Cognitive Functions for Successful STEM Implementation

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Abstract*:* Revolution 4.0 requires the transformation of science education worldwide. The new STEM educational ecosystem is crucial for this process. In this article we present important national strategies for the implementation of STEM into education in some countries of EU, UK, US, China, and Australia. In STEM education, the countries develop STEM knowledge, STEM skills and STEM values and attitudes. A systematic development of cognitive skills gains more and more attention, because solving real life problems in STEM requires not only knowledge of science, technology, engineering, and math, but also some key concepts, cognitive processes and process skills which must be developed explicitly. We present a big overlap of concepts, skills, and values between what is required in STEM Education and what Feuerstein Instrumental Enrichment, a method of developing cognitive functions, offers.

TRENDS IN IMPLEMENTATION OF STEM IN DIFFERENT COUNTRIES

The concept of STEM was only defined in the early 21st century, however, its beginning is dated back to the 1980s, when in the US it was predicted that there will be a big need of educated people in the field of science and technology in the future. Since 2006, the concept of STEM education has gained in popularity, and it is now a common concept of education in the USA. This is evidenced by the increasing number of STEM education graduates and STEM workers in the USA and worldwide, too.

In this article, we provide an overview of the adopted national strategies for the implementation of STEM into education in the US, EU, Australia, China, which present the trends in the transformation of education in countries and can also be inspiring for Slovakia. Here is a short overview of countries with the STEM strategy:

US – *America's Strategy for STEM Education* was adopted in December 2018 (National Science and Technology Council, 2018) and presents the Federal Government's five-year strategic plan for STEM education. It is based on a vision for a future where all Americans will have lifelong access to high-quality STEM education and the United States will be the global leader in STEM literacy, innovation, and employment. The plan accordingly strengthens the Federal commitment to equity and diversity, to evidence-based practice, and to engagement with the *National Informal STEM Educational Network* (https://www.nisenet.org/) through a nationwide collaboration with learners, families, educators, communities, and employers. Americans also report annually to the Congress and the wider STEM education stakeholder community the progress of the STEM strategy. (Office of Science and Technology Policy, 2019) The last goal of this Strategy is to prepare the STEM workforce for the future. They introduce for pathways: 1. *Develop and Enrich Strategic Partnerships* – Strengthen relationships between educational institutions, industry, community organizations to leverage resources for the purpose of providing the student with meaningful learning opportunities. 2. *Engage Students where Disciplines Converge* – Draw on knowledge and methods across disciplines to solve complex, real-world problems in STEM using innovation, creativity, and initiative. 3. *Build Computational Literacy* – Design integrated approaches to teaching and learning computational thinking and promote digital literacy and cyber safety. 4. *Operate with Transparency and Accountability* – Develop and apply metrics that assess progress in meaningful ways and disseminate them to external stakeholders.

United Kingdom - STEM Learning operates *The STEM Learning Network* (STEM Learning, 2022) and it is the largest provider of STEM education and career support to schools and colleges. This organisation built *STEM Community (https://community.stem.org.uk/home*), where support for STEM implementation into education is provided at regional level.

EU - For the last 15 years, the STEM strategy has gained the attention of the countries of the European Union that have created *The EU STEM Coalition Network* (2022) of 19 countries (FIGURE 1) which is the ambassador for the implementation of the STEM strategy in education. 14 countries have their national STEM strategies or STEM platform, and 5 countries have national or regional organizations active in the field of STEM. Slovakia is not a member of this Coalition yet.

