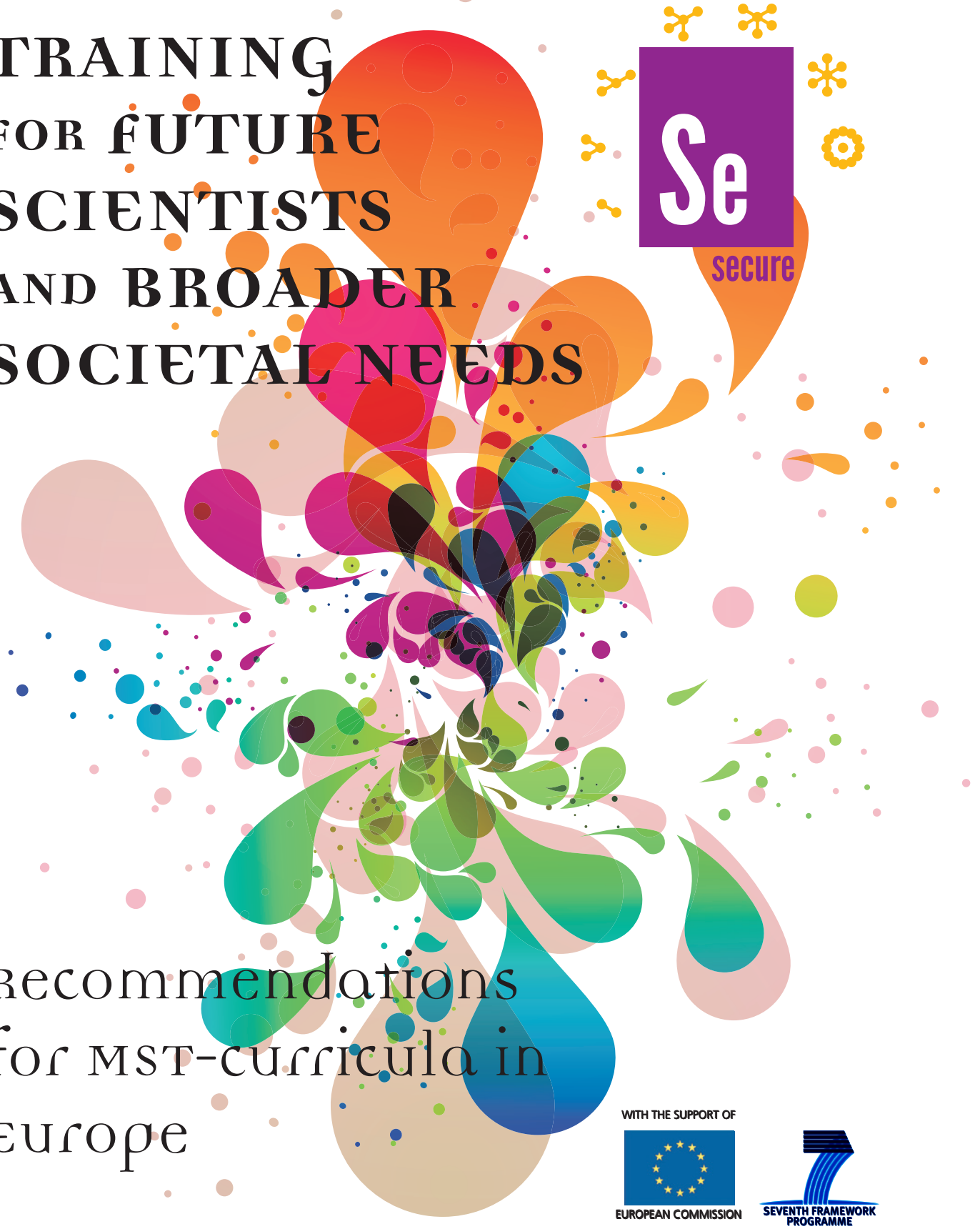
BALANCING THE NEED BETWEEN TRAINING FOR FUTURE SCIENTISTS AND BROADER SOCIETAL NEEDS



Recommendations for MST-curricula in Europe

WITH THE SUPPORT OF
EUROPEAN COMMISSION
SEVENTH FRAMEWORK PROGRAMME

GENERAL INFO ABOUT SECURE

OBJECTIVES

Improving MST curricula and their delivery in Europe, in order to

- make MST more accessible and enjoyable for all children
- create a vivid interest in mathematics, science and technology
- find a good balance between training for future scientists and broader societal needs
- let children understand the societal role of MST

Providing relevant and rigorous research data about MST curricula and their delivery and translating them in recommendations for stakeholders.

