INTRODUCING NEW STEM TOPICS IN THE CURRICULUM


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Abstract

Fast-advancing societal changes require flexible educational systems, ready to equip students with the skills and competencies needed to respond to them. Projects in science education tend to be quick in picking up these trends and are already producing materials and activities aimed at introducing new scientific thought in the classrooms. But curriculum change in many countries is often a lengthy process, involving complex decision-making mechanisms. This paper draws from the discussions between managers and representatives of over 20 projects in science education, which took place during the 10th Scientific Projects Networking Event and attempts to shed an overview on potential ways of introducing new STEM topics in educational curricula across Europe and beyond.

Keywords: STEM, Curriculum, subjects, projects, policy, interdisciplinary learning, cross-disciplinary learning

Introduction

Scientix, the community for science and maths education in Europe, initiated by the European Commission (Research and Innovation DG), has set up the Scientix observatory to provide a regular overview of the state of play of different themes related to science and maths education. The themes and initiatives examined vary in duration, scope, audience and methodology, yet all of them include elements of e-learning and the use of various online tools for education, communication, or data collection.

This article draws from the discussions between project managers and project representatives who participated in the 10th Science Projects Networking Event organised by Scientix on February 26th 2016 to discuss best ways to introduce new STEM topics in the curriculum.

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Education strategies: written and taught curriculum

The educational curriculum is broadly defined as “a normative document (or a collection of documents) setting the framework for planning learning experiences” (Cedefop, 2012, p.30). Whilst there are undoubtedly wide country variations between educational curricula across Europe, Cedefop’s definition already suggests some commonalities: the formal nature of the document (or collection of documents), the planning and assessment process that underpins curriculum change and its normative nature, to name but a few.

However, a clear difference can be drawn between: [1] the design of the written curriculum (of the normative document/s) and [2] the implementation of the curriculum in real learning scenarios, i.e. the taught curriculum (Cedefop, 2012, p.30). If the written curriculum provides a normative framework for the implementation of teaching and learning activities, the taught curriculum is more than the simple implementation of the normative document/s. Each of the two stages often involves different stakeholders. Country differences included, in the development of the written curriculum a variety of stakeholders can be consulted, from pedagogical advisors and government representatives to members of the academia, teachers, industry representatives, etc. Whereas they do have a notable influence in the implementation of the taught curriculum, other factors may influence the manner in which teachers choose to carry out their lessons – such as the organisational culture of the school or, on a micro-level, the individual teacher’s preference for one approach or the other.

A good example of differences between the policy priorities of national curricula and their practical implementation is given in Kearney (2016): while inquiry based learning is addressed as a priority in STEM education by 80% of the 30 countries surveyed, only 7% of the respondents admitted to actively promoting small group activities (closely associated to inquiry-based approaches) in science classes (pp.13). This illustrates the gap between policy and practice and provides an indication that, although desirable, curriculum change may not be a pre-requisite for the introduction of new STEM subjects in the classrooms.

It is beyond the scope of this paper to detail the processes of implementation and design of educational curricula across Europe. However, marking this difference may help projects in science education identify ways to make their resources and activities of use in the classroom. This is a particular problem for projects which operate internationally, often in countries with very different curricular approaches.

Changing the written curriculum is often a lengthy process, requiring greater efforts to influence stakeholders involved in the development and design of the normative documents; nevertheless, targeting groups that are normally not involved in the decision-making processes at the normative level, such as teachers, heads of schools, parents and students, and thus attempting to influence the taught curriculum, could increase the chances of introducing project resources in the classroom.

The need for including new STEM topics

Research has shown that the number of students interested in pursuing science careers is on a descendent trend (Rocard, 2007; European Commission, 2015); this is of concern not only as it threatens the quality of research and innovation in sciences and mathematics, but also because it leaves students lacking essential skills. Moreover, employment in STEM profession is growing despite the economic crisis and the demand is expected to increase (EC report on
Encouraging STEM studies for the labour market, 2015). Added to the well-known issue of balancing the gender gap between male and female STEM workers, it is becoming evident that more needs to be done for increasing the appeal of STEM subjects and STEM careers.

