STEM
BEST PRACTICE
ACADEMY

A PATHWAY TO ENTREPRENEURIAL STEM LEARNING SUCCESS

From Base to Raise

From
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Faculty of Education
Higher Colleges of Technology (HCT)

www.stembestpractice.com

Publisher's Note:

At STEM Best Practice Academy, we believe that the children of today are the leaders of tomorrow, and today's educators play a critical role in preparing a child ready for their future. Educators globally have the most important job, so it is essential to pay close attention to how we train and support both new and experienced educators.

STEM Best Practice Academy, through a combination of online and in person workshops, conferences, magazine and talk shows, creates a platform for educators to imbibe new competencies, future skills, and high impact values.

This booklet is designed to guide the implementation of entrepreneurial-STEM learning through incorporating entrepreneurial practices into STEM education. The content covers the pedagogy and practices of E-STEM including the E-STEM objectives, E-STEM model, the strategic plan to apply E-STEM activities, and the rubric to assess students' learning outcomes.

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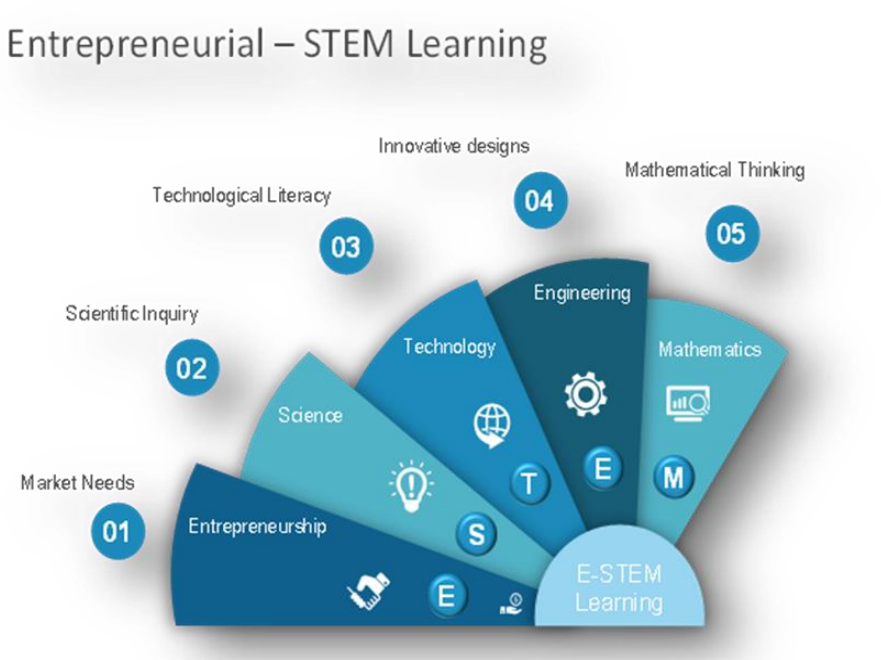

About the author

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Marwa Eltanahy, a Doctor of Education, and curriculum developer, has more than 15 years of experience in the educational field. Before joining Higher Colleges of Technology, she worked as a head of academics, overseeing the development and implementation of academic strategies that aligned with international standards and national frameworks.

She has published a series of studies on E-STEM (Entrepreneurial-STEM) learning and has created a new educational model (Entrepreneurial- STEM model) to incorporate entrepreneurial practices into STEM education to improve students' entrepreneurial competencies. The model has been successfully tested and implemented in a variety of schools around the world, and it has been presented at several international conferences and to government bodies.

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STEM education has often been regarded as national priority and staple in the education reform because Science, Technology, Mathematics and Engineering are considered as the main disciplines that reflect the development of a country's economic situation. For more effective STEM implementation in its early stage, there is a need for an integrated framework to guide STEM educators. The literature recommended restructuring STEM education to accommodate entrepreneurial practices because STEM professions are not desirable for everyone and STEM designs could be easily lost unless involving a basic understanding of the market.

PEDAGOGY

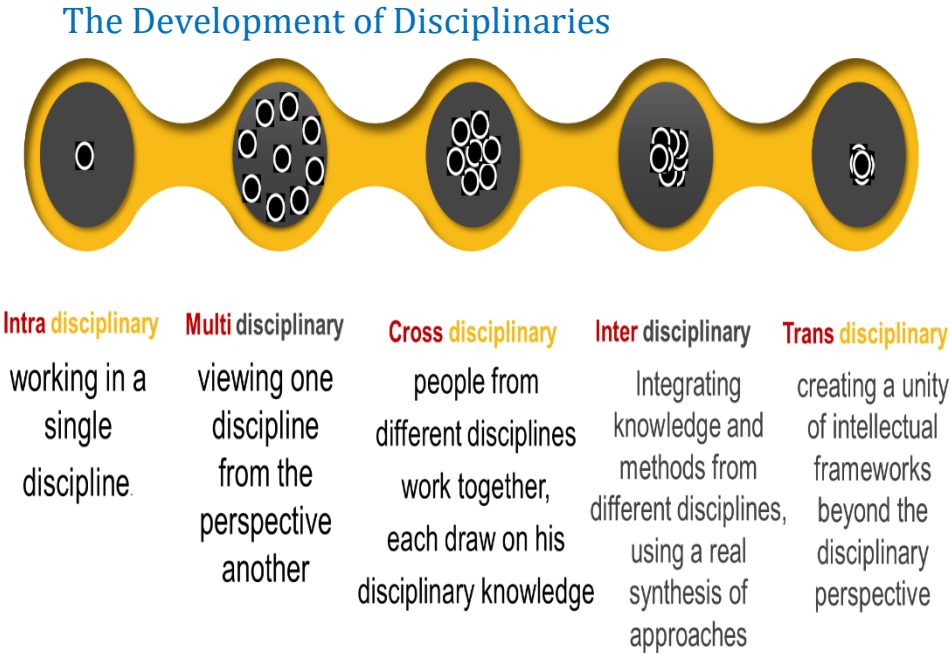


Figure 1: The development of Disciplinaries

The Development of Disciplinaries explain the different levels of integration of knowledge you apply in your teaching and learning practices. Each circle in the diagram represent one subject or one discipline.

For example:

- Teachers who are experts in their subject knowledge only and apply their activities in isolation from other disciplines are adopting an intradisciplinary approach.
- Teachers who are using some content from other disciplines to support their lessons are adopting a multidisciplinary approach. (Different teachers for different disciplines in schools).
- Teachers who work on cross-curricular links and activities are adopting cross disciplinary approach
- Teachers who are collaborating to integrate both knowledge, practices and methodologies of teaching from different disciplines are adopting interdisciplinary approach.
- Teachers who are guided by a big project or theme or a problem to solve it through integrating all possible content, practices, methodologies, strategies are adopting transdisciplinary approach.

In the transdisciplinary approach, you can see that all circles that represent the disciplines are overlapping. The more they get closer by higher integration, the more their boundaries will disappear, and get back to form one circle. However, this circle does not represent one discipline anymore. It represents one

theme or one project or a problem that students work on, and integrate all what should be integrated to address this issue.

