CHAPTER 8

The Diffusion of Entrepreneurial Practices at Schools through STEM Education

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Abstract

Although not much attention is given in the literature to how STEM and entrepreneurial practices can be integrated at schools, the previous academic perspectives reflect the desire and the need to investigate new pedagogical models that enhance this incorporation in education because it is never too early to acquire some entrepreneurial competencies (Winkler, Troudt, Schweikert, & Schulman, 2015). In order to achieve the learning goals of in high school, education-through entrepreneurship is emphasized as the main approach of incorporating entrepreneurial practices (Johannisson, 2010). This approach focuses mainly on the pedagogy rather than the content through implementing competency-based teaching strategies (Lackéus, 2015). This chapter delivers a detailed review of the literature regarding infusing entrepreneurial practices into STEM education from different angles. The main idea is to encourage students to practice self-employment by leading or engaging in business activities in order to experience an entrepreneurial work position. Attention is mainly given to entrepreneurial competencies that can be enhanced through this educational implementation. Thus, competencies developed through the implementation of STEM and entrepreneurial work activities that identify twenty competencies selected to form the student-competency profile, entrepreneurship education (EE) and its teaching approaches, the relationship between entrepreneurship and STEM education, and finally the common pedagogical approaches that support both STEM and entrepreneurial learning are discussed.

Keywords

STEM education – entrepreneurship education (EE) – entrepreneurial learning – entrepreneurial STEM learning (E-STEM) – entrepreneurial competencies

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1 STEM Education

STEM education refers to integrating knowledge across Science, Technology, Engineering and Mathematics disciplines (STEM) that are effectively intertwined together to produce innovative designs through a new integrated curriculum. Over the past few decades, slight attention and little integration were given to both engineering and technology subjects (Bybee, 2010) because the main emphasis was given to promoting only mathematics and science disciplines as isolated subjects. More recently, the integration between STEM disciplines was defined as an effort to find connections to combine the four STEM subjects or some of them in one lesson or class to solve problems (Kelley & Knowles, 2016). Accordingly, the objectives of integrated models based on the STEM curriculum can mainly focus the content on one or two of these disciplines. However, the context is for other STEM subject areas. For example: the most recent American educational standards (Common Core State Standards CCSS) applied for Mathematics and (Next Generation Science Standards NGSS) applied for science could be utilized to make meaningful connections across these two disciplines. At the same time, students can apply these learning standards in an engineering context through a design-based approach (NRC, 2014). Thus, STEM is considered as a form of an interdisciplinary inquiry that emphasizes teaching meaningful knowledge from integrated subjects in a student-centred environment to solve real-life problems (Capraro, Capraro, & Morgan, 2013). Accordingly, areas of STEM content in K-12 are considered as "collective curriculum" (Roberts, 2013, p. 22). However, STEM experiences in high school tend to be passive because a considerable part of the content is presented through lectures rather than modern strategies of teaching. The traditional implementation of teaching instruction comes as a result of teachers' beliefs and professional identity that often influence their acceptance of reforms (Hargreaves, 2004).

Despite the fact that real world questions are inherently interdisciplinary, most schools have traditionally separated the main four disciplines of STEM, which confuses most students in recalling the required information from each subject and connecting it to the questions. In order to make connection between the four STEM subjects, Kelley and Knowles (2016) proposed a framework of integrated STEM disciplines by presenting a block and tackle of four different pulleys where each of them represents the common practices used from each of the four STEM disciplines to lift a load. The four main pulleys that represent this framework are scientific inquiry, technological literacy, mathematical thinking and engineering design. Enhancing the integrity of this system requires implementing harmonious practices to tackle its complex relationship. Moreover, it is not necessary to equally integrate all the four domains of STEM content in all learning experiences. However, it is crucial for teachers to establish a successful level of integration based on the relationship between the domains in this mental model. This approach is highly recommended in education because its methodology allows students to make use of different types of knowledge to propose significant and concrete solutions to address non-traditional tasks (Dedovets & Rodionov, 2015). Moreover, it creates a unique experience that develops students' personalities through shifting the teaching approach from accumulating summary knowledge to independently using access to diverse resources of knowledge in many contexts outside the traditional learning settings. A substantial amount of literature confirmed that PBL and project-based learning (PjBL) strategies are the most successful strategies used in the classroom to enhance meaningful outcomes of STEM education (San, Alıcı, & Şen, 2018).

