



Flanders
State of
the Art

STEM Framework for Flemish Schools Principles and Objectives

DEPARTEMENT OF
EDUCATION & TRAINING

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STEM

SCIENCE TECHNOLOGY ENGINEERING MATHS

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Dear principal,

Dear teacher,

STEM is a concept - a phenomenon almost - which is deeply rooted in today's challenges and at the same time looks expectantly to the future. We all notice how our daily lives are increasingly defined by a never-ending flow of developments in healthcare, communication technology, energy or mobility, to name just a few areas that are faced with a lot of changes. Education should make sure that children and young people are given equal access to these STEM evolutions and are able to discover their passion and talent for STEM.

Maybe your school choose the name 'STEM school', or maybe- for even good reasons, not. However, it does not mean the latter give less thought to STEM and to how the four-letter word can/should/may be fleshed out. STEM has managed to gain a strong foothold in our education, in your school and class.

Many people are trying to figure out how to implement STEM at school.

Apart from promoting an increased and different focus on science, technology, engineering and mathematics, STEM is also about the connection between these 4 disciplines, about thoroughly and critically reflecting on social and scientific challenges, about creating contents at school and classroom level and about establishing partnerships in and outside school, with great intensity and much enthusiasm.

Schools which have questions about STEM can make use of this framework. to provide clarity: we have compared the main Flemish as well as some international reference frameworks. This comparison in any case reveals that there is a broad consensus on the key ingredients of good STEM. The STEM framework allows schools, teachers and school management teams to acquire a shared understanding of the different STEM components and makes them realise that the whole is more than the sum of its parts.



The STEM framework also wants to truly recognise the people who make STEM: you, the teachers and school principals who, day after day, invest in this new story. Many of you have joined the STEM Learning Networks which emerged spontaneously and are still expanding. The STEM framework wants to acknowledge these Learning Networks and give them space to grow, preferably in consultation with the school advisory services and with STEM trainers, STEM scientists and STEM professionals outside school.

Children and young people are born researchers: they are specialised in constantly exploring their world. STEM acknowledges this natural urge and directs them towards deepening, insights, and finally maybe a STEM specialisation through a better study and career choice.

This framework provides direction for (head) teachers who want to make a start with STEM at school and in the classroom. It is not meant to be used as a 'straitjacket', but as a guideline. I wish you great success and joy in using it.

Hilde Crevits

Vice-Minister-President of the Government of Flanders

Flemish Minister for Education



Summary

STEM has gained popularity in Flemish education in a short period of time. **But what exactly is STEM?** What is presented here, is a general framework containing the main STEM principles and objectives. This framework can be used by everyone in education and seeks to support as well as deepen the enthusiasm surrounding STEM. The framework focuses on both “STEM literacy” and “STEM specialisation”. It mainly aims to continue to inspire everyone who is engaged in STEM. To that end, it concentrates on ten dimensions (based on Flemish and international reference frameworks) and the recognition of STEM Learning Networks.

This framework is especially designed for (pre-) primary and secondary education. It will serve as a point of reference which can be used for implementing STEM in daily classroom practice and for continuously improving STEM within the Learning Networks in an inquiry-based manner.

6 Finally, the framework may also serve as a source of inspiration for all bodies investing in STEM, like for instance STEM Academies, companies, sectors and scientific institutions. Ideally, they can use this framework to examine their own approach and to be in dialogue with the education sector, in a formal and informal context.

STEM is an **internationally well-known acronym** that captures the areas of science¹, technology, engineering and mathematics².

STEM is about developing scientific, technological and mathematical insights, concepts and practices (S, T & M) and using them to solve complex questions or real-life problems (E).

Therefore, within education, STEM implies bringing together the different components of the acronym

to identify social and scientific challenges in a coherent manner, solving them in an inquiry-based manner and communicating about them. A STEM challenge can just as easily start with a social problem, a technological realisation or a key scientific concept. However, the broad correlation between the STEM components and the link with social reality are always the main focus.

Naturally, STEM also implies that the various disciplines are taught in the best possible way.

In other words, STEM ensures that important scientific, mathematical, technological and engineering-linked concepts and practices are understood and applied in an **interdisciplinary** manner. This clearly shows that they are founded on great STEM principles and ideas that can be applied from various angles. Other essential elements for addressing a STEM challenge are problem-solving skills, planning and carrying out research, analysing and interpreting data, formulating explanations and solutions and subsequently analysing and disseminating them. The STEM provision is thus considered in a broader context, in which both STEM-related and cross-STEM links are established.

Moreover, a STEM policy at school involves **customisation**, which means it is tailored to the specific initial situation and context. It selects themes, objectives, actions, methodologies and materials which tie in as closely as possible with the specific initial situation and the school's (other) policy choices. STEM thus takes into account its participants' development and specialisation levels, backgrounds, gender, etc.