Entrepreneurial – STEM Pully System

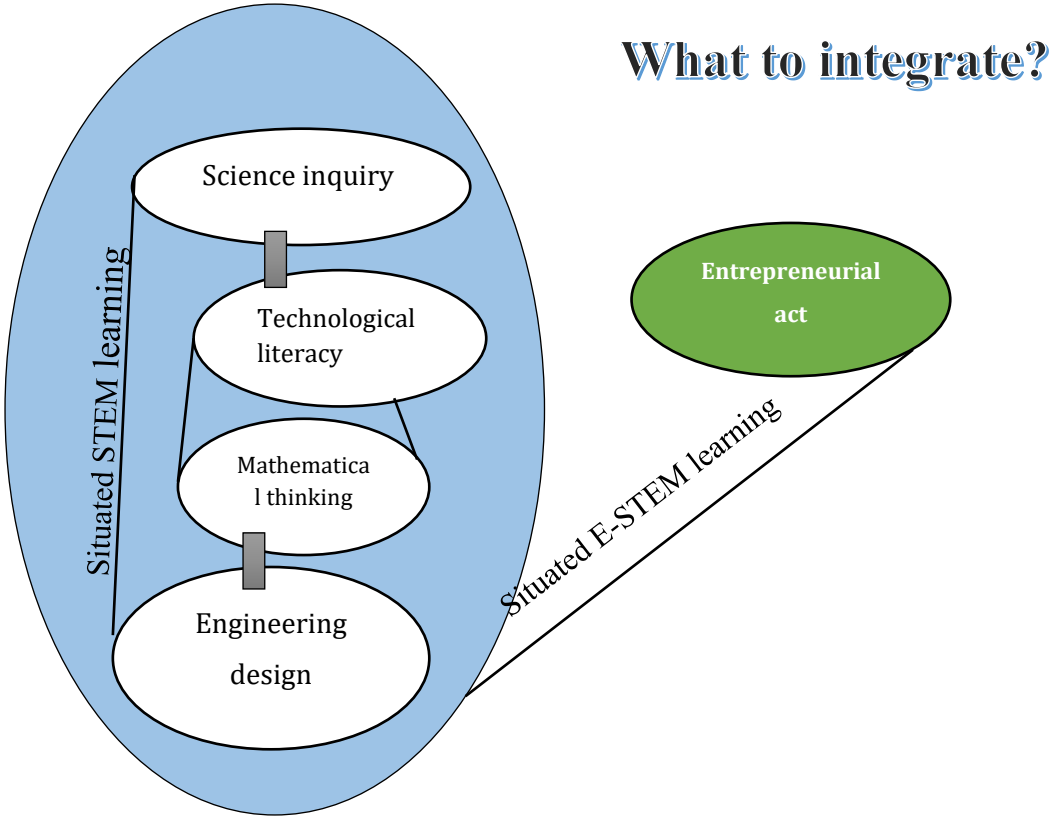
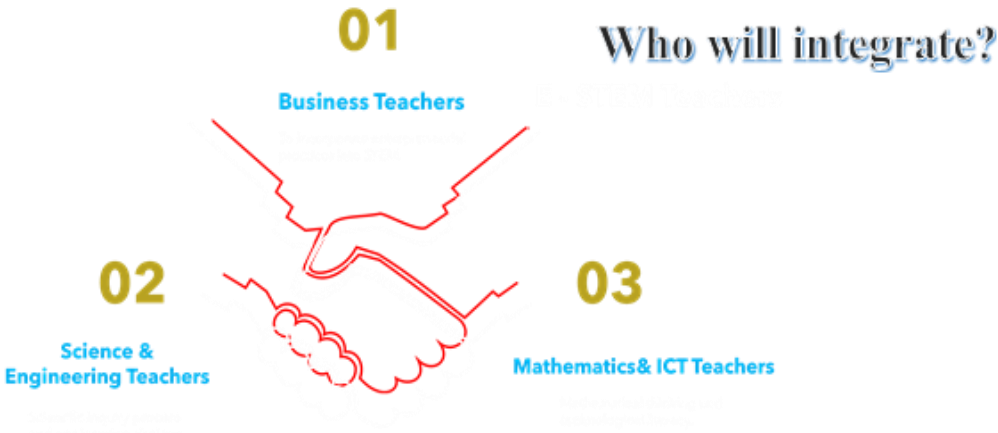


Figure 2: E-STEM Pully System (Eltanahy et al. 2020a)

Figure 2 shows the main pulleys that present the integrated practices of scientific inquiry, technological literacy, mathematical thinking and engineering design to a new pulley of entrepreneurial act, to develop a new pulley system of integrated E-STEM learning. In this regard, the available joint potential of STEM disciplines is utilized to make learners think, perceive and behave in a more entrepreneurial manner. As a start, E-STEM practices could be applied on the edge between cross-disciplinary and interdisciplinary to be gradually and consistently developed to reach transdisciplinary level of integration.

E-STEM Practitioners



Integrating entrepreneurial practices into the STEM context adds an additional layer of complexity for STEM teachers. To ensure successful implementation of E-STEM practices, it is crucial to foster collaboration between business teachers and other disciplinary STEM teachers. This joint effort will facilitate the integration between STEM and entrepreneurial principles to give students a thorough understanding of the entrepreneurial concepts that can be deepen gradually. Moreover, the inclusion of business teachers will ensure the incorporation of real-world examples, industry connections, and insights into current market trends which enhances the authenticity of the learning process. Hence, E-STEM practices provide students with meaningful learning opportunities that allow them to apply their STEM knowledge in practical situations while giving them valuable exposure to the business world (Eltanahy et al. 2020a).

The Focus of Entrepreneurship in Different Educational Stages

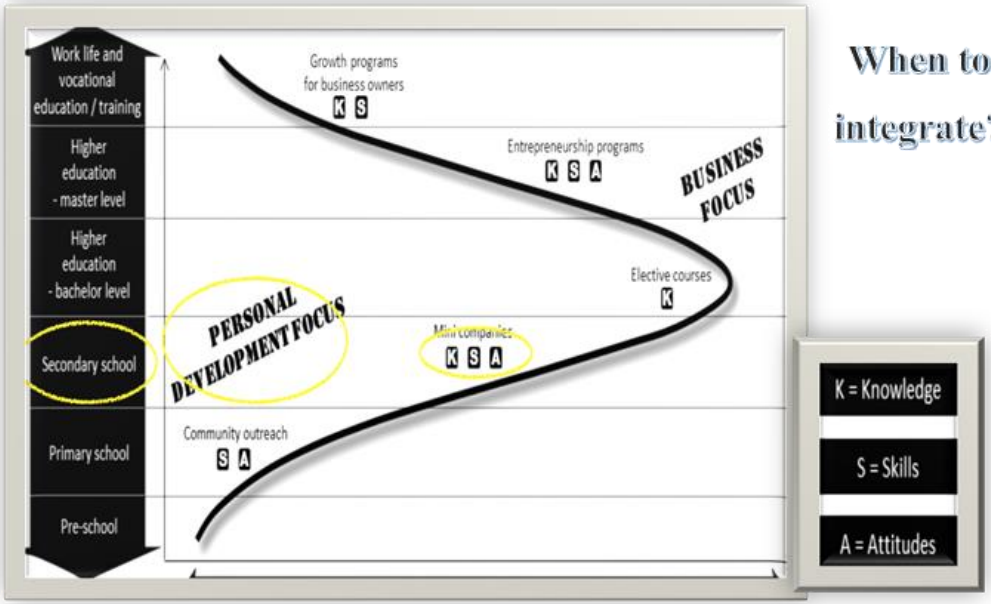


Figure 1: The Focus of Entrepreneurship in Different Educational Stages (Eltanahy et al. 2021)

