



CEDEFOP

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of Vocational Training



Education and Culture DG
Lifelong Learning Programme

Study visit group report

Group No 227

Title of the visit Bulgarian school experience of forming key competences in mathematics and sciences

Topic Learning mathematics and science

City, country Sofia, Bulgaria

Type of visit General education

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Group reporter Alba Bernardini

1. One of the objectives of the study visits programme is to exchange examples of good practice among hosts and participants. Cedefop will select well-described projects/programmes/initiatives and disseminate them to former participants and a wider public, including potential partners for future projects. Therefore it is important that you identify and describe all aspects that, in your view, make these projects/programmes/initiatives successful and worth exploring.

The study visit was very successful in that it provided a structure and context for a team of education professionals with a range of backgrounds and from across Europe to share ideas and develop views. Part of this consisted of an exchange of examples of good practice. This included the following examples:

It is important that students develop self-confidence and the ability to communicate ideas in an effective and engaging way. We were impressed by the confidence and assurance of students we met in Bulgarian secondary schools who spoke well (in English), presented ideas effectively and responded to questions in a lively and creative way. It is also important that students are enthused by the engaging and creative nature of Maths and Science; we were struck by the enthusiasm and engagement of Bulgarian students in a supplementary Maths lesson, who were keen to engage with activities, highly effective at organising themselves and reflected upon their learning.

The results of international comparisons such as PISA provide a powerful tool for countries to evaluate their provision and ask questions about possible improvements. We learned that in many countries teachers are encouraged and expected to focus on competencies rather than content and how this has implications for the structure and amount of pre and in-service training and for the provision of teaching materials and other resources.

In response to the need to students to internalise questions and challenges for them to become meaningful several countries are moving from using a behaviourist approach to a constructivist one. This involves students in exploring ideas and develops concepts which can then be embedded through skilful teaching.

We learned about the way that in many countries there is a strong emphasis upon interactive teaching, with students being supported and encouraged to be active rather than passive learners. We learned about how, in many countries, teachers and lecturers, drawing upon research into pedagogy and didactics, are producing and disseminating high quality teaching materials and guidance for their use. We heard about the generation and use of teaching materials that challenge students in both Maths and Science with real problems, use enquiry based learning, develop critical thinking skills and encourage them to identify effective solutions.

We heard about the way that the structure of learning is as important as the activities, for example in Maths teachers could adopt a sequence within each lesson of manipulative, graphic and symbolic phases.

Several countries have developed supplementary programmes to support and challenge very able students, sometimes involving significant additional commitment from teachers and other professionals. These programmes may well give students access to concepts and experiences above age related expectations, involve working with engaging experts and lead to the development of skills such collaboration and teamwork.

We also learned about the way that new technologies can be used to support effective learning. This included hardware such as interactive whiteboards and multiple mice and applications such as Geogebra which encourage students to explore ideas and develop a range of strategies.

The group consisted of the following people: Dr.Muharrem Aktumen (Turkey), Prof.Alba Bernardini (Italy), Dr.Ekrem Cicek (Turkey), Martin Deckert (Germany), Stefanie Hutschgau (Germany), Dr.Cigdem Kilic (Turkey), Karine Millon-Faure (France), Margarida Saraiva (Portugal), Galya Shumanova (Bulgaria), Rosa Arcos de Torres (Spain), Fatima Vallhonestá (Spain) and Ed Walsh (Britain).

Describe each of the good practices you learnt about during the visit (both from the hosts and from one another) indicating the following:

title of the project/programme /initiative	country	name of the institution that implements it (if possible, provide a website)	contact person (if possible) who presented the programme to the group	whom the project/ programme/ initiative addresses	what features of the project/programme/initiative make it an example of good practice
International Science and Maths Olympiads	Bulgaria Germany	Ministry of Education, youth & science Biology: www.ibo-info.org/ Chemistry: www.icho.sk/ Physics: ipho.phy.ntnu.edu.tw/ Maths: www.imo-official.org/ Informatics: ioinformatics.org/index.shtml	Galya Shumanova gshum@abv.bg	Gifted and talented students in Maths and Science.	Participating in events that involve students in presenting ideas to a range of people to motivate students. It is possible to encourage talented students to supplement their regular classroom provision.
“Research into the theory of the cognitive process” by Alba Bernardini	Italy	Published as “la motricità, dall’oggettivo al soggettivo nel processo cognitive e riabilitativo” (2008)	Prof.Alba Bernardini albabernradini@virgilio.it	All students, but particularly relevant to students with learning difficulties	Promoting teachers’ knowledge of the cognitive process theory to support the development of teaching approaches to support the progress of all pupils.
GeoGebra software	Turkey, and others	www.geogebra.org	Dr.Muharrem Aktumen aktumen@gmail.com Ahi Evran University	Supports learning in range of aspects of geometry and algebra	Enables students to develop and present ideas, comparing strategies and evaluating them.
“Every student can learn mathematics” mathematics curriculum	Turkey	www.mersin.edu.tr	Dr.Cigdem Kilic ckilic6@gmail.com	Teaching of primary mathematics	Supporting move towards teaching based on constructivist principles, using the learning areas supported by connection, communication, problem solving and