In essence these elements are already **known from existing reference frameworks** like the attainment targets and the cross-curricular attainment targets from the core curriculum: “Education must support young children and pupils in the gradual development of their personal lives and their – subsequent- critical and creative functioning in society”. These principles are applied in an interdisciplinary context within STEM.

STEM addresses **future linked issues** which increasingly form part of our society. Just think of the challenges in the fields of sustainability, mobility, energy, health and welfare, new media, art, culture and design. The challenges these sectors are faced with are no longer monolithic and delineated. And neither have the relevant solutions. These themes require critical approaches and solutions to which all STEM components contribute. However, non-STEM related insights also matter to be able to ask relevant questions and find suitable solutions. That is why STEM is resolutely oriented towards **innovation**: it responds to current challenges and looks for innovative and creative solutions through the interconnected STEM components.

¹ “Sciences” is to be understood as “the exact sciences”

² For a decisive answer in the terminology debate “technique and/or technology”, we have based ourselves on TOS21: the concept of “technique” is used, which also encompasses “technology”. Department of Education and Training & Department of Economy, Science and Innovation (2008). TOS21. Technische geletterdheid voor iedereen. Standaarden en referentiepunten. Eindrapport van Techniek op school voor de 21ste eeuw. <http://www.ond.vlaanderen.be/nieuws/2008p/files/0827-tos21.pdf> hniek op school voor de 21ste eeuw. <http://www.ond.vlaanderen.be/nieuws/2008p/files/0827-tos21.pdf>

This reveals itself in a wide range of STEM courses and professions.

This interdisciplinary and innovative aspect of STEM also recurs in the fact that STEM is prepared, audited and dealt with in team. STEM is all about **teamwork**. About teams of pupils looking together for a solution for a scientific/technological problem and of teams of teachers working together to shape STEM in their school. Finally, STEM actors outside the school are ideally also involved in school-based STEM. In this way, STEM becomes a new learning strategy.

STEM shows that new developments in science and technology, as well as social challenges, require cooperation from various domains. That is why the present STEM framework not only focuses on the content-related dimensions of STEM, but also seeks to recognise the **STEM Learning Networks**.



We live in a rapidly changing knowledge society in which transitions play a major role. Just think of the paradigm shifts that are taking place in the fields of health, energy, ageing, globalisation, ecology, sustainability, etc. We cannot but conclude that, since the turn of the century, these themes have become much more important in our thoughts and actions. Nobody can deny it: technological, scientific and ICT developments, which respond to these realities have a growing **impact on our daily lives**. Science surprises us on a daily basis with developments that succeed each other at cruising speed. In other words, all aspects of society are gaining momentum due to constant innovations and challenges, including the many developments in the field of STEM.

According to the European Union, science education at school should help make all children and young people **feel involved in debates** that are inspired by science and technology and which influence our daily lives.

STEM is also about **education and the labour market**. At certain moments in their school careers, young people have to make choices. Therefore, it is crucial to show them the wide range of

opportunities, to help them make these choices and to point out to them the inextricable link between various professions in a highly technological and scientific knowledge society. STEM thus furthers the knowledge and technology intensive economy by assisting young people in their search.

However, STEM is not exclusively about education and the labour market. The Flemish Education Council summarises it as follows in its Reflection instrument³: “STEM is not just there for the labour market, but also because it has an intrinsic educational aspect”. Recently, the US National Science Board even dedicated a separate report to this⁴. This report clearly demonstrates the positive impact of STEM on young people’s future personal functioning, next to its impact on their professional functioning. The EU reached the same conclusion in a recent report⁵. Both reports clearly state the following:

- STEM competencies are essential for being able to function in the 21st century, with more attention being paid to inquiry-based learning and working, links between knowledge and practice, problem-solving skills, creative out-of-the-box thinking, cooperation, etc.).
- STEM has a very broad purpose in professional life. It concerns both ‘direct’ and ‘indirect’ STEM jobs.
- Great potential remains in a number of target groups which currently still have too few STEM competencies and do not sufficiently avail themselves of STEM opportunities.

That is why education should focus on STEM on the broadest possible scale, both for social and individual related and for economic reasons. “Broad” means broad in terms of providing STEM competencies and broad in terms of reaching as many pupils as possible.

³ Flemish Education Council, Department of Economy, Science and Innovation & Department of Education and Training (2013). Reflection instrument STEM www.stemopschool.be

⁴ Revisiting the STEM Workforce <http://www.nsf.gov/nsb/publications/2015/nsb201510.pdf>

⁵ Science Education for Responsible Citizenship, juni 2015 http://ec.europa.eu/research/swafs/pdf/pub_science_education/KI-NA-26-893-EN-N.pdf





STEM in Flemish education

There is no doubt about it: STEM has met with more than remarkable response in a short period of time.