Figure 3 illustrates that the main focus of entrepreneurial learning in different stages of learning. Secondary school (circled in yellow) lies in between primary and higher education, where the focus is given to the development of students' personal and entrepreneurial knowledge, skills and attitude through the implementation of educational practices that provide students with the opportunity to be able to add

values or establish mini companies. Thus, the acquisition of entrepreneurial knowledge should start in the secondary stage through experiential learning activities to be prepared for the entrepreneurship education as an elective course or program offered in higher stages of learning. However, teachers should intentionally work on design-based, and theme-based learning activities in the earlier stages to develop students' scientific and design skills and prepare them for more integrated practices. Through high education, the focus on integrated entrepreneurial learning should increase further to teach students how to create a venture or start up a new business. Accordingly, the focus on integrating entrepreneurial learning in STEM context should be as follow:

- **Primary education**: Design thinking skills through theme-based learning.
- **Secondary education**: Entrepreneurial-STEM Learning that focus on developing student-competency profile through Project-based problem solving and experiential learning activities.
- **Higher Education:** Entrepreneurial-STEM Learning that focus on developing student-competency profile through project-based learning and venture creation activities that might lead to making a profit.

Integrating Pedagogical Methods

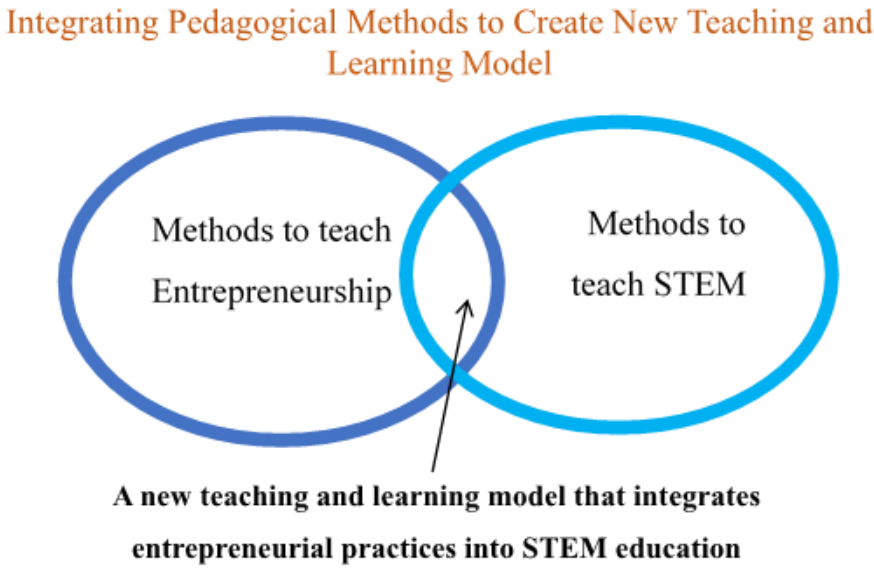


Figure 1: E-STEM Teaching Model

Educational connections: incorporating entrepreneurial practices into STEM education requires integrating pedagogical methods from both disciplines. Essentially, it needs a relevant combination of teaching and learning practices from STEM education and entrepreneurship courses. Integrating pedagogical methods from both STEM and entrepreneurial learning will lead to the development of a new teaching and learning model (E-STEM) that incorporate entrepreneurial practices into STEM curriculum.

Teaching approaches of entrepreneurial Learning

Table 1: Teaching Approaches of Entrepreneurial Learning (Eltanahy et al. 2021)

Differentiated Elements	Education for Entrepreneurship	Education through Entrepreneurship
Perspective	Content-oriented perspective	Pedagogy-oriented perspective
Purpose	Enrich declarative knowledge	Creates authentic and relevant learning experience
Focus	The profession and knowledge about venture creation	Personal development and entrepreneurial competencies
Curriculum	Entrepreneurship knowledge is offered as a separate school topic or subject	Method embedded in other topics or through interdisciplinary learning
Outcomes	Direct Knowledge about how to start a venture and how to make a business plan	Developing competencies: attentiveness, sociability, self-esteem, perseverance, motivation & forward-thinking behavior
Method	Lecture-based education	Practice-based education
Foster	Cognitive entrepreneurial skills	Non-cognitive entrepreneurial skills
Enhance	Negative engagement of students in the learning process	Positive engagement of students in the learning process
Educational Stage	Higher Education	Secondary education & Higher Education

Teaching strategies of E-STEM Learning

Table 2: Experiential Learning (Eltanahy et al. 2021)

Elements of implementation	Experiential Learning
Technique	Unusual and creative
Nature	Learning by doing and discovering
Learning responsibility	Students are more responsible about the learning process
Learning context	In the classroom as well as in different real-life contexts
Resources	Unlimited sources of knowledge
Expected Outcomes	Different for each student
Reflection	Is highly required

The effective implementation of STEM activities as well as entrepreneurship usually take place in an experiential learning context through different learning pedagogies like problem-based learning (PBL), and project-based learning (PjBL). In this essence, incorporating entrepreneurial practices into STEM education should be applied in experiential learning environment where project-based problem solving is one of the best pedagogies used to enhance students' learning outcomes.

Table 3: Project-based Problem Solving (Eltanahy et al. 2021)

Elements of implementation	Project-based Problem Solving (PjbPS)
Problem Identification	Educational scenarios or dilemmas are given to students to represent an engineering problem. Questions were raised in the class discussion to help students gain clear insights about the problem under investigation
Data collection	Students identify the necessary data and resources needed to solve the problem. Moreover, they decide on the required communications that might facilitate their endeavor.
Research process	Learning journey is initiated to recognize the possible solutions that might address the given problem. Students apply discovery-based learning that start by forming hypotheses, planning and making and repeating experiments to confirm or reject their hypothesis
Designing	Students consider the obtained results and decide on the required engineering design to solve the problem. Ideas discussed, available materials and equipment determined in order to create the new design
Communication	Students present their work to the class and reflect on their learning with all the challenges they faced and how they were overcome. Besides, they explain the function and uses of their design.