RESEARCH ACTIVITIES

The research activities focus on the MST curricula in Europe as they are:

- Intended by curricula makers and authorities
- Implemented by teachers
- Experienced by learners

TARGET GROUP

The target group for the research are 5, 8, 11 and 13 year old learners, their MST curriculum and their MST teachers. The target group for the results are all people baring responsibility for MST education

OUTCOMES

The SECURE project will provide scientific research results to enhance the debate among policy makers on the purpose of school MST education, whether this purpose is being addressed in practice through school curricula, and what perceptions both learners and teachers have on science.

PARTICIPATING COUNTRIES

Austria, Belgium, Cyprus, Germany, Italy, the Netherlands, Poland, Slovenia, Sweden, United Kingdom

VALORISATION

- Facilitating science events on the participating schools in all involved countries
- Discussing the preliminary results with an international expert group.
- Organising national and international conferences

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STIMULATE THE INTEREST FOR MST-SUBJECTS MORE EFFICIENTLY FROM AN EARLY AGE ONWARDS, WITH SPECIAL ATTENTION FOR THE CRUCIAL AGE OF 10 YEARS OLD

SUPPORTING EVIDENCE

- The positive attitude of learners towards MST-education decreases with the age. A drop in motivation is gradually visible in all participating European countries for mathematics, science and technology for the ages of 8-11-13 years old.
- The biggest and most problematic drop is localized in between the ages of 8 and 11 years old, which is clearly situated in an early stage of the school career of the learners.
- The TIMSS 2011-study reports a decrease of positive attitudes for both mathematics and science between the 4th grade (average age: 10) and the 8th grade students (average age: 13-14). The SECURE results are consistent with those findings and provide additional information for earlier ages.
- The decrease of the positive attitude towards MST is accompanied by a decrease of self-confidence of the learners for the related school subjects.
- In international scientific literature, the age of 10 is defined as a crucial age for the development of a positive attitude towards MST (Turner & Ireson, 2010).
- The formal curriculum documents in the consulted 10 European countries promote to connect to the interests of the learners for MST in a general and open-ended way.
- According to the perception of the MST teachers, almost all MST teachers across all ages (>90%) agree that motivating pupils for the subject is one of the most important goals and only 1/5 or less of the teachers perceive that his/her pupils are not interested in the subject.

CONCLUSION

In view of both future scientific (school) careers and the general importance of science in society, it is recommended to promote a more positive attitude towards MST for all learners from an early age on. The age of 10 is suggested as a crucial age. Further research should be facilitated to explain the nature of the crucial drop of interest and effective strategies should be found to counter-act the tendency.

SUGGESTIONS FOR FUTURE IMPROVEMENTS

supra and macro level	macro level	micro level
The attitudes for learners towards mathematics, science and technology subjects should be considered as an important indicator for the educational success of MST. Targeted and evidenced intervention programmes should be facilitated taking into account the importance of the early stages of education.	The curriculum documents should indicate clear minimal goals for the attitudes of the learners.	Teachers should have a clear and realistic image of the attitudes of their learners towards MST and be supported to enlarge their expertise to stimulate a more positive attitude.

PROVIDE MORE CHALLENGES AND MORE SUPPORT FOR BOTH HIGH-FLYERS AND LOW-ACHIEVERS BASED ON A SYSTEMATIC APPROACH AND EMPOWERING CURRICULA

SUPPORTING EVIDENCE

- Although all formal curriculum documents value the importance of differentiation in general, this intention is not always consequently translated and consolidated into clear and differentiated goals for both low-achievers and high-flyers.
- 80% or even more of the teachers indicate that they feel themselves limited in teaching by pupils with different academic abilities. This trend is most outspoken for the teachers of 13-year-old learners.
- According to the perception of MST-teachers, the formulated curriculum goals for highly talented learners are often not fully applied and achieved during the lesson.
- Most of the teachers undertake efforts to differentiate during their lesson in view of high- and low-flyers, but this differentiation seems not yet to be an integral and systematic part of all the lessons. In some lessons, half or slightly less of the MST teachers create same-ability groups, whereas half or more of them also create mixed-ability groups. For mathematics, only 20% of the teachers indicate to differentiate often during their lessons. For science and technology, differentiation even less frequently applied, since only 10% of the teachers report to actively differentiate during classes.
- For science and technology, teachers express that there is not enough materials available for both high-flyers and low-achievers.
- More than one third of the mathematics teachers agree that they find it difficult to find teaching materials for highly talented pupils which is confirmed by a slightly larger group of the science and technology teachers.

CONCLUSION

High talented learners should receive every chance to further improve their MST competences and be challenged during their school career to construct a firm and tempting ground for a future scientific professional life. Also learners with lower abilities and a less outspoken scientific profile should be maximally supported in their learning process. Although differentiation for high- and low-achievers is acknowledged in the daily classroom-practice, MST could benefit from a more systematic approach in which it becomes a structural point of attention for every lesson. The need for additional learning materials for both target groups needs to be recognized. The additional formulation of goals in the formal curricula can help to set clear standards.

SUGGESTIONS FOR FUTURE IMPROVEMENTS

macro level	marco and micro level	macro and micro level
Clear goals should be set for different abilities in the formal curricula to provide clear standards which challenge each learner to maximize his/her talents.	Teachers need to be supported by professional training and by facilitating them with appropriate learning materials.	The conditions for teaching should be optimal to facilitate the learning processes (group-size, time, location).

PRIMARILY WORK ON THE PROMOTION OF INTEREST FOR MST-SUBJECTS FOR BOTH BOYS AND GIRLS AT EARLY AGE (INCLUDING KINDERGARTEN), TAKING INTO ACCOUNT GENDER-SPECIFIC DIFFERENCES

SUPPORTING EVIDENCE

- In the formal MST curricula documents, there is no specific gender-related focus detected, nor specific guidelines for raising the interests of girls within MST.
- In general, SECURE has detected significant gender differences related to the attitudes of boys and girls towards the different subject fields of MST at all ages (8-11-13). The picture is rather complicated and shows a lot of variety between the ages, the subjects and the different countries. Within this diversity, some general trends can be indicated.
- First of all, there can be concluded that the number of statistically significant gender differences increases with the age.
- Secondly, there are some trends within the different subject fields of MST. Whenever the attitude towards mathematics and technology and physics (as a separate subject) is different across genders, the boys show a more positive attitude, while the girls show a more positive attitude towards biology at age 13, whenever the statistically significant difference is the case.
- In the teacher questionnaires, close to 80% of MST-teachers of all ages express not at all to be limited in their teaching by gender differences. From teacher interviews, it can be concluded that gender differences are no primary focus for the MST teachers and that they try to motivate boys and girls in an equal way.

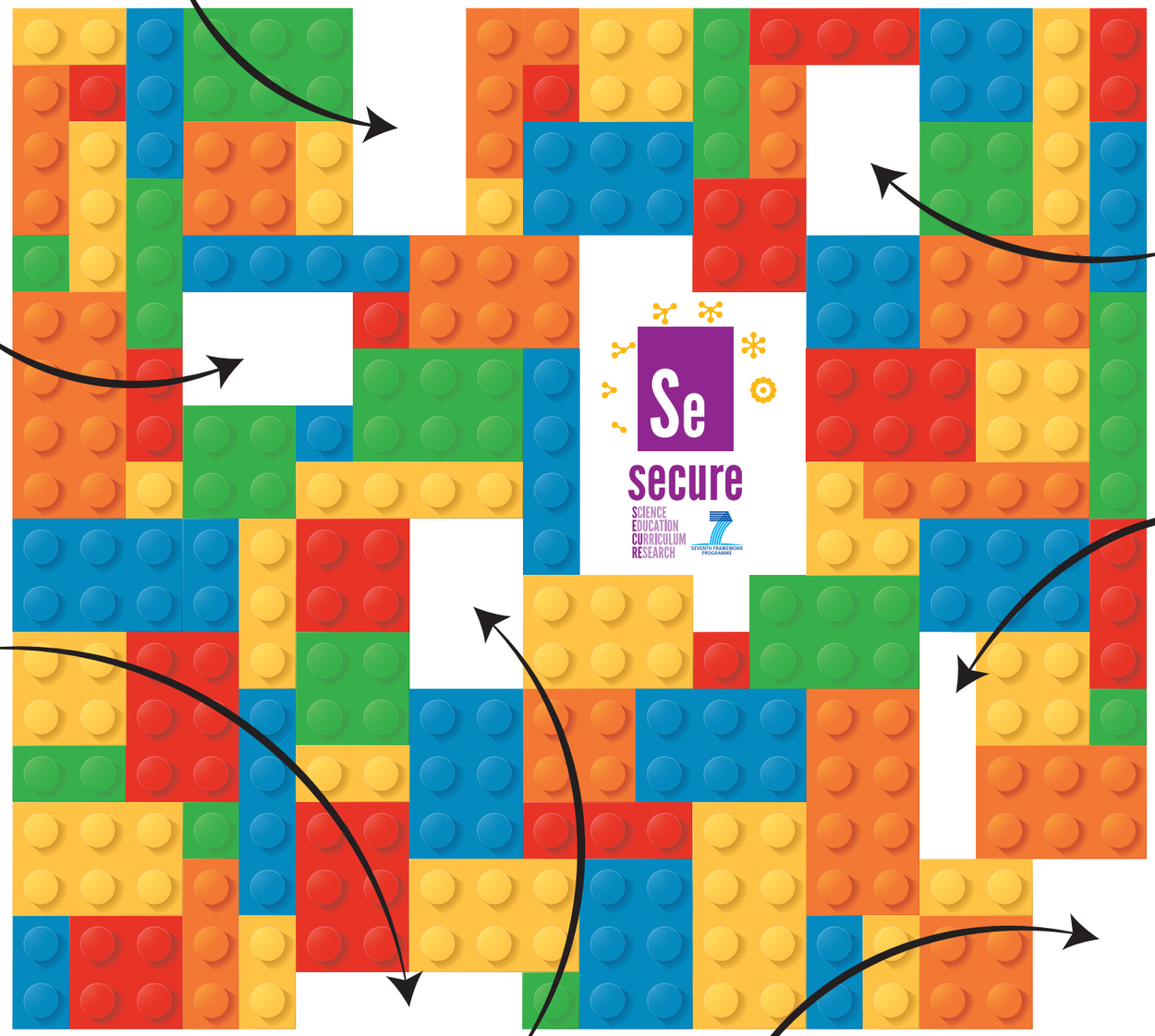
CONCLUSION

From a European perspective and for the future of scientific careers, the gender imbalance is an important issue, which needs further attention and additional actions and research. This overall concern is not yet translated into the examined formal curriculum documents, nor does it seem to be a primary focus of the daily classroom practice. For the target-ages of SECURE, it is concluded that the focus should be on the general promotion of the motivation of both girls and boys for MST in the beginning of their school career with a more increasing awareness for the gender differences between them for the higher ages (11-13 year olds).

SUGGESTIONS FOR FUTURE IMPROVEMENTS

supra & macro level	macro & meso level	macro level	macro & meso level	macro level
Further research and actions on how to promote a general gender awareness for the indicated ages.	Equal balancing in providing role models for MST from an early age onwards.	Attention for gender differences could be more explicated in formal curriculum documents.	Training of teachers to raise the awareness for gender differences.	Collaboration and discussion between the different actors of education to create common goals for dealing with gender differences.

The overall aim of the SECURE project is to make a significant contribution to a European knowledge-based society by providing **RELEVANT RESEARCH DATA** that can serve as the basis for a public debate among policy makers and other stakeholders on how **MST CURRICULA AND THEIR DELIVERY CAN BE IMPROVED** in order to encourage and prepare children from an **EARLY AGE** on for **FUTURE CAREERS IN MST**, whilst at the same time making MST more accessible and enjoyable for children so that they will keep **A VIVID INTEREST IN MATHEMATICS, SCIENCE AND TECHNOLOGY,** and understand **THE IMPORTANCE OF THEIR SOCIETAL ROLE**, throughout their adult lives.



NEW AND CHALLENGING GENERAL MST FRAMEWORKS NEED TO BE ESTABLISHED TO SUPPORT INNOVATIVE MST-EDUCATION!

SUPPORTING EVIDENCE

- In Europe, the progress in MST-education has been stimulated by several actions of the Seventh Framework Programme (Science in society). Policy documents like the Rocard report have had an impact on the perception of the central purpose of MST-education.
- Recommendation 2006/962/EC of the European Parliament on key competences for lifelong learning is an important reference tool for the EU countries to develop their education systems. For MST especially, the mathematical competence and the basic competences in science and technology and the digital competence are relevant for shaping and positioning MST-education within the EU countries.
- The screening of the national formal curriculum documents, executed in the SECURE project, testifies of the rich variety of educational systems that are present in the 10 involved EU countries. MST-education is shaped in different forms and translated into different MST-subjects. Although there are similarities between the curricula in the different countries, at least minor differences are located in all items of the curriculum (goals, content, rationale, learning activities, time, location, assessment, teacher role).
- The SECURE curriculum research concludes that the competences of mathematics, science and technology (EU key competence 3) are well covered in the national curriculum documents. Reference to competence 4 (digital competence) is present in curricula of eight countries, either in general aims and objectives or MST goals, or both. Nevertheless, attention paid to put them both into every-day practice varies a lot from country to country, and even from school to school.
- On the school level, above 40% of the mathematics teachers and slightly more teachers of science and technology indicate not to have a documented vision concerning MST education or to be unaware of such a vision. Slightly more than half of all MST teachers deny or are unaware of a documented vision on preferred learning strategies for MST. During the interviews with the teachers, the statement was frequently expressed that they benefit from clear descriptions of the goals and the rationale of MST for the implementation in classroom-practice.

CONCLUSION

Innovative and challenging frameworks for MST on both international, national and school-level seem to have an impact on the formal curricula and their implementation. In view of the common goals within Europe to ensure the role of science in society and to promote future scientific careers, it is important that the involved member states can shared their visions on the future of MST and that new innovative frameworks within Europe are formulated.

SUGGESTIONS FOR FUTURE IMPROVEMENTS

supra level	national level	meso level
Encouraging discussions on the rationale of MST within Europe and providing frameworks that can inspire further innovation of national MST curricula.	Formal curricula need to make explicit references to inspiring international, national and regional frameworks.	Innovative documented visions on MST education need to be available at school-level and discussed with the teachers.

INQUIRY-BASED SCIENCE EDUCATION (IBSE) CHALLENGES LEARNERS, BUT STILL NEEDS TO BE MORE STRUCTURALLY AND CONSEQUENTLY IMPLEMENTED IN CURRICULA AND IN PRACTICE

SUPPORTING EVIDENCE

- In the majority of the core curricula, the progress in incorporating (elements of) inquiry-based science education is visible.
- From the interviews with learners, we learn that learners are motivated when being given personal responsibility and when there are actively involved. Learners are motivated by practical activities, not such much by theory. They admit active learning is the most motivating and efficient.
- During the interviews, teachers acknowledged the profits from implementing IBSE in view of increasing the motivation of the learners.
- Teachers also report having difficulties in implementing IBSE during science lessons due to a lack of time, space or equipment. 50% or slightly more of all MST-teachers express that there is not enough time available for practical activities.
- Learners indicate that they predominantly have to listen to the teacher's explanations during classes.
- The majority of MST teachers indicate that they - in at least some lessons - ask their pupils to work together in small groups as well as letting then work on problems on their own.
- 60 % or more of the science and technology teachers lets learners conduct and design experiments and investigations in at least some of their lessons.
- Almost 60% of the mathematics teachers ask his/her learners to work on a problem for which there is no immediately obvious method of solution.