Communities of Practice are formed in (pre-)primary and secondary education where teachers inform and encourage each other with regard to STEM. STEM is high on the agenda of (pre-service) teacher training institutions. More than 60 Flemish STEM Academies⁶ are active, which often work closely together with schools.

Secondary schools that start STEM in the first stage are the front line in co-designing the contents and approach of the new STEM education, within the existing structure of secondary education. Their communication is often targeted on pupils with a clear interest and strong aptitude for STEM, i.e. (potential) future STEM professionals. However, not all the schools adopt this approach. Some prefer a STEM module that is offered to all pupils to support a potential choice for STEM in the second stage.

In Flemish education STEM is part of an evolving and dynamic framework.



Basic principles of the STEM framework

“A STEM framework will be provided, which will describe and clarify what is to be understood by STEM and will outline the ingredients of good STEM education. The framework wants to support the good practices that have emerged and encourage the STEM Learning Networks by further deepening STEM and allowing it to grow through the meeting of the minds.” (excerpt from a speech by Flemish Minister for Education Hilde Crevits, 9 June 2015)

The STEM framework wants to bundle together the key Flemish and international insights that have developed around STEM over the past years into a

manageable tool. We must indeed not lose focus or jeopardise pupils' equal access to STEM because of the broad interest.

The STEM Action Plan of the Government of Flanders

The STEM Action Plan of the Government of Flanders⁷ has increasingly turned the spotlight on science and technology. The action plan was drawn up at the Flemish Parliament's request and aims to encourage young people to choose a STEM course and ultimately a STEM job. The action plan argues in favour of innovative and thematically challenging STEM education. The study by the Flemish Council for Science and Innovation 'Kiezen voor STEM'⁸ (Choosing STEM) (2012) identifies the shortages on the labour market (with great consequences for economic growth and the knowledge society) and analyses the transition of STEM pupils from secondary to higher education on the one hand and the entry of STEM graduates in the labour market on the other. The ROSE (2010) and the SECURE studies (2013)⁹ discuss points of attention concerning the contents of science, mathematics and technology and how this ties in with young people's interest in STEM themes.

With its Action Plan for the Promotion of Careers in Mathematics, Exact Sciences and Technology” (in short “the STEM Action Plan 2012-2020”), the Government of Flanders has outlined the general framework. Apart from Education and Training, the policy areas of Economy, Science and Innovation and of Work and Social Economy are also contained in STEM. Other structural partners of the action plan are the Flemish Education Council, the Flemish Council for Science and Innovation and the Socio-Economic Council of Flanders.

The action plan has 8 objectives:

- To provide attractive STEM education
- To reinforce teachers, trainers and mentors
- To improve the study and career choice process
- To attract more girls to STEM courses and

⁶ <http://www.stemacademie.be>

⁷ <http://www.stemopschool.be/stem-actieplan>

⁸ <http://www.vrwi.be/publicaties/rapport-kiezen-voor-stem>

⁹ <http://Roseproject.no>

<http://www.thomasmore.be/onderwijsmensen-uit-tien-landen-formulieren-aanbevelingen-stem-onderwijs-europa>



professions

- To focus on excellence
- To adjust the courses provided
- To encourage sectors, companies and knowledge institutions
- To enhance society's appreciation of technical professions

We will embed these objectives in the present framework and distinguish between “STEM literacy” and “STEM specialisation”.

The STEM Platform which is composed of experts from the IT sector, the media, universities and university colleges constantly stimulates the government to keep the STEM Action Plan up-to-date and dynamic. So far, the Platform has submitted 4 advisory opinions which stressed the need for clarity, among other things.

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Distinction between STEM literacy and STEM specialisation

Education should not only offer young people the knowledge and skills to be able to deal with the rapidly changing world, but should also provide them with tools for actively shaping their future. In other words, STEM is important to get to grips with the challenges in society and the scientific world, to acquire an insight into the prevailing opportunities and challenges, to link amazement and enthusiasm to insight and a critical view, to gain understanding of the diversity of angles and approaches for solving social and scientific problems and to become acquainted with the related professions.

To be able to realise interaction between innovation in society and in education, an **innovative educational vision** of science, mathematics, technology and engineering is required. So far, the main focus of STEM has not been embedded by everyone nor in every approach or educational provision. With this framework we maximally aim to realise STEM 'literacy' for all (broad approach) and STEM for future STEM professionals (deepening of

specialisations).

According to the You for Youth network, **STEM literacy** is “(...) the ability to understand and apply concepts from science, technology, engineering and mathematics, including computer science and interdisciplinary strategies, in order to make informed decisions, create new products and processes, and solve problems”¹⁰. An addition to this is that STEM literacy is also the awareness of the roles which science, technology, engineering and mathematics fulfil in modern society¹¹. It is agreed that every child, even as early as in (pre-)primary education, can be ‘STEM-literate’ according to the above definition, on the understanding that problems/products/processes can be very easily dealt with and be acquired through co-creation and teamwork.

