Thematic Working Group on
Mathematics, Science and Technology
(2010 – 2013)

FINAL REPORT

Addressing Low Achievement in
Mathematics and Science
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Executive Summary

Background

Good level of understanding of mathematics, science and technology is an essential component for a successful, professional and social life. Therefore, the current situation of more than 20% of young Europeans not reaching a minimum level of basic skills in mathematics and science is alarming. This estimate is based on the results of the Programme for International Student Assessment (PISA)\(^1\) survey which has been conducted every three years since 2000. Furthermore, the culture of science and the scientific way of critical questioning is a key prerequisite for the proper functioning of the technologically and politically complex democratic society.

It is important to bear in mind that according to results from PISA 2009, differences between European countries explain only 10% of the total variance (spread) in mathematics and science performance. By contrast, between-school differences represent 37% in science and 35% in mathematics and the differences that are found within schools just over half (53% in science, 54% in mathematics) of the variance meaning that what is happening within schools themselves explains more than half of the achievement differences, whereas the differences between countries only accounts for one tenth.

The concept of low achievement is not addressed as such in most Member States’ education policies. There exist a number of policies that targets children at risk of becoming low achievers because of their socio-economic status and/or migrant status. There are also policies that aim at supporting students with special educational needs, but this group is not the same as low achievers. The state of play is that in many countries, while there generally are policies addressing low achievement in literacy, little is done to address low achievement in mathematics, science and technology (MST).

Shortcomings in support for low achievement in MST are highlighted in the Eurydice reports on mathematics and science education\(^2\). Furthermore, according to some estimates of the effect of educational achievement on economic growth, the potential aggregate gains\(^3\) for the European Union could reach €21 trillion if Europe was to realize the official EU benchmark of less than 15% low achievers in basic skills by 2020.

Findings of the Thematic Working Group on Mathematics, Science, and Technology:

The Thematic Working Group on Mathematics, Science, and Technology (TWG on MST) was established in order to provide guidance to Member States to reduce the share of low achievers in reading, mathematics and science to below 15% by 2020, as measured by PISA (below level 2\(^4\)). The tools for this exercise include peer-learning, literature review of the research evidence, experts’ presentations, open discussions, etc. The results of this effort are highlighted below. The TWG on MST discovered that there is a difference among member states and policy makers in the understanding of what constitutes low achievement.

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\(^1\) http://www.oecd.org/pisa/keyfindings/pisa-2012-results.htm
\(^3\) Discounted value of future increases in GDP until 2090
achievement and what is meant by students with special needs. These cohorts overlap with each other and with the group of students with socio-economic disadvantage. There is also a difference to be made between special-needs intervention and special-needs status among different countries. For example, in England, 17% of students experience some form of special-needs intervention, while only 3% are assigned special-needs status5. In Finland, 23% of children have part-time, special needs education, while only 8% have an official status6. This report focuses solely on "low achievement". Low achievement is the situation where a child fails to acquire basic skills while they do not have any identified disability and have cognitive skills within the normal range. In those cases, low achievement may be considered as a failure of the education system.

Another finding of the TWG is that there are strong links between low achievements in different subjects. Low achievers in one basic skill tend to be low performing also in others. Science is unusual when, compared to other subjects in that a large proportion of primary teachers appear to have had little training in teaching science and may sometimes lack confidence in teaching the subject. This is less the case for mathematics.

To a great extent low achievement is related to early-school leaving, socio-economic disadvantage and migrant status. Among the findings of the TWG is also the data in support of the notion that in the vast majority of cases there is an overlap between low achievement in literacy, mathematics and science, i.e. students tend to under-achieve (or excel) in all three areas of basic skills. Moreover, the TWG concluded that gender does not appear to play a role in low achievement in mathematics and in science, which is not the case for reading.

Variability over a period in the same country provides evidence that low achievement is an outcome of the education system and not of an innate level of ability of the children. For example, in Poland, results have significantly improved over the last 20 years. In contrast, in Bulgaria, results have significantly worsened since the early 90s due to the socio-economic turmoil associated with the period of transition to market economy and are now gradually improving. Furthermore, based on the progress observed in some countries, TWG concluded that it is possible for the Member States to reduce the number of low achievers in mathematics and science to fewer than 10% of all 15 year-olds.

Policy Recommendations of the TWG on MST

In its efforts to determine "what works" in terms of tackling low achievement from a policy perspective, the TWG identified several policy areas for possible intervention. In needs to be pointed out that the observations and recommendations listed below are the product of an imprecise analysis of different experiences of the Member States and the available data in the literature. One of the most important conclusions of the TWG is that there is an urgent need to improve the research base of the characteristics of MST education that can reduce the number of low-achieving students. This is the conditio sine qua non for evidence-based policy making in the EU.

First, at the level of curricula, teaching methods and student assessment, the TWG emphasised the need to teach science appreciation and science in context. The goal of this approach is twofold. On the one hand, it is designed to underpin the interest in MST by

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relating to students’ everyday experiences and to increase the relevance of maths and science education. On the other hand, this approach will serve the entire student population, including the under-achieving and the high-achieving students, possibly directing the latter towards careers in science, technology, engineering and mathematics (STEM). The integration of MST teaching with other subjects in a multidisciplinary and interdisciplinary manner as well as the mainstreaming of numeracy and science across the curriculum was also identified as a useful tool in combating low achievement. Finally, the TWG thought that setting explicit curricular standards as well as the use of formative and diagnostic assessment and feedback designed to improve student understanding and attainment, especially for science, are much needed steps towards improvement.

Second, at the level of provision of support for students at risk of low achievement, the TWG emphasized the imperative to create the conditions for early diagnosis of low achievement in mathematics and science, monitoring, and intervention at school level. It recommended that the support is to be integrated and delivered within regular school hours with a special focus on students from low socio-economic and/or migrant backgrounds. In this context, the modern, information/computer-assisted technology was identified as a useful tool to promote personalised learning in order to support each student. This would involve further development of student-centred, ICT-enabled, projects-driven learning.

The focus on support should be directed not only at students but also at teachers. Currently, there is no sufficient expertise among teachers on how to tackle low achievement in mathematics and science. Subject teachers and those teaching students with special needs also need support in terms of motivation, further training, release time, etc. This could be achieved through offering career paths with enhanced prestige, pay scales, in recognition of their efforts in combating low achievement.

Third, at the community and school level, the TWG found that what is needed is the development of a holistic approach to school education e.g. greater liaison between schools and the wider community, with the participation of families, public-health, commercial and social services, businesses, civic players, universities, public-private partnerships, etc., focusing on equity and cooperation, not on choice and competition. Also, the same holistic approach is to be applied within the school itself by breaking the barriers between the subjects and taking advantage of the different ways students learn, including non-formal and informal education. There should be wider development of instructional tools for emotional/behavioural management by emphasising social-emotional literacy (not self-esteem), self-restraint, persistence and self-awareness aiming at promoting the general well-being and motivation of students. Finally, the TWG emphasised the need to increase parental involvement by enhancing support and information for parents and facilitating greater involvement by parents in supporting the work of the school.

Finally, at the highest political level, the TWG concluded that lowering the number of low achievers to a target under 15% or even 10% (with intermediate milestones) would require a strong political commitment on part of national and EU authorities. This would involve the inclusion of science in the definition of basic skills. This is still not the case in many Member States. It was recognized that there is a need to ensure that the issue of low achievement is taken into account at all levels of the educational system and in all policy decisions. In addition, Member States should develop a system for identifying and sharing effective policies and best practice that can be replicated, adapted and used by policymakers, teachers, schools, local authorities and external partners. This system is to promote policies that are long-term, and expertise-based as well as policies that are aligned and reinforce each other.
1. Introduction

In modern, technology-driven times, Europe’s economic and social development relies on highly skilled populations. Living a fulfilling and productive life is also increasingly challenging for individuals without a minimum level of skills in numeracy and literacy. A certain level of knowledge of mathematics, science and technology is essential for successful participation in all aspects of modern society. Therefore, the current situation, where more than 20% of young Europeans are not reaching a minimum level of skills in mathematics and science, is alarming and untenable.

Unless something is done to change this situation, it could undermine both Europe’s economic development and social stability. Furthermore, a culture of science with its emphasis on critical questioning and problem solving is a key prerequisite for the effective functioning of a modern, technologically and politically complex democratic society.

A report by the European Expert Network on Economics of Education (EENEE), *The Cost of Low Educational Achievement in the European Union*, (Hanushek and Woessmann, 2010), uses estimates of the effect of educational achievement – as measured by international student achievement tests – on economic growth to simulate the impact of improved educational achievement for individual EU countries and the EU as a whole. According to these calculations, the potential aggregate gains\(^7\) for the European Union could reach €21 trillion if Europe was to realize the official EU benchmark of less than 15% low achievers in basic skills by 2020.

The report suggests that if each nation were to achieve the level of Finland, the top-performing country in Europe, potential gains could reach €87 trillion by 2090.

The state of play is that in many countries, while there generally are policies addressing low achievement in literacy, little is done to address low achievement in mathematics, science and technology (MST).

Shortcomings in support for low achievement in MST are highlighted in the Eurydice reports on mathematics and science education\(^8\). These reports confirm the lack of systematic policy attention to low achievers both in mathematics and in science: “specific national support policies for low achievers in science subjects do not exist in any European country. Instead, support is covered by a general framework of measures for students with learning difficulties, irrespective of the subject. These include differentiated teaching, one-to-one tuition, peer assisted learning, tutoring and ability grouping.”

The May 2009 Council conclusions on a strategic framework for cooperation in education and training ("ET2020")\(^9\) restated the importance of literacy and numeracy as fundamental elements of key competences and of making mathematics, science and technology more attractive. The new benchmark adopted by the Council under the framework aims at an adequate level of basic skills in reading, mathematics and science, by calling for the share of low achievers in reading, mathematics and science to be reduced to below 15% by 2020.

The ET2020 work programme also gave a mandate for the Commission to establish, together with Member States, new Thematic Working Groups to address these issues. It emphasises

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\(^7\) Discounted value of future increases in GDP until 2090


that while the cooperation is about exchanging good practices and peer learning, this effort should produce "clear and visible outputs" that can be easily disseminated and that provide Member States with practical and useful tools for their policy work.

This document explores what educational policies can do about low achievement in MST.

Reducing low achievement (LA) in general and in mathematics and science in particular (LAMS) has been on the education policy agenda at least since the launch of the Programme for International Student Assessment (PISA) survey back in 2000. The LAMS levels are still unsustainably high in a number of countries. This leads to the question as to what the obstacles to progress on the issue of low achievement in mathematics and science are. Other key questions include: What works and what does not work? Which policies should be abandoned and which should be promoted?

2. The Thematic Working Group – Mandate, Composition and Activities

The Council’s conclusions on increasing the level of basic skills in the context of European cooperation on schools for the 21st century (2010) can be considered the legal basis for the activities of the Thematic Working Group (TWG) on mathematics, science and technology (MST). The Council invited the Commission to facilitate the identification and dissemination of good practices in the field of attainment in mathematics and science, to help Member States achieve the 2020 benchmark. The conclusions also contain an invitation to launch joint pilot projects, implementing with EU funding interventions with a common assessment framework. In addition, the Council’s conclusions on basic skills (2010) emphasised the importance of such qualities as problem solving, critical thinking and creativity.

One of the five new benchmarks adopted by the Council aims at reducing the share of low achievers in reading, mathematics and science to below 15% by 2020, as measured by PISA. The TWG on MST was established in order to provide guidance to Member States to reach this objective.

