INSTEM

Innovation Networks in Science, Technology, Engineering & Mathematics

WP2 Synthesis Report: Summary

INSTEM and the synthesis of learning from STEM education projects in EU Framework 7 and Lifelong Learning Programmes

This report is based on a review of documents supplied by 20+ of the STEM (Science, Technology, Engineering & Mathematics) education projects funded in FP7 and the LLP. The full report is as comprehensive as possible but cannot be exhaustive, due to the continual proliferation of projects and documents. Its conclusions are set out below as recommendations.

The INSTEM synthesis reflects the consensus view of project coordinators, who have had experience of STEM projects over many years and who are acommitted to improving the state of STEM education in Europe and elsewhere. The key message of this report is that there should be a coherent approach to STEM education in Europe during the period of the Horizon 2020 programme and beyond (2014-2025). The funding of STEM education projects by the EC is an important contribution to revitalising teaching and learning in these subjects, and all the projects reviewed here are fully committed to a pan-European movement towards innovative policies in STEM education. As this report shows, however, innovative policies do not necessarily lead to the use of new methods, whilst inquiry-based learning should be considered along with other enhancements to practice, such as the increased use of formative assessment.

Why this report is necessary

This report results from meetings in 2010 between coordinators of STEM education projects, who decided that it was useful for projects to talk to each other in order to make progress on the overall objective of improving STEM education in Europe. This resulted in the formation of the ProCoNet group of project coordinators committed to collaboration and knowledge exchange within inquiry-based STEM education.

The INSTEM project was formed by the ProCoNet group to synthesise the activities of current and completed projects to provide a reference point, from which further activities could be developed. This report does not attempt to evaluate the success of individual projects or project actions. Such evaluations are carried out routinely within projects or by designated external evaluators on a project-by-project basis. We therefore took project reports and other public-domain documents at face value, subject to a degree of interpretation based on contextual factors. We have not attempted to compare the overall value of different projects' approaches to promoting IBL, since no objective criteria or comparable data exist for this purpose. For example, we should not only equate success with the number of teachers reached or number of journal articles published. The relevant data and success criteria could only be established through additional research beyond the scope of this report, and of INSTEM as a whole. We therefore took project findings and outcomes as being the best that could be achieved by that team, at that time, using available resources.

Conclusions

The INSTEM report is not a manual or handbook for introducing or reinforcing inquiry-based teaching and learning. Such publications are already available from a range of sources including projects themselves, as described in the appendix, and within the general literature on teaching and learning. It provides evidence for rethinking how we approach projects in STEM education, as summarised in our recommendations below.

The main area of potential future learning identified in the report concerns student engagement. This is the key to success in education, and student disengagement is targeted by the EC within areas such as early dropout and low rates of participation in tertiary education. It might, therefore, be considered that student opinion and student voice would be more prominent in the discourse of inquiry-based science education. This is not, however, the case, as we discuss in the full version of the report. Further research is needed to find out how students and teachers actually respond to IBL.

It is clear that the existing infrastructure within the STEM education community lacks effective mechanisms for meta-level learning from projects. Projects already know how to provide support for teachers and informal educators to do inquiry in and out of the classroom. They also know that the implementation of inquiry is heavily dependent on systemic factors, and that these factors should be addressed. Since many of these factors relate to national education policy, and are therefore beyond the reach of EU policy instruments, addressing them requires direct liaison with national agencies and policymakers.

Although portals and repositories have been created for this purpose and project websites can remain online, but there is an acknowledged problem with the sustainability of projects.

It is clear that there is support in the literature for a model of good teaching and learning, which applies across the curriculum and which encompasses such areas as goals, expectations, clear outcomes, formative feedback in both directions and respect for difference (Hattie, 2009)[1]. Unfortunately, inquiry based learning has been promoted as a 'magic bullet' solution to an economic problem, rather than for its own sake. The trajectory of potential scientists is not well understood and should be studied, not only through pedagogical research in schools, but also through curriculum studies, higher education research and labour market analysis.