To encourage STEM literacy in pre-schoolers and young people it is essential for teachers to have a certain courage and (self) confidence in terms of STEM and STEM education, so they can ‘act’ as researchers together with the pupils. They have insight into STEM contents, including systems and STEM processes, at their own level. This implies having an understanding of the fundamental concepts of/ on each STEM discipline, as well as an insight into the connection between the different disciplines.

STEM specialisation means far-reaching STEM literacy and a deliberate choice for a STEM discipline and/or STEM profession. STEM specialisation should not only be associated with cognitively strong pupils. Specialisation should also be available for all pupils in general, vocational, technical and arts secondary education. STEM literacy should therefore not just be available for one group of pupils and STEM specialisation for another group (cognitively strong) pupils.

STEM policy at school

To introduce a STEM vision in education, two important instruments were developed over the past years: following the STEM Action Plan, the Flemish Education Council conducted a review of STEM. On the basis of this review a **STEM Reflection instrument**¹² was designed to encourage schools to reflect on their STEM policy and practice and to further develop it and - if necessary - adjust it. Also following the STEM Action Plan the Education

¹⁰ www.y4y.ed.gov

¹¹ <http://www.downway.org/e-books-list/stem-integration-in-k-12-education-status-prospects-and-an-agenda-for-research-ed-by-margaret-honey-et-al.37t70.html>

¹² <http://www.stemopschool.be/>

Inspectorate carries out inspections of the quality of STEM education in (pre-)primary education and in secondary education. The results were published in the publication 'Onderwijsspiegel 2014'¹³. During its inspection the **Inspectorate** used a 'Quality Framework' (**kwaliteitskijker**) which allowed it to place the findings in the right context and verify them against the desired quality.

Both instruments include a desired quality image for STEM. Their main added value is that they inspire to an assessment of existing practices and at the same time describe a potential growth path. Therefore, the present STEM framework makes use of the analyses and recommendations from both the Flemish Education Council and the Education Inspectorate. Research is currently being carried out into a **STEM teaching methodology** for (pre-) primary education ("STEM voor de Basis"¹⁴) and for the 2nd and 3rd stages of primary education ("STEM@School"¹⁵). The insights of the participating research groups - in close collaboration with the school advisory services and broad-based school clusters - are also taken into consideration in the present framework.

STEM initiatives and STEM research

In an international context, one cannot ignore the growing number of STEM conferences and the amount of STEM research¹⁶. The STEM framework takes account of the recurring STEM dimensions from some of this research. Last, but not least, the framework also wants to recognise the many **STEM initiatives in schools**. They reveal great enthusiasm and creativity. For this reason, the STEM framework focuses on the STEM Learning Networks. STEM is indeed a dynamic whole: the recognition and growth of the people who implement STEM on a daily basis are just as important as the scientific insights into its constituent components.

In other words, the Flemish STEM framework does not want to confine itself to a bullet points list of STEM principles. The enthusiasm in education - among pupils, teachers, trainers and school advisory services - is explicitly recognised and supported. Ideally, these STEM actors form Learning Networks in which they exchange good practices and learn from each other. They are essential to keep STEM

and the associated learning process up to date and continuously reinforce it. The Learning Networks thus constitute the dynamic component of the present STEM framework.



Objectives of the STEM framework

The framework wants to be a reference point against which schools can verify their STEM practice. What is presented here is intended to capture the core of STEM, without being exclusively targeted on one specific level or type of education, or without restraining the schools' capacity to adjust it to their own needs. The framework mainly seeks to provide direction. As a result, within compulsory education STEM is a story for (pre-) primary education and all types of secondary education: general, technical, arts and vocational secondary education. The bridges between those types of secondary education should not only be kept open, but be actually built.

Organising a STEM module in the unprescribed teaching time of the first stage should by no means limit the study choices in the 2nd and 3rd stages.



Good STEM should also be specifically oriented towards target groups which cannot immediately identify themselves with the STEM story. Both current and future initiatives in schools should be able to identify with the present framework, irrespective of whether they adopt a more abstract or a more concrete approach. Every school paying attention to STEM in whatever form can draw inspiration from it and is encouraged by it to question and sharpen its approach. In this way the framework hopes to realise further (joint) reflection and an exchange of ideas and good practices, which will deepen the meaning of STEM.



What is the focus of the Flemish STEM framework?

STEM is an acronym in which the whole is more than the sum of its constituent parts.