Main Building Blocks of E-STEM Building

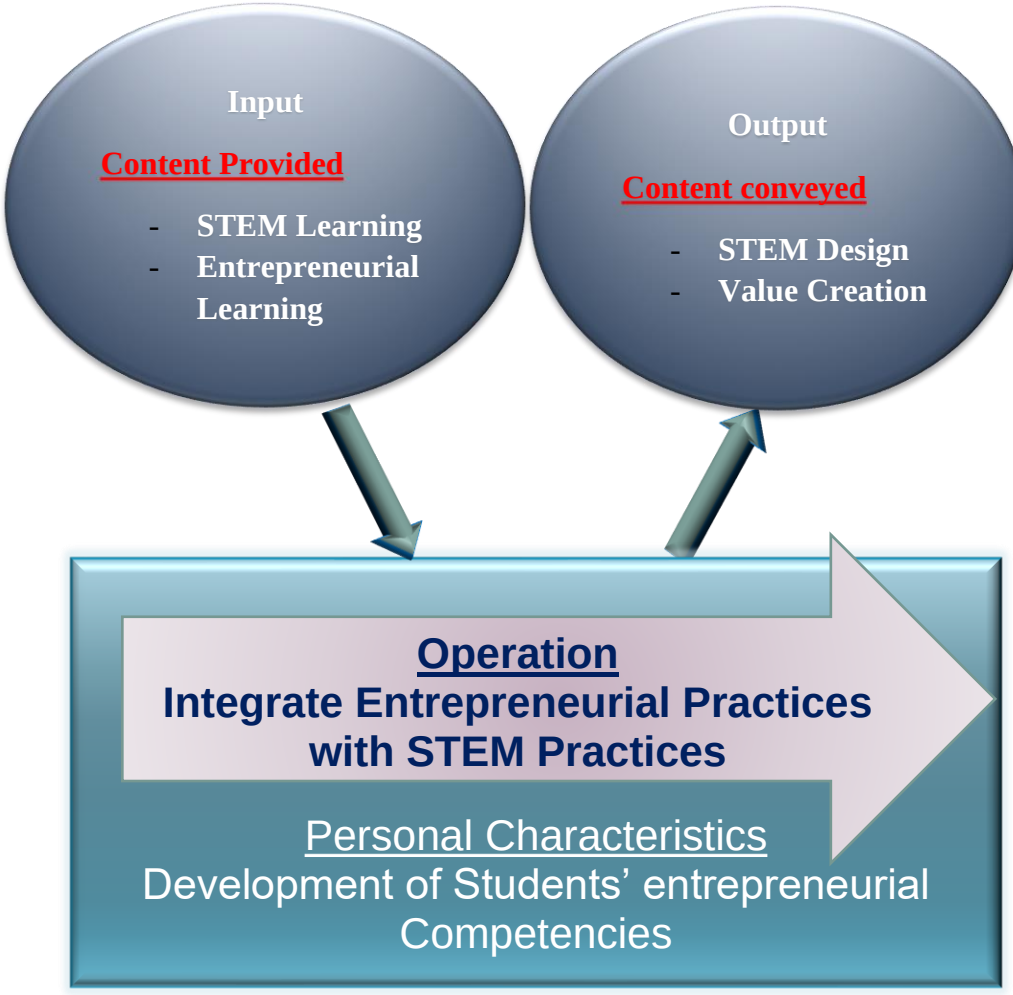


Figure 5: The Main Building Blocks of E-STEM Learning (Eltanahy, 2023a)

Figure 5 illustrates the four main building blocks that help educators to understand the E-STEM model. The block of '**input**' is represented by the content integrated from both STEM and entrepreneurial learning. Incorporating entrepreneurial practices into STEM education represents the block of '**operation**' where a variety of activities should be applied to process the input. The block of **'output'** refers to the content conveyed to add new value and create a STEM design. Finally, the whole model targets the **'personal characteristic of students'** through the development of their entrepreneurial competencies.

Interdisciplinary E-STEM Model

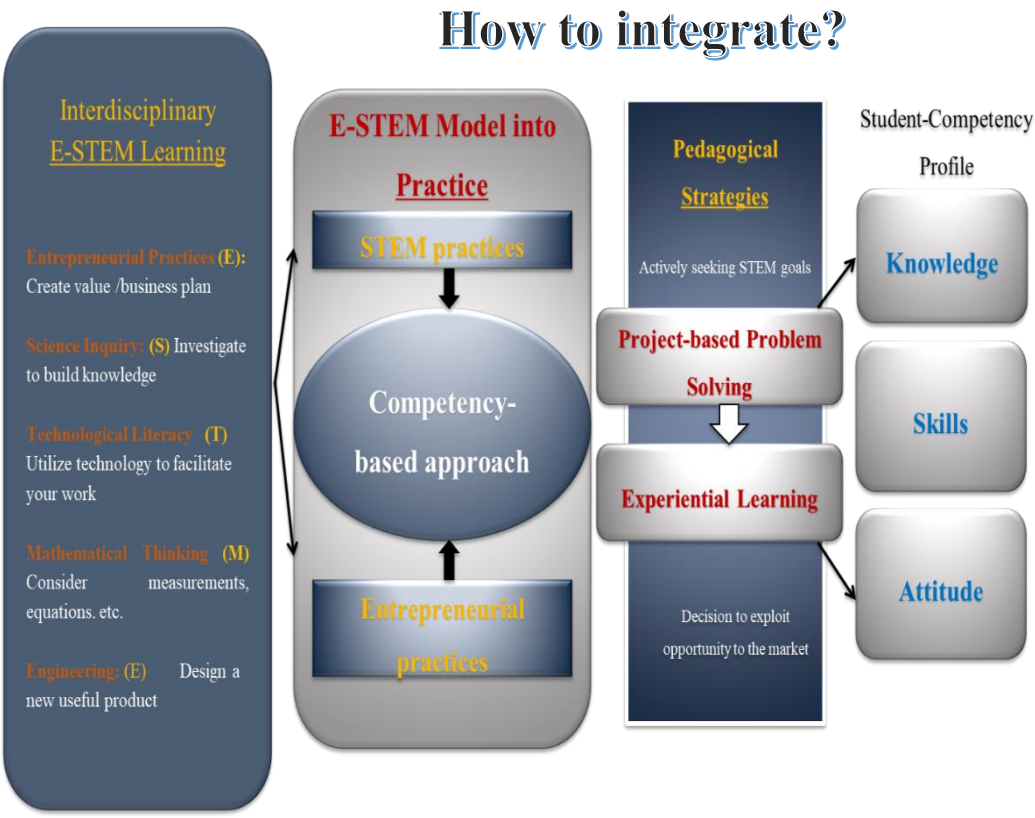


Figure 6: Interdisciplinary E-STEM Model (Eltanahy et a. 2020b)

E-STEM model aims to guide STEM educators to incorporate entrepreneurial practices into their teaching instructions in order to close the gap between students' STEM designs and market needs.