The work of the TWG on MST was launched in 2010. The group has as single focus how to address low achievement and student motivation in mathematics and science. The operational objective of the group is the production of a report on policies for reducing LAMS.

NOTA BENE: The TWG on MST and its final report do not explore the issue of technology education (the "T" in MST) because of the absence of internationally agreed definitions or standards in this area and because the benchmarks mentioned above refer only to mathematics and science achievement as measured by the OECD Programme for International Student Assessment (PISA).

The Thematic Working Group (TWG) is composed of representatives (experts in mathematics and science education) from 23 member states or associated countries. These are: AT, BE (Fl and Fr), BG, CY, CZ, DE, DK, EE, ES, FI, FR, IE, IT, LT, LV, MT, NO, PL, PT, SE, SI, TR, UK (Northern Ireland) and SE.

The Directorate General for Research and Innovation, EURYDICE, and OECD also take part in meetings.

The focus of the TWG is peer-learning within the field of MST education at school level.

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Peer Learning Activities (PLAs) were organised in Finland, Estonia, Northern Ireland, Republic of Ireland, Flanders and Slovenia.

Peer-learning is a process of European cooperation whereby policymakers, stakeholders and practitioners from one country learn, through direct contact and practical cooperation, from the experiences of their counterparts elsewhere in Europe in implementing reforms in areas of shared interest and concern. The focus is on policy measures rather than classroom practices, for example.

The PLAs findings are not research-based and are meant to motivate policy reform.

The peer-learning approach was complemented by a literature review, the results of which are considered in this report.

Several presentations were given by group members to inform the group about policies existing in their countries, and to encourage collective reflection (The list of presentations is contained in the appendices).

A seminar was organised where group members were given the opportunity to exchange with project leaders from EU funded projects related to MST education.

**Acknowledgements**

The TWG expresses its gratitude to the host countries, to individual organisers of PLAs, and to all those teachers and education professionals who shared their experience and expertise with us, speakers at meetings and PLAs (from EURYDICE, OECD, Poland, Pollen, KCL).

3. **Definition of Low Achievement in Mathematics and Science**

In order to ensure comparability between EU Member States, the EU benchmark identifies low achievement on the basis of the definitions used by the PISA survey in which scores range from level 1 to level 6 (the highest level).

According to the TWG mandate, and the European benchmark, low achievers in mathematics and science are students who do not reach the level 2 of PISA in Mathematics and Science. This level is considered to reflect the necessary basic skills. It is measured at 15 years of age.

“Students whose proficiency in mathematics is limited to Level 1 or below can, at best, perform simple mathematical tasks in familiar contexts. They will find it difficult to think mathematically, limiting their ability to make sense of a complex world. A priority for all countries is to ensure that as many students as possible attain at least the baseline proficiency Level 2.” *(PISA 2009 at a Glance, OECD 2010)*

The table below gives the percentage of European students scoring below level two in PISA:

<table>
<thead>
<tr>
<th></th>
<th>Students below PISA level 2 – Europe’s averages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2006</td>
</tr>
<tr>
<td>Reading</td>
<td>24%</td>
</tr>
<tr>
<td>Mathematics</td>
<td>24%</td>
</tr>
<tr>
<td>Science</td>
<td>20%</td>
</tr>
</tbody>
</table>

“Students whose proficiency in science is limited to level 1 will find it difficult to participate fully in society at a time when science and technology play a large role in daily life (PISA 2009 at a Glance, OECD 2010).”

Individual countries percentages of LAMS, are contained in the appendices.

What does PISA level 2 mean?

In Mathematics:

According to PISA, in mathematics, “level 2 students can interpret and recognise situations in contexts that require no more than direct inference. They can extract relevant information from a single source and make use of a single representational mode. Students at this level can employ basic algorithms, formulae, procedures, or conventions. They are capable of direct reasoning and literal interpretations of the results.”

By contrast, students at level 1 “can answer questions involving familiar contexts where all relevant information is present and the questions are clearly defined. They are able to identify information and to carry out routine procedures according to direct instructions in explicit situations. They can perform actions that are obvious and follow immediately from the given stimuli.” (PISA 2009, volume 1)

In Science:

“At Level 2, students have adequate scientific knowledge to provide possible explanations in familiar contexts or draw conclusions based on simple investigations. They are capable of direct reasoning and making literal interpretations of the results of scientific inquiry or technological problem solving.”

“At Level 1, students have such a limited scientific knowledge that it can only be applied to a few, familiar situations. They can present scientific explanations that are obvious and follow explicitly from given evidence.” (PISA 2009, volume 1)

Not reaching level 2 means that students are not able to perform at least 50% of tasks at PISA level 2.

Some of those not reaching level 2 will be at level 1, which means that they succeeded in at least 50% of tasks at this level, while others will be below level 1.

The great variability among countries shows that something can be done to improve the achievement in maths in science.

The TWG mandate is based on PISA data. However, in order to facilitate the work of the group, a clearer definition of what constitutes low achievement in mathematics and science (LAMS) was required. In particular, it was felt necessary to distinguish between LAMS and a number of closely related groups of students such as students with special education needs (SEN), students from disadvantaged socio-economic backgrounds, early school leavers, etc.

One of the limits of a definition based on PISA is that low achievement is only measured at age 15. The group decided to study low achievement from the early years of education to 15
years as there was a consensus that effective policy had to tackle the roots of low achievement early in a student’s formal education.

The TWG’s working definition of LAMS was agreed as: Students, that at any stage of their education up to age 15, fail to acquire the basic level of mathematics and science skills relevant to their age group.

This definition is based on student achievement, because this is where education policy is most likely to have a significant impact. While social, economic and health issues (regarded as key to the definition of other categories of students) have an impact on educational attainment, and as such must be addressed by education policy. The decision to concentrate on achievement had the advantage of allowing the TWG to focus on the education processes alone.

4. Review of the literature on LAMS

4.1. LAMS and differences with other categories of students

It is known that there is an overlap between different categories of students and low achievement. These categories include students with special education needs (SEN), early school leavers (ESL), low achievement in literacy, students from disadvantaged socio-economic backgrounds and from migrant families.

Role of the socio-economic background

The share of LAMS is higher among students from disadvantaged socio-economic backgrounds. The index of economic, social and cultural status utilised by the PISA data illustrates that students from the lowest (bottom quarter) socio-economic backgrounds are 2.7 times more likely to also be amongst the lowest achievers (bottom quarter) in mathematics\(^\text{12}\). Furthermore, on average across the OECD, students from single-parent families are also 1.3 times more likely to be amongst the lowest achievers. The findings relating to socio-economic background highlight the potential effect of policy strategies where engaging parents with their children’s education may have positive outcomes for those students at greatest risk of underperforming.

Low achievement cuts across all socio-economic groups, even among the most privileged groups of students.

As can be seen on the graph below, there is a large variability in low achievement and in the impact of socio-economic background between countries. Finland and Estonia both have a low percentage of LAMS. The impact of socio-economic background on the risk of low achievement is also less in these countries.

\(^{12}\) \text{http://www.oecd.org/edu/school/programmeforinternationalstudentassessmentpisa/34002216.pdf}
Students with special educational needs

In many countries, a number of LAMS students do benefit from support designed for students with SEN. There is not always a clear-cut distinction between low achievement and learning difficulties, and SEN programmes are sometimes the most commonly available type of support.

In fact, the definition of SEN differs largely from country to country. There is also a difference to be made between special-needs intervention and special-needs status. For example, in England, 17% of students experience some form of SEN intervention, while only 3% are assigned SEN status. In Finland, 23% of children have part-time, special needs education, while only 8% have an official status. Some countries use the term SEN for students that this report defines as low achieving.

In general, SEN status implies disabilities, whether physical or cognitive. For example, mathematical learning disability and dyscalculia are often used as synonyms referring to inherent disability with an estimated prevalence rate of between 4-10 % in the population.

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15 Dyscalculia is defined as being a clinical condition, analogous to dyslexia which may impede young learners in mathematics. This is currently the subject of cognitive research in clinical settings. See Butterworth, B and Yeo, D 2004, Dyscalculia Guidance
The concept of those with mathematical difficulties is a broader concept by comparison because it simply refers to any group of students with poor achievement in mathematics.

In contrast to SEN, low achievement generally can be addressed through timely and targeted educative intervention, and there is no identified disability. Low achievement is often temporary.

The cohort of LAMS students contains some level of overlap with the cohort of disadvantaged students and students with special needs. While the overlap is far from total it does sometime lead to confusion. For example, low-achieving students frequently come from families with low socio-economic status, and a number of low achieving students have special education needs. In some countries there is no distinction drawn between LAMS and students identified with SEN. This report focuses solely on LAMS.

Relationship between LAMS and early school leaving

These represent two approaches to understand and address the failure to acquire basic skills. Early school leaving (ESL) approaches the issue from the perspective of qualifications, while LAMS focuses on skills acquisition. There is probably a significant overlap between the groups of students leaving school without any formal qualifications and those failing to acquire basis skills, as it is must be difficult for a student to sustain secondary education without having acquired basic skills, particularly in mathematics. In terms of policy development, however, these two approaches lead to different types of policy that can complement and support each other. An example of such policy that targets both ESL and LAMS is DEIS in Ireland.

Relationship between LAMS and the migrant population

Research shows that there are also significant achievement gaps between native, first-generation and second-generation migrants when it comes to performance in mathematics and science. Only relatively small percentages of native students fail to reach the level 2 threshold according to the findings concentrating on mathematics achievement in PISA 2003 and the PISA 2006 data for science. On the other hand, more than 40% of first-generation students in Belgium, France and Sweden fail to reach level 2 in mathematics.

The term ‘early school leaving’ is used in connection with those who leave education and training with only lower secondary education or less, and who are no longer in education and training. (COUNCIL RECOMMENDATION of 28 June 2011)


18 The term ‘early school leaving’ is used in connection with those who leave education and training with only lower secondary education or less, and who are no longer in education and training. (COUNCIL RECOMMENDATION of 28 June 2011)
immigrant students succeed – A comparative review of performance and engagement in PISA 2003). Similarly, according to PISA 2006 focussing on science, 37% of first generation migrants fall into the category of low achievers.

**LAMS and low achievement in other subjects**

There are also strong links between low achievements in different subjects. Low achievers in one basic skill tend to be low performing also in others. In the PISA report concentrating on the assessment of mathematics in 2003, the correlations between the PISA assessment areas is provided. The estimates demonstrate the relationship between achievement in mathematics and achievement in the other subject domains. The high correlation results presented in OECD (2004) Problem Solving for Tomorrow’s World – First Measures of Cross-Curricular Competencies from PISA 2003 illustrate that students doing well in mathematics are likely to do well in reading and science, with the converse also being true.²¹

![Diagram showing correlations between science, reading, and math achievement](image)

Among the low performers in science in PISA 2006 …

**The gender factor**

The evidence on the gender gap for literacy illustrates that girls are outperforming boys in their reading skills by almost a year by the time they are 15 years of age.²² Over a quarter (25.9%) of boys are low achievers in reading compared to 13.3% of girls. On the other hand, the gender differences are insignificant both in mathematics and science. The most recent PISA 2009 data highlights that for students in the EU-25, 21% of boys are low achievers in mathematics compared to 23.5% of girls.²³ The gap between boys and girls in science achievement is also narrow. Girls outperform boys in this domain with 18.6% of boys being low achievers compared to 17.1% of girls. Therefore, from a policy perspective, strategies have to be put in to tackle LAMS across the board, regardless of gender.