STEM is not the sum of (more) science, technology,

¹³ http://www.ond.vlaanderen.be/inspectie/Organisatie/Documenten/spiegel/Onderwijsspiegel_2014.pdf

¹⁴ <http://www.stembasis.be>

¹⁵ <https://www.kuleuven.be/samenwerking/avlnascholingen/ns2014/pptal27D>

¹⁶ <http://outlier.uchicago.edu/s3/> <http://www.washingtonstem.org/>



mathematics and a new part “engineering”. Both from a Flemish and international perspective, STEM is about forward-looking interaction between disciplines which allows room for 21st century skills and interdisciplinarity. To that end it uses the ownership of the learning and implementation pathway by teachers, pupils and school management teams, in consultation with the broad STEM sections outside of school. The dimensions described in the STEM framework constitute the core which each STEM team can fall back on and further develop within the school’s vision and remit.

STEM focuses on the following dimensions and principles:

1. Interaction and coexistence of the separate STEM components of the acronym with respect for each component’s individuality
2. Problem-solving learning through the application of STEM concepts and practices
3. Researching and designing in a skilled and creative manner
4. Thinking and reasoning, modelling and abstracting
5. Strategically using and developing technology
6. Acquiring an insight into the relevance of STEM in itself and to society
7. Obtaining and interpreting information and communicating about STEM
8. Working together in team
9. Acquiring 21st century skills
10. Innovation

These dimensions are relevant to both “STEM literacy” and “STEM specialisation”.

1 Interaction and coexistence of the separate STEM components of the acronym with respect for each component’s individuality

The four constituent components S-T-E-M of the acronym are used together to tackle problems. This requires the establishment of links between science, technology, engineering and mathematics. STEM is aimed at collaboration between several disciplines or, in other words, an interdisciplinary approach.

An interdisciplinary approach is about contents that are addressed with insights, concepts and practices from all the other components. As a matter of fact, such an approach need not be limited to STEM disciplines. STEM is often complemented with input from other disciplines: for instance through historical links. Art and design too can be usefully integrated into STEM. New ‘languages’ provide inspiration for dealing with the new constituent whole. Coding and programming (so-called computational thinking) are definitely components of STEM.

Technology seems to make a good seedbed for interdisciplinary working methods. Today, technology is growing ever more complex and covers more and more different disciplines (not just science, but for instance also society and ethics). Technology can also be used as a meaningful learning situation for modelling mathematical concepts. However, the opposite applies as well: activities with central focus on mathematical concepts are excellent for attracting ‘engineering’.

For further discussion, we again refer to the sound and substantiated visions that are developed in existing Communities of Practice in which teacher training institutions, school advisory services and developers of individual best practices from (pre-) primary schools and secondary schools meet, like for instance the Learning Network of “STEM voor de Basis” and the Learning Networks for secondary education.





2

Developing problem-solving skills through the application of STEM concepts and practices

STEM is about developing scientific, technological and mathematical insights, concepts and practices (S, T & M) and using them to solve complex questions or real-life problems (E). The starting point is always a scientific, mathematical or technological challenge, selected from a meaningful situation. STEM concentrates on contextually rich education.

STEM contents focus on a limited number of big ideas. This allows for concepts to be examined and understood in depth. The emphasis is on crucial conceptual knowledge and practices. This implies more than knowing (often isolated) facts and methods, and even more than an isolated deepening of the discipline of the constituent STEM components. It is about cohesion. Cohesion shows why a mathematical, scientific or technological idea is important, often - though not exclusively - in a link with social challenges. Acquiring a concept/practice not only generates the pure, discipline-linked insight which is immediately linked to this, it also provides an insight into its potentially broader applicability when developing both theoretical models and practical solutions.

Naturally, the focus and depth in the various levels of education will differ. It is important that a limited number of challenges are selected on the basis of the pupil's level of education and course of study to pursue depth and cohesion in the interdisciplinary learning process¹⁷.

- Finding a possible explanation for the problem or a technological solution which is reflected in a technological design.

STEM education is thus characterised by challenging assignments with a problem-based and functional character. Inquiry-based, problem-solving, creative and critical thinking is the subject of instruction. The learning environment stimulates exploration and experimentation. Pupils learn to ask research questions and develop and apply generic or subject-specific solution heuristics depending on individual needs. The aim is to realise a high degree of self-steering, which allows them to build or rebuild concepts themselves.

According to the attainment targets the technological process consists of 5 steps: problem identification, design, manufacture, use/application and evaluation. In recent literature, additions to this process can be found. In reality a technological process is rather an iterative process. Certain steps must be repeated to secure the optimum outcome. (www.stemopschool.be)

This means that STEM education devotes explicit attention to the development and application of design skills. These skills include brainstorming, researching, designing, testing and improving. To this end teachers teach these skills and develop assignments which allow pupils to apply them in a functional manner. They not only give feedback on the created design (product), but also on the specific character of the completed process.

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3

Researching and designing in a skilled and creative manner

STEM is aimed at linking curriculum contents with research and design skills. This includes:

- Asking questions and defining the problem in order to delineate and identify real-life problems and challenges.
- Conducting research to find answers, refine research questions and formulate new questions - including analysing and interpreting data.

