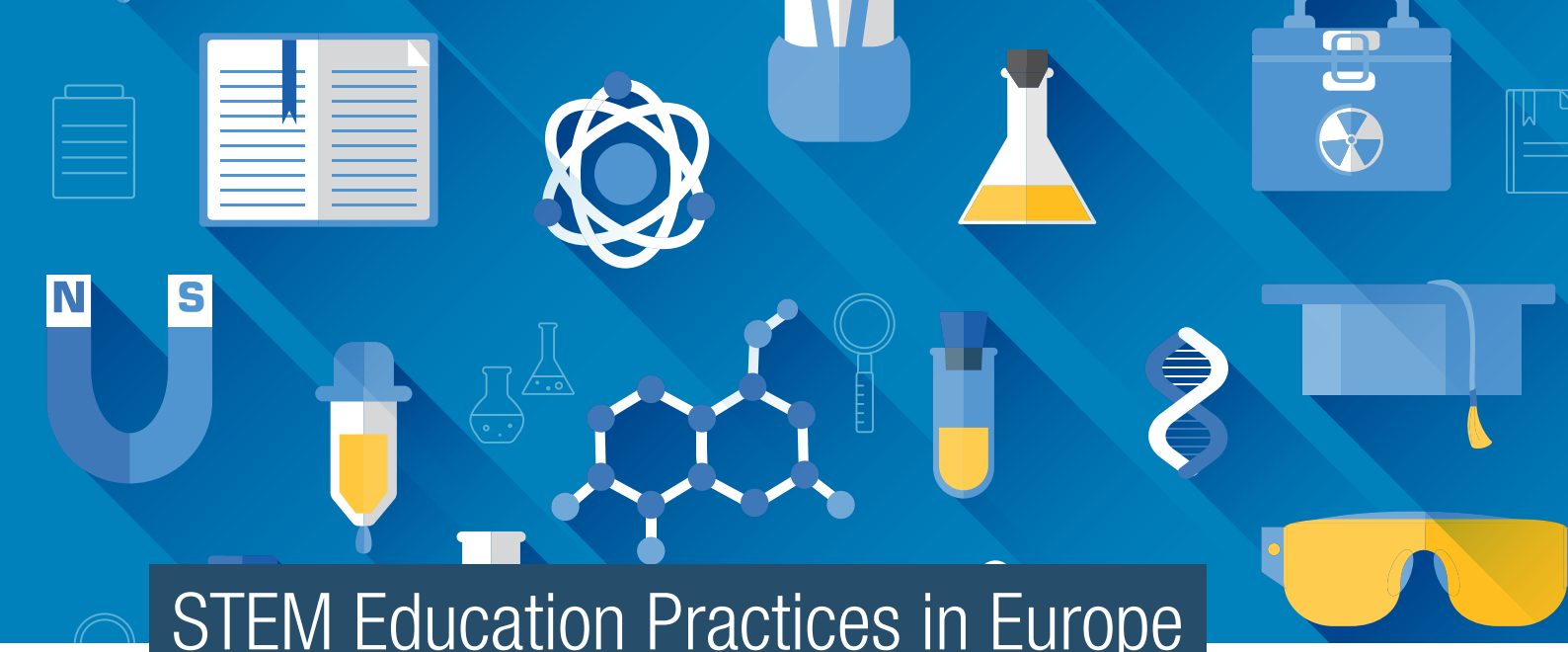
RECOMMENDATIONS

The following recommendations were put forward to address the STEM education challenges identified in this first report:

1. **Attracting more students and teachers to STEM education through a global approach from primary to adult education** that will better anticipate the skills needed for the society of the future;
2. **Breaking down the barriers between subjects with pragmatic initiatives** (teacher training sessions, publishing contents, sharing best practices, etc.) to improve the quality of STEM education by building on each country's strengths;
3. **Evaluating and integrating curriculum and pedagogical innovations**: all energies must be oriented in the right direction with value-added purpose-built technologies and services that need to be provided; positive experimentations need to be rolled out across the entire education system and disseminated among European countries (sharing of best practices, ideally in line with a common European framework);
4. **Developing a common European framework of reference for STEM education** and coordinating national STEM initiatives related to publishing pedagogical content to ensure teachers' needs are being met;
5. **Fostering deeper collaboration with universities and industry to develop STEM teachers' skills**.

These five points reveal a major strategic issue. While European countries participating in the study described their ambitions and actions regarding STEM education, it is difficult to observe at present the implementation of an integrated strategy involving all the domains and actors concerned on a national or European scale.