approach					reasoning skills
Primas project	Spain	www.primas-project.eu	Rosa Arcos de Torres rosarcos@gmail.com	Students in Maths & Science.	Supports enquiry based learning, providing teachers with materials and encouraging the development of new ones.
“Thinking Critically, thinking better” project Implementation of Vocational Courses and a variety of approaches are proposed	Portugal	Escola Secundária de Fonseca Benevides www.esec-fonseca-benevides.rcts.pt Ministry of Education and Science www.dgidec.min-edu.pt/	Margarida Saraiva margaridasaraiva09@gmail.com	All students in maths & science	Problem solving is used and higher order thinking skills are encouraged and supported. Development of vocational courses promoting both better learning and enlarging the opportunities of certified qualification. The official curricula of sciences propose a diversity of approaches enhancing hands on activities.
Deepens programme	Spain		Rosa Arcos de Torres rosarcos@gmail.com	Able students in science and maths	Provides investigations to stimulate able students and develop key competencies
Students’ scientific congresses	Spain	http://plataforma.cep-marbellacoin.org/moodle/course/view.php?id=269	Rosa Arcos de Torres rosarcos@gmail.com	Able students in science and maths	Provides investigations to stimulate able students and develop key competencies
Teacher researcher initiative	France	AMPERE	Karine Millon-Faure kmmf@hotmail.fr	All students in maths	Teaching materials have been developed, real problems and multiple strategies expected and evaluated.
SINUS transfer FIBONACCI	EU	www.sinus-transfer.eu/ www.fibonacci-project.eu/	Stefanie Hutschgau stefanie.hutschgau@st muk.bayern.de-	All students in science and maths	Improve the competence in both mathematics and science
Teacher quality assessment	Turkey		Ekrem Cicek ekrcicek@gmail.com	All teachers	Discussing teacher assessment methods

* You can describe as many good practices as you find necessary. You can add rows to the table.

2. The study visits programme aims to promote and support policy development and cooperation in lifelong learning. That is why it is important to know what you learnt about such policies and their implementation during your visit. You are invited to describe your findings concerning the following:

2.1 APPROACHES TAKEN BY PARTICIPATING COUNTRIES (BOTH HOST AND PARTICIPANTS') REGARDING THE THEME OF THE VISIT. ARE THERE ANY SIMILAR APPROACHES/MEASURES IN PARTICIPATING COUNTRIES? WHAT ASPECTS ARE SIMILAR AND WHY? WHAT ASPECTS ARE DIFFERENT AND WHY?

During the study visit it became clear that there were many similarities in the approaches being taken by teachers in the countries represented, primarily due to the similarity of the challenges being faced. Where there were differences this was primarily because in some countries, such as Turkey, education is organised on a centralised basis and structural changes impact on the whole system. On the other hand, countries such as Germany have a decentralised system; this makes it easier for a locality to respond to change but more of a challenge to embed developments across the whole system.

- It was felt that there was significant value in promoting collaborative work between teachers, researchers and inspectors so that developments are based upon effective classroom practice and evidence based research. Several countries represented were placing importance upon lessons being linked to everyday contexts and experiences so that students could see how Science and Maths are useful to make sense of their world.
- Importance was being increasingly attached to the consideration of the student as a cognitive, affective and psychomotor person; to improve learning it is essential to understand the learning process and the optimum conditions for it to occur.
- Value was placed upon teachers being able to use and confident to draw upon a variety of different styles of teaching to meet the needs of students. Teachers shouldn't be following a set routine in their teaching but should be responding creatively to students' learning needs.
- Several countries represented indicated that in their respective systems emphasis was being placed upon teaching being based on key competences.
- In both pre-service and in-service teacher training importance should be given to the role and skills of practical work and demonstrations; these will support the balancing of theory and practice in lessons.
- Consideration should be given to developing students' aspirations to support gifted students and to supplementary provision for students making less than expected progress.

2.2 CHALLENGES FACED BY PARTICIPATING COUNTRIES (INCLUDING HOST) IN THEIR EFFORTS TO IMPLEMENT POLICIES RELATED TO THE THEME OF THE VISIT. WHAT ARE THE CHALLENGES? ARE THEY COMMON CHALLENGES? IF SO, WHY? IF NOT, WHY NOT?