4

Thinking, reasoning, modelling and abstracting

Important components of STEM are critical thinking and the choice and adoption of a suitable systematic approach when looking for solutions. Pupils are therefore expected to be able to abstract a scientific, mathematical or technological problem and to describe a scientific, mathematical or computing model using a suitable (simple) concept. Naturally, this must always be adjusted to their level and their degree of excellence and/or STEM

¹⁷ VFor (pre-) primary education we refer to the "STEM voor de Basis" teaching methodology of the Inter-expertise Network of Teacher Training, with links to Nature of Science. For the 2nd and 3rd stages of secondary education we refer to the vision shaped in "STEM@School" by the partnership of KUL, UA, Katholiek Onderwijs Vlaanderen and Go!. We also want to make an explicit reference to "Big Ideas" and inquiry-based learning: new teaching methods for challenging and relevant science education. www.enwaugent.be www.onderzoekendleren.be

specialisation. It is also important that pupils learn to deal with different levels of abstraction or practical approaches for one and the same research or design problem.

This means, among other things, that contents are gradually developed and are embedded in clearly specified learning lines, while taking account of the pupils' level of development and spheres of experiences.

5 Strategically using and developing technology

Sometimes, several types of technologies are used to solve a problem. STEM wants to make sure pupils are capable of examining which technologies are needed or usable to address a certain problem. This consideration is not just dictated by practical elements, but also by an analysis of the limitations, risks and impact of a certain technology in view of an ethical and responsible use. STEM also encourages pupils to reflect on the improvement or development of new technologies and put them into practice or to devise creative and innovative ideas.

6 Acquiring an insight into the social relevance of STEM

STEM wants to engage in inquiry-based learning through real-life experiences and socially relevant challenges.

The world is constantly changing: care, mobility, availability of raw materials and energy, ageing, global warming, digitisation, food security, food production, availability of water and other energy sources require constant attention and new mindsets and approaches. STEM may help to 'get a grip' on these changing realities and keep a sustainable approach in mind.

It goes without saying that pupils are greatly interested in these new social developments and themes. Therefore, STEM should preferably tie in with, but not remain limited to their areas of interest.

In addition, explicit attention should also be devoted

to girls. Girls are less self-confident when it comes to STEM and identify themselves to a lesser extent with technicians, scientists and engineers (VWRI, 2012). Researchers like Hussénius¹⁸ emphasise the importance of integrating the gender perspective into STEM education and research. Placing central focus on social challenges is one of the most effective ways of increasing girls' interest.

7 Obtaining and interpreting information and communicating on STEM

STEM requires pupils to be capable of identifying, critically analysing and summarising information about science, technology, engineering and mathematics. In the first instance this implies correctly reading, interpreting and using graphs, figures, text, audio, video, etc. Another element is using correct jargon and clear language in general when communicating on science, technology, engineering and mathematics. Pupils are capable of giving and substantiating an opinion or argument by evaluating and gathering several information sources.

8 Working together in a team

Pupils' autonomy is enhanced and they are actively and explicitly involved in the search for solutions in a team. As a result, they share ideas, are open to opinions and approaches of others and effectively work together as an interdisciplinary STEM team to achieve a common goal.

STEM at school cannot be "initiated" by one single teacher. STEM should always be teamwork at each level, precisely because of its interdisciplinary cohesion. The team of STEM teachers outlines a learning pathway for itself in cooperation with STEM professionals. Current themes, innovation and a forward-looking vision are key in this.

Providing children and young people with insights into STEM ideas is only possible when their ideas of/on the STEM world are taken into account. Each child and young person has ideas or opinions on STEM. However, when pupils' personal ideas or

¹⁸ <http://bit.ly/1Mc9I7X>



alternative concepts are just about themselves and are not confronted with other ideas, in the long run it will become very difficult for pupils to think/work in a more abstract manner and especially to link abstract matter to everyday practice. In this case they use the taught scientific contents merely to support their personal alternative concepts. During a learning process with others, the different ideas of pupils, teachers, scientists and technicians are confronted with each other in order to clarify some fundamental concepts or big ideas.

That is why the interaction between ideas and the teamwork which encourages this interaction are essential.

Even when considered from other angles, STEM is best implemented in a team: good STEM should be based on a meaningful context and teachers should always take pupils' areas of interest into account (naturally, without wanting to limit itself to this). In addition, teachers will always try to work together with professional STEM stakeholders outside school. This may be (private) companies, but also schools that provide other STEM disciplines and courses.