The report is thus positioned at a natural crossroads on the way to better STEM education. We hope that we have indicated a clear direction for the future, which we summarise below in a series of recommendations at various levels. Our overall message is that a systemic approach is needed, with extensive interdisciplinary collaboration, reference to existing research and, where necessary, new research to provide evidence for action.

[1] Hattie, John (2009) Visible Learning: A synthesis of over 800 meta-analyses relating to achievement, London, Routledge.

What we mean by STEM

For our purposes, we have chosen the term STEM because it reflects a wide range of topic areas in schools where science and/or mathematical concepts are relevant.

In writing this report, we are conscious of a range of views on this issue, and in particular, the view that mathematics, whilst critical to science careers and indeed to advanced scientific literacy, is qualitatively different to science when it comes to inquiry. We are also aware that technology can be widely interpreted in school contexts, from the use of technology in delivering science to 'science & technology studies (STS) where these topics are critically examined in their social, economic and philosophical contexts. Meanwhile, there is little study of engineering at school level, although there is a strong argument for teaching engineering to encourage what de Bono calls "operacy"[2].

In order to conform to increasingly widespread usage in European discourse, however, we use 'STEM' where appropriate to cover situations where 'science and mathematics' might not capture the full range of relevant situations.

We should also explain the variations in acronym between IBST, IBSE, IBST/E, IBL and so on. IBST (Inquiry-Based Science Teaching) was the original official version, but our preferred version is IBL (Inquiry-based Learning), with the implication that both teachers and learners are involved in the learning process.

INSTEM Recommendations

Section A: **EU policy**

A.1: Long-term Vision

- Educational change should be implemented in line with a well-defined long-term vision, whilst permitting imaginative actions to be implemented at local level. STEM education should contribute to life skills as well as science career opportunities, in order to maximise its value to young people.

A.2: What is Innovation?

- There should be a wider interpretation of 'innovation' in relation to educational interventions, to allow for methods complementary to IBL, some of which have been around for many years, such as formative assessment.

A.3 Sectoral coherence

- Greater coherence is required between policies and actions in primary, post primary and the tertiary sector, in order to maximise the effectiveness of inquiry-based methods.

A.4 STEM education and research

- There should be more links between existing research and STEM teaching and learning practices.

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[2] http://www.edwdebono.com/cort/introduction.htm

A.5 Impact of STEM projects

- There is a need for shared understandings about what constitutes impact for STEM projects and the creation of monitoring and feedback systems to ensure that these are based on robust evidence.

A.6: Time frames

- The project duration for educational projects needs to reflect the long-term reality of school timeframes.

A.7: Project management at EC level

- Collaboration between the European Commission Directorates and executive agencies (such as EACEA and REA) and project coordinators should be intensified.

A.8: A coordination plan for the future of STEM education in Europe

- There should be a clear coordination plan until at least 2025 for actions related to education, with positive coordination between Horizon 2020 and Erasmus Plus, and explicit connections to policy instruments.

Section B: National Policy

B.1: Pedagogy, Curricula and Assessment

- There should be better alignment between pedagogy, curricula and assessment systems.

B.2: Resources

- There should be better coordination between curricula, textbooks, online resources and teacher needs and competences.

B.3: Teacher Professional development

- There should be more coherent and learning-oriented professional development programmes for teachers, in order to improve their confidence and repertoires of actions in relation to IBL. Teacher professional development is essential and requires time, space and a coherent purpose and structure. One-off events are rarely successful in embedding new practices, which require time for reflection and ongoing peer-learning processes.

B.4: Student voice

- More attention should be paid to student voice and rights in relation to STEM subjects. In particular, the role of IBL in relation to low achievement, and in relation to gifted students, should be more closely examined. IBL can have positive effects on both ends of the spectrum, but its form and content will differ in both cases. Many students are increasingly focused on high-stakes assessments, and IBL is not always perceived as helpful in passing exams. Consequently, there needs to be a dialogue between teachers and students concerning learning methods.