The promotion of STEM education is currently a priority in many European countries. Countries are prioritising to various degrees the adoption of inquiry based learning, the integration of effective use of ICT in science education and the development of new and revised STEM teaching and/or learning resources (Kearney, 2016, p.5). Responsible Research and Innovation, an issue high on the European policy agenda (Science Education for Responsible Citizenship, 2015) and which can have significant impact in motivating students to pursue science education, is somewhat lower on the individual countries’ list of priorities. Less prioritised, as well, are the issues of addressing the gender balance and of offering career guidance in relation to STEM education (Kearney, 2016).

New STEM topics have a large potential of getting students interested in STEM subjects, as they provide opportunities for students to consider and debate the effects of important societal changes in a scientific/technical context. Issues such as global warming, the challenges of an ageing population, the effects of new scientific discoveries, etc. are themes perfectly adapted to a more student-centred approach to education, providing perfect environments for teaching methods such as inquiry-based learning and contextual problem-solving. The literature (Gibson et. al., 2002) provides evidence of the positive impact that innovative teaching approaches such as inquiry based learning can have on motivating students and raising their interest in STEM subjects. Sanders (2008) argues for the integrated teaching of STEM subjects, which would better engage students in scientific inquiry and contextual problem-solving and thus provide them with an improved learning environment.

These methods can attract more students towards STEM subjects, but the ways in which they find practical applications in classrooms are usually decided at school, or even at teacher level (Kearney, 2016). If influencing the written curriculum can be more problematic, projects in science education have the unique opportunity of contributing to the taught curriculum, by closely collaborating with their teacher stakeholders. An overview of how some of the projects present at the 10th Scientix Projects’ Networking Event are making their mark into the promotion and uptake of new STEM disciplines in the classroom is provided in the following sections.

**Advantages and challenges in the adoption of new STEM subjects**

Adopting new STEM subjects in the classroom have some clear advantages. Firstly, they tend to reflect contextual, real-life knowledge, compared to the teaching of separate disciplines that may be more abstract in nature. They also help students develop transversal skills such as critical thinking, problem-solving and collaboration; and they tend to contribute to the increase of student motivation. By contextualizing scientific thinking, projects have the possibility of addressing larger societal challenges, and there is a clear tendency towards this in projects such as Universe Awareness1, EU Space Awareness2 or RRI Tools3.

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Moreover, new STEM subjects can cover areas of science and technology that traditional, separate teaching may not be able to do (such as nanoscience and nanotechnology, robotics, and so on), due to their trans-disciplinary nature. Their introduction into the taught curricula has the potential of opening new career paths for students and closing skills gaps in emerging industries.

However, some important challenges to the introduction of new STEM topics in the educational curricula remain. Whilst some of them have been addressed in the previous section of this paper (the rigidity of the written curriculum in most countries, for instance, and a perceived resistance to change), we will list here some of the most prevalent issues that may arise:

- The need to train teachers into adopting new pedagogies and new working styles. New STEM subjects tend to be interdisciplinary, and thus may require more collaboration between teachers from two or more different subjects. This would mean that more time may have to be allocated by teachers to planning these activities than it would otherwise be necessary in traditional teaching.
- The necessity of teaching materials, designed with pedagogical expertise that take into consideration the balance between the need for students to acquire, apart from the understanding of the bigger picture, discipline-specific foundational skills
- The availability of tools to make the teaching more efficient and to encourage the uptake of new STEM disciplines inside or outside the classrooms

### Addressing challenges in science education through new STEM subjects

There is large scope for projects in science education to address some of the challenges of introducing new STEM topics in the taught curricula, and many of them play an important part in supporting this in different areas. We will look in this section at initiatives that, through the collaboration between projects in science education, schools, but also universities or private companies, effectively address some of the most stringent issues raised by the teaching of new STEM subjects.

### Teacher training

Teacher training is an important aspect of introducing new STEM. The University of Valencia⁴, for instance, is using results of scientific research in cognitive neuroscience and education to inform strategies that can be applied in the classrooms to motivate young students’ involvement in science and mathematics. Training teachers into these new practices is also addressed within University of Valencia’s programmes. TEMI⁵ is a major player in this field, collaborating with teacher training institutions and teacher networks from 11 European countries to implement innovative training programmes to guide teachers in the use of enquiry in science teaching. TEMI’s approach is also structured around contextual learning, encouraging teachers to use “mysteries” in the teaching of scientific concepts. The project

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⁵ [http://www.teachingmysteries.eu/](http://www.teachingmysteries.eu/)
supplements classroom training workshops, drama based activities and other skill building exercises with online support in the form of smartphone apps, videos, publications and online training seminars.