**Conclusion**

Evidence from the UK\textsuperscript{24} relating to those who are consistently low achievers include the features above in terms of immigrant status and socio-economic background, as well as students with high rates of mobility between different schools and ‘looked after children’ (i.e. those who are being cared for by the State). These characteristics of low achievers do not work in isolation from each other. Rather, these features can interact and place students at increased risk of being a ‘low achiever’ due to a variety of these factors (through cumulative disadvantage).

The concept of low achievement is not addressed as such in most Member States' education policies. There exist a number of policies that target children at risk of becoming low achievers because of their socio-economic status. There are policies that aim at supporting students with special education needs, but this group is not the same as low achievers. Many students fail to achieve basic skills in mathematics and science while they do not have any identified disability and have cognitive skills within the normal range.

What is meant here by “low achievement” is the situation where a child does not acquire basic skills for no apparent reason (e.g. a specific physical or cognitive disability). Therefore, in those cases, low achievement may be considered as a failure of the education system.

Variability over a period in the same country provides evidence that low achievement is an outcome of the education system and not of an innate level of ability of the children. For example, in Poland, results have significantly improved over the last 20 years. In contrast, in Bulgaria, results have significantly worsened since the early 90s due to the economic and social turmoil related with the transition to market economy which led to a disintegration of the traditional school model and cultural attitudes.

4.2. What is specific about LAMS, compared with low achievement in general?

The situations pertaining to mathematics and science are quite different. Mathematics is generally recognised as being at the core of basic skills. Hence, most education systems are organised to provide some form of support for low achieving students in mathematics. Science, on the other hand, is explicitly considered in many countries as part of the core basic skills, and little or nothing is organised by the system to support students failing in science. They can even choose to stop studying it in many cases.

Science is also unusual when, compared to other subjects in that a large proportion of primary teachers appear to have had little training in teaching science and may sometimes lack confidence in teaching the subject. This is less the case for mathematics. Primary teachers are often not at ease with teaching science.\textsuperscript{25}

In most countries, LAMS support is directed towards literacy and to a lesser extent mathematics. There is often very little support available in science. For example, in Estonia there are specialists in schools for logogaedic (speech and language therapy) help, but no specialists trained to support in mathematics. This is also true for Austria.

This review goes beyond individual interventions to also include policy-relevant factors that can feed into the wider debate (at systemic level) about effective strategies in these domains. However, there are a number of limitations. The main limitations encountered was the relative lack of an evidence base, particularly in relation to what works for low achievers specifically

\textsuperscript{24} Department for Education (2012) Literacy and numeracy catch up strategies

\textsuperscript{25} See for example: Primary Science Teacher Confidence Revisited: Ten Years on, Murphy and al., 2007
(as opposed to achievement in general) and for the domain of science. Thus, the resulting evidence is considered tentative and exploratory in nature, and highlights the need for large-scale research and evaluative work.

The review focuses on policies and interventions that target low achievers. However, it is important to note that a number of interventions that aim at improving general achievement levels can also help low achievers, and that some measures specifically designed to help low achievers have also been found to raise the achievement of other students.

This is confirmed by PISA data\(^{26}\) at the aggregate level, since high-performing countries such as Finland achieve their high performance by minimising the proportion of low achievers. Many of the best-performing countries have a relatively modest gap between the strong and weak performers. Moreover, equity and high achievement go, in this respect, hand in hand. Low achievement amongst students is an issue not only of improving the effectiveness of teaching and learning. Tackling low achievement is also related to providing an equitable system of education\(^{27}\).

### 4.3. Measures to combat LAMS

It is important to bear in mind that according to results from PISA 2009, differences between European countries explain only 10% of the total variance (spread) in mathematics and science performance. By contrast, between-school differences represent 37% in science and 35% in mathematics and the differences that are found within schools just over half (53% in science, 54% in mathematics) of the variance meaning that what is happening within schools themselves explains more than half of the achievement differences, whereas the differences between countries only accounts for one tenth.

On the basis of the TIMSS assessment in 1995, the International Association for the Evaluation of Educational Achievement\(^{28}\) explored effective schools in science and mathematics. The report found that few school factors (such as school size, class size and school climate) were consistently related to student achievement in mathematics and science across all countries. Rather, the school variables that influence achievement in these areas are very different across countries or groups of countries. This was in contrast to the consistency of home background indicators of socioeconomic status and of parental support for academic achievement.

Therefore, the evidence suggests that out-of-school factors, particularly those related to family background, account for much of the differences that we can observe in student achievement in the domains of mathematics and science.

Identifying factors that have shown causal links to improvements in either mathematics or science achievement is very difficult. The effects of educational reforms are not immediate and it is generally not possible to identify which aspect of reform is associated with improvements. For example, reforms that have taken place in Portugal\(^{29}\) included reducing grade repetition, a new system for evaluation teachers and an emphasis on teacher training

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\(^{26}\) OECD (2004) Learning for Tomorrow’s World: First Results from PISA 2003  
\(^{29}\) See the Eurydice network, “Mathematics Education in Europe: Common Challenges and National Policies.”
which may have individually or jointly contribute to the significant decrease in the proportion of low achievers in mathematics. It is difficult to examine the effects of these factors in isolation from one another.

The PISA and TIMSS data limit their potential to identify causal relationships between factors and outcomes. According to the literature, several interventions at systemic level may play a role in combating LAMS:

- Early childhood intervention and care
- Parental involvement
- Curricular modifications
- School environment
- School inputs
- Classroom characteristics and instructional strategies
- Assessment
- Progression rules

All of the above-listed interventions have been discussed by the TWG.

5. Policies specifically aimed at reducing LAMS

5.1. Including science in the definition of Basic Skills

For action by policy-makers at national level.

The importance of the basic scientific skills for all is not well established. There is often neither a clear definition of these basic skills nor of how they are monitored. In many countries, e.g. Norway, science is not even considered a basic skill. If Europe wants to reach its target of less than 15% of LAS in science, it is crucial that science is considered as a key part of basic skills to be achieved by all students.

In PISA, scientific literacy is defined as: “an individual’s scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science-related issues, understanding of the characteristic features of science as a form of human knowledge and enquiry, awareness of how science and technology shape our material, intellectual, and cultural environments, and willingness to engage in science-related issues, and with the issues of science, as a reflective citizen.” (OECD 2010, p.137).

The strong dependency of science achievement on mathematics, of how mastery of mathematics supports students’ success in science is well known. At the same time, mastery of literacy is also an essential prerequisite for achievement in science. For example, the significantly lower performance of boys in literacy may be related to their slight lag behind girls in science achievement. In a general sense, science is indeed not a basic skill per se because it builds upon the existing levels of mathematics and reading skills. However, as noted in the introduction, given the complexities of the modern society, scientific literacy is an essential component of basic skills today.

A second reason for the inclusion of science in the concept of basic skills may be related to the fact that a growing body of research shows that, for evolutionary reasons, human beings are generally not inclined to apply the “scientific way of thinking” as referred to by Cromer.
also called “critical thinking” by Carrol (2011) and “slow thinking” by Kahneman (2012). As Carrol (2011) puts it: “The fact is that it is our natural inclination to go with our gut feelings and intuitions. Questioning our instincts, first impressions, and what the majority of people around us believe does not come naturally... We humans don’t really like to face facts... Selective thinking is our natural way of thinking”. Cromer (1993) talks of “the heretical nature of science.”

The natural tendency of the human mind to employ intuitive thinking rather than inductive/deductive reasoning and logical argumentation requires special educational efforts in the area of science education. Cromer (1993) argues that the key to success is reform at the middle school level. That the critical and systematic way of looking at the world does not come naturally to most humans and that instilling it requires specific educational efforts needs to be recognized by teachers and policy-makers.

5.2. Teaching science in context

For action by teachers at school level.

Reforming the curriculum should place an emphasis on the context in science education, i.e. on its relevance to students’ life. For example, this approach may include teaching the social, ethical and environmental aspects of science as well as the creation of links to industrial enterprises, research centres, public-health and other services. Teaching science in context is aimed at both the general population of students and at those students who are naturally inclined to venture deeper in the field of MST.

The relevance of scientific knowledge to everyday situations seems to be the key to getting students interested in science because of the largely negative image of MST as a profession (Encouraging Student Interest in Science and Technology Studies, OECD 2008). Relevant content and hands-on demonstrations that relate to students’ interests lead to higher retention. Interest in science and technology is observed to decline most sharply around age 15. Overspecialisation and the lack of social dimensions in the curriculum can deter students from pursuing MST studies.

Science evolved as a result of our curiosity and our desire to understand the nature and operation of the universe. The application of the Scientific Method, involving observation, reason and experiment has led to an increase in our scientific knowledge and our ability to decipher the rules the universe appears to obey. It has always been the case, however, that the most interesting phenomena are the ones where these rules don’t work rather than where they do. This is how new rules are discovered and fresh advances are made. This exploratory nature of science should be embraced at all stages in the education system and be made equally accessible to all students.

5.3. Towards science appreciation and awareness

For action by teachers at school level.

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Science is fundamental to our worldview, a shared and universal platform for understanding our material world, its development and challenges. Therefore, in the definition of basic skills in science, it may be appropriate to place the emphasis on the appreciation and awareness of science and on the scientific way of thinking as opposed to the mastery of the scientific concepts in the physical and life sciences. We face many daunting challenges as a society, not all of which can be solved with more science and mathematics education, however an understanding of science’s open-ended, evidence-based processes — rather than just its results — is essential in meeting those challenges.

This approach is aimed at the general population of students who are not expected to specialize in MST. For those students, there may be a need for a paradigm shift from scientific content towards the process of scientific inquiry and the history and philosophy of science. This approach seems especially appropriate given the difficulties encountered by the majority of people with the scientific way of understanding the world.

Scientific literacy is an important tool in overcoming the anxiety that many individuals feel towards science and technology. This anxiety is thought to be particular to Europe (vis-à-vis USA or Asia) and is considered by many as a major obstacle to Europe’s economic growth and technological innovation.

5.4. Promotion of the feasibility to continuously decrease LAMS

For action by policy-makers and teachers at national and school level.

The feasibility of making significant and continuous reduction in LAMS should be demonstrated and promoted at national level. A percentage of no more than 10% of any age group being described as low achievers in mathematics, science and technology should be achievable over the long term. There are many examples in different countries of policies that improve the achievement of all students and reduce the number of students who fail to acquire basic skills in MST.

Raising awareness is particularly important because there is often a perception that mathematics and science rely more on individual ability than other basic skills. For example, some students may be described as “not the scientific kind” or “not made for maths”, while equivalent labels relating to reading/literacy would raise eyebrows. Stakeholders, including families and students may consider that certain individual students are naturally less able in mathematics and science, seeing mathematics and science ability as an individual characteristic, rather than the result of an educational process. However, at the level of basic skills (not higher-order mathematics and science), such views are indefensible.

The situations of Member States are of course diverse and each country will need to define its own strategy, timeframe and improvement pathways, but the key point is that all Member States accept that a lower rate of LAMS is achievable through reform and application of education policy.

Some countries did show significant improvements of their rates of LAMS between PISA 2006 and 2009. Among them are Italy, Portugal, Poland (science), Latvia, and Romania. Estonia, Finland, and the Netherlands are already at the level targeted by the benchmark for both mathematics and science while Germany, Hungary, Latvia, Poland, Slovenia and the UK have achieved the target for science. This is also the case in Flanders. The examples of

science performance on PISA for Finland, and Estonia show that a target of 10% should even be achievable over the longer term.

Peer learning activities identified that there was a diversity of beliefs about what is the rate of LAMS that is unavoidable. For historical and cultural reasons, a number of education stakeholders, at policy level as well as at practice level, may consider that current levels of low achievement are inevitable. One of the factors that allowed some countries to significantly reduce their rate of LAMS while others faced more difficulties, may be linked to differences in beliefs.