Student-Competency Profile

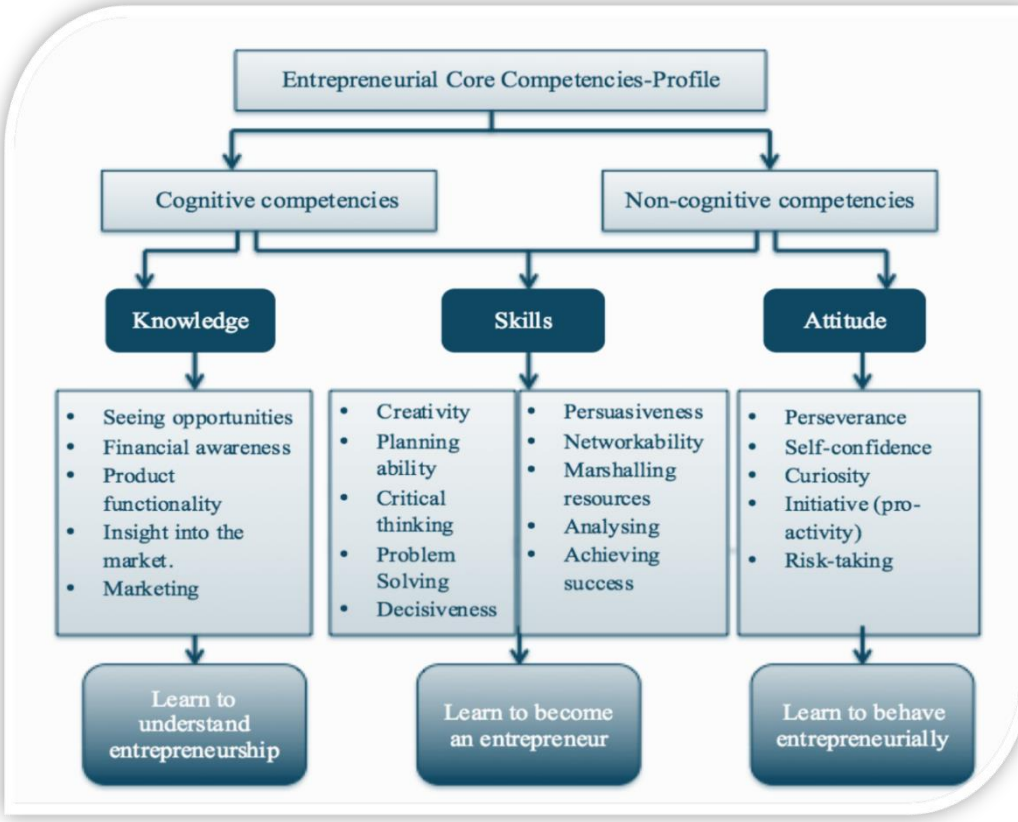


Figure 7: Student-Competency Profile (Eltanahy et al. 2021)

The implementation of E-STEM model focuses more consistently on developing twenty entrepreneurial competencies that form the student-competency profile. These competencies include knowledge, skills and attitude that E-

STEM practices and activities emphasized during the implementation to be developed.

- ***Entrepreneurial Knowledge***

Entrepreneurial knowledge is perceived as the necessary information and useful experiences that have been learnt and successfully gained during carrying out an entrepreneurial activity in learning context.

Seeing opportunities is the ability to recognize and seize suitable opportunities attached to the entrepreneurial process. This knowledge can be taught in the educational setting not only to establish new business but also to develop entrepreneurial habits of mind that are required in the real working environment.

Financial awareness refers to the ability of students to realize the average cost of their projects and to understand how to keep the final cost of what they are doing under control. A basic understanding of financial facts is required to enhance students' consciousness of all forms of expenditure during conducting their educational project as well as creating new business.

Product functionality is a cognitive entrepreneurial competency that refers to the overall ability or the function of the product or design made by students. It also refers to how each product facilitates users' tasks and addresses their needs. Learning and applying this competency will help STEM students to identify the need of their designs and enhance their awareness of developing a meaningful purpose of their work instead of depleting their learning time for making products that are not needed for any users in the market.

Having insight into certain target market refers to a students' ability to assess any possible risks in order to be ready to overcome them. This ability can be developed through many steps that are all closely related to the students' orientation towards learning. Starting by identifying the equivalent products that have been delivered to the market to provide customers with the same service.

Marketing refers to the ability of students to introduce their products or services to the market. Getting the word out about the value you are trying to create or the business you are developing can be achieved through many channels such as networking or online media, school exhibitions, competitions, posters in or outside school, brochures, newsletters and emails.

- ***Entrepreneurial Skills***

A variety of skills have been recognized as being essential to apply and incorporate entrepreneurial practices into education. Notably, STEM-related skills are progressively relevant to other fields, and not exclusively identified with STEM disciplines. The E-STEM model highlighted ten entrepreneurial skills that are essential for both STEM education and entrepreneurial learning. **The first five competencies are more likely to be developed in the educational setting, while the second five skills are usually developed more effectively via real life communication.**

Creativity is the ability to imagine and think of new, useful and valuable ideas. This cognitive skill is vital to design innovative products in the E-STEM class. it is highly relevant to problem solving strategy that is recommended for effective STEM implementation.

Planning is a cognitive skill referring to the ability of students to structure a certain task. Hence, problem-based learning is the best strategy to be utilized in E-STEM learning where students work on complex as well as ill-structured problems to enhance their cognitive

development. Planning is an essential practice that allows students to think ahead in the light of specific vision to reduce expected risks.

Critical thinking is a cognitive skill that is defined as the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action.

Problem solving is the ability to use all available methods to overcome certain challenge through identifying the problem, generating alternatives and evaluating them, then finally implementing the best possible solution

Decisiveness refers to students' cognitive ability to make reasonable decisions, which is a necessary asset for STEM students as well as entrepreneurs. Making clear-cut decisions should rely on deep search via a variety of information resources in order to draw rational assumptions.

Persuasiveness is a skill that refers to students' ability to convince others to accept their desired way of thinking,

which requires applying the contextual standards of public speaking, presentations, and debate activities.

Networkability is a non-cognitive skill that refers to the social scaffolding dimension internal and external to the educational setting. It also refers to the effective relationships with adults outside the school atmosphere that can support students to persist and create new channels to serve the learning process.

Marshalling resources is a skill, which refers to the ability of students to identify, gather and reasonably organize different resources in order to exploit the best opportunities for starting-up new business.

Analyzing data is perceived as the ability to evaluate information in both inductive and deductive methods. Students who discuss and work together to assess complex situations to make well-balanced choices develop their analytical skills.

Attaining personal success relies on the potential need of a student to become an achiever, which is seen as a skill as well as an attitude. Therefore, the need for achievement is

defined as the individuals' desire to do their best in order to achieve an internal sentiment of accomplishment.

- ***Entrepreneurial Attitude***

All the following competencies related to entrepreneurial attitude, revolve around students' beliefs on their ability to perform a task and face its challenging obstacles.