It was noticeable in the discussions that there was agreement about the challenges across all the countries represented.

- Several countries reported that Maths and Science may not be perceived by students as being desirable areas of study to specialise in and that there was a challenge for teachers and curriculum developers to address this.
- Research evidence indicates a widening attainment gap between higher and lower attaining students. Programmes to improve the quality of teaching sometimes, paradoxically, increase this gap as new strategies may be adopted most readily by good teachers and have a more immediate impact upon higher attaining students.
- In some countries there seems to be a lack of political will to make the improvement of education a priority and to allocate resources accordingly. In several countries becoming a teacher is not a particularly attractive option in terms of conditions of service; this may make recruitment and retention a very important issue and pedagogical changes harder to embed.
- The quality of pre-service teacher training needs to be such that teachers are well prepared with appropriate pedagogical content knowledge and a good understanding of generic practices in effective teaching and learning.
- The expectation and provision for continuing professional development varies significantly from one country to another, but is rarely sufficient to fully support teachers in changing practice. Even if it is sufficient to implement organisational changes it rarely gives opportunities for professional reflection.
- In several countries teachers are expected to encourage students to achieve certain outcomes which are stipulated. However, the teaching approaches that may lead to these outcomes are not self-evident and may require significant investment in research and training.
- In many countries there has been an emphasis upon moving away from delivering content to developing competencies. This has sometimes been difficult to fully embed in classroom practice and has required a lot of support.
- In several countries a key challenge is the devising of learning activities and frameworks to support students in internalising questions and ideas in order to make learning authentic and avoid disengagement.
- In a centralised system, changes may have significant resource implications and the rate of change may be slow; however it may be harder for unwilling teachers to resist changes. In a more decentralised system it may be easier for a dedicated group of educational professionals to support change in a locality but this can give rise to significant inconsistencies across an area.

2.3 NAME AND DESCRIBE EFFECTIVE AND INNOVATIVE SOLUTIONS YOU HAVE IDENTIFIED THAT PARTICIPATING COUNTRIES (BOTH HOST AND PARTICIPANTS) APPLY TO ADDRESS THE CHALLENGES MENTIONED IN QUESTION 2.2. PLEASE MENTION SPECIFIC COUNTRY EXAMPLES.

- Provision of effective support for teachers' professional development, especially, but not only, in the first few years of their careers.
 - In Spain and Germany a range of courses is offered by training centres, run by education boards
 - In the United Kingdom, a range of training providers offer short and long term courses for teachers and other school staff. This includes Science Learning Centres and the National Centre for Excellence in Teaching of Maths
- Ensuring that teachers' training is developed and delivered by people with recent and relevant classroom experience.
- Effective use of constructivist pedagogy to support active learning and to develop constructivist teachers.
 - In Turkey there is a whole scale change from teaching based on behaviourist principles to that based on constructivist principles. The "Every student can learn mathematics" program is based on the learning areas supported by of connection, communication, problem solving and reasoning skills, and on the notion that for the outcomes to be effective students have to internalise the context.
- Development of teachers' knowledge of the cognitive process theory to support the development of teaching approaches to support the progress of all pupils.
 - In Italy, the primary research conducted by Prof. Alba Bernardini into a new theory of the cognitive process and its application to the study of maths. This concluded that the cognitive, perceptive and motor processes are the same; it asserted the importance in learning of sensing the underlying processes through motor experiences.
- Students being supported to become more active in their own learning and take greater responsibility for it.
 - In Bulgaria the challenging of students with mathematical problems which they select from, explore, develop solutions and develop thinking to the level of successfully competing in international competitions.
- Developing the role of teaching based upon the development of competencies so that learning is not simply based upon the acquisition of knowledge
 - In Germany lessons are referenced against competencies as well as guiding principles or topics and progress assessed against these competencies.
 - In Bulgaria, some science competitions are based on scientific competencies in which teams of students attempt challenges.