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9 STEM as a vehicle for 21st century skills and competencies (OECD)¹⁹

'The 21st century skills and competencies' are a combination of cognitive, interpersonal and intrapersonal characteristics that support deeper learning and knowledge transfers. Cognitive competencies and skills include critical, innovative and creative thinking. Interpersonal characteristics encompass communication, collaboration and responsibility. Intrapersonal characteristics include flexibility, initiative and metacognition. (Honey et al., 2014). Social competencies also fall under these competencies, like having the courage to argue in favour of something, entering into a dialogue and collaborating (mutually, with others, like companies and research centres). On the basis of STEM, the 21st century skills and competencies will always have to be acquired from a scientific, mathematical or technological angle.

The 21st century skills and competencies are

essential for all pupils and for all job profiles. STEM makes sure they that they take centre stage. In fact, these elements currently already feature largely in (cross-curricular) attainment targets.

10 STEM and innovation

STEM stands for innovation in society, in science, mathematics, engineering and technology, as well as for innovation in education.

Are we not all amazed at the landing of a space probe on a planet or the technology that is needed to programme the robot arm for an assembly line or an operating theatre? Do we not all have concerns about climate change and wonder whether water will become the new petrol: an expensive energy source that is drying up? Do we not all ask ourselves sometimes where the communication technology is taking us?

Jointly planning and brainstorming about this within a team of teachers, in line with young people's social environment, whenever relevant, and in consultation with the STEM world outside school, obviously also generates a highly innovative learning process.

¹⁹ 21st Century Skills and Competences for New Millennium Learners in OECD Countries - <http://bit.ly/1NPMAIL>

²⁰ Advies 20, juni 2015 <http://www.vrwi.be/publicaties/advies-206-viaams-jeugd-en-kinderrechtenbeleidsplan-2015-2019>

²¹ <http://www.scholierenkoepel.be/info/standpunten/STEM>



STEM, choice of studies and professions

From the advisory opinion of the Flemish Pupils' Association:

"Pupils usually do not have a clear view of where their future is headed. Some pupils are attracted by a course of study which offers job security and potentially a high salary. Others opt for what they find interesting at that moment (...). That is why young people want to be informed as well as possible about courses of study and jobs so that, throughout the years, they can make the choices that best suit them."

Advisory opinions of the Flemish Council for Science and Innovation and the Flemish Pupils' Association reveal that the link between education and labour market and better study choice guidance services are crucial.

The Flemish Council for Science and Innovation gives advice²⁰ with regard to the Flemish Youth and Children's Rights Policy Plan 2015-2019: "Education which focuses on a positive study choice on the basis of the young person's insights, interests and abilities may help address the shortage of STEM graduates from secondary education. A precondition is that attention is simultaneously devoted to reformed science and technology education with more emphasis on subject-specific inspiring STEM teachers, inquiry-based learning and a study choice guidance pathway."

In its opinion of September 2014 ("Advice from pupils on study choice guidance for STEM disciplines") the Flemish Pupils' Association highlights a serious shortage in this respect.

The association surveyed almost 500 15 to 16-year-olds about the motives behind their choice of studies and the extent to which this choice was inspired by STEM²¹. The outcome of this survey deserves our attention: young people say that, generally, they receive much too little information about the wide range of courses and consequently acquire too little insight into the career choices which certain courses lead to. Therefore, young people focus on what

they perceive as the "strongest" courses, in order to maintain as many opportunities as possible.

Although young people want to make positive choices, they can only do so when they have all the basic information at their disposal. That is why pupils want contextually rich education with permanent, broad and realistic information about all courses of study and their links with professions. They want education that focusses on a time-tested and complete range of information, which means information about all courses of study, so that the important choices which young people have to make anyway are made, to a much larger extent than is the case today, on the basis of dependable insights.

In this context the STEM framework sets two main goals:

1. STEM seeks to arouse and deepen young people's interest in a general sense.
2. Focusing on STEM implies establishing an inextricable link with STEM outside school, not in the least through a focus on STEM professions, and therefore also on study choices and the cohesion between the different professions within professional STEM²².



STEM Learning Networks

"Provide impulses to cross-level consultation forums aimed at exchanging expertise: this will allow conceptual insights, knowledge, teaching practice insights and methods aimed at high-quality STEM education to mutually reinforce each other."
Onderwijspiegel 2014 – Recommendations

"When integrating an inquiry-based approach into classroom practice, pupils learn on the basis of problems for which they try to provide answers through inquiries. Meaningful contexts, think-and-do questions, reflection and interaction, data collection, analysis and evaluation, in a widely accepted vision at school is not a task of individual teachers".
VLOR Reflection Instrument

²⁰ Advisory opinion, 20 June 2015 <http://www.vrwi.be/publicaties/advies-206-vlaams-jeugd-en-kinderrechtenbeleidsplan-2015-2019>

²¹ <http://www.scholierenkoepel.be/info/standpunten/STEM>

²² See Also: http://www.onderwijskiezer.be/v2/extra/stem_opleidingen.php - <http://www.vlaanderen.be/nl/werk/werk-zoeken/knelpuntberoepen-en-knelpuntopleidingen>



The framework already stressed several times that the way in which STEM is realised in education is a unique example of the ownership which teacher teams and school (communities) take up with regard to the innovation of their remit. STEM implies learning from and with each other; teamwork at every possible level. A dynamics is created which transcends the remit or even the school itself.