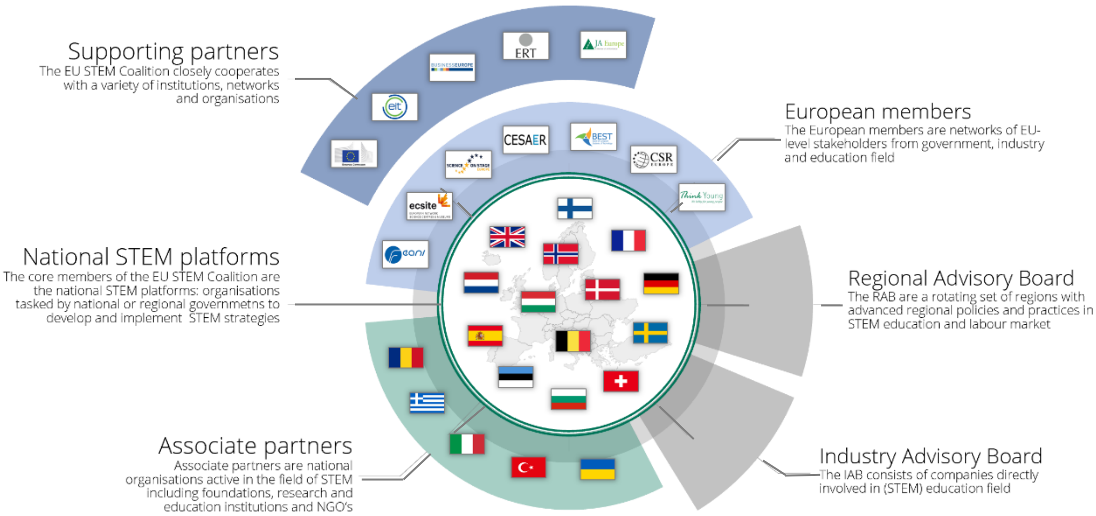

FIGURE 1 *The EU STEM Coalition Network, source: https://www.stemcoalition.eu/about*

EU - Ireland - *STEM Education Policy Statement 2017 - 2026* implemented in November 2017 (Ministry of Education and Skills, 2017). The Ireland ambition is to have the best education and training service in Europe by 2026, meaning Ireland will be internationally recognised as providing the highest quality STEM education experience for learners that nurtures curiosity, inquiry, problem-solving, creativity, ethical behaviour, confidence, and persistence, along with the excitement of collaborative innovation.

TABLE 1 The STEM education experience in early childhood settings and schools (Ministry of Education and Skills, 2017).

Early Childhood themes, Primary priorities, Junior and Senior Cycle Key Skills								
Level 4	**Senior Cycle key skills**	Critical and creative thinking		Communicating	Information processing		Being personally effective	Working with others
Level 3	**Junior Cycle key skills**	Managing information and thinking	Being literate Being numerate	Communicating	Staying well	Being creative	Managing myself	Working with others
Level 2	**Primary priorities**	Develop thinking, learning and life skills		Communicating well	Be well	Engage in learning	Engage in learning	Have a strong sense of identity and belonging
Level 1	**Early childhood themes**	Exploring and thinking		Communicating	Well-being		Identity and belonging	

The main goal is focusing on creating a sustainable STEM education eco-system. It is the wider society´s responsibility and it will play a key role in enabling and encouraging learners to become active and responsible. STEM education focuses on developing a range of *Key Skills* (*TABLE 1*) that are essential for living and working in today's world. Learners will engage in a range of activities that include a) using their skills and content knowledge to creatively solve problems; b) imagining, questioning, and exploring; c) collaborating with others; d) engaging in inquiry and analysis; e) innovating, designing, and making; f) testing and modifying their solutions to complex problems.

EU - Belgium – Important documents are *STEM Action Plan 2012-2020* (Department of Education and Training, 2016) and *STEM Action Plan 2020-2030* (Vlaamse Onderwijsraad, 2019). The National STEM platform is an independent group advising The STEM Steering Committee and The Government of Flanders and it gives advice and suggests priorities for education to the STEM Steering Committee.

Australia - *National STEM School Education Strategy 2016 – 2026* was endorsed by Australia Education Ministry in December 2015 (Department of Education, Skills and Employment, 2015). A National focus on STEM in school education is critical to ensure that all young Australians are equipped with the necessary STEM skills and knowledge that they will need to succeed. The main goals of STEM Strategy in Australia are:

1. Ensure all students finish school with strong foundational knowledge in STEM and related skill,
2. Ensure that students are inspired to take on more challenging STEM subjects. The schools form a critical part of a broader STEM education ecosystem which includes pre-schooling, vocational education and training, higher education, workplace training and development. The strategy has identified five key areas (TABLE 2) for national action through which school education has the greatest leverage.

TABLE 2 Key areas for implementation STEM strategy (Department of Education, Skills and Employment, 2015).