**Teaching tools and materials**

As an integrative approach, context-based teaching needs to include a variety of points of view and educational resources. Beside the need to train teachers into working collaboratively, there is an additional need to offer them the right tools to efficiently conduct their classes. Projects can offer much support in this area, from offering virtual teachers spaces to start collaborations and discuss their needs (the communities of practice run under Scientix 2\(^6\) or under Digital School\(^7\) in Greece are good examples of spaces for teacher collaboration) to providing them with effective online tools that can be used in their classrooms.

There is a variety of projects that offer online resources with the aim of motivating the student uptake of science and mathematics. Go-Lab provides an online platform for the teaching of science and mathematics which includes remote science laboratories and their online models (online labs) for large-scale use in education. The Go-Lab Portal offers students the opportunity to perform personalized scientific experiments with online labs, and teachers a way to enrich their classroom activities with demonstrations a web-based pedagogic community. Web based Virtual Laboratories\(^8\) is another project that draws from pedagogical research to offer students the possibility to conduct realistic virtual experiments in a safe environment.

**Introducing new STEM outside the classroom**

Where the inclusion of new STEM in the classroom is not possible (due to a topic being very specific, with a very limited interest group, etc.), out of school activities such as competitions and science fairs can complement the information received in class and motivate students by allowing them the opportunity to engage with new developments in science and technology. A good example of that is the D3MOBILE METROLOGY WORLD LEAGUE\(^9\), an international championship in 3D precision modelling on mobile phones aimed at 14-18 years old, which manages to disseminate the importance and practical applications of metrology. The 3\(^{rd}\) edition of the championship received over one thousand registrations from 33 countries around the globe. Archipelag Matematyki\(^10\), implemented in Poland, is an out-of-school program that looks to explain otherwise abstract mathematical principles through an interactive online game available to students and teachers alike.

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\(^6\) [http://www.scientix.eu/](http://www.scientix.eu/)

\(^7\) [http://dschool.edu.gr/](http://dschool.edu.gr/)

\(^8\) Information about the project was extracted from the projects’ presentation during the 10\(^{th}\) Science Projects Networking Event organised by Scientix on February 26\(^{th}\) 2016. The presentation is available on the event’s webpage: [http://www.scientix.eu/web/guest/networking-event/10th-spne-after](http://www.scientix.eu/web/guest/networking-event/10th-spne-after)

\(^9\) [http://d3mobile.es/?idioma=en](http://d3mobile.es/?idioma=en)

\(^10\) [http://www.archipelagmatematyki.pl/](http://www.archipelagmatematyki.pl/)
Addressing societal issues through the introduction of new STEM subjects

Some projects are ideally positioned to join together the introduction of new subjects (such as astronomy) and addressing important social issues. Universe Awareness successfully combines the production of educational resources ready to be used in schools with teacher training and pedagogical research. The project also pilots an after-school programme including weekly workshops with refugee children in the Netherlands. Indeed, social background remains one of the most important factors to influence school performance (Eurydice, 2011, p.21), and studies show significant differences between the achievements of foreign-born and native-born students, with underachievement amongst the foreign-born students being almost twice as that of native-born students (European Commission, 2015; Kearny, 2015). This is an issue that can only be addressed by a major effort that involves governmental stakeholders, but projects can play an important part in drawing attention to these matters. Another example of good practice in this sense is the Islamic astronomy heritage box developed by EU Space Awareness, a toolkit which includes educational resources focusing on the Islamic contribution to astronomy aiming to dispel social stereotypes and pass on a message of a common cultural heritage to both refugee and European children.

Conclusions

Science education occupies a privileged position in advancing research and innovation, but also in tackling key social issues. Getting students engaged in important contemporary issues (such as global warming, improving water and air quality, health etc.) may help improve the attractiveness of scientific careers amongst the young. Pursuing this path would involve in a lesser degree the promotion of STEM education, but more a reconsidering of the way STEM is being taught, with greater attention being allocated to integrative teaching approaches and collaboration across disciplines. Projects in science education can play a significant role in this sense, by developing innovative lesson plans/learning scenarios that tackle the taught STEM curriculum – the actual practice of teaching science and mathematics in schools.

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References:


