

**The SECURE Project Research on Science Curricula and Teachers' and Learners'****Opinions on Science Education**

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### Abstract

The SECURE project has been founded under the 7<sup>th</sup> Framework Programme to make a significant contribution to the European knowledge-based society by providing relevant research data and translate them into recommendations that contribute to the public debates on mathematics, science and technology (MST) curricula and their objectives in view of balancing the needs between training future scientists and broader societal needs. A rigorous research program conducted by the SECURE consortium scrutinizes and compares current MST curricula for pupils aged 5,8,11 and 13 in ten member states, as they are intended by the authorities (legal documents), implemented by the teachers and perceived by the learners. The research at all three levels is designed in accordance to the curricular spider web (van den Akker, 2003). The instruments used to this end consist of a transnational comparative screening instrument for MST curricula, as well as teacher and learner questionnaires and interview protocols. Research in altogether 150 classes of each age has been done by the middle of the project lifetime. Currently the elaboration of summaries of national curricula documents takes place and the analysis of the school collection data at the national level is carried on. The results will be delivered in the last six months of the project lifetime.

*Keywords:* MST education, European program, research in science education, curriculum, teacher, learner, perception, curriculum spider web, questionnaire, interview, recommendations

## **Introduction**

In its latest policy initiatives and outputs in education and training the European Union restated the importance of science literacy and numeracy as fundamental elements of key competences (European Commission 2010; European Council, 2009, 2010). It was recognized that

more investment should be undertaken to increase the number of graduates in science, technology, engineering and mathematics (STEM) so as to create the right conditions to deploy key enabling technologies, essential in the R&D and innovation strategies of industry and services. (European Commission, 2010)

## **Rationale**

SECURE is founded as a collaborative project under FP7 to provide research results of current mathematics, science and technology (MST) curricula across Europe. The overall aim of the SECURE project is to make a significant contribution to the European knowledge-based society by providing relevant research data that prompt public debates on this issues. Based on good practices and other research results SECURE will formulate a set of recommendations for policy makers and other stakeholders on how MST curricula and their delivery can be enhanced. These improvements would need to focus on encouraging and preparing children from an early age on for future careers in MST. At the same time curricula should make MST more accessible and enjoyable for all children so that they will always keep a vivid interest in mathematics, science and technology, understanding the importance of their societal role.

## **Theoretical Framework**

Different meanings of “curriculum” can be found in different contexts of educational research (Taba, 1962; Beauchamp, 1982; Jackson, 1992; Pinar, Reynolds, Slattery & Taubam, 1995;

Walker, 2003). Processes of curriculum development are focused on the improvement and innovation of education. Since the process of curricular development usually takes place in several years and, as van den Akker and Kuiper (2007) have shown, is usually characterized by multi component cyclical structures, the ongoing curriculum research may be used to ameliorate incessantly the quality of the development process and the curriculum itself.

To get a complete overview of the curriculum, its analysis should be done at five different levels with respect to the curriculum users (van den Akker, 2003): Supra (international), Macro (national), (Meso (school, institute), Micro (classroom, teacher), Nano (pupil, individual). Another perspective refers to the typology of curriculum representations, built on the work by Goodlad (1979) which is especially useful in the analysis of the processes and the outcomes of curricula. Six different representations of a curriculum are shown in Table 1.

In 2003, van den Akker proposed curriculum representation on a spider web (Figure 1) with Rationale located in the center and nine other components (Aim and Objectives, Content, Learning activities, Teacher role, Materials and Resources, Grouping, Location, Time, Assessment) placed around it, becoming the nine threads of the spider web, connected at five curriculum levels.

### **Objectives**

The specific objective of the SECURE project is to provide relevant and rigorous research data and translate them into recommendations that contribute to the debate among policy makers on science curricula and their objectives: balancing the needs between training future scientists and broader societal needs.

The cores of the project are: the analysis, the comparison between the aims and the content of the current MST curricula in the member states; identification of shared grounds among existing MST curricula; identification of good practice in the member states;

establishing how curricula are put into practice by MST teachers and how current curricula affect learners' competences, motivation and perception of the relevance of mathematics, science and technology.

### **Method**

A total of 11 partners in 10 EU countries (Figure 2), of which 7 universities and 2 pedagogical institutes are involved in the project: Thomas More Kempen (Belgium), Dienst Katholiek Onderwijs vzw (Belgium), Universität Graz (Austria), University of Cyprus (Cyprus), Technische Universität Dresden (Germany), Università degli Studi di Udine (Italy), Studiecentrum Leerplan Ontwikkeling (the Netherlands), Uniwersytet Jagiellonski (Poland), Univerza v Ljubljani (Slovenia), University of Gävle (Sweden), Nottingham Trent University (the UK).

The SECURE research is focused on 5, 8, 11 and 13 year old learners, their science curriculum and their teachers. The choice of these ages was done to investigate in a comparable way among the involved countries the bridges and the gaps that exist in curricula, on one hand - between kindergarten and primary school and, on the other hand - between primary and middle schools.

To ensure a profound view on the MST-curricula at the different levels, the research focuses on:

- (1) The formal intended MST-curriculum by comparing written MST curricula in the 10 participating EU countries. It was decided to focus on mathematics, technology (technics), and (natural) sciences (restricted to biology, chemistry and physics, physical geography).
- (2) The implemented MST-curriculum which takes into account the perceptions of teachers who put the curricula into practice in the day-to-day class activities.

(3) The attained experiential curriculum which focuses on the learning experiences of the pupils, the final and most important recipients of the MST-curriculum.

### **Implementation of the Research in Schools**

Data collection in schools took place in two phases: a pilot study, conducted only in four member countries (Germany, Italy, the Netherlands and the United Kingdom) and, then, the systematic, core studies. The pilot study involved a small number of classes and was performed to test and evaluate the first version of the school data collection instruments. After piloting, the instruments were redesigned and in all ten member countries the systematic collection of data in schools has been performed in 15 classes of each age group of learners. On the whole approximately 600 classes, 1000 teachers of mathematics, science and technology, and 10000 learners have been involved in the study.

### **Research Instruments**

The research framework was constructed upon the curriculum spider web (van den Akker, 2003). The research instruments consist of curriculum screening instrument (CSI), and of the school data collection instruments: teacher questionnaires, learner questionnaires (limited to 8,11 and 13 year olds) and interview protocols for all age groups of pupils and their teachers.

#### **Curriculum screening instrument**

The curriculum screening instrument consists of two formats:

- the “format1” level, which provides, in a descriptive way, all information on the documents themselves;
- the “format 2” level, giving in depth insight into the curricula documents and answering the questions about their content, relating to all 10 fields, as the spider web indicates.

#### **School data collection instruments**

To get information on the perceptions of people involved in these curricula, draft questionnaires for all ages of learners (except 5 year olds) and the teachers are developed,

using the curriculum documents mentioned above. The questionnaires are grounded on existing scientific literature on science education and science curriculum reform. (e.g. Atkin & Black, 2003; Black & Atkin, 1996; van den Akker, 1998). Existing instruments from previous relevant studies such as Alting (2003), Bennett, Gräsel, Parchmann and Waddington (2005), van Driel, Bulte and Verloop (2008), van Langen (2005) – and Schreiner and Sjøberg, (2004), TIMSS (1995, 1999, 2003, 2007), and PISA (2000, 2003, 2006, 2009) have all been used as a starting point for the development.

Other useful sources for instrument development and use could be research instruments developed/applied by SECURE partners, including those instruments currently being used as part of a comprehensive evaluation study on new context-based science curricula in Dutch Senior Secondary school (Kuiper, Folmer, Ottevanger & Bruning, 2009, 2010).

All questionnaires were piloted and very extensively discussed, question by question by members of the SECURE design and analysis group. During these discussions very different opinions and perceptions on education and educational systems occurred. Nevertheless the group agreed on the set of questions put forward. The spider web framework upon which everybody agreed was very helpful for reaching such agreement.

Apart from questionnaires, SECURE also decided to gain additional information on teachers' and learners' perceptions by organizing interviews. The guidelines for these interviews were provided, again, discussed in depth by the research and analysis team. All partners report on the results of the interviews according to a given format. Key ideas of this format are: (1) additional information must be gathered, (2) the information should be in line with the questionnaires, following the spider web framework, (3) the report should contain a summary of all interviews of the same kind (horizontally), (4) the report should mention



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relevant and clear quotes of the people being interviewed as examples of how ideas are expressed.

## **Data and findings**

### **Curriculum Screening Research**

The most common MST curriculum documents of all disciplines in a country (Macro level or sub-macro level) have been screened according to the designed curriculum screening instrument, covering all 10 fields of the curriculum spider web. The documents used have different origins but need to be official or at least authorized.

With “format 2” each member country provided an extended and descriptive summary of all relevant MST curricula of about 40-50 pages. All of them have basically the same content. However, after the first attempt of the cross-country analysis it was revealed that the results are less consistent than previously expected, thus an additional set of specific questions has been prepared by partners and the second, more profound round of curriculum screening is taking place.

### **Data Collection in Schools**

#### **Questionnaires**

After intensive discussions the questionnaires were adapted by the design and analysis work group of SECURE and made slightly flexible, looking for a suitable equilibrium between reaching the goals of getting information on teachers’ and learners’ perceptions in their given educational system and relevance for the research itself. This was possible since the results of the questionnaires did not need to be analyzed in a comparative way, but would be used to generate a country-specific information on the perceptions of teachers and experiences of learners of the visited schools in view of the written curricula (triangulation

analysis). However the questionnaires having a solid common ground still make it possible to extract examples of good practice transferable to other countries.

The teacher questionnaire was split in two parts: one for the mathematics teacher (176 questions), and one for the technology/science(s) teachers (more than 180 questions). It was asked to fill out only questions relating to the discipline given in the same class that was questioned (if disciplines are integrated or if teachers teach several disciplines the advice was that all relevant questions need to be filled out). The bundle contains 23 pages and on average it took about 1 hour to fill it in.

The questionnaires for the 13 year olds were rather complex because in most project partner countries learners get several disciplines given by several different teachers. The questionnaire contains about 234 questions and on it took about 1 hour to complete the questionnaire. The 11 year olds got almost the same questionnaire. However, in countries where integrated science is taught for that age, the number of questions could be slightly reduced. It resulted in 13 pages of questions.

The 8 years old got a reduced questionnaire, not covering three of the 10 fields of the spider diagram, i.e.: the rationale (vision, mission), aims & objectives of curricula, the role of the teacher. It was judged that for those fields it would be too hard for learners of that age to give adequate answers to questions. 111 questions are posed on 5 pages.

The 5 years old learners is a different story. After some preliminary piloting of very simple questionnaires with a limited group of 5 years old, it was recognized that it would be extremely difficult to get relevant answers from them. Hence no questionnaire for 5 years old has been implemented within SECURE.

### **Interviews**

It was decided to use the interview research tool in 6 out of 15 classes of each age per country and to interview in those classes all teachers of all disciplines covered by the

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research. Such an interview took typically approx. 45 minutes. In the same 6 classes of age 8, 11, 13, a set of 4 learners (2 girls and 2 boys) randomly chosen were also subject to an interview. These lasted about 35-40 minutes each. Since no other means were left, the only way of getting information from 5 year olds was by interviewing them, like the other classes, 2 girls and 2 boys, but of all 15 classes involved. The interview was set up to cover only two fields of the spider web. These also took usually little more than 30 minutes.

### **Discussion and Conclusions**

Given the preliminary analysis of the curricula of 10 countries on the ten spider web components, a transnational comparative study is taking place. Data of questionnaires are brought together and are now being analyzed in depth. A large part of the students and the majority of the teachers expressed thanks for the quality of the questionnaires and the opportunity given to them to reflect on some curricular aspects in a guided way. Teachers remarked also their interest in dissemination of the results and were curious to compare the situation of their own classes with the other. An analysis method on the interviews is adapted and is carried out now.

The final research report is planned to be prepared in the following months. Almost five months before the end of the project, a meeting of the external expert group will take place to study the results, to give feedback on study conclusions and forthcoming recommendations and to give an opinion of the relevance of the project findings from the perspective of other countries, mostly from the EU.

Other European projects will benefit from the SECURE outcomes, adapting their strategy and the implementation methods of the research done. The dissemination of the results is foreseen from the beginning and the length of the 2013 and aim at returning the results to the schools that cooperated, inform local and national authorities on the outcomes and inform the European educational MST community as well.

