How can classroom teaching be improved to enhance students’ learning of STEM subjects and improve the uptake of STEM careers?
Introduction

Few European countries have an overall strategic approach to promoting education in science, technology, engineering or mathematics subjects. Those that do focus primarily on the curriculum in schools, teaching methods and teacher education. Most strategic approaches also involve a range of partners such as governments, companies, subject associations and higher education institutions. This policy work is in response to a number of concerns which include:

- declining interest in science studies and related professions
- rising demand for qualified researchers and technicians
- concern that there may be a decline in innovation and, consequently, economic competitiveness

In order to counteract such concerns policymakers, including those without an overall strategy, have undertaken a range of activities which include:

- promoting scientific culture, knowledge and research by familiarising pupils and students with scientific procedures and by disseminating scientific research results to schools
- making students understand what science is used for, namely through contact with companies in science-related fields
- enhancing and supporting the implementation of the science curriculum, subjects and teaching
- providing teachers with continuing professional development (CPD) focusing on practical work and inquiry-based learning
- supporting students at school in science activities
- increasing recruitment to STEM by encouraging talented pupils and motivating students to choose STEM careers by making school science more work-relevant

Most European countries recommend that STEM should be taught in context. Usually this involves teaching STEM in relation to contemporary societal issues. Environmental concerns and the application of scientific achievements to daily life are recommended for inclusion in STEM lessons in almost all European countries.

Strengthening teacher competences is also a particularly important concern. Countries which have a strategic framework for the promotion of STEM normally include the improvement of teacher development as one of their objectives. School partnerships, STEM centres and similar institutions all contribute to teachers’ informal learning and may provide valuable advice and deliver formal CPD activities for teachers. Career guidance is promoted also, but usually as part of the career guidance mechanisms already in place, not necessarily involving teachers of STEM and frequently by making the examples used in class more relevant to the ‘real world’.

---

1 Science Education in Europe: National Policies, Practices and Research Euridyce Report 2011
Overview

This digest describes how one project, InGenious\(^2\), whose characteristics include many of the points above, has successfully enabled a range of schools across 26 European countries to effect change in the interest students display in STEM subjects and STEM careers and increase their likelihood of taking up such careers when they leave education. The project was three years in duration and involved 500 teachers, 350 schools, and 15,000 students from primary and secondary schools, and further education as participants.

Teachers and their students were invited to evaluate 35 different classroom activities whose purpose was to place learning within industrial contexts. The activities themselves had been developed with, and by, employers or industry experts. This included opportunities for teachers and students to visit industries, take part in online discussions with employers, meet experts in their classrooms and question them about their jobs, partake in novel classroom experiments and explore how learning science, maths and other technology subjects can help when choosing a career or job in later life.

As part of the activities in their STEM lessons they had the opportunity to learn first hand about what a career in such areas was about and how they could involve themselves in it. Teachers who taught the STEM subject were also responsible for teaching about, and helping students understand, the qualities of individuals who worked in that industry. Sometimes this teaching took place in conjunction with careers counsellors or with an employer but the basis for the lesson was that, not only was the STEM subject knowledge embedded in a real industrial context, but the jobs which that STEM knowledge could lead to were promoted to students too.

In order to evaluate the efficacy of the activities in promoting knowledge and careers, surveys were collected from teachers and students every year exploring their opinions of the activities they had undertaken and the results of these analysed to provide information about their impact on students and teachers.

Impact on students

Students reported that the activities in which they had participated were interesting, and for the greater majority had had an impact on their understanding of STEM careers. In addition, when responding directly to questions about a job in STEM subjects, both primary and secondary students were more likely to state a preference for a job in a STEM industry following project participation as the corresponding graphs show.

\(^2\) The report of the full project can be found here: www.ingenious-science.eu
Students views on the impact of the activities

- **Percentage of student responses**
  - Learnt about qualities required to work in STEM: 65%
  - Learnt about practical applications and real life use of science and maths: 72%
  - Learnt about industrial processes: 61%
  - Learnt new things about jobs in industry and science: 65%
  - The activities improve understanding of topics that are studied: 71%

InGenious: pre- and post-secondary school questionnaires

Long term impact on secondary pupils' interest in STEM careers

% of pupils who *Agree a lot* or *Agree a little* with the statement "I would like to get a job related to science and technology"

- **Overall change: 8%**
  - Girls: 45% (pre-project level) +11% (post-project improvement)
  - Boys: 65% (pre-project level) +7% (post-project improvement)

Legend:
- Purple: pre-project level (n=8534)
- Blue: post-project improvement (n=5955)
Impact on teachers

Teachers were enthusiastic about the impact the project had on their own teaching skills, with 98% believing it had had some impact and 81% believing this impact to have been high or medium. The proportion of teachers who felt the impact to have been a high one increased steadily throughout the three years.