B.5: School management and governance

- There needs to be commitment at school governance/management level to implement new practices effectively. Schools need to support IBL through collegial interaction, the provision of time and space for professional development and by tapping into the wide range of available resources at European and national level.

B.6: Teacher collaboration and professional networks

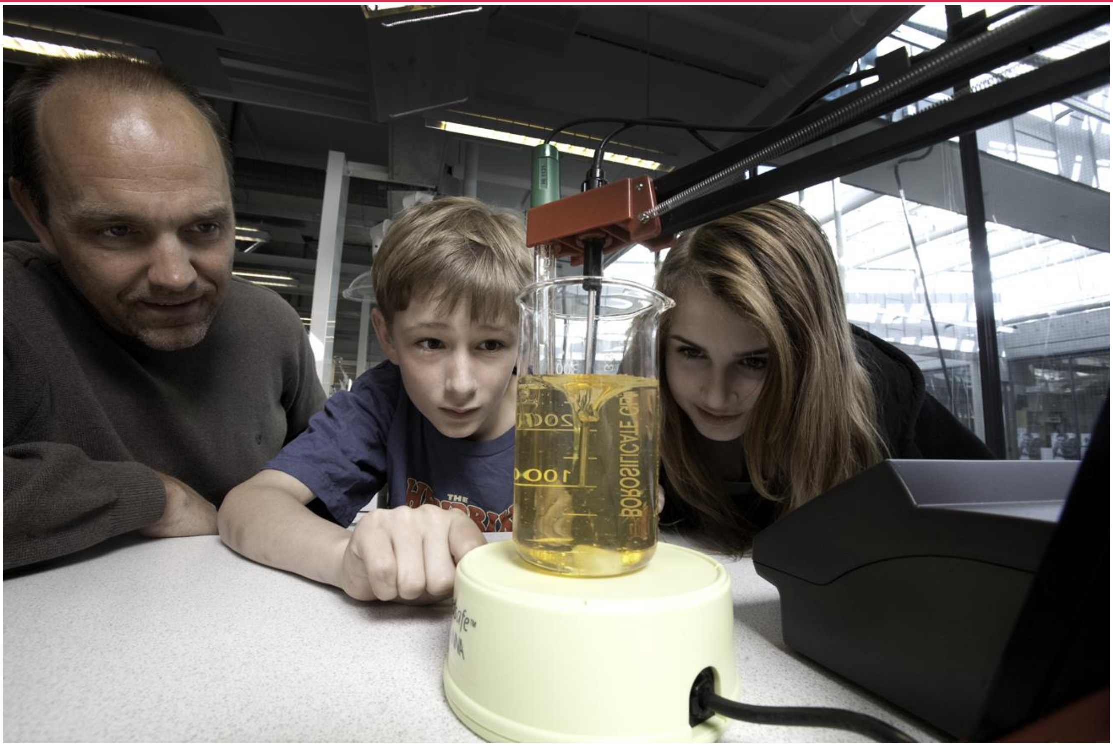
- Inter-disciplinary working and teacher collaboration are essential to maximise the potential of innovations in teaching and learning. The demands of inquiry-based learning on teachers require a greater use of professional networks, including collaboration with colleagues, the informal sector and researchers.

B.7: Classroom environment

- The essential precondition for IBL to have any effect is an inquiry-friendly classroom environment, in which student questions are valued and curricula are sufficiently flexible to allow for deviations from planned lessons. Many teachers lack the resources for effective IBL, either physical resources such as equipment and supplies, or the subject and pedagogical knowledge required to implement it effectively. They need to be supported in order to create inquiry-friendly classrooms.

B.8: Placing Inquiry in context

- Inquiry is not synonymous with hands-on learning and the provision of resources or worksheets for activities with pre-determined outcomes is not inquiry in the true sense. On the other hand, the role of prior knowledge should be recognised, and there are many aspects of science or mathematics that do not lend themselves to discovery by students. Inquiry should be one method amongst others, balanced between the need to encourage creativity and curiosity, and the everyday problems of classroom management and content delivery faced by teachers.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The opinions expressed in this document do not reflect the views of the European Commission.

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