Documentation of data collected, its analysis and the production of reports on the aspects of the curricular spider web for math, science and technology will be disseminated. To reach this goal, seminars and scientific happenings will be organized inside the involved school, in the partners' organizations and through mass media.

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Figure 1. Curriculum spider web

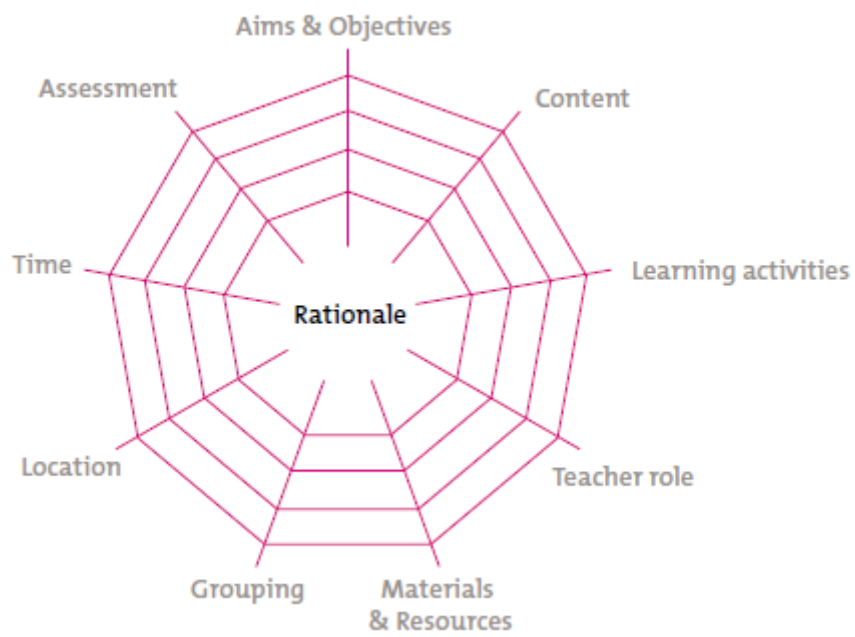




Figure 2. SECURE member states

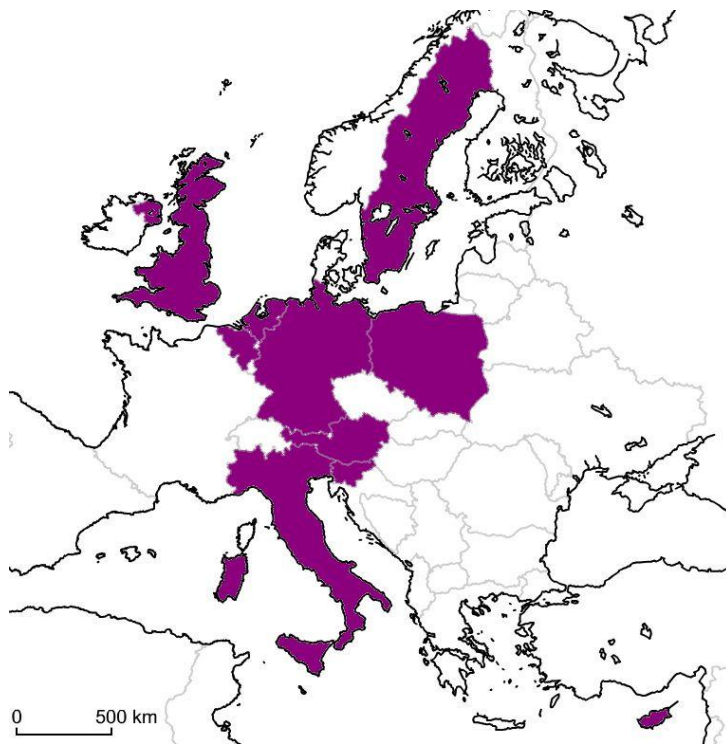


Table 1

*Curriculum representations*

Intended	Ideal	Vision (rationale or basic philosophy underlying a curriculum)
	Formal/written	Intentions as specified in curriculum documents and/or materials
Implemented	Perceived	Curriculum as interpreted by its users (especially teachers)
	Operational	Actual process of teaching and learning (also: curriculum in action)
Attained	Experimental	Learning experiences as perceived by learners
	Learned	Resulting learning outcomes of learners