STUDENT	TEACHER	SCHOOL	PARTNERSHIPS	EVIDENCE
Increasing student STEM ability, engagement, participation, and aspiration	Increasing teacher capacity and STEM teaching quality	Supporting STEM education opportunities within school systems	Facilitating effective partnerships with tertiary education providers, business, and industry	Building a strong evidence base

China - 2029 Action Plan for China's STEM Education (Zhang, 2019). In February 2017 the Ministry of Education in China has announced to officially add STEM education into the primary school curriculum, which is the first official government recognition of STEM education. This plan aims to allow as many students to benefit from STEM education as possible and equip all students with scientific thinking and the ability to innovate. Among the highlights is the scientist-enterprise cooperation, which through the cooperation between scientists and enterprises, can integrate resources, mobilize institutions, talents, devices, funds, and projects, and promote scientific and technological innovation.

STEM COGNITIVE SKILLS

For a long time, knowledge and skills have been segregated according to subjects in our school curriculum. With increasing challenge of growing amount of information and increasing demand of employee´s *soft skills* in the labour market, educators had to change their focus from encyclopaedic knowledge and segregated school subjects to teach life competencies, soft skills and look for big ideas across subjects to make the learning content more connected to real life. Our state started to develop *competency-based curricula*, changed the scientific content knowledge goals, and added performance standards demanding problem solving skills in 2008. Already in 90´s it was clear that *it is not enough to raise curriculum standards*, there must be *cognitive intervention* (Adey & Shayer, 1994), too.

There are *many benefits* of integrated education like STEM. STEM integrates different fields of science in such a way that students learn not only *knowledge, skills, attitudes, and values* needed for the 21st century, but the knowledge, skills, attitudes, and values are interconnected, contextualized, and expected to be internalized deeper than when using traditional curriculum. *STEM competent* individual can use *knowledge* associated with science, technology, engineering, and mathematics – the big ideas (knowing what) in everyday life, has *STEM skills* (e.g., cognitive skills, communication skills, psychomotor skills), *attitudes and values* (curiosity, integrity, objectivity, open-minded, diligence and perseverance, systematic approach, responsibility, precision, and appropriate risk taking) associated with the disciplines (Ng, 2019).

Focusing closer on *STEM and cognitive skills*, STEM improves *higher order thinking skills* that enable the student to retent the knowledge better, make students better problem solvers, logical thinkers, develops their creativity and technological literacy (Stohlmann et al., 2012). Higher order thinking skills refers to processes of analysing, evaluating, and creating. According to Anderson et al. (2001), in *analysis* one must draw connections between ideas by differentiating, organizing, or attributing. In *evaluation* the process of checking and critiquing to justify a stand or a decision is used and *to create* (to produce new or original work) one must generate ideas, plan the steps, and produce the product (TABLE 3).

According to UNESCO (Ng, 2019), a range of cognitive skills in STEM education are developed: information management and processing (identifying, collecting, processing, and using relevant data to make decisions), critical, creative, and analytical thinking, problem solving skills, scientific investigation, creativity, and computational thinking.

TABLE 3 Cognitive processes (Anderson, et al., 2001) and STEM abilities examples (Ng, 2019).

COGNITIVE PROCESS	MEANING	STEM ABILITIES EXAMPLES
ANALYZE	= to break material into its components and determine how the parts are related to one another and to an overall structure *Differentiate* - distinguish the relevance or importance of the parts in relation to the whole *Organize* – build systematic and coherent connections among pieces of presented information and make a coherent structure *Attribute* – ascertain the point of view, biases, values, or intention underlying communications; deconstruct and determine the intentions	Distinguishing fact from opinion Distinguishing relevant from extraneous material Connecting conclusions with supporting statements Determining how the ideas are related to one another Finding evidence in support of the author´s purposes Making an outline, table, matrix, hierarchical diagram…
EVALUATE	= making judgments based on criteria (e.g., quality, effectiveness, efficiency, and consistency and standards) *Check* – make a test for internal inconsistencies or fallacies in an operation or product; test, detect, monitor, coordinate *Critique* – judge a product, solution or operation based on external imposed criteria and standards	Checking, if the conclusions follow the data if the data confirm the hypothesis Detecting if the material contains parts which contradict each other The ability to judge what are the positive and negative consequences
CREATE	= to put elements together to form a coherent or functional whole; to reorganize elements or parts into a new pattern or unique structure *Generate* = represent the problem and offer alternatives or hypothesis that meet certain criteria (think divergently) *Plan* = devise a solution method that meet´s problem´s criteria (establish subgoals, break the task into subtasks…); design *Produce* = carry out a plan for solving a given problem that meets certain specifications; construct	Generating different ways, solutions, alternatives to a described problem (What would happen if…? What are the possible uses of…?) Design a study to test various hypothesis