- In Spain, courses based on the history of science and maths, which develop the ability to apply concepts to different contexts and to undertake different ways of thinking.
- In Spain the Deepens programme which offers supplementary provision in the form of investigations to stimulate able students and develop key competencies. There are also resources centres, such as CREAMAT, where teachers can send activities focused on key competencies to share with other teachers.
- Increasing the role of demonstrations and practical work in lessons where this is not well established.
 - In Spain, the Primas (pan-European) Project supports enquiry based learning in both Maths and Science; it both provides teachers with materials and encourages the development of new ones.
 - In Bulgaria the students competing in international competitions benefit from preparation which includes expert demonstrations and extensive opportunities for practical work.
 - In Portugal, school labs have been recently equipped and the official documents stimulate teachers to propose more frequent hands on activities.
- Using learning activities that make explicit links to everyday life, have been developed and evaluated by practising teachers and are based on didactic research.
 - In Portugal the “Thinking Critically, thinking better” project in which problem solving and the use of higher order thinking skills are encouraged and supported.
 - In France, the teacher researcher initiative, in which teaching materials have been developed, real problems produced for students and multiple strategies expected and evaluated. This is strongly based on an ongoing dialogue between teachers and researchers and has resulted in materials rooted both in research and in practice.
 - In Germany there have been projects in science to link everyday life with learning. The units are based on the teaching conception of *Chemie/Biologie/Physik im Kontext*: The starting point for a teaching unit is a real-life context which shows the importance of biology, chemistry and physics for everyday life. Science subject knowledge is developed in this context and ascribed to basic concepts which are fundamental for all questions in biology, chemistry and physics. The lessons are characterized by as much methodological variety as possible and are conducted in four phases. (www.chik.de/, www.bik.ipn.uni-kiel.de/, www.ipn.uni-kiel.de/projekte/piko/index.html)
- To increase the attraction of science in Germany students can do practical work outside school in so called “Schülerlabore”. These are special labs in universities or research institutions, where students can do experiments or research of their own. Mostly students visit these “Schülerlabor” as a class or group accompanied by a teacher. (www.lernort-labor.de)

- Students participating in events that involve them in presenting ideas to a range of people and being motivated by the experience.
 - In Bulgaria teams of students prepared to compete in a range of competitions including international Olympiads in a range of subjects. This was supported by supplementary lessons and tuition at the university.
 - In Spain, Portugal and Germany students are encouraged to participate in Science Fairs and Congresses, so that they develop experience in presenting ideas both to large and small numbers of visitors
- Effective use of new technologies to enable students to develop and present ideas.
 - In Turkey and Spain, extensive use is made of GeoGebra software to support students to develop a range of mathematical strategies and evaluate them.
 - In Turkey, increased use of calculator and computer technology but planned in such a way as to increase rather than diminish psychomotor abilities.
 - In Bulgaria, the effective design and presentation of concepts and investigations by students and teachers, resulting in a greater impact on learners.
- Educational systems may approach the issue of low parental expectations by increasing the amount of contact that students have with the school, to provide an alternative and positive influence.

2.4 ASSESSMENT OF THE TRANSFERABILITY OF POLICIES AND PRACTICES. COULD ANY EXAMPLES OF GOOD PRACTICE PRESENTED IN THIS REPORT BE APPLIED AND TRANSFERRED TO OTHER COUNTRIES? IF SO, WHY? IF NOT, WHY NOT?

There was a large degree on unanimity regarding the challenges being faced and the nature of effective solutions and this supports the widespread transferability of solutions.

It was felt that none of the initiatives referred to was ‘country specific’ regarding its potential application and that all of them were based on European wide principles of effective pedagogy. Issues of transferability are less likely to be linked to the nature of the policies and practices than to the way in which education is administered in various countries. This is related to the degree of centralisation in a country and also the extent to which individual teachers have the freedom to select and deploy innovative teaching strategies. However, some of the developments that were explored have resource implications and there may be difficulties in adopting these for this reason.

3. Creating networks of experts, building partnerships for future projects is another important objective of the study visit programme.

Please state whether and which ideas for future cooperation have evolved during meetings and discussions.

Members of the group are already in e-mail contact and there have been a number of discussions between individuals relating to the use of particular programmes.

A possibility for a future project would be learning about the primary research conducted into the cognitive approach and how this leads to an understanding of how students approach questions: by the stages of perception, abstraction and answer. This could lead to a greater understanding of how the development of teaching activities needs to engage both left brain and right brain functions to lead to effective learning. (See reference to author in section 1).

Another possibility would be a project based more explicitly on inquiry based learning in maths and science, with a tight focus upon the development and deployment of high quality teaching materials.

A further possibility would be the effective use of new technologies in maths and science. Such strategies can, if used well, promote independent learning and creativity.

4. What is the most interesting/useful information that the group believes should be communicated to others? To whom, do you think, this information will be of most interest?

Possibly the outcome that will have the greatest impact is the identification and sharing of learning activities that promote the active role of students in lessons, challenge them to think critically and creatively and encourage internalisation of questions and concepts. This will be of particular interest both to teachers and teacher trainers (both pre and in-service). Teachers are always keen to learn about new activities that will engage and inspire students.