Perseverance is the process of being persistent when doing a task despite difficulties or challenges that might delay achieving the required objectives. Being perseverant is strongly attached to students' self-efficacy that reflects their beliefs towards their abilities to achieve complicated tasks and to deal in a flexible way with changing and vague situations

Self-confidence is a competency referring to students' belief in their ability to successfully achieve the task. Students with high self-confidence and self-efficacy are more independent and often remain committed to their vision and proud of the learning process they went through, and that not only can make them more open to surprises, but also help them to adopt with its challenges.

Curiosity or being learning-oriented is a non- cognitive competency that refers to the strong desire of students to learn about certain topics, which make them elicit, understand and acquire the required knowledge independently, and apply the new knowledge in a different practice to solve its authentic problem.

The sense of taking initiative and being a proactive individual refers to students' ability to turn their ideas into action and to tackle unexpected problems. Having a proactive personality and an action-oriented mindset is highly required.

Risk-taking is a competency referring to the ability of students to take new risks and persist in intellectualism. E-STEM learning as a creative process of inquiry encourages the approach of learning by doing. This process is challenging at the school level as well as rewarding because STEM students are allowed to take risks to develop their ideas and make their own designs or products under the supervision of the E-STEM staff.

Practice: E-STEM Implementation

E-STEM Strategic Plan

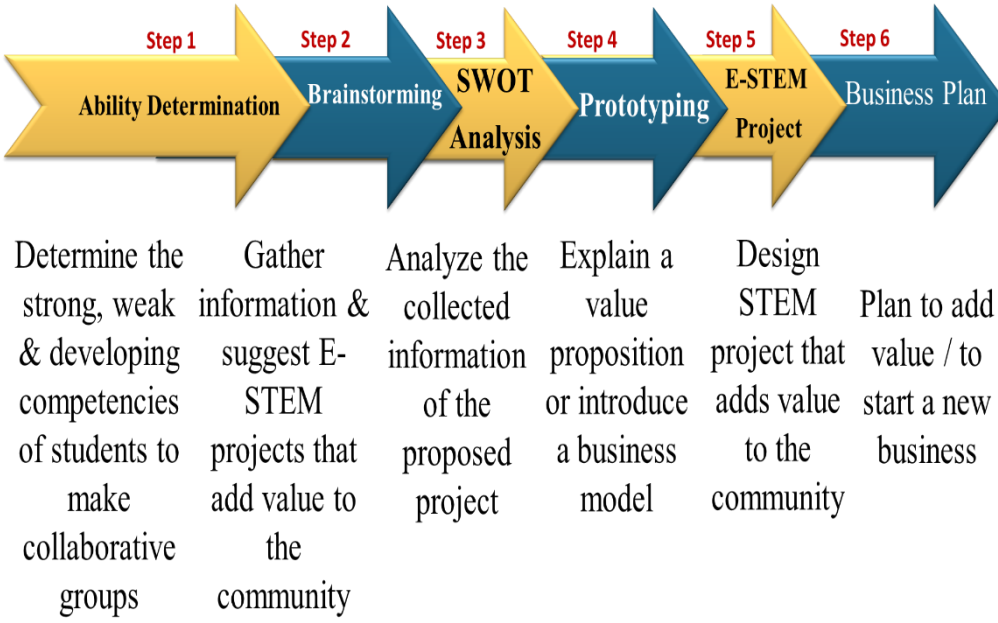


Figure 8: E-STEM Strategic Plan (Eltanahy et al. 2020b)

Figure 8 demonstrates the main six activities that form the E-STEM model that allow students to experience entrepreneurial learning in a STEM context in order to develop entrepreneurial competencies.

- **Ability determination of each student:** The student-competency profile should be introduced to STEM students in order to determine their strengths and

weaknesses, as well as competencies that should be developed.

Table 4: The Form of Ability Determination of Students (Eltanahy, 2023a)

<table>
<tr><th colspan="4">Student- Competency Profile</th></tr>
<tr><th colspan="2">Cognitive entrepreneurial</th><th colspan="2">Non-Cognitive</th></tr>
<tr><th>Knowledge</th><th colspan="2">Skills</th><th>Attitude</th></tr>
<tr><td>Seeing opportunities
Financial awareness
Product Functionality
Insight into the market
Marketing</td><td colspan="2">Creativity
Planning ability
Critical Thinking
Problem Solving
Decisiveness</td><td>Persuasiveness,
Networkability
Marshalling resources
Need For success
Analyzing</td><td>Perseverance
Self-confidence
Self-knowledge,
Initiative (pro-activity)
Risk-taking</td></tr>
<tr><td colspan="4">- Use the competencies listed above in the students-competency profile to determine your strengths and weaknesses as well as the competencies that you are working on its development.</td></tr>
<tr><th colspan="4">Ability determination of each student</th></tr>
<tr><td>Strong</td><td>Weak</td><td colspan="2">Developing Competencies</td></tr>
<tr><td></td><td></td><td colspan="2"></td></tr>
</table>

Table 4 represents the form of the ability determination of participating students where they were asked to self-assess their abilities to complete the given form.

- **Making collaborative groups:** according to the strengths and weaknesses determined by each student, collaborative groups of students should be formed to work on the E-STEM model.
- **Brainstorming:** each group discuss their ideas of E-STEM projects that they suggest for implementation. At this step, students should discuss the need and the value of each idea in order to select the best E-STEM project for implementation.
- **SWOT analysis:** It is a tool used by each group of students to analyze the information of the proposed E-STEM project to clarify the strengths, weaknesses, opportunities and threats that they are expecting to face during the implementation. Furthermore, students will identify the available and the necessary resources to achieve the project. Examples of questions that guide this analysis as follow:

Strengths	**Weaknesses**
1. What is our advantage as a team? 2. What resources do we have? 3. What products are performing well?	1. Where can we improve? 2. What products are underperforming? 3. Where are we lacking resources?

Threats	**Opportunities**
1. What regulations might threaten the implementation?	1.What technology can we use to improve the project?
2. What do our competitors do well?	2. Can we expand our networkability?
3. What issues might be clear barriers?	3. What new market segments can we explore?
4. What consumer trends threaten business?	4. Which support our families and schools can provide?

Table 5: The Form of SWOT Analysis of the E-STEM Project (Eltanahy, 2023a)

Analysis of the proposed E-STEM Project			
Strengths (S)	Weaknesses		Threats(T)
Resources: (Funding, equipment, products, training…etc.)			
Resources Available		Resources Needed	

Table 5 represents the form used to employ the SWOT analysis of the proposed E-STEM project of each group of participating students.

- **Prototyping:** school conference or class presentations should be designed to give students the opportunities to convince the surrounding community the need for their E-STEM project as well as create interest before actual implementation. Thus, during the presentation, students focus on the value proposition or introduce a business model that can serve the target audience. In addition, surveys should be conducted to clarify whether people accept and encourage their ideas.
- **E-STEM Project**: Instead of placing an emphasis in only teaching the content or developing the skills needed for the workplace in a different setting, then hoping the students will realize the connections to real-life situations., the interdisciplinary approach used to implement the integrated E-STEM model seeks not only to locate applicable connections between E-STEM disciplines but also provide a relevant context for the learning experiences. Students should understand the value and the need of their proposed design as well as the target audience that will gain benefits from this service.