2 Entrepreneurship Education

Due to a constant change in the economy, the stability of employment is no longer guaranteed, and it should not be perceived as linear any longer. That is why it is necessary that schools provide students (as the future workforce of the community) the learning opportunities to develop the essential entrepreneurial competencies to cope with the challenges of the work context (Costa, Caetano, & Santos, 2016). Therefore, education was called for action because it is a prerequisite for enhancing entrepreneurial initiatives that help to raise productivity in all economic zones (Hamad Khan, Shahab, Hameed, & Qadeer, 2016).

Learning is defined as the process of constructing knowledge through authentic experiences, where the acquisition of this content knowledge and skills can guide students' future behaviour. Thus, students' entrepreneurial motivation is strongly affected by the learning entrepreneurship course (Jakarta, 2019). Basically, there are unlimited strategies that enable educators to respond quickly to the important requirements of any productive sector. That is why the World Economic Forum (2014) believed that creating a conducive ecosystem is highly supported by successful educational contributions. Peter Drucker is one of the major thinkers in America who explored the area of innovation and entrepreneurship in terms of the essential practices – he explained that entrepreneurship is neither mysterious nor magic and it is not inherited but it can be taught and learned.

Hallam et al. (2015) believed that identifying the entrepreneurial potential of the students as early as possible critically influences the economic success.

Thus, entrepreneurship as a force that impacts the economic situation of any country should not be underestimated. Moreover, the literature of EE found that the acquisition of entrepreneurial competencies is not significantly related to students' demographic characteristics such as gender (Kumara & Kumar, 2010). More importantly, practice to implement a positive approach toward challenges can turn them into entrepreneurial learning (Funken, Gielnik, & Foo, 2018). Therefore, the emphasis is placed on the responsibility of the educational sector in generating more entrepreneurs. Hence, EE is mainly considered as a stand-alone subject that is usually offered as an elective course to learners in business-related studies. Diffusing entrepreneurial activities to be accessible to all students of different streams is a real challenge that requires an interdisciplinary approach to raise students' awareness of entrepreneurship and to develop their abilities (Wilson, 2008). There is an on-going discussion in the entrepreneurship literature about how to incorporate entrepreneurial applications into the existing course framework because it acts as a catalyst for economic growth (Teerijoki & Murdock, 2014).

Heinonen and Poikkijoki (2006) limited the aim of entrepreneurial activities at increasing students' knowledge about entrepreneurship in order to develop an enterprise. Afterward, the European Commission (2012) expanded this narrow view to a broader statement to define EE as "a process through which learners acquire a broad set of competencies which can bring greater individual, social and economic benefits since the competencies acquired lend themselves to application in every aspect of people's lives" (p. 7). This definition reflects the multiple objectives of conducting entrepreneurial practices; for example, it offers training and guidance on how to plan for business start-up. Although the corporation of entrepreneurial practices in education is a critical challenge for teachers, it enhances students' entrepreneurial mindset through developing a set of lifelong entrepreneurial skills (Kuratko & Morris, 2018).