CONCLUSION

In both the core curricula as well as in the daily classroom practice, elements of inquiry-based learning are being included. Both teachers and learners agree that IBL promotes the motivation for the MST-subjects. Next to practical and structural obstructions for the full implementation of IBL in practice, it is not yet an integral part of most of the MST-lesson, but only applied during some of the lessons.

SUGGESTIONS FOR FUTURE IMPROVEMENTS

macro level	macro, meso & micro level	macro & meso level
Guidelines for further implementation of IBL in relation to the central aims/goals of MST should be formulated.	The necessary conditions for the promotion of IBSE should be provided (flexible time schedule, the organisation of the learning space, sufficient equipment). Use of home materials, tools and devices is highly recommended. A special emphasis should be put on a group work and peer instruction.	Stimulating professional development of teachers to grow their expertise in innovative learning and teaching methods for MST.

THE INTEGRATED USE OF ICT AND MULTIMEDIA IN TEACHING AND LEARNING REQUIRES SPECIAL ATTENTION

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SUPPORTING EVIDENCE

- Emphasis is put on the integrated use of ICT and multimedia in teaching and learning in many core curriculum documents, while at the same time the research shows that the use of computers and digital resources during MST classes is very limited across countries. More then 40% of the mathematics teachers indicate not to use a computer for solving mathematical problems and 30% of the science and technology teachers state the same for solving a scientific or technical problem.
- The majority of MST teachers report that a shortage of computers, software and hardware does not limit their teaching activities or only a little bit.
- In other recent research is concluded that, although curriculum documents promote the integrated use of ICT within the learning and teaching process, teachers mainly focus on the development of technical ICT skills (Tondeur, Van Braak & Valcke, 2007). This shows on the one hand the gap between the intended formal curriculum and the implemented curriculum and on the other hand the need for appropriate implementation-strategies to stimulate an integrated use of ICT.

CONCLUSION

Although, ICT and multimedia competences are an important part of modern society and are part of the EU key competences, there is room for a more frequent and integrated use of ICT and multimedia during MST classes. The orientation of ICT and multimedia should be in line with the intentions of the core curriculum documents, which promote ICT and multimedia a means to deepen the actual learning process and not solely as a technical skill.

SUGGESTIONS FOR FUTURE IMPROVEMENTS

macro & meso level	meso level
Stimulating professional development of teachers that is oriented towards integrated use of ICT and multimedia in teaching and learning.	Constructing school-based ICT curricula can give direction to an integrated use of ICT and multimedia.

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COLOPHON

This document is the result of the joint work of the following SECURE-partners:

Thomas More University College	Belgium
University of Graz	Austria
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Technische Universität Dresden	Germany
Università degli Studi di Udine	Italy
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Höghskolan i Gävle	Sweden
Nottingham Trent University	United Kingdom

Design: Marc Herman (Artefact)

References:

Tondeur, J., Van Braak, J. & Valcke, M. (2007). Curricula and the use of ICT in education: Two worlds apart? *British Journal of Educational Technology 38/6,* 962-976.

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Recommendations for MST-curricula in Europe

1. stimulate the interest for MST-subjects more efficiently from an early age onwards, with special attention for the crucial age of 10 years old.

2. provide more challenges and more support for both high-flyers and low-achievers based on a systematic approach and empowering curricula.

3. primarily work on the promotion of interest for MST-subjects for both boys and girls at early age (including kindergarten), taking into account gender-specific differences.

4. New and challenging general MST frameworks need to be established to support innovative MST-education!

5. Inquiry-based science education (IBSE) challenges learners, but still needs to be more structurally and consequently implemented in curricula and in practice.

6. The integrated use of ICT and multimedia in teaching and learning requires special attention.