Business Plan: The business plan is designed to help STEM students work more deeply on the cognitive competencies that emphasize the entrepreneurial knowledge, such as

product functionality, insight into the market, marketing and financial awareness.

Table 6: Business Plan Form (Eltanahy, 2023a)

E-STEM idea			
What is your E-STEM idea? What is its name?			
What makes your idea different?			
What does this name say about your project/business? Is it unique? Memorable? Easy to pronounce?			
Product Functionality			
How will your product/service stand out from the competition? What is its function?			
Why will people want your idea? Is it needed?			
Insight into the market			
Top competitor(s):	Equivalent product/service:		
Target Market & Demographics			
Who are your target audience? Who are your customers? Ex. Kids, teenagers, men, women…etc.			
What is your target market passionate about?			
Marketing			
How will you get the word out about your service/ business? Networking? Online (website, social media)? Posters? Newspapers? Email?			
Where will you make your service or sell your product? Finding customers?			
Financial Awareness			
Pricing	Profit		
How much will you charge?	Sale price of item:	Cost of item:	Profit:
What is your competitors' charging? (If applicable)	How much will you make on each sale? (Profit=income-expenses)		

What will you do with the money you make? Reinvest in a business? Save for college? Donate?

Table 6 represents the form of the business plan used to allow students to learn and apply more entrepreneurial knowledge regarding their E-STEM project. Students were asked to answer all the given questions in the plan that focus on their idea, functionality of the STEM design, and marketing and financial awareness (Eltanahy & Mansour, 2022)

Assessment: E-STEM Rubric

The analytical rubric developed (Tables 7-10) is a tool designed to evaluate students' E-STEM outcomes. It includes four dimensions (E-STEM projects, entrepreneurial knowledge, skills, and attitude). Criteria of each dimension are organized in clusters, with objective and measurable descriptive statements for each criterion to make the assessment process easier.

Table 7: Analytical Rubric to Assess Students' E-STEM Projects (Eltanahy & Mansour, 2023b)

Competency-based Assessment 'GRADING CRITERIA'	***Achievement that does not meet the E-STEM requirements***	***Achievement that minimally meets the E-STEM requirements***	***Achievement that moderately meets the E-STEM requirements***	***Achievement that is mostly meets E-STEM requirements***	***Achievement that is significantly exceeds the E-STEM requirements***
Percentage	**(F) 59**	**(D) 60 – 69**	**(C) 70 – 79**	**(B) 80 – 89**	**(A) 90 – 100**
Scale	**1**	**2**	**3**	**4**	**5**
E-STEM Project	**E-STEM ACHIEVEMENT INDICATORS**				
Purpose	The project has no SMART purpose that adds a value to the community	The project has SMART irrelevant purpose	The project has moderately SMART relevant purpose	The project has mostly SMART relevant purpose	The project has clearly SMART relevant purpose
Interdisciplinarity	The project has no integration between different disciplines and no entrepreneurship opportunity is created	Has 2 integrated disciplines with a minimal an entrepreneurship opportunity	Has 3 integrated disciplines with a minimal an entrepreneurship opportunity	Has 3 integrated disciplines with a good an entrepreneurship opportunity	Has at least 4 integrated disciplines with an excellent entrepreneurship opportunity
Work Distribution	No task distribution and no collaboration between members of the group to be completed on time	Minimal task distribution and poor collaboration between most of students of the group	Fair task distribution and collaboration between half of students	Good task distribution and collaboration between majority of students	Excellent task distribution and collaboration between all members

Prototyping	No E-STEM prototype is presented to show its service	Poor E-STEM prototype is presented	Fair E-STEM prototype is presented	Good comprehensive E-STEM prototype is presented	Excellent comprehensive E-STEM prototype is presented

Table 8: Analytical Rubric to Assess Students' Entrepreneurial Knowledge in E-STEM Context (Eltanahy & Mansour,2023b)

Scale	1	2	3	4	5
E-STEM Knowledge	**E-STEM ACHIEVEMENT INDICATORS**				
Integrated Knowledge	Demonstrates significant gaps in E-STEM knowledge. Shows misconceptions and lack of relevant details/evidence for E-STEM project.	Demonstrates slightly sufficient understanding of integrated E-STEM disciplines. Shows some misconceptions and provides very little relevant details/evidence for E-STEM project.	Demonstrates moderately sufficient understanding of integrated E-STEM disciplines. Shows few misconceptions and provides little relevant details/evidence for E-STEM project.	Demonstrates mostly sufficient understanding of integrated E-STEM disciplines. Provides adequate relevant details/evidence with minor inaccuracies for E-STEM project.	Demonstrates in-depth understanding of integrated E-STEM disciplines. Provides solid relevant details and accurate evidence for E-STEM project.
Financial Awareness	Do not use financial skills including budgeting to control the cost of the E-STEM project.	Minimally realized/reduced the average cost of the project by 10%.	Fairly realized/reduced the average cost of the project by 20%.	Good reduction to the average cost of the project by 30%.	Excellent reduction to the average cost of the project by up to 40%.

Product Functionality	Unaware of the project's potential to add value to the community through useful features and functions.	Partially aware of a basic set of capabilities and features that can benefit users.	Adequately aware of a reasonable set of capabilities and features that can serve users' needs.	Well-informed about a comprehensive set of capabilities and features that can effectively facilitate users' tasks.	Highly knowledgeable about all capabilities to fully meet users' needs and provide exceptional value to the community.
Market Research	Did not identify target audience or mention existing equivalent products in the market.	Identified relevant target audience but did not mention existing equivalent products.	Identified inaccurate target audience and one existing equivalent product.	Identified relevant target audience and most existing equivalent products.	Identified all relevant target audience and all existing equivalent products.
Marketing	No recognition or seizing of suitable marketing opportunities for E-STEM ideas.	Recognized minimally suitable marketing opportunity but for inappropriate audience.	Recognized moderately suitable marketing opportunity but for slightly appropriate audience.	Recognized mostly suitable marketing opportunity for appropriate audience.	Recognized excellent suitable marketing opportunity for absolutely appropriate audience.