Similarly, teachers felt that teaching the various activities had helped them learn to contextualise their lessons better in real life applications, with 84% of teachers reporting the project had had a high impact on this ability by year three. Teachers also felt that their capacity to advise students about STEM careers had improved by virtue of contact with employers, either virtually or within the classroom. Again, the proportions are similar, with 83% believing they were much better equipped to help students with career advice by the final year of the project and 97% acknowledging they dealt better with advice on careers in STEM.
Post-pilot teachers’ feedback on the project (pilots 1 2 3)

**Impact on teachers** “My teaching skills and practices have been enhanced”

<table>
<thead>
<tr>
<th></th>
<th>Pilot 1</th>
<th>Pilot 2</th>
<th>Pilot 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>96%</td>
<td>63%</td>
<td>72%</td>
<td>81%</td>
</tr>
<tr>
<td>98%</td>
<td>72%</td>
<td>81%</td>
<td>98%</td>
</tr>
</tbody>
</table>

Impact on teachers “My abilities to teach STEM subjects in the context of real life applications have improved”

<table>
<thead>
<tr>
<th></th>
<th>Pilot 1</th>
<th>Pilot 2</th>
<th>Pilot 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>97%</td>
<td>68%</td>
<td>70%</td>
<td>84%</td>
</tr>
<tr>
<td>98%</td>
<td>70%</td>
<td>84%</td>
<td>98%</td>
</tr>
</tbody>
</table>

Impact on teachers “I am better able to advise my pupils on careers in science, technology and industry”

<table>
<thead>
<tr>
<th></th>
<th>Pilot 1</th>
<th>Pilot 2</th>
<th>Pilot 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>91%</td>
<td>64%</td>
<td>74%</td>
<td>83%</td>
</tr>
<tr>
<td>97%</td>
<td>74%</td>
<td>83%</td>
<td>97%</td>
</tr>
</tbody>
</table>

**What brought about this impact?**

The feedback provided by teachers in surveys, focus groups and in case studies demonstrated that just participating in the project itself had helped them to improve their teaching and to change the learning experience of students. At the start of the project many of them admitted that they did not use examples of resources from industry in their teaching very often and that, by and large, they knew little about working in a modern industrial workforce and the qualities required in such jobs. Contact with employers in the workplace and in the classroom or online, the chance to question and understand how and why processes took place, and what characteristics workers in such jobs would need, greatly enhanced their teaching ability. In addition the project also enabled teachers to widen their professional networks to include other teachers in their schools, some of whom were not teachers of STEM, local STEM businesses and other students in classes outside the project.

One of the most important aspects of the project was the opportunity to enhance their own professional development. Teachers regarded the impact of the professional development activities to be one of the highlights of the project for them. In particular, contact and sharing ideas with others, be they employers, teachers or project leaders, was a key feature which teachers reported upon enthusiastically.
Whilst this is a clear indication of the success of the CPD, it does bring into question the degree to which such a wide range of development as teachers are asking for is sustainable.

However this requires a great deal of investment, both of time and energy on behalf of individuals and organisations in the future. Is there sufficient evidence from the project to persuade policymakers and industrial funders that this much-valued outcome of the project can be replicated economically within different education systems?

The project has demonstrated that four aspects are important to make a significant difference to teaching and have an impact on student learning and their choice of career in the future:

• Interesting classroom and extra-curriculum activities
• Inputs from experts, through the development of learning resources as well as direct interaction with teachers and students
• Addressing the real life applications of STEM knowledge as well as benefits of having a career in a STEM area of work alongside STEM teaching in the classroom
• Integrating professional development for teachers through interactive and online resources as well as face to face opportunities to address issues with both colleagues and experts creates a culture of continuous improvement

Having a bank of well tried and tested materials and resources is not enough. For teachers to progress in their understanding, embrace new opportunities for their students and influence their career choices, this seamless professional development to improve their own understanding is a critical first step.

Governments, policymakers and CPD providers need to play their part. They must invest in the resources which will enable teachers to maintain this culture. Some good examples have been seen in the project of events, online activities and support groups, all of which require resources for their establishment and maintenance. But ensuring STEM teachers themselves are knowledgeable enough about STEM careers and the use of STEM knowledge in employment to teach it alongside their subject seems to be the all-important key. This takes investment and commitment.