To cope with the fast pace of technological innovation, European education systems need a better vertical integration of their STEM policies, with better relations between schools, universities and companies in STEM fields. They need a better horizontal integration too for developing a balanced approach between the different parts of the STEM block of subjects.



STEM Education Practices in Europe

MAIN FINDINGS

Increasing the motivation of students towards studying STEM subjects and raising achievement in these areas are important challenges faced by European education systems, and the way STEM is approached in schools is key to addressing them. The STEM Education *Practices* in Europe report's key findings are divided into five main areas, covering: pedagogical approaches used in STEM teaching; access to and use of resources and materials; professional development and support for STEM teachers; experience and educational level in STEM teaching; and teachers' attitudes and influence of the environment.

1. Pedagogical approaches

Traditional direct instruction remains among the most highly reported pedagogical approaches in STEM teaching. This trend slightly increases in high-frequency classes (classes which are taught over three or more sessions per week), an indication that, if more classroom time is available to teachers, it is not used to bring more innovative approaches into teaching.

A prevalent subject in European curricula, Mathematics was identified in the STEM Education Policies Report (October 2018) as being "a key lever to transforming STEM teaching and learning". The present study found that the subject appears to be taught more often through teacher-focused, less diverse and less contextualised pedagogies than the other, STE subjects. At the other end of the spectrum, ICT teachers appear to be using student-centred pedagogical approaches to a much higher degree, reporting the lowest use of traditional teaching, as well as the highest use of project/problem-based learning and collaborative learning.

2. Resources and materials

With the exception of ICT subjects, teachers report an extensive use of paper-based materials in their teaching, alongside mainly presentation aids (slideshow presentations and audio or video materials), a finding in line with the high reporting of teacher-led instruction highlighted above.

Science and technology teachers also point to insufficient access to experimental labs, an indication that pupils may not be given sufficient opportunities to do practical work as part of their science learning.

3. Professional development and support for STEM teachers

The majority of STEM teachers surveyed have not taken any ICT-related professional development or training related to innovative STEM teaching in the last two years. When they do follow training, teachers tend to update their knowledge online and in their own time.

In terms of supporting groups, most teachers rely on their colleagues in the same subject for updating their knowledge. In general, a divide can be observed between the teachers' high use of collaboration in the classroom, and their own professional practice (38% of STEM teachers surveyed report having received little or no support, even from their colleagues in the same discipline).

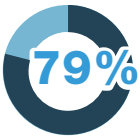
General

3,780 participants from **38** countries

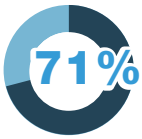
Pedagogy

TRADITIONAL INSTRUCTION REMAINS DOMINANT

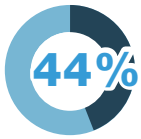
Traditional direct instruction



Project/problem-based approach



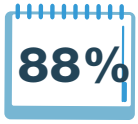
Inquiry-based science education



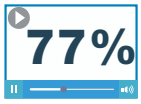
Resources

PAPER-BASED MATERIALS ARE USED EXTENSIVELY

Paper-based materials



Audio/video materials

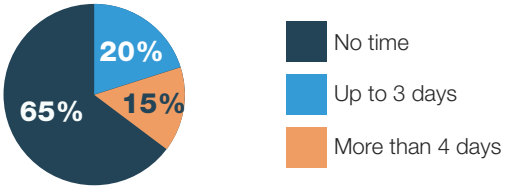


Collaborative online tools

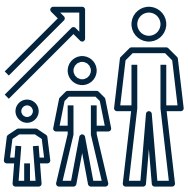
Professional Development

LIMITED TIME ON PROFESSIONAL DEVELOPMENT

STEM teachers spent, on average, limited time on professional development in the last 2 years



Experience



EXPERIENCE INCREASES INNOVATION

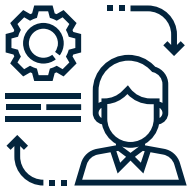
STE teachers with 30+ years of experience compared to teachers with 4 or less years of experience

↑**25%** more teaching with experiments

↑**8%** more project/problem-based approach

↓**12%** less traditional direct instruction

Attitudes



THERE IS ROOM FOR COLLABORATION WITH INDUSTRY

STEM teachers would like more resources from the industry

25% use resources from the industry now

93% would like to use more resources from the industry

4. Experience and educational level in STEM teaching

With more experience, teachers are more willing to integrate constructivist pedagogical approaches in their classes and limit the use of direct instruction. This trend can be observed in all other subjects, except Mathematics, where traditional instruction remains high, with little variation according to experience.

As national end-of-secondary-education exams approach, it appears that more diverse pedagogies increasingly give way to traditional teaching, with instructional practices such as Inquiry-Based Science Education, project/problem-based learning and personalised learning being particularly affected.