COGNITIVE PREREQUISITES FOR STEM COGNITIVE PROCESSES

Mental operation (e.g., comparing) is like a computer application, like a tool to accomplish the given task and it is content-free. Cognitive process is when we use a mental operation with concrete content and proceeding (comparing the characteristics of apples and pears). If we want to run the application correctly, we must fulfil some conditions (one must know, how to activate the app, enter the correct commands, follow some steps), otherwise the application will not work in a way we want to process the given content. If we want the students to compare "apples and pears", there are some essential abilities, *prerequisites* of this cognitive process, which are inevitable conditions to run this process of comparing. Feuerstein calls them *cognitive functions* (Feuerstein, 2006). Different cognitive functions are needed in different phase of the mental act (input, elaboration, output phase), see TABLE 4.

TABLE 4 Cognitive functions. Source: Feuerstein, R. Hadassah Wizo-Canada Research Institute, 1976.

INPUT PHASE **Gathering information**	ELABORATION PHASE **Processing / Using information**	OUTPUT PHASE **Expressing the Solution**
Clear perception Systematic search Labelling Spatial orientation Temporal orientation Conservation Precision and accuracy Using 2+souces of information at one time	Defining the problem Relevant cues Comparing Remembering Summative behaviour Seeing relationships Logical evidence Interiorization Hypothetical thinking Inferential thinking Systematic planning Categorization Flexibility Reversibility	Overcoming egocentric communication / behaviour Overcoming blocking Overcoming trial and error Precision and accuracy Visual transport Restraining impulsive behaviour Motivation

Cognitive processes and cognitive functions are usually not described in textbooks, but we somehow expect them from our students. The school tasks challenge the students to perform them, but we usually do not develop them intentionally and explicitly. So, when a student did not compare apples and pears correctly, a teacher can make conclusion that the student is either not able to compare "*apples and pears",* or he do not know *how to compare* correctly but he is usually not aware of cognitive functions behind this process. Maybe the student doesn´t search the data systematically (*input phase),* or he does not sum gathered data to ensure himself he has them all *(elaboration phase)* or he answers impulsively *(output cognitive functions),* see TABLE 4.

Feuerstein developed 14 instruments (it is called *Feuerstein Instrumental Enrichment Program* - FIE) to develop these cognitive functions in children and adult and his method is known worldwide helping not only children with different disabilities but increasing the learning potential at common schools (in Czech Republic there are many primary schools teaching this method as a separate subject). Through a type of learning called *mediated learning experience* (MLE) as with a catalyst he changes the thinking of the child and causes the child to learn. He simultaneously deals with child´s *cognition* and *motivation* (Feuerstein & Lewin-Benham, 2012) and the change in child´s thinking changes the cognitive structure of the brain (Feuerstein, 2006).

Mediated learning is a type of interaction only when intentionality, meaning and transcendence is mediated. The mediator focuses the attention on the stimuli to "create significance from the vast number of stimuli that continually impact our senses" (Mentis, Dunn-Bernstein, & Mentis, 2008), that is *mediation of intentionality*. *Mediation of meaning* occurs when values, beliefs (at cognitive level – why do we do something, what is the context), energy and enthusiasm (at affective level) is communicated to the child, and it creates the need. No situation is value free, says Mentis. It is important to raise up a generation which has the need to look for meaning otherwise it will have a blind existence, generation which fails to ask how or why, fails to notice (Feuerstein & Lewin-Benham, 2012). *The mediation of transcendence* promotes "the acquisition of principles, concepts, or strategies that can be generalized to issues beyond the present problem" (Mentis, Dunn-Bernstein, & Mentis, 2008). The specific issue or activity is linked with others, new relationships among things are formed and *the need system* of the child is enlarged (Feuerstein & Lewin-Benham, 2012), the curiosity increased.

Similarly in STEM, teachers present real life problems, thus intentionally focusing the student´s attention on significance of the learning content. Asking the how and the why, the search for meaning, is one of the core processes in STEM lessons. The teachers are expected to connect the learning content to *big ideas* in the same subject field as well as to other fields, because „the number and the strength of these connections are indicators of their level of understanding ", says UNESCO (Ng, 2019). So, UNESCO, too, challenges the curriculum developers and teachers to identify big ideas, to do the bridging, in other words to mediate the transcendence.