The belief in the feasibility of reducing the rate of LAMS translates at the level of teachers into the belief that every child can acquire basic skills and that it is the responsibility of the education system to make it happen.

Following from this, every occurrence of durable low achievement should result in the quality education provision being questioned. Teachers should be made aware of the range of resources, tools and methods available to prevent and overcome it.

**Actions:**

School leaders, decision makers within local authorities as well as teachers should receive training - including in-service training - specifically relating to low achievement in mathematics and science.

Interventions should raise teacher awareness of their responsibility in addressing LAMS and facilitate a shift from the belief that some students are inherently liable to underachieve in MST to one where low achievement is seen as the failure of the teaching and learning process.

Communication highlighting successful cases: schools or areas where the number of LAMS was successfully reduced should be prioritised. This should include circulation of research evidence from PISA and other international studies. At EU level, this communication should be through school/teachers networks, media outlets, etc.

**Example:**

In Ireland, various projects take into account the importance of teacher attitudes toward students’ capabilities. Programmes to support students are based on the belief that every student is capable of success and that the state is obliged to provide the education that allows them to succeed.

For example, DEIS encourages teachers to raise their expectations for student achievement, and to help them reach their potential. DEIS coordinators are expected to work directly with teachers to uncover the attitudes they have, and to make sure that they have not lowered expectations for LAMS students.

5.5. **Placing the issue of LAMS at the centre of the policy agenda**

*For action by policy-makers and teachers at national level.*

In countries where there is a strongly shared belief that it is the responsibility of the system to ensure that every student acquires basic skills, the requirement of basic skills for all, and thus the issue of low achievement are often at the centre of education policies. Low achievement is

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34 Professional Development and Reform in Science Education: The Role of Teachers' Practical Knowledge, VAN DRIEL, BEIJAARD, AND VERLOOP, 2000
so complex and has so many multiple forms and roots that only a system-wide approach can address it. There is no single successful strategy. For each and every policy decision, the question of implications for LAMS would be addressed, e.g. in initial and continuous teacher training, curriculum design, inspection activities in schools and school strategic planning.

The issue of basic literacy skills acquisition is indeed embedded or mainstreamed in education policy in many countries. This is less common for basic numeracy, and it is rarer still for scientific literacy, while including basic skills in technology in education policy is even at an earlier stage of development. The goal is to make the question of low achievement in mathematics and science ubiquitous, part of the frame for analysis of every policy decision.

In some countries, this may require cultural shift for many second-level teachers and thus for teacher educators. Countries should create national strategies for meeting the agreed targets by taking into account the cultural mores of each member state. One strategy should include member-state participation as full partners in PISA and TIMSS.

An educational legal framework for meeting the benchmark could also be created. This framework might specify the legal right for low-achieving students to obtain appropriate support, (BE, DK, SE, EE and FI)

One example is the initiative in Denmark called "An even better public school in Denmark” which has three national objectives for the development of the public school:

• The public school must challenge all students to reach their full potential
• The public school must lower the significance of social background on academic results
• Trust in the school and well-being must be enhanced through respect from professional knowledge and practice in the public school.

In order to fulfill these three goals, the parties to the agreement agreed upon a reform of the Danish public school as follows:

• A longer and varied school day with more and improved teaching and learning.
• An enhanced professional development of teachers, pedagogical staff and school principals
• Few and clear objectives and simplification of rules and regulations.

5.6. Monitoring LAMS at system level

For Action by policy-makers and teachers at national level.

Monitoring the numbers of low achieving students is central to informing decision makers and enables them to take appropriate actions in order to improve matters where necessary. A clear definition of responsibilities at the different levels of the system plays a strong role in the implementation of policies aimed at reducing the number of LAMS.

Hard data are needed to be able to identify and address LAMS. Feedback about the effect of interventions is needed for evidence-based policies, and for designing support.

Depending on the country, monitoring is managed at different levels: central, regional, and in school for example. In some countries, or regions, monitoring is based on samples of schools. Flanders is one such example. In some countries the national authority designs and produces national tests that are meant for school self-assessment. Each school can decide whether to submit their students to it or not (e.g. in Finland).
Data are to be generated at class, school, regional and national levels including self-evaluation. In BE(Fr) such tests are already being used while they are also being developed in Ireland for introduction in 2016 at secondary level.

Obviously monitoring is a sensitive question. In order to make sure that all stakeholders feel comfortable with and positive towards this process, some countries, Flanders and Austria for example, have been particularly careful to make clear that the outcome of monitoring was more support, rather than sanctions, for weaker schools.

In some other countries or regions, monitoring does lead to a succession of measures that can range from support to sanctions and this was made possible through a longer term effort to develop a culture of accountability and quality insurance among education stakeholders.

**Examples:**

In Ireland, following the recent decline in 15 year-olds’ performance in the PISA mathematics and science assessments, the Department of Education and Science has introduced a number of measures to monitor more closely student performances. *The Literacy and Numeracy for Learning and Life* strategy adopted in 2011 presents a number of targets at different education levels, including halving the proportion of students performing below level 1 in PISA, reducing the proportion of low achievers in national tests and increasing the share of students taking higher level mathematics in their final examinations. Standardised assessments in reading, mathematics and science would be introduced at the secondary level in 2016.

In Estonia, at primary and lower secondary levels (basic school) Estonia applies national monitoring tests. Those tests are designed to give teachers and students an indication of acceptable standards and to provide the ministry with a picture of real performance levels (for evidence-based policy making). No sanctions are applied to schools or teachers on the basis of these results and the results are not made public.

On the other hand, at upper secondary level, school performances are closely scrutinised, results are made public, and the culture of accountability is relatively strong. This culture of accountability has been particularly developed since the year 2000.

In 2010, after years of preparation, Denmark implemented national tests in several subjects including mathematics biology and physics/chemistry. The tests are compulsory for all students in public school and the mathematics tests are situated in the 3rd and 6th grade. The tests are digital and automatically provide the teacher with detailed feedback about student achievement in three profile areas as well as overall performance. The tests also provide parents with feedback in the shape of a performance sheet showing their child’s score compared to the national mean. The Danish national tests are among the first adaptive digital testing system in the world. The tests are a good tool for formative assessment and give teachers the opportunity to discover students in mathematical difficulties so that these students may receive the necessary support.

### 5.7. Developing expertise in providing support for LAMS

*For action by policy-makers and teachers at national level.*

The situation in the different countries represented within the working group differed significantly on the level of awareness and training that the average teacher received regarding the identification and support for students facing difficulties in mathematics and science.
Primary teachers may often have greater awareness and training relating to numeracy difficulties than in the sciences and technology. Typically, general teachers have had training in teaching mathematics but would need special training on mathematics didactics for low achieving students.

Secondary teachers may have received less training on the causes and nature of low achievement, such as self-confidence and self-organisation, but may be more aware of subject-specific difficulties.

In a few countries, most primary teachers undergo some training to allow them to know how to identify and support students with difficulties. This is the case, for example, in Finland.

In Slovenia, every teacher has been through a training aiming at promoting the use of ICT in education, and this training has also been used as a tool to train them in other important subjects including how to help and support students in difficulty.

In Finland and Estonia, there is a category of teachers that are specialised in supporting students facing difficulties, whether or not they have identified special education needs. These teachers are trained as general teachers and have an additional training in pedagogy and didactics for students facing difficulties. They work within one or more given schools and offer extra support to students in a flexible way. They have the expertise, experience and time to offer a personalised support to students in a wide range of different situations. They are primarily teachers, which helps to avoid the stigma that could sometimes be associated with the involvement of other professionals such as therapists, and they focus on varying the teaching approaches to find the most appropriate model for each child. They often work collaboratively with speech and language therapists, occupational therapists, educational psychologists and other relevant professionals.

These support teachers seem to be useful resources in countries that have them. Their specialisation allows developing and capitalising on their expertise and know-how.

Another benefit that arises from the generalisation of such professionals is that in order to train them, universities have to develop courses on support for low achievers and to create centres with expertise in this area.

In conclusion: Each teacher’s initial and continuing professional development should include component on LAMS and specialists should be made available in every school.

In the majority of countries, first-level support is provided by teachers without any particular training or specialisation in learning support or SEN education. This support is considered as part of their general teaching responsibility.

In a number of countries, some of the support can also be provided by less qualified professionals such as teaching assistants or individuals recruited on an ad hoc basis. A recent report about the situation in England, reported that most of the support (for children with SEN) is given by teacher assistants with no or little qualification in supporting low-achieving children.

Examples:

In Finland, the support is given by the usual teacher but also by a team of professionals that have a specialisation in supporting low-achieving students

15% of teachers are qualified as “special education teachers”. This means they generally have had one additional year of training compared to classroom teachers, dedicated to student support. Some others study directly special education for 5 years. They have a slightly higher salary than regular teachers and are working with smaller groups of students.
In Estonia, there is a great variability in the support offered by schools as it is the responsibility of the state and local government to make provision and of the head teacher to organise it out of the school budget.

The support team for students facing difficulties may include a mix among the following types of professionals:

- “Remedial teachers”, called also sometimes “special education teachers”. There is generally one remedial teacher per school and they have been through a specific training. They teach children in small groups, generally during the normal school day, but also sometimes after school. They will often provide support in mathematics.

- “Social pedagogues”. Their responsibility is to deal with inappropriate behaviours such as absenteeism or anti-social behaviours. They are educated in social science at university level.

- Speech therapists, called *logoped*, are also involved in the support and schools usually have one among their team, possibly shared in the case of smaller schools.

- Psychologists, that provide support for students, parents and teachers.

- A nurse.

These support teams provide support to students and also to teachers and parents. For example, they provide help and advice on how to deal with specific developmental or behavioural problems and may organise training on specific themes for teachers, for example, on language development.

Another source of support is provision of daily sessions when teachers are available on demand to answer students’ questions.

In Norway, the program called New Possibilities aimed at educating all mathematics teachers (in-service training) in new teaching methods for LAS at lower high-school level.

Expertise in LAMS in FI and EE is provided by specialists while in Sweden and other countries support is provided by non-specialists.

In Ireland, there are specialists in each school.

In Denmark, there is the example of the National Centre for Science Education (DK)\(^{35}\), which is supported by the government. The strategy of this Centre includes three main objectives.

- Development of systematic knowledge sharing within the area
- Improving the scientific dimension of the general education of all children and young people
- The National Centre for Science Education, Denmark supports the development of knowledge environments with special competences in science, technology and health

These are derived from the law on “Establishment of a national centre of the education in science, technology and health”

\(^{35}\) [http://nts-centeret.dk/images/stories/89457_8s_A5_-_National_strategi_GB.pdf](http://nts-centeret.dk/images/stories/89457_8s_A5_-_National_strategi_GB.pdf)
5.8. Identification of LAMS students in need of support

For action by teachers at school level.

Students who for various reasons are low achievers are identified and receive targeted intervention by the system (FI and EE). This is not the case in Sweden where there is a reluctance to identify students in need.

Early identification tools that allow teachers to understand where and why children have difficulties are a key element of support.

In some countries, teachers will identify the need for support in an informal manner, based on their expertise. This is, for example, the case in Finland where teachers are specifically trained in this area. In Estonia, the needs are first detected by the teacher, and subsequently analysed and refined by a team that includes the teacher, school-based support specialists and other professionals. Some other countries or regions prefer systematic methods for identifying this cohort of students at different levels of the education system.

Examples:

In Northern Ireland, policies are in place to provide an ICT-based diagnostic assessment at least once a year in primary education for identifying and monitoring achievement levels for students. This aims at allowing teachers and parents to adjust their support, and is accompanied by central ICT support and a programme of teacher training.

In Finland, identifying the students’ needs is the responsibility of the school (teachers and the school principal supported by the school nurse, sometimes also by the school psychologist and/or school social worker and parents). There is no systematic screening as a national policy, but numerous screening tools have been adapted and are freely available to teachers.

The team of teachers (general and specialised) are responsible for identifying and qualifying the needs for support for each student. This team is called the “Student Welfare Group”. They then design a support plan and implement it. This ownership of the full process, which makes the teachers fully responsible for the success of the designed support actions, may be one of the factors that make the Finish support system successful.

In Estonia, the head of school has to appoint a special education needs coordinator, who gives support to teachers for identifying the needs, and organises the collaboration between teachers and support specialists for implementing the support measures.

5.9. Acting immediately and intensively in cases of LAMS

For action by teachers at school level.

The study of the different examples from different countries led TWG members to consider that one of the key elements of a successful policy against low achievement in MST is the speed and intensity with which the system is allowed to react to a given student’s need.

There seem to be a consensus that effective intervention against low achievement has to take place as soon as the need arises and to be as intensive as required to solve the difficulties met by the student so as the intervention can be limited in time. This appears to be both more effective and less stigmatizing. In both Finland and Estonia, the different education stakeholders that the TWG met, pointed out that a key factor to avoiding low achievement was to react very quickly, as soon as possible after the first difficulties appear.

In many countries though, the support available to students without identified special needs is limited in quantity and type. It is often limited to a few hours of collective support a week,
with this support being sometimes given by teachers or assistants without specific qualification for that task.

Examples:

In Finland, a student that has been absent due to illness will automatically be provided special support, preventing him/her from becoming a low achieving student. It was pointed out that the support had to be designed at the right level of intensity from the beginning, to avoid the situation becoming permanent.

Some professionals pointed out that many difficulties can be detected as early as Kindergarten and that this early detection allows reacting before or at the very beginning of primary school. The specific training and education of Kindergarten teachers to detect these needs for support could therefore be a factor of success.

In Finland, for example, there is a legal right for each student to obtain support if they face difficulties in achieving these basic skills while in Estonia this right is stipulated in the Basic Schools and Upper Secondary Schools Act.

In Denmark, a recent political decision was made to increase the number of school hours corresponding in average to the length of a school week over one year, by 30 hours for form level 0 → 3, 33 hours for form level 4 → 6 and 35 hours for form level 7 → 9.

In order to achieve the objective of early intervention and quick response, the decision process that leads to attributing resources to a student must be designed as a quick and easily actionable process. It means also that significant resources have to be made available.

5.10. Support integrated within the regular teaching and learning process

For action by teachers at school level.

It is crucial to integrate support as a normal part of the teaching and learning process. Introducing learning support for a large share (20-30%) of students in the first grades of primary education reduces stigmatization and allows it to be seen as part of everyday teaching and learning. Another factor mentioned as contributing to preventing low achievement is the practice of team teaching. Different teachers will naturally use different approaches and this increases the chance that the student will be exposed to the kind of approach that best suits them.

Examples:

In Finland, the TWG observed how support is integrated as a normal part of the learning process. The support can first be informal and given by the teacher. Then, if the need for support appears to be more substantial, other professionals, including teachers with a specific training for special support, may become involved. It seems that parents and children do not express fear of stigmatisation and do not report a feeling of failure when students are offered additional support.

Several reasons are given for this high acceptance of special support:

- It is relatively frequent: about 23% of students are being given special support at any given time.
- It is effective: it is designed as a short term tool that can be quite intensive but generally results in the problem being solved and the support being discontinued.
- It is presented as a right for the student, and never as a sanction.
As one of the experts phrased it “they are not impaired children, they are children that need support”. Another way to explain this approach was given by the head teacher of the school the group visited: “Everyone has some needs for special support everyday”

There is no clear cut distinction between the regular support for a temporary difficulty and the dedicated and more structured support that can be given in the context of Special Educational Need. They are part of a continuum of support.

In Finland, the school visits allowed members of the TWG to observe lessons that were strongly student-centred and activity based. The classrooms were laid in a way that allowed flexibility and group work with tables reorganised easily to suit best each activity. Technology was commonly used and in particular computers allowed different students to carry on different tasks at the same time. The teachers were both leading the whole activity and circulating between groups to give personalised guidance.

The presentation given to the TWG members outlining the approach to primary/classroom teacher education and training placed a strong emphasis on personalisation of teaching and learning. Indeed, one of the main goals of teacher education was described as follows: “teachers should be able to diagnose students’ knowledge, skills and affects and, based on this, differentiate classroom activities”.

### 5.11. Support provided in the early years

*For action by teachers at school level.*

If schools move towards more personalised learning and focus more on individual needs, learning support could be offered on a large scale in the early years. The identification of difficulties can start in early childhood education and care. It is well-known that children who have difficulties with basic mathematical tasks during Early Childhood Education and Care (ECEC) continue to experience difficulties throughout education.

Early mathematics skills set the foundations for later mathematical ability and may predict later academic achievement even more accurately than early reading. European and U.S. experience shows that early intervention programmes, especially those targeted at disadvantaged children, can produce large positive socio-economic returns, and that these persist well into adulthood.

Skills are needed for kindergarten teachers and ECEC professionals. Early access to support for LAMS should be made the rule.

For example, in Slovenia all three and five year-olds are seen by a psychologist and speech therapist. They will not focus only on language but will also focus on early mathematical skills. This is followed by the provision of support for kids with early mathematics or reading difficulties. In Finland, kindergarten teachers are educated to identify children’s individual needs and to provide relevant support.
5.12. **Management of behaviour/emotional aspects and metacognitive skills**

*For action by teachers at school level.*

It is well known that low achievement is associated with a range of factors that are not only cognitive in nature. PISA has shown, for example, that factors such as self-concept and self-confidence, but also self-organisation are strongly associated with achievement. LAMS are often related to poor attendance, behaviour and poor attitude towards school in general and MST in particular.

The TWG members found that in countries where the support system is strong (e.g. EE and FI) and where there is an expertise on how to support low achievers, the support also encompasses these emotional components and is not limited to just its cognitive aspects.

In Estonia, education stakeholders mentioned that low achievement was often coupled with behavioural problems especially absenteeism. Hence, the support system that was presented to the group had a strong component of discipline and management of behaviour.

In Finland, the question of damaged self-confidence and the need to make sure that every child felt able to learn was mentioned as a key point to tackle low achievement. A PLA in Northern Ireland showed the importance of school leadership in tackling emotional and attitudinal problems and the need for policy to foster and recognize school leadership.

Meta-cognitive and self-regulation strategies include those where the teacher helps students become more aware of how they learn and to develop effective learning strategies, such as setting goals, monitoring and evaluating their own learning. Higgins et al. (2012)\(^{36}\) have found a large base of evidence showing high levels of impact of such approaches, and that this impact tends to be particularly strong for lower achieving students. According to them, this impact has been more often shown for literacy and mathematics but it has also been evidenced for science.

5.13. **Increasing parental involvement**

*For action by policy-makers and teachers at national and school levels.*

Whereas the success of family literacy programmes is fairly well documented in terms of their effects on literacy, less is known about the potential impacts of parental involvement and family numeracy interventions on mathematical skills. Available evidence supports the claim of a positive effect of family engagement on numeracy. Analysis of TIMSS data reveals that at both fourth and sixth grades, students have higher achievement in mathematics if their parents report that they are “often engaged in early numeracy activities with their children”. The motivation and support for engaging with numeracy amongst young children begins with parents in the home.

Therefore, the evidence points to the importance of informing and engaging with parents in order to ensure successful outcomes for students in mathematics.

A review of “Mathematics Teaching in Early Years Settings and Primary Schools” in the UK concluded that the involvement of parents is crucial for the success of interventions while at the same time acknowledging that due to shortcomings in their own mathematics skills, parents may not always be in a position to provide the support needed for their children. This

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emphasises the potential of including the whole family in family numeracy programmes and the advantages in addressing parental skills, when necessary.

Parents of LAMS students may lack trust in the education system, and programmes. Therefore, parental attitudes should also be addressed. For example, Ireland sets targets of parental involvement for students whose families are detached from their children’s school performance (The DEIS programme). Among other things, this programme provides training for parents with low levels of education to be able to support their children.

In order to promote two-way communication, in schools that are part of this programme, dedicated school teachers have their main focus on outreach and communication with parents. These teachers are referred to as Home School Community Liaison Officers (HSCL). These are teachers who are relieved of teaching duties while they take the post of a HSCL.

Other type of actions towards parents include:

- Involvement of parents in informal learning settings (clubs, excursions, science fairs, etc.)
- Helping parents to develop their own MST skills (inform them and support them in accessing specific adult education programmes).
- Developing and making available ICT and materials for parents to help their children. Example: Maths and science dictionaries for migrant parents to enable them to support their children (Ireland).

5.14. Promotion of student-centred, ICT-enabled, project-driven learning

For action by teachers at school level.

In a personalised model of teaching and learning, students of different abilities are taught together and the teaching and learning sequences are differentiated so as each one can be presented with adequate material and challenges. This allows students to feel part of a continuum of abilities and reduces the risk for stigmatisation.

This also allows teachers to care for the needs of all students, for example helping future scientists to develop excellent skills while providing basics skills to all students.

Among the enablers to this model are:

- The use of ICT-based teaching and learning;
- Certain teaching and learning approaches such as project-based teaching and learning (where the students carry a project individually or in small groups); and
- The presence of more than one professional per group of children.

In some countries, this second adult can be a teaching assistant, while in other cases it can also be a second teacher (“team-teaching” or “co-teaching” or in-class cooperative support).

These three categories of enablers are particularly relevant to MST as these subjects are well suited to ICT integration and project-based teaching and learning. The presence of a second professional also provides opportunities for supporting the main teacher in cases where they would need more expertise and/or self-confidence in MST subjects (e.g. in Finland).

Another example is the Science municipality project in Denmark. The Science Municipality project 2008-2011 was carried out by the Danish Science Factory on behalf of Ministry of

Education. The large-scale development project was aimed at improving science education in one-quarter of all Danish municipalities through a number of political and organizational initiatives designed to rally science education stakeholders to a mutual and sustained effort to promote science education. The Danish TIMSS-2011 report states, that there is a significant tendency that students attending schools in Science-municipalities perform better in science and mathematics than students attending schools in other municipalities and concludes, that the Science-municipalities initiative seems to result in improved student performance.

5.15. Promotion of networking between teachers/schools on LAMS issues

For action by teachers at school level.

5.16. Promotion of partnerships between schools and external partners

For action by policy-makers and teachers at national and school levels.
Science centres, industry, teacher-training colleges, universities, museums, etc.

5.17. Addressing socio-economic disparities leading to LAMS

For action by policy-makers and teachers at national and school levels.

In some participating countries, policies are in place that specifically target schools that have more students from disadvantaged backgrounds, giving them either more resources, e.g. higher budget, additional teachers, teaching assistants, more equipment or access to specific prevention programmes. There is special focus on migrant students as a source of LAMS.

These policies that provide additional resources to schools with a high rate of less advantaged students are known to carry a risk of stigmatisation. It often leads to more social segregation. In some countries, the support for schools is organised as a continuum, in order to avoid this stigmatisation. The additional resources are then attributed to every school according to the number of its students that are from disadvantaged background.

These policies are linked to the question of social segregation and how to attract a mixed audience in certain schools. There are some indications that show that low achieving students do better in a mixed ability group. However, there is also evidence about better advancement of LAMS in academically homogeneous student groups. Academically homogeneous does not at the same time mean socially homogeneous. Social homogeneity linked to lack of resources produces discrimination.

5.18. Emphasis on the research-based knowledge of policies tackling LAMS

For action by policy-makers and teachers at national and school levels.

Further developing and disseminating the research-based knowledge of policies that actually produce results work and of policies which don't.
6. General policies aimed at improving overall achievement levels

6.1. Curriculum

For action by policy-makers and teachers at national and school levels.

6.1.1. Mainstreaming numeracy across the curriculum

The promotion of numeracy as a cross-curricular priority emerged as a measure that can have a high impact on low achievement in MST.

In this model, numeracy is mainstreamed across the curriculum and the responsibility for each student to acquire basic numeracy skills is shared by the whole school team. The principle is to explicitly show the mathematics behind other subjects and hence to provide students with a large number and variety of mathematics learning contexts and materials, and to increase the relevance of mathematics for students.

In vocational training students meet technological challenges which often can be solved by using mathematical and scientific knowledge and methods. Taking in a technological problem as a starting point can in both general and vocational training be used for developing mathematical and scientific skills in realistic examples.

This appears to also create opportunities for cross-subject teachers’ collaboration and whole-school team work, and above all, it significantly increases the exposure time to mathematics.

For example, in Northern Ireland the new flexible curriculum puts literacy, numeracy and ICT at the core of curriculum and identifies them as cross-curricular skills. This new curriculum also defines cross-curricular goals (e.g. thinking, problem solving, managing yourself and relationships with others, numeracy), and a strong emphasis on direct application of knowledge and skills in a variety of contexts. Standards are cross-curricular – in other words, they apply to student attainment in literacy and numeracy across the curriculum.

Every teacher, whatever the subject they teach, is required to work on numeracy. Materials are provided to support numeracy teaching in other subjects than mathematics.

The new Using Mathematics programme encourages a cross-curricular approach to applying numeracy skills. Teachers of different subjects are encouraged to invite students to:

• Choose the appropriate materials, equipment and mathematics to use in a particular situation;
• Use mathematics to solve problems and make decisions;
• Develop methods and strategies, including mental mathematics;
• Read, interpret, organise and present information in mathematical formats;
• Use mathematical understanding and language to ask and answer questions, talk about and discuss ideas and explain ways of working;
• Develop financial capability.

In Ireland, each school is required to have a literacy and numeracy strategy, with explicit targets. School are inspected to evaluate progress against these targets.

6.1.2. Setting explicit curricular standards

Setting explicit curricular strands is particularly important in science because, in a number of countries, science is little taught at primary school. Minimum standards of achievement early
on in primary education can reinforce the importance given to science teaching and thus can increase the opportunities for all students to acquire basic scientific skills.

In some countries, the curricular design allows both teachers and students to focus on student progression, each step of acquisition being identified so as the low-achieving students can build self-confidence on the basis of this visible progression.

In Northern Ireland, assessments are to be based on standards for levels of performance. The standards, which are cross-curricular, were developed through a process of consultation with teachers and teachers’ unions, principals, inspectors and policy makers.

Teachers should have access to a range of resources for curriculum with examples of what good performance looks like at different levels of progression. These examples are intended to support teachers in thinking about how they might structure the work they are doing. The tools also reinforce the language of progression.

Since not every child will progress at the same rate, schools also monitor the percentage of students who are progressing at least one level in each key stage. These levels of progression are very specific, and are expressed in terms of what children should be able to do at different stages.

In Ireland, the DEIS programme encourages teachers to scaffold learning – setting clear, measurable targets at the appropriate levels for different students. Similarly, the LCA and JCSP programmes emphasise the importance of breaking learning into discrete, manageable units so that students receive feedback on how well they are doing as they progress.

**6.1.3. Other curricular points**

- Avoiding over-prescriptive and over-ambitious curricula,
- Differentiation of MST curricula, (e.g. basic/standard/enhanced) while not allowing students to opt out.
- Integrated science teaching in early lower secondary, to mitigate the dive in interest in sciences after the transition from primary education
- Continuing to promote inquiry based science education
- Scaffolding
- Developing learning to learn skills

**6.2. Teachers**

*For action by policy-makers and teachers at national and school levels.*

As was mentioned above, the situation regarding teachers’ beliefs, awareness and capability relating to students at risk of low achievement varies. Through initial and continuous professional development, there should be continuous support for all teachers to achieve the right balance between subject matter knowledge, subject specific didactics knowledge and general pedagogical classroom knowledge. This generally means providing more MST content knowledge and subject specific didactic knowledge in the sciences for primary teachers, while secondary teachers would often need more general pedagogical classroom knowledge and didactical knowledge.
Some research has shown that interventions focused on teacher’s instructional practices and classroom management strategies were particularly effective for mathematics and science in elementary school.

The focus of the interventions reviewed by the TWG was on teacher instructional practices and classroom management strategies. The goal of these interventions was to enhance the teachers’ abilities to motivate children, to engage their thinking processes, to improve classroom management and to adapt instruction to students’ needs. One important characteristic of these interventions was the extensive professional development, usually including follow-ups and continuing interactions among the teachers themselves.

Teacher coaching, and continuing professional development focused on instructional practices and classroom management strategies seem to be effective with associated costs being much lower than those of other key but expensive factors such as teacher qualifications and salaries. For example, they:

- Support teachers in acquiring specific competences (defined as knowledge, skills and attitudes) on low achievement (learning difficulties, support, diagnostic, and misconceptions), personalisation/differentiation of teaching (including subject-specific didactics, personalised learning materials and tasks for different achievement levels) and subject-specific competences in didactical use of ICT
- Promote and facilitate teacher collaboration and teamwork around students facing difficulties:
  - Between subjects (maths-science-technology)
  - With other subjects
  - Through school teams
  - With other professionals supporting these students
  - At transitions (primary-secondary, etc.)
- Promote a more general collaborative culture among MST teachers and reinforce networking:
  - Through subject specific teacher networks
  - Through collaboration between teachers, teacher educators and researchers

The status of the teaching profession seemed to be relatively better in countries that had among the lowest rates of LAMS. As an example, Finland reports no difficulty in recruiting teachers and teaching is perceived as an attractive profession.

The question of the how attractive the teaching profession is, is of specific importance in MST, as there is often a strong competition for MST graduates with other, financially more rewarding, MST careers.

Ireland has recently focused on empowering teachers to develop more teaching and assessment materials themselves. They have also encouraged teachers to observe each others’ lessons, and to work collaboratively to strengthen teaching and learning.

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6.3. Assessment and feedback

*For action by teachers at school level.*

Some countries participating in the TWG are promoting the use of formative and diagnostic assessment as a tool to fight low achievement.

Formative and diagnostic assessments (including student self-assessments) are frequently used as a tool for feedback and learning for the cohort of students, not only individual students.

These forms of assessment allow to accurately identify the needs of each individual student, to uncover student misconceptions and to give them more precise feedback.

Feedback has been shown to have very positive impact on learning in literacy, mathematics and to some extent in science, as highlighted in Higgins *et al.* (2012). The authors point out that feedback provides the learner and/or the teacher with information about the learner’s performance in relation to the learning goals and allows the teacher and the learner to reappraise the approach being adopted. “It can be about the learning activity itself, about the process of activity, about the student’s management of their learning or self-regulation or (the least effective) about them as individuals. This feedback can be verbal, written, or can be given through tests or by means of ICT. It can come from a teacher or someone taking a teaching role (including students acting as teachers) or from peers.”

Diagnostic assessment is sometimes computer-based and computer-graded, which can allow for adaptive diagnostic assessments, in which the questions presented to each individual student are based on their answers to precedent questions, offering questions that are adapted to their level.

The role of formative assessment can be described as “diagnosis rather than autopsy.” In other words, teachers should use diagnostic and formative assessment to identify student needs and potential barriers early on in the learning process, when remediation is easy to put in place, while the exclusive use of summative assessment could lead to a situation where the teacher would just “make a record” of students’ failure at the end of a period, when it is too late “treat” the problem.

Diagnostic assessments allow for identifying learning needs early on so that teachers may adjust overall strategies. When teachers assess learning formatively, they pay attention to gaps between student performance and learning goals as part of the routine teaching process. Based on these assessments, teachers may then provide students with feedback and guidance. Learning can then be scaffolded, so that next steps are appropriate to the students’ needs and level of progression.

Students are also partners in this process. They know the goals and are therefore more likely to work toward them. Participants also noted the importance of tracking students’ progress with them (particularly in the case of LAMS). Students are then able to see their progress over time and to build their confidence in their ability to succeed.

Some countries also promote the use of a wide range of assessment, to better accommodate the needs of a wide range of students. Among this diverse range, self-assessment and portfolio are thought to present specific opportunities for low achieving students in MST.

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Example

Traditionally, schools in Ireland have emphasised student assessment through terminal examinations, rather than ongoing assessment.

Programmes targeted to LAMS, however, incorporate more frequent assessment of learner progress.

Project Maths, for example, promotes small group work, having students write out what they have learned and areas where they need clarification. Students are assessed daily in the course of classroom interactions. Low- and underachieving students have been found to be among those who are most enthusiastic about Project Maths.

DEIS encourages teachers to scaffold learning and to set clear, measurable targets at the appropriate levels for different students. This is an important formative assessment technique. Similarly, the LCA and JCSP programmes emphasizes the importance of breaking learning into discrete, manageable units so that students have feedback on how well they are doing as they progress.

In Northern Ireland, diagnostic assessments include computer-based assessments of literacy and numeracy skills (centrally designed by the Curriculum Authority), which are administered between September and December each school year for students 7 to 11 years old. The assessments are “adaptive”. In other words, students who answer a question correctly are given a harder question, while those who answer incorrectly are given an easier question. These assessments, which last approximately 30 minutes each, are computer graded. The data are intended for use within the schools. There is no central collection of data, although schools are required to report the results to parents.

The impact of assessment and feedback practices on students self-concept and progression: In the Northern Ireland school visits, the school leadership team described how teachers across the school worked collaboratively to try different formative assessment strategies (for example, using the “two stars and a wish” approach to giving feedback, with positive remarks as well as feedback on where a student may improve their work), monitored the impact on student performance, and discussed ways to improve new practices with their colleagues. This collaborative approach to embedding new practice across they whole school may be particularly effective.

Denmark: "Mandatory national IT-based tests. 40

Tests are seen as a tool for the continuous evaluation of the student learning outcomes. In this view, the tests also constitute a tool for teachers in relation to organizing the further teaching and to adapt teaching to the single student’s needs. Thus, the mandatory national tests also have a formative purpose.

In some conditions, assessments could support student motivation and interests, while in others it could discourage them. Student engagement in the assessment process is important. For example, students may set learning targets with teachers, and may assess the quality of their own work. In addition, students could also re-do tests as a learning tool.

The **Northern Ireland** strategy supports students in taking ownership of learning and assessment. Students take greater ownership of their learning, personal development and career planning through the Records of Achievement (now a statutory requirement). Students start to record their progress in different subjects when they start post-primary years. Twice a year, they update the records and track their achievements, positions of responsibility they have held, and their school activities. Teachers are expected to reflect with students on their progress and goals. The results of these records are included in summative reporting at the end of Key Stage 4 and in Sixth Form. These Records are important tools for students to self-assess and to plan ahead.

Other forms of support for teachers may include research-based training, tools, portfolios tracking their own work, and opportunities to reflect on their practice. Formative assessment should be modelled in teacher training and professional development to reinforce the methods, demonstrate practical approaches to integrating new assessment methods into practice, and to improve teacher learning. The support of school leaders (including department heads) is also essential to supporting shifts in teacher attitudes, as was observed in school visits in both Ireland and Northern Ireland.

### 6.4. Holistic approaches to school education

*For action by policy-makers and teachers at national and school levels.*

The TWG is in favour of promoting the whole-school approach to teaching and learning, including the provision of health-care, dietary and social services as well as the conversion of schools into centres for community learning (“community schools”). The entire school environment including addressing mental-health issues, bullying, handicapped children, etc. plays a role.

For example, in Ireland, participants pointed out the role of the whole-school culture in preventing low achievement. School heads provided a lot of support even in curricular and pedagogical areas, and were not confining their activities to administrative tasks. School heads’ attitude and engagement appeared as crucial.

The support given by school leaders (including department heads) is essential to supporting shifts in teacher attitudes, as was observed in school visits in a number of countries. PLA participants remarked that school leaders’ own attitudes have a strong impact on school culture. School heads may also need to shift attention from administrative duties to strengthen their pedagogical leadership and provide stronger support for teachers.

Other aspects of quality structures for school that may contribute to successful policy against low achievement in general and in MST are:

- Supporting **distributed leadership**: mid-management and departmental structures within schools
- Supporting **school self-evaluation** with a focus on achievement and an ambition of success for all
- Providing a **rich information system** to school management, where assessment results are fed back to schools
- Providing administrative structures or school networks for **quality improvement** in schools
- Redirecting **inspection** towards constructive counselling on developing schools as a whole, addressing low achievement explicitly

- Providing at central, national level ICT platform for schools to create **virtual classroom environments**, to liaise with parents and with other subject teachers.

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**Example:**

In Flanders, School autonomy relies on the existence of support organisations. These organisations act as service providers and step in at school request.

Each school network in Flanders has its own **pedagogical advisory services** (also called educational guidance services), responsible for supporting schools within the network.

Among their responsibilities are:

- Supporting schools in realising their pedagogical project
- Supporting schools to enhance the quality of education
- Supporting schools after audit by the inspection
- Introducing and stimulating innovation in schools
- Providing training for staff and school leaders

The group was presented in details with the activities and organisation of one of these pedagogical advisory services, responsible for supporting the schools within the „GO!“ network, the public school network of the Flemish community.

The support this organisation provides is pedagogical, subject-specific and organisational, i.e. system oriented, helping schools to build the capacity to meet the challenges brought with their newly extended autonomy.

Initially aimed at helping schools solving their problems, the focus of this organisation shifted in the last 8 years towards supporting school development. The new goal was given by the concept of “policy building capacity” introduced in the Flemish educational system.

This led to a number of fundamental changes:

- From subject and system apart to an integrated approach
- From problem driven to school development
- From a focus on individual teachers to a focus on school teams
- From working as an individual adviser to working as a supportive team

This new approach is referred to as “**integrated support**“. To organise this integrated support regionally based support teams were created that contain both subject and system experts (5-6 advisers). These support teams are responsible for handling all questions in their region (about 40 to 45 schools). They use the same framework as the inspectorate to analyse schools (CIPO – which stands for Context, Input, Process, Output).

Similar services were mentioned in Ireland (responsible for support in literacy and numeracy strategy, school development and leadership development) and in Denmark (for general secondary schools).
6.5. ICT and innovative learning environments

For action by policy-makers and teachers at national and school levels.

ICT offers opportunities for enriched teaching and learning practices, particularly in subjects where experimentation and visualization are key such as in MST. The TWG members were able to observe examples of ICT use in MST teaching and learning such as lessons using computer generated simulations, interactive blackboards or feedback devices.

A number of these technical tools allow enriching MST teaching and learning with visualizations and simulations. Visualization is particularly important in mathematics and can be very helpful for many students.

Others make experimentation easier, safer and more time- and cost-effective, allowing a larger range of them to take place.

The number, quality and variety of these visualizations, simulations and experimentations are believed to play a part in both the ability of some students to better understand MST concepts and their engagement in the study of these subjects.

Using ICT-based learning tools enables to adapt the learning process to the multiple forms of intelligence of different students.

ICT tools are powerful in improving and increasing communication between education partners. Communication environments are more and more present in schools and facilitate communication within the whole-school community.

TWG members were able to observe the importance of these environments and other ICT tools as facilitators for communication and involvement of the whole community of stakeholders around students: parents, teachers, student peers, companies when relevant. This involvement can have a special value in the case of students at risk of low achievement.

ICT provides a wide range of tools to facilitate teaching and learning of MST. They for example encourage personalisation, and adaptation to each student pace.

ICT facilitate a teaching format in which each child is engaged in their own tasks and the teacher is free to navigate between them. This allows the teachers to tutor children most at need (both low and high achievers for example). This way, more teacher effort can be transported to teaching situations of higher complexity.

Game format for teaching and learning can allow disengaged students to gain interest for MST learning, they can support motivation to perform difficult tasks and maintain effort, and they can also help children with MST anxiety to overcome it by studying MST in a different context. For all these reasons, they can bring a lot of useful opportunities to students most at risk of low achievement.

Participants pointed to adaptive assessment as another promising use of ICT in MST education. These computer-based assessments, mentioned earlier, adapt the each test question to the recorded achievement of the student to the questions previously asked, thus allowing to progressively adapt the test to the student level. These assessments allow a fine knowledge of each and every student level and difficulties, including those achieving particularly high or particularly low, thus making possible a better personalisation of subsequent teaching.

Among other approaches and tools, ICT tools contribute to diversify teacher approaches, which can benefit low achievers both by sustaining their engagement and by offering them a larger variety of types of exposure to MST.
The integration of ICT tools in a broader high quality didactic approach is key to the success of any ICT policy for MST Education: “Pedagogy should lead ICT instead of the unfortunately frequent situation where ICT leads the pedagogy.”

Key factors of success:

- Teacher specific competence and ownership
- Availability of high quality materials
- Integration in a broader didactic approach

These conditions being met, ICT can significantly improve the quality of the MST education, being more engaging for students and more effective in producing high quality outcomes.

Example: in Slovenia, an ambitious ICT policy as a driving force for improved quality of MST Education

Participants were able to observe that an ambitious ICT policy can provide the ground for in-depth work and improvement on different aspects of MST Education.

The introduction or promotion of new tools provides a favourable context for generating change in many areas of education.

Supporting teachers in developing their use of ICT does not only mean helping them to become competent in the use of these technologies but also helping them to become proficient/expert at using them for teaching. Using technologies in teaching and learning can and often should involve a shift in pedagogy.

In Slovenia, a major training programme has been organised for teachers around the notion of e-competence. This was the occasion for in-depth training. Teachers were offered the opportunity to work and reflect on their practices and become part of networks for a longer term improvement process. The goal of these trainings was much broader than the simple acquisition of ICT competences and was instead the development of a teaching competence that would include the use of ICT tools whenever relevant.

Participants agreed that any ICT policy in MST Education should aim at supporting teachers to carry out these didactic changes, so that the teaching changes really in substance and not only superficially.

Hence, a policy targeting ICT can also be an opportunity for any given Education system to promote and implement major didactical improvements.

7. Recommendations:

7.1. At school level

- Formative and diagnostic assessment to be used as a tool to tackle LA and to provide feedback to the LAS with their participation in the assessment process.
- Developing a whole-school approach aimed at tackling the LAS problem is needed.
- Providing support to LAMS students is a more beneficial, cost-effective approach to dealing with LAMS than allowing repetition of the school grade.
• Curricular reform
  - Emphasis on context in science education which is relevant to LAMS (including social, ethical and environmental aspects as well as participation of working-life enterprises and science centres).
  - Promote the vocational aspects of education as a tool for tackling poor motivation
  - Mainstreaming of numeracy across different subjects
  - Targeted policies towards LAS are more efficient in tackling LAMS than general policies.

7.2. At national/regional level
• Monitoring number of low achieving students
• Provide intensive continuum of support from the early stage of low achievement in MST through flexible tools for identification of LAMS, integrated approach to the support (across the curriculum, across school structures, local responsibility), improvement of teacher expertise in LAMS, emphasis on the motivational/behavioural aspects of LAMS, personalisation of teaching and learning in target settings, efficiency of the support provided (number of LAMS students per number of support persons), etc.
• Include science in the basic skills of national curricula
• Creation of professional networks specifically designed for LAMS.
• Raising awareness of the nature, consequences of low achievement and on the feasibility of solving the LAMS problem. (Using general social networks, media outlets, EU-led campaigns)
• Self-evaluation tools for the government to assess how effectively they address low achievement?

7.3. At EU level
• Set a more ambitious target for the level of LAMS in the EU (less than 10% of MST according to PISA)
  - Continue monitoring numbers of LAMS at EU level using PISA and TIMSS
  - Encourage member states to participate as full partners in PISA and TIMSS
  - Create national strategies for meeting the target having in mind the cultural specificities.
• Promote research on the effect of different education policies on LAMS (to include policy makers in the conduct of calls for research), especially in science education. Broaden the evidence for policy making in the field of LAMS.
8. National initiatives in the area of low achievement in MST

Denmark

An even better public school in Denmark

In Denmark it is the government’s vision to have a public school that challenges all children to reach their full potential. It is the government’s intention to improve the quality of the public school through a number of different initiatives:

Three clear national objectives for the development of the public school:

- 1: The public school must challenge all students to reach their full potential
- 2: The public school must lower the significance of social background on academic results
- 3. Thrust in the school and well-being must be enhanced through respect from professional knowledge and practice in the public school.

These goals shall contribute to setting a clear direction and a high mutual level of ambition for the development of the public school, and furthermore, to ensure a clear framework for a systematic and continuous evaluation. In order to fulfil these three goals, the parties to the agreement agreed upon a reform of the Danish public school, based on three main areas of improvements, mutually supportive of one another, and which might contribute to the improvement of the students’ academic standards:

- A longer and varied school day with more and improved teaching and learning.
- An enhanced professional development of teachers, pedagogical staff and school principals
- Few and clear objectives and simplification of rules and regulations

Belgian French Community (Bfr)

Brief description of the Bfr system

There are different nets of schools.

- Depending directly from Bfr
- Subsidized by Bfr

(by ex. Catholic, town, common or provincial schools)

There are regulations imposed to all the schools by laws but a part of liberty is accorded to the managers. The rules maintain uniformity between the nets and allow the changing of school and net for students.

Each school has a personal project according the decrees (condition to be subsidized).

The directions manage their schools under the control of inspections (finance, quality of the education offer, …).

41 For further information read the agreement between the Danish Government (the Social Democrats, the Social-Liberal Party and the Socialist People’s Party), the Liberal Party of Denmark and the Danish People’s Party on an improvement of standards in the Danish public school (primary and lower secondary education).

http://eng.uvm.dk/~media/UVM/Filer/English/PDF/131007%20folkeskolereformaftales_ENG_RED.ashx
The inspection is above the different nets and made reports on their visits to the Ministry each year.

**The Bfr decrees to enhance the system**

In Belgium, a decree is a law of a community or regional parliament.

Remark: A lot of information about the Bfr education system can be downloaded from the official website: [http://www.enseignement.be/](http://www.enseignement.be/)

**How to learn at home when you can’t go to school?**

*Illness or inability to move*

Décret organisant l’enseignement à distance de la Communauté française


**How to learn after school and get a job?**

*How to reinsert the professional world after a gap between school and life?*

Décret organisant l'enseignement de promotion sociale


**How to learn at school and on a workplace simultaneously?**

*A regulated mixture between learning at school and learning practice on workplaces.*

Décret organisant l'enseignement secondaire en alternance


**How to learn when you have a handicap and how eventually reinsert a school with other students?**

*A regulation to reinsert children coming from special schools in the “normal” school system.*

Décret organisant l’enseignement spécialisé


**How to give special tools, money and help for schools in poor part of towns or country?**

**How to give the same chances for all children in education?**

Décret organisant un encadrement différencié au sein des établissements scolaires de la Communauté française afin d'assurer à chaque élève des chances égales d'émancipation sociale dans un environnement pédagogique de qualité


**Generalities**

The Bfr publishes each year the state of the system. Several benchmarks are pointed.

*How to measure the progresses of the system through the years?*

**ALL THE BENCHMARKS OF THE EDUCATIVE BELGIUM (FR) SYSTEM. EACH YEAR AN ISSUE.**

**LES INDICATEURS DE L'ENSEIGNEMENT 2012**

The education system is guided by a pilot team and controlled by inspection.

**A law to establish the aims of the guiding system (Pilotage) of the education**

Décret relatif au pilotage du système éducatif de la Communauté française


**A law to establish the aims of the control system (Inspection) of the education**

Décret relatif au service général de l'inspection, au service de conseil et de soutien pédagogiques de l'enseignement organisé par la Communauté française, aux cellules de conseil et de soutien pédagogiques de l'enseignement subventionné par la Communauté française et au statut des membres du personnel du service général de l'inspection et des conseillers pédagogiques


**Some experimental innovations**

In 2012-2013, some schools get special funds to introduce interactive whiteboards or “ipads” for all a classroom.

All those projects are punctual but evaluate by inspection in special missions.

**Events to promote MST**

A special congress dedicated to the novelties in technologies and the way to teach with them.


A special congress dedicated to enhance formation of math teachers, the novelties in technologies and the way to teach with them and the new publications.

Each year a theme (2013-2014: Math and Culture). The participation is free and a lot of speakers are selected in other countries. (26-28 august 2013 Brussels)

http://www.sbpm.be/

A special congress dedicated to enhance formation of sciences teachers (21-23 august 2013)


Each year since more than 10 years a event in all the universities to share knowledge between specialists, students and citizen.

PRINTEMPS DES SCIENCES

http://www.printempsdessciences.be/

A colloque to be hold 14th 15th november 2013 on Math and Society (Liege)

http://dev.ulb.ac.be/urem/Colloque-des-Mathematiques-Palais

A special event on education to sustainable development (22-25 october 2013)

http://www.assises-ere.be/
Links to the inspection reports

Rapport général de l'Inspection 2010-2011
Rapport inspection 2010-2011 (….maths)

Concerns in particular maths and scientific formation

Rapport général de l'Inspection 2011-2012

Concerns in particular maths and education via technology

Norway:

Equity in Education

- means to provide equal opportunities in education regardless of abilities and aptitudes, age, gender, skin colour, sexual orientation, social background, religious or ethnic background, place of residence, family education or family finances. Equity in Education must therefore be understood on the system level, using a national perspective based on overriding legislation, regulations and syllabuses, and on an individual level, adapting the education to individual abilities and aptitudes.

Adapted education

- the school owner (the local or county authority), and the administration and staff at the educational institution must undertake to provide satisfactory and adequate teaching based on the individual's abilities and aptitudes. Special education - is a right guaranteed by the Norwegian Education Act which is intended to ensure adapted and equitable education for persons who do not, or cannot, gain satisfactory benefits from the regular teaching programme.

Special education

While adapted education is for everyone, the right to special education is determined by an assessment of the individual by experts. The decision that is reached must be so clear and complete that there is no doubt about the scope, structure and content of the teaching programme. All students receiving special education should have an individual learning plan.

Before a decision about providing special education is taken, an expert assessment should be made. If special education is refused, reasons must be given.

Then we have the students with complex learning difficulties, to whom we find difficult to define

We have great in the correlation between teacher density and the pupil's learning outcomes. Neither national nor international studies show unambiguous results. Many of the surveys emphasise that for certain groups, e.g. students who have parents with a low level of education and students in the earliest Years of schooling, increased teacher density can have a positive effect on learning outcomes(Wiborg et al. 2011 and Bonesrønning

In Norway we have tried higher teacher density for the youngest children, and the result at TIMSS increased. May be because of the hinges of teacher density or because the schools
works better and harder with the math education. The average number of students per teacher in an average teaching situation is 13.4 when all of the hours of instruction are counted.

In Norway we have great focus on math skills for the last to year. It seems to get some result. But still there are more focus on reading and writing in home language.

In math we have increased the school hours for the youngest students, many teacher have got in service training in math and how to educate in math, and the evaluation system and tests have been more precisely, and the teacher used a better system for formative assessment, evaluation for learning. We have a homework assistance program, and more than half of the students 1 to 4. grades took part in this program this year.

Support for teachers and kindergarten:

**Norwegian Centre for Mathematics Education**

The Norwegian Centre for Mathematics Education was established August 1, 2002 and its primary task is to lead and coordinate the development of new and improved working methods and learning strategies in the mathematics education, from kindergartens through teacher education in Norway. The Centre shall also contribute to a close and good Nordic cooperation.

The Centre's primary targets are first and foremost teachers teaching mathematics in schools and teacher education, teacher students at Colleges and Universities and teaching aids developers. In order to build a general positive view at mathematics, parents, media and the public are also important targets for our activities.

**Norwegian Centre for Science Education**

Central tasks for the centre include implementation and use of the national curriculum, framework plan for content at kindergartens and assignments and national campaigns, encompassing quality developments, assessments and development of expertise. The centre's activities shall be linked to the principal goals laid down for the sector, with a long-term perspective.

The centre shall help reinforce efforts related to the sciences in compulsory school and kindergarten. In addition to the common core subject of science, the centre has a particular responsibility for the science and technological subjects within the programme area of science in upper secondary education. The scope for the centre's activities shall be nationwide.

**RENATE Center**

The RENATE Centre's goal is to strengthen the position of science in society and increase the recruitment of youth to science education and professions. RENATE's goal is to be a driving force in recruiting young people to science, with our main focus on young people's educational and career choices. Students, students, parents, counsellors and teachers are therefore our main audience.

**The Norwegian Centre for ICT in Education**

The purpose of the Norwegian Centre for ICT in Education is to contribute to the realization and the development of ICT policy. It shall further cooperate with relevant public and private institutions. The centre will also participate in international cooperation. Our main goals are to improve the quality of education and to improve learning outcomes and learning for children, students and students through use of ICT in education.
Bulgaria

During the past years, the need of reforms was a live question in Bulgaria and the implementation of a 10-year long-term National programme for development of school and preschool education started in 2006. The National programme has been developed according to the demands of the dynamic global economy and the challenges, which are determined by the objective for developing knowledge-based economy in the European economic area. One of the main goals is lowering the number of students in compulsory school age who are out of school or are dropped out. In support of the implementation of this programme Ministry of Education and Science launched a number of initiatives some of which are listed below.

From 2006 under the motto “The school – a student’s desired territory” Ministry of Education and Science annually organize a number of working seminars throughout the country during which schools have the opportunity to present their experience in interactive education, extracurricular and other activities, which contribute to the enhancement of achievements, students’ motivation and as a final objective, ensure higher quality of education. One of the main directions in this initiative is finding the right approach to students with learning difficulties. The best pedagogical practices on the regional level are shown during the 2-3 days national conference.

National Programme "With care for each pupil"
lojenie6_S_grija_zv_seki_uchenik-1.pdf

From 2008 the Ministry of Education and Science is in charge of organization and implementation of the programme "With care for each pupil". One of the modules in this program is "Providing further training for pupils to improve their level of achievement in the general education". The school shall develop a project to apply for funding under that programme.

The programme aims are:

- Providing an opportunity for further training for children who have problems in learning
- Motivating teachers to work with pupils, taking into account their individual abilities and interests;
- Encouraging the use of innovative approaches in the teaching and learning for children with different abilities.

The further work with the pupils involved in the Programme "With care for each pupil" is performed in small groups, consisting of 4 to 8 pupils. The number of pupils depends on the particular organization in the school. The training is carried out twice a week. Target group for math and science is students in 1-8 grades.

The selection of pupils for inclusion in the groups is based on national external assessment and on their achievements in mathematics and science in the previous years.

The classes are conducted in the school, after the end of the regular classes. The School Board should decide whether such classes to be taken by the teacher, who takes the regular classes, or by another teacher.
At school level should be decided what kind of additional learning materials to be purchased and used to motivate the pupils and to support the learning of the lessons.

In recent years the data from the National external assessment and PISA provide information about the trends for reducing low achievement in Math and Science in Bulgarian schools.

**National External Assessments**

http://www.ckoko.bg

From 2007 in the end of the each school year, Ministry of Education and Science organize national external assessments in mathematics and science for students in 4th grade, 7th grade and 12th grade. The Centre for Control and Assessment of the Quality in Education is a state scientific-informative unit of the Ministry of Education and Science, responsible for National external assessment in mathematics and science at the end of the initial stage (4th grade) and at the end of the 7th grade. The main aims of the external assessment are:

- to register performance in view of the state educational requirements and syllabi
- to draw national programmes and make necessary policy changes

The Ministry and the Center for Control and Assessment of the Quality in Education are jointly responsible for Matura (School leaving examination). Mathematics and Science are elective subjects for Matura (at the end of the 12th grade).

**Project: Improving quality of general education**

Jan 2012 - Dec 2014

http://www.mon.bg/left_menu/projects/OP-HR/

The project has a main aim to synchronize the package of documents related to the secondary education and training with the new structure of secondary education set out in the National programme for development of school and preschool education (2006-2015). The main project activities are updating curriculum in all subjects for primary education and elaboration of new curriculum in all subjects for upper secondary education. Changes in the curriculum are designed to include eight key competences for lifelong learning in the mandatory training in all levels of school education. The new curriculum include more hours of practical activities in all subjects. The proportion of lessons for new knowledge to practical lessons is at least 60:40. A new element is the inclusion of a section on cross-curricular links and activities that can be conducted inside or outside the classroom.
In initial training teachers attend the subject “Inclusive education” and there is the same programme for in-service training which include specific problems for different subjects. There are also other in-service training seminars for teachers and there is a projects in National Education Institute for Math for train and support the teachers and schools.

Every kindergarten and school has at least one special support from Advisory Service (employed within the school): svetovalni delavec, psiholog, socialni pedagog, specialni pedagog.

At each school, additional assistance is provided in the form of additional supplementary lessons (at least a few hours a week, varying between schools) and individual help individuals.

Who is responsible?

Kindergartens or schools are responsible. Teachers or school teams have the autonomy to assess who deviates from the average (studies have shown that teachers are very well identified, especially teachers of mathematics). The discovery of specific problems, include school counsellors and special institutions, which produce a more detailed assessment for the future direction of children with specific difficulties. For students with deficits in the area of reading, writing or numeracy special multidisciplinary commission do a good diagnostic evaluation. In addition to schools also parents have a responsibility, who may suggest directing their child in a program tailored to the implementation of additional professional support (1-5hours) to the commission for guidance.

- What criteria?

Identify general learning difficulties of students following areas are important (the concept was adopted in committee on schools and must comply; the areas are much more in more detail):
- general cognitive ability,
- specific cognitive abilities,
- meta cognitive skills,
- linguistic functioning,
- learning motivation,
- emotional functioning,
- Social inclusion and functioning,
- biological, physical functioning and health,
- home and school environment.

National testing, which includes mathematics and science subjects in the twelve (optional) year olds and fifteen year olds (required).