Over the years, remarkable initiatives have been taken by school teams in this respect. Meanwhile, a number of STEM Learning Networks have been set up. Sometimes this is a working group from one school, for instance, which informs dozens of teachers from other schools. Other times it is a broader partnership where school advisory services, schools, colleges of higher education and universities meet. In short, a unique kaleidoscope of knowledge exchange formula, which each time expresses the desire to improve, learn from each other, exchange information and share best practices.

The interest in STEM should of course not be curtailed by the fear “of not getting it at all” or by the conclusion that STEM simply was not part of the standard package of the course programme. STEM is and will always be a continuum of growing insights and learning to formulate answers to fascinating challenges and new problems. In this respect all the schools which focus on STEM - like the broader STEM world and the STEM professionals - are constantly looking to improve. That is why the Learning Networks are vital partners for STEM. This framework wants to give the STEM Learning Networks the space they need and allow them to further grow. All STEM schools, but in fact all the schools that want to learn more about why STEM is promoted, have every interest in joining a Learning Network. Actually, every school that highly values STEM should be a member of a STEM Community.

The sounding board group which was consulted for this framework explicitly mentions some other additional incentives which it feels should be inherently connected to the choice for STEM: apart from being a member of a Learning Network, they, for instance, also mentioned reviewing curricula and exchanging teachers between schools. Ideally, STEM takes place in an environment with plenty of contemporary media (both digital and non-digital), technology and infrastructure would exchange material and knowledge as much as possible.

It was suggested that all schools would use each other's infrastructure.

Partnerships with innovative STEM partners outside school

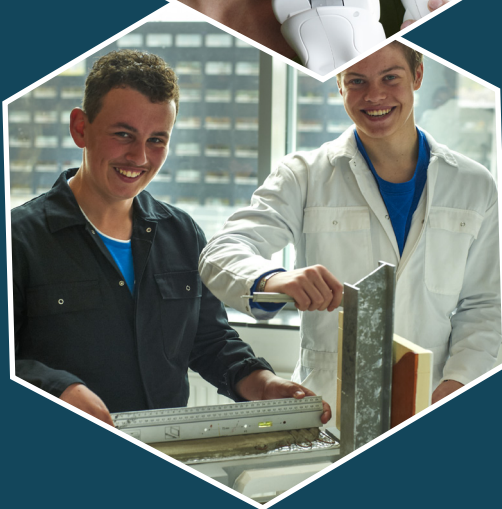
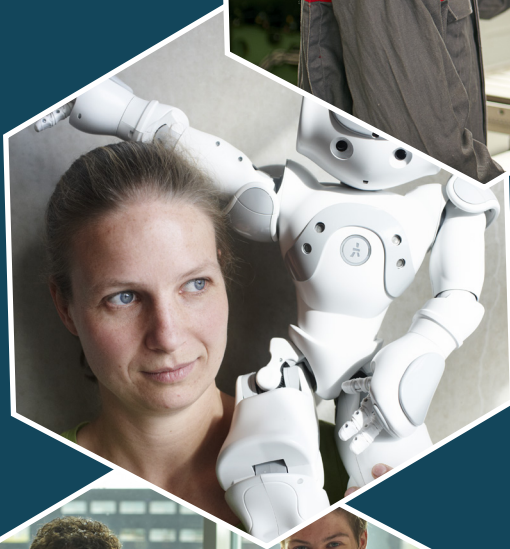
It is an essential dimension of good STEM that it is driven by a partnership of subject teachers who - often together with other colleagues - adopt an interdisciplinary approach to, complement and sharpen the cohesion, connectivity between components and their common view on a specific problem.

However, the cooperation in the context of STEM extends beyond the teacher team. Both alignment and cooperation take place with STEM opportunities outside school, like STEM Academies, and especially also companies and sectors, at the level of both the product and the process. We already pointed to the large demand for STEM profiles in industry and the sectors and to young people's need for in-depth information about jobs. By establishing relevant and sustainable links with STEM professionals, their companies, their approach, etc. an important part of the STEM story can be realised. Naturally, this can also be done in the context of a Learning Network, or at least be started there.

Involving external partners requires the forging of partnerships between the school, the teachers and the pupils on the one hand and the potential partners outside school on the other: families, companies, other educational institutions, governments, organisations interested in promoting STEM (museums, science centres, etc.)²³.

This framework can therefore also serve as a source of inspiration for STEM partners outside school. It is precisely this integrated “spider web” or network of contextually rich challenges in a partnership between partners in and outside school that makes STEM an innovative learning pathway.





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