The overlap between the main concepts FIE and STEM *big ideas* framed by *the National Research Council* (NRC) in the United States and *the International Baccalaureate Organisation* is large (International Baccalaureate Organization, 2014). They both highlight the same cross-cutting concepts and the importance of making them explicit to students.

TABLE 5 Overlapping cross-cutting concepts FIE and STEM. National Research Council (Quinn et al., 2012).

BIG IDEAS (Made up of cross-cutting concepts)	EXPLANATION
Patterns	Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.
Cause and effect	Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
Scale, proportion, and quantity	In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.
Systems and system models	Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
Energy and matter	Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.
Structure and function	The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.
Stability and change	For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

The **key concepts** in STEM and in Science within *the Programme International Baccalaureate (IB)* common with Feuerstein´s concepts in instruments are *change, relationships, system, balance, transformation, consequences, form, models, function, movement, patterns, evidence, interaction*, that is 13 out of 15 IB concepts (International Baccalaureate Organization, 2014). There is also overlap between **process skills** needed for STEM and developed by FIE: *observing, classifying, making inferences, predicting, communicating, using space-time* *relationships*, *interpreting data*, *defining operationally*, *controlling variables*, *making hypothesis*, and experimenting (Bahagian Pembangunan Kurikulum [Curriculum Development Division], 2016) as cited in Ng (Ng, 2019).

TABLE 6 STEM practices and STEM skills (Ng, 2019) compared with Feuerstein Instrumental Enrichment (https://www.feuersteintraining.co.uk/instrumental.htm) made by authors of this article.

STEM	FEUERSTEIN INSTRUMENTAL ENRICHMENT
STEM PRACTICES Asking questions and defining problems	**Organisation of Dots:** learning how to inhibit impulsiveness, to search systematically, to project virtual relationships, to formulate principles, to plan strategies, to be precise and accurate
Developing and using models	**Organisation ins Space 1:** learning to perceive and project spatial relationships, reducing egocentricity, increasing flexibility of thinking and representational thinking
Planning and carrying out investigation	**Comparisons:** learning to develop spontaneous comparative behaviour, improving the ability to establish relationships
Analysing and interpreting data Using mathematics and computational thinking	**Analytic Perception:** learning to divide wholes into components and construct wholes by projecting the relationships between parts. Develop an analytic approach to life.
Constructing explanations (for science) and designing solutions (for engineering)	**Illustrations:** learning how to perceive problems and discover the solutions. Developing the ability to decode details, use hypothetical and inferential thinking. Learning how to perceive relationships.
Engaging in argument from evidence	**Categorisation:** learning to organize items and project relationships among broader concepts, to focus on the most stable and essential attributes to an object, to process several sources of information. Developing flexibility and divergent thinking, differentiation, and discrimination.
Obtaining, evaluating, and communicating information **SKILLS IN OBTAINING AND COLLECTING INFORMATION:**	**Numerical Progressions:** learning to compare, to infer and reason deductively, establish a hypothesis, to form a rule for the connection between successive events, to draw accurate conclusions. It mediates precision, discrimination, and a willingness do defer judgment until all the elements have been worked out.
Listening and questioning Observing Seeking and finding resources	**Family Relations:** overcoming the episodic grasp of reality, projecting relationships, a precise using of language, inferential thinking, analytic thinking, deductive reasoning to justify conclusions based on logical evidence
Investigating and exploring Collecting data Solving problem and making conclusion / decision	**Temporal Relations:** helps mediate an adequate temporal orientation and an appropriate and precise use of temporal concepts and relationships. Learning to perceive and project highly abstract relationships, to predict, anticipate, plan, and prioritize future events.
SKILLS IN ORGANIZING AND DISPLAYING DATA SYSTEMATICALLY	**Instructions:** focuses on coding and decoding verbal and written information, to communicate with clarity and precision. Students can interpret and transmit complex instructions.
Recording Comparing and contrasting Categorising and classifying Planning and managing data	**Orientation in Space 2:** provides a practice in the use of external, stable, and absolute system of reference. The instrument encourages divergent thinking by eliciting the many possible alternatives for reaching a given objective.
Evaluating and reflecting Analysing	**Transitive Relations:** learning to select relevant and appropriate information, to explore data systematically to make a conclusion, providing with tools for investigating both the validity and the truth of their own conclusions and those of others.
	Syllogisms: learning to discriminate between valid and invalid conclusions and between possible and inevitable outcomes, to be ready to make inferences and draw conclusions and justify them with logical evidence. It fosters inferential and abstract thinking.
	Representational Stencil Design: students must extrapolate from the known and rely on logic to identify constructions, mentally to construct a design through a complex series of steps.