5. Teachers' attitudes and influence of the environment

Three out of four of the teachers surveyed share a positive vision of innovative STEM teaching with their colleagues and the head of school, and this is linked positively with the amount of innovation brought into the classroom. Teachers appear open to collaborating with STEM industries in various domains to enhance teaching and learning.

RECOMMENDATIONS

The analysis of the STEM Education Practices teachers' questionnaire provides a good insight into how teachers in Europe approach STEM teaching. The results of the survey reflect a diverse landscape, with STEM teachers trying their hand at new pedagogies and diversifying the resources and materials used, but also indicate that there is still a need for support on a number of actions in order to advance effective STEM education at the European level.

1. Supporting innovative STEM teaching practices and networks based on Inquiry-Based Science Education (IBSE), and other student-centred pedagogies

The high frequency of reported traditional instruction and of paper-based materials in STEM teaching, contrasted with the notably lower reporting of student-centred approaches, such as inquiry-based or problem/project-based approaches, suggests that there is still a lack of confidence, at the level of STEM teachers, in approaching more innovative pedagogies, an aspect particularly notable among less experienced teachers.

The STEM Education *Policies* report proposed the development of a common European framework of reference for STEM education, to evaluate and integrate curriculum and pedagogical innovation.

On a similar line, the results of the STEM Education Practices study call for actions in supporting European networks of exchange and assistance for STEM teachers to build confidence in approaching innovative teaching inside and outside the classroom. The fact that teachers tend to turn primarily to their peers for professional support shows the important impact teacher networks can have. Programmes should also address initial teacher education to ensure that new teachers are appropriately trained to approach innovation in their practice.

2. Offering relevant professional development opportunities for STEM teachers and strengthening school-industry collaboration

The report's findings raise concerns regarding the professional development of STEM teachers. There is a clear need to support the development and dissemination of relevant STEM training programmes which encourage teachers to build their subject and pedagogical knowledge as well as their confidence in using new technologies in the classroom. Appropriate mechanisms to recognise and support teachers' efforts to improve their teaching should be put in place.

Educators appear to be open to school-industry collaboration – a very positive sign, as school-industry 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 to produce educational content. However, STEM teachers report rare use of industry-based educational materials, an indication that their general openness towards collaborating with STEM industries is not being met with

an appropriate response. Strengthening school-industry collaboration is essential to ensure that teachers are in a good position to help their students develop relevant skills, and for companies to support the improvement of the labour force of tomorrow.

3. Innovating the STEM education curriculum and assessment

Pressure to prepare students for final exams is the main factor affecting STEM teaching, and the impact can be observed in the overall decrease in the use of student-centred pedagogies as students advance to higher educational levels. An important factor is the way the curriculum is written and expected to be taught. Assessment policies that give sufficient weight to formative evaluation methods are needed so as not to inhibit the use of innovative pedagogies in the final years of education. Evidence-based initiatives that develop and test new assessment methods compatible with innovative teaching practices should also receive appropriate support.

4. Supporting the development and implementation of whole-school STEM-oriented strategies

The school context plays an important role in advancing the STEM agenda. The report provides evidence to suggest that teachers appear more confident in approaching pedagogical innovation when they have the support of their peers and the school administration. Developing a clear STEM strategy at the school level to promote and support innovative STEM teaching can play an essential role in coordinating efforts to improve the quality of STEM teaching and to ensure that STEM teachers benefit from the appropriate support to improve their practice.

5. Strengthening trans-disciplinary collaboration to encourage the uptake of integrative STEM teaching

Integrative STEM teaching should also be addressed. The teachers surveyed report a relatively high use (68%) of "integrative learning", but only 53% coordinate their teaching with teachers of other disciplines. An integrative approach to STEM education cannot be carried out in isolation and without curriculum flexibility. The STEM Education *Policies* report encouraged the uptake of pragmatic initiatives directed at breaking down the barriers between STEM subjects. Such initiatives should also consider strengthening teachers' collaboration and encouraging the exchange of good practices across disciplines to ensure that the conditions are met for a meaningful integrative STEM education in classrooms across Europe.

Acknowledgements

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The “Science, Technology Engineering and Mathematics Education Policies in Europe” report (October 2018) and the “Science, Technology Engineering and Mathematics Education Practices in Europe” report (December 2018) are two Scientix Observatory publications from Scientix, the community of science education in Europe, carried out in collaboration with Texas Instruments. Both reports and related information can be accessed online at the following link: www.scientix.eu/observatory/stem-education-practices-europe

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