Table 9: Analytical Rubric to assess students' entrepreneurial skills in E-STEM context (Eltanahy & Mansour, 2023b)

Scale	**1**	**2**	**3**	**4**	**5**
E-STEM Skills	**E-STEM ACHIEVEMENT INDICATORS**				
	No preparation, management, or adjustment of procedures to achieve the desired E-STEM project.	Slightly inaccurate planning for preparing, managing, and running activities,	Fairly accurate planning for preparing, managing, and running activities,	Mostly accurate planning for preparing, managing, and running activities, and	Fully accurate planning for preparing, managing, and running activities, and

		and adjusting procedures.	and adjusting procedures.	adjusting procedures.	adjusting procedures.
Creativity	Did not generate, recognize/ develop new ideas, alternatives, possibilities to create an original E-STEM design	Demonstrates slightly satisfied performance to apply and extend knowledge, skills and ideas to create mostly copied E-STEM design	Demonstrates fair performance to apply and extend knowledge, skills and ideas to create possibly copied E-STEM design	Demonstrates good performance to extend knowledge, skills and ideas to create probably original E-STEM design	Demonstrates excellent performance to extend knowledge, skills and ideas to create a definitely original E-STEM design
Problem Solving	Do not solve any problems that faced the project to achieve its purpose.	Demonstrates slightly inappropriate solution of most of the problems	Demonstrates fairly appropriate solution of many of the project's problems	Demonstrates slightly appropriate solution of most of the project's problems	Demonstrates absolutely appropriate solution of all of the project's problems
Critical Thinking	No clear or rational thinking to identify and understand the logical connection between ideas to make diagnosis and reasonable judgments.	Minimally connected ideas, understood pros and cons, made a few diagnoses, and applied some reasonable judgments.	Moderately connected ideas, understood pros and cons, made diagnoses, and applied some reasonable judgments.	Mostly connected ideas, understood pros and cons, made diagnoses, and applied good reasonable judgments.	Effectively connected ideas, understood pros and cons, made diagnoses, and applied excellent reasonable judgments.
Persuasiveness	Did not present or demonstrate the idea to convince the audience of the importance or need of the E-STEM project.	Slightly influential evidences and reasons presented through verbal and non-verbal communic	Somewhat influential evidences and reasons presented through verbal and non-verbal communic	Very influential evidences and reasons presented through verbal and non-verbal communication, with	Extremely influential evidences and reasons presented through verbal and non-verbal communication, with

		ation, with the audience barely convinced of the need for the project.	ation, with the audience moderately convinced of the need for the project.	the audience mostly convinced of the need for the project.	the audience highly convinced of the need for the project.
Organizing resources	Poor resource organization resulting in ineffective use.	Limited resource organization leading to a limited use of most of them.	Good resource organization leading to a good use of at least half of the resources.	Very good resource organization leading to a very good use of most of the resources.	Excellent resource organization leading to an excellent use of all resources.
Analyzing	No SWOT analysis presented/mentioned to show the nature, relationship, advantages, disadvantages, opportunities, and threats of the E-STEM project.	Demonstrates emerging level of SWOT analysis from gathered sources and evidences	Demonstrates developing level of SWOT analysis from gathered sources and evidences	Demonstrates a very coherent, and appropriately SWOT analysis from gathered sources and evidences	Demonstrates in-depth SWOT analysis from organized and synthesized information and evidence from relevant sources
Networkability	Not communicating effectively with new or known people who could help with the E-STEM project.	Limited communication with new people and fair communication with known people who could be useful.	Slight communication with new people and moderate communication with known people who could be useful.	Clear communication with both new and known people who could be useful.	Effective communication with both new and known people who could be useful.

Table 10: Analytical Rubric to assess students' entrepreneurial attitude in E-STEM context (Eltanahy & Mansour,2023b)

Scale	1	2	3	4	5
	E-STEM ACHIEVEMENT INDICATORS				
Perseverance	No attempt made to overcome difficulties, failure, or opposition faced by the project	Made a single attempt or poor effort to overcome difficulties	Made a few attempts and a fair effort to overcome difficulties	Made some attempts and a good effort to overcome difficulties	Continued effort despite facing project difficulties, failure, or opposition
Self-confidence	Lack confidence in abilities and decisions to achieve the task	Some doubts in abilities and decisions	Fairly confident in some abilities and decisions	Mostly confident in many abilities and decisions	Strongly confident in all abilities and decisions
Initiative	No action taken to start, improve, or solve problems in an E-STEM project	Weak action taken to start, improve, or solve problems	Occasional proper action taken to start, improve, or solve problems	Frequent proper action taken to start, improve, or solve problems	Consistent and well-reasoned action taken to start, improve, or solve problems
Risk-taking	Avoid taking risks or trying new things to achieve the goals of the E-STEM project	Slightly takes risks or tries new things	Occasionally takes risks or tries new things	Often takes risks or tries new things	Willing to take calculated risks and try new things to achieve

Principles of E-STEM Learning

In the light of the findings of the ongoing research concerning E-STEM learning, the main principles of Integrated E-STEM learning that identify the objectives, pedagogical approach and strategies, and outcomes of this interdisciplinary learning are as follow:

1. E-STEM learning should contribute towards cultivation of entrepreneurial STEM-literate students because entrepreneurial literacy and competencies are essential to equip learners with the basic knowledge, skills and attitudes for future careers.
2. E-STEM learning should incorporate integrated practices of the main pulleys of E-STEM acronym to make use of scientific inquiries, mathematical thinking, technological tools, engineering designs and entrepreneurial act that all support the science reform endeavor.
3. E-STEM learning involves useful STEM designs in a situated learning environment where innovation, creativity, invention and entrepreneurship values are emphasized.

4. E-STEM learning should focus on the development of the student-competency profile that contains the core entrepreneurial competencies (cognitive and non-cognitive) needed to overcome workplace challenges.
5. E-STEM learning should be implemented via interdisciplinary approach where new knowledge is embedded in integrated practices to solve real problems and add values to the society.
6. E-STEM learning should engage students in real business practices through enhancing entrepreneurial literacy to provide new solutions, construct new knowledge, and offer new values to the local community.

References

Eltanahy, M., Forawi, S. & Mansour, N. (2020a). STEM leaders' and teachers' views of the integration of the Entrepreneurial Practices into STEM Education in High School in the United Arab Emirates. Entrepreneurship Education. 3(2), pp. 133-149. Springer

Eltanahy, M., Forawi, S. & Mansour, N. (2020b). Incorporating entrepreneurial practices into STEM education: Development of Interdisciplinary E-STEM model in high school in the United Arab Emirates. Thinking Skills and Creativity Journal, 37, p.100697. Elsevier

Eltanahy, M. Forawi, S., Mansour, N. (2021). The Diffusion of Entrepreneurship Practices at Schools through STEM Education. Mansour, N. & EL-Deghaidy, H.: STEM in science education and S in STEM: from Pedagogy to learning. Rotterdam: Brill-Sense Publishers

Eltanahy, M., & Mansour, N. (2022). Promoting UAE Entrepreneurs using E-STEM Model. The Journal of Educational Research, 115(5), pp. 273-284

Eltanahy, M. (2023a). Innovative Pedagogy and Practice for E-STEM Learning. Peter-Burton, E. & Kaya, S.: Enhancing Entrepreneurial Mindsets through STEM Education. Springer Nature.

Eltanahy, M. & Mansour, N. (2023b). Assessment in the Context of entrepreneurial-STEM: Creating a rubric to assess E-STEM projects in the United Arab Emirates. The 9th International Conference on Education (ICEDU 2023). 16h– 17th March 2023. The International Institute of Knowledge Management

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