STEM practices describe the attitudes, behaviours and activities that STEM workers use while investigating phenomena and design, building models and systems to solve problems (Ng, 2019). For comparison of STEM practices and skills with FIE, see TABLE 6. **STEM values**, e.g., *curiosity*, *open-minded attitude*, *diligence and perseverance*, *systematic approach*, *cooperation*, *responsibility*, *precision*, and many others are strongly supported throughout all 14 FIE Instruments. In conclusion, there is a question rising – why not to teach the students to think with a verified method of FIE, if STEM education requires cognitive skills even more than segregated science subject.

DIFFICULTIES IN IMPLEMENTATION OF STEM

For STEM implementation, creating STEM education ecosystem is crucial. As the experiences of other national strategies show, the curriculum change is not enough, the area of school education must be enlarged from “the stone walls” of the school to museums, research institutions, universities, companies, industry associations. That is tightly connected to new teaching forms, new school schedules and new communication networks.

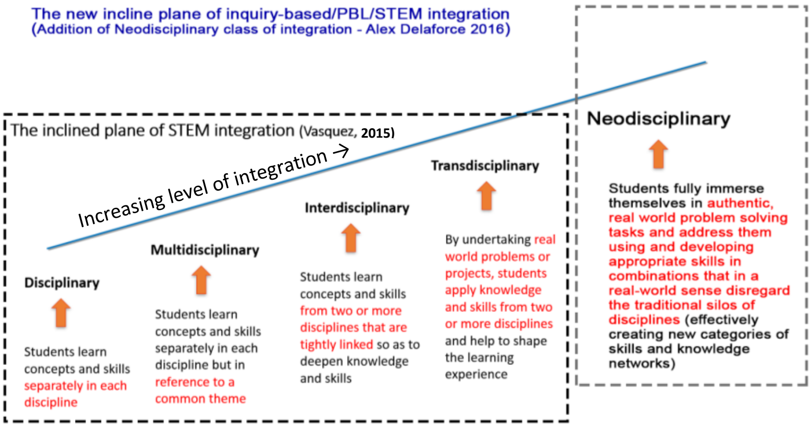

FIGURE 2 The new incline plane of inquiry-based/PBL/STEM integration (Vasquez, (2015); Delaforce (2016)).

In Slovakia we have implemented cross-cutting themes into separate disciplines (e.g., healthy lifestyle into biology, chemistry, and physics) that belongs to multidisciplinary approach (see FIGURE 2). In the past, the project *The Foundational Approaches in Science Teaching* (FAST) was experimentally verified at low secondary level in Slovakia, in which several specific topics from biological, chemical, and physical angle were taught (e.g., the topic Energy) in one subject. This approach can be considered as interdisciplinary. *Problem-based learning* dealing with ill-structured problems (often disciplinary), and *project or inquiry-based learning* are regarded as “in-between” approaches between discipline-based learning and transdisciplinary approach. STEM education is characterized as transdisciplinary (merging knowledge and skills of several disciplines) and neodisciplinary approach (the students address real life problems with appropriate skills in combinations that are different from traditional sets of skill, thus they create new categories of skills and knowledge), see UNESCO (Ng, 2019). Creating strategy of STEM implementation in Slovakia must have clear vision of which approach do we choose (FIGURE 2) and then give the schools enough personal, organizational, technical, and financial freedom to implement it.

We should be aware of what *environmental factors* must be considered for teachers to effectively implement integrated STEM education. Stohlmann (Stohlmann et al., 2012) summarizes the factors which can help the teachers to feel that they have the support they need to be successful: 1. partnering with a local university, 2. attending professional development, 3. taking advantage of training offered by curriculum companies, 4. having common teacher planning time, 5. encouraging open communication. All these can help the teachers to be courageous to enter the STEM education and persevere.

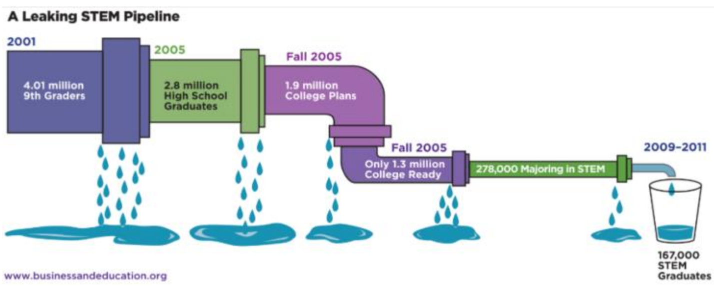

FIGURE 3 An illustration of the " leaking " STEM pipeline showing how more and more students do not end up pursuing STEM careers despite initial interest (Ahn et al., 2016).

The number of students who enter the STEM education at the secondary level of primary school up to the university graduates over the years drastically decreases (FIGURE 3). It was called the Leaky STEM Pipeline

Problem (Blickenstaff, 2005). Addressing this problem, scientist suggest different solutions to retain the students in STEM fields, for instance, providing *mentoring* (Blickenstaff, 2005) or *cognitive intervention* through Feuerstein Instrumental Enrichment (Ben Hur, 2006). Ahn with the team highlights that even the best content instruction does not guarantee improved learning, the crucial factor of taking advantage of learning the content is *motivation*. They suggest some principles to encourage motivation (TABLE 7).

TABLE 7 Principles to encourage the students to stay in STEM field

Principles to encourage the students to stay in STEM field
1. Humanize content knowledge by providing the stories behind the product (the real stories of scientists)
2. Reveal the inner and external struggles a scientist went through
3. Make the learning process vivid with explicit actions and strategies (students learn can directly model after the scientists´ behaviour when encountering similar struggles)
4. Portray the outcome benefits of struggling that are relevant to the individual's life
5. Act out motivated actions and embody the model's actions (students internalize that exceptional talent is not required to succeed in science)

Along with the boom of STEM education, Zhang (2019) comes with some misunderstandings, to which great importance must be given, he says: 1. STEM education is nothing but skill training; 2. The form is more important than the scientific spirit; 3.The learning result is more important than the learning process (The tendency of emphasizing results over processes in STEM education needs reversing so that students can form a correct understanding of true scientific spirit from an early age, which pays less attention to the final outcome and more to the process and methods of scientific inquiry, including whether the problem is justified, whether the researching scheme is reasonable, whether the logic is rigorous, and whether the conclusion is reliable, etc. as to help students construct their own scientific understanding and form a more perfect way of thinking). 4. Education is nothing but STEM education.

Although STEM education is attracting attention, more and more parents and children begin to recognize the important role of communication skills, empathy, business knowledge, leadership and other "soft skills" in personal growth which can be used outside of STEM education.

CONCLUSION

With this article we intended to underline important aspect of STEM implementation. Concerning strategies – Slovakia needs to catch up the STEM implementation by preparing an action plan of STEM implementation, using the success stories of other countries, especially we recommend inspiring with Irish and Australian national strategies. Implementing of STEM is not a matter of an individual school, but it is a matter of network made of Ministry of Education, municipalities, schools, parents, private sector, NGOs., etc. One factor repeated like a chorus in above mentioned national strategies is the quality of pre-service teachers at universities and continual professional development of teachers - practitioners in schools.

Concerning cognitive skills – STEM implementation refers not only to the change of curriculum, forms and methods, tools (e.g., textbooks) but as UNESCO (Ng, 2019) highlights, the pillars of STEM Education must be build. They are STEM knowledge (big ideas), STEM skills (science skills, cognitive skill, and technological skills), STEM values and attitudes. Only developing all this dimensions, the students can become *STEM competent*. Therefore, it is crucial to train teachers and pre-service teachers not only in science knowledge and science skills, but the teachers must be trained in cognitive functions and processes and must be able to mediate them to their students. Such cognitive training like *Feuerstein Instrumental Enrichment* is a verified method how to teach the students to think and we assume that it would make the STEM implementation easier for the teachers. Developing students´ cognitive skills makes the students able to solve the real problems of everyday life, to bring innovations coming with industrial Revolution 4.0.

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