The literature introduces a set of entrepreneurship terminologies that all have been used in publications related to the sector of education. Thus, the concept 'entrepreneurship education' refers to the process of learning how to become a self-employed person through setting-up a venture. While, 'enterprise education' refers to the learning process of entrepreneurship that broadly gives more attention to the development of students 'mindset, attitudes, skills, abilities and personalities (QAA, 2012), such as whether they were able to run their own actual business or were just working on the process of planning to start a new one. In the United Kingdom, 'entrepreneurship education' and 'enterprise education' are the most frequent concepts used in publications, whereas only the former term is often used in the United States, which causes misunderstanding. That is why the term entrepreneurial education was proposed as a unifying concept that encompasses both the previous definitions including entrepreneurial learning and practices that lead to the development of students' entrepreneurial competencies (Erkkilä, 2000). Furthermore, students' acquisition of entrepreneurial knowledge tactics is one of the important consequences of entrepreneurial learning experiences, while the number of entrepreneurial competencies is numerous, and the nature of the entrepreneurial project affects the development of a selected set of these competencies according to the activities applied (Djilali & Boucha, 2018).

3 Competencies Developed through STEM and Entrepreneurial Practices

Competencies have been perceived as the aptitude that helps apply a combination of skills and information in a specific professional context (Lans, Verstegen, & Mulder, 2011). Educational competencies required in the workplace including knowledge, skills and attitudes are important economic issues because they empower students to compete with their equivalents worldwide successfully. STEM focuses on implementing educational frameworks that guarantee all understudies to move on from secondary education with the essential capabilities and competencies in science, innovation, designing and math. These abilities are basic to enhancing general secondary school graduation and school preparation rates as well as supporting the economic development of the country (Bybee, 2010).

Work activities represented in practices implemented in the learning process for both STEM and EE have some commonalities that enhance the development of students' core learning competencies. Table 8.1 identifies the commonalities of those practices and highlights the suggested competencies that can be developed through consistent implementation based on the literature of both STEM and entrepreneurship fields.

Learning STEM helps students to build constructive knowledge of the features of STEM subjects, as well as an understanding of how this integrated knowledge shape the physical world. Beyond the acquisition of disciplinary knowledge, STEM education enhances students' intra-disciplinary skills such as creativity, problem-solving and critical thinking skills (Murphy, MacDonald, Danaia, & Wang, 2018) that all are essential to create new values. On the other hand, the implementation of entrepreneurial practices such as making a business plan, collecting and analysing relevant information, considering benefits and relative costs and applying alternative solutions to solve unexpected problems, are critical influences that help develop personal competencies of

TABLE 8.1 Competencies of entrepreneurial STEM learning

STEM education		**Entrepreneurial learning**	
Competencies	STEM practices	Entrepreneurial Practices	Competencies
Creativity	Suggest new idea and work to improve performance and produce it	Propose a business initiative	Initiative, pro-activity (Pepin, 2012)
Interdisciplinary thinking (Capraro et al., 2013)	Integrate knowledge from science, math, technology and engineering to make an innovative product	Integrate knowledge from different relevant disciplines with technology to start up a venture enterprise	Information technology (Dedovets & Rodionov, 2015)
Planning ability (Elizabeth, Kaila, & Alexandra, 2017)	Plan inquiries and adjust procedures for better outcomes (STEM product)	Make a business plan and take the risk (Hamad et al., 2016).	Risk-taking, Seeing opportunities
Reflective thinking, problem-solving	Synthesize connections between ideas from STEM disciplines and think reflectively to solve any problems	Analyse information, organize resources and evaluate results to choose the best solution, cope and adapt to different situations	Flexibility, insight into the market
Decision making, critical thinking	Consider the relative materials and benefits of actions to decide the most effective resources	Consider benefits and relative costs to select the most proper one (Hassain Naser, Zaman, & Nuseibeh, 2009).	Financial awareness, product functionality

(*cont.*)

TABLE 8.1 Competencies of entrepreneurial STEM learning (*cont.*)

STEM education		Entrepreneurial learning	
Curiosity, self-knowledge	Search to be updated and use relevant knowledge, attend courses, ask for experts' opinions	Keeping up-to-date technically and applying new knowledge to the job.	Communication skills, networkability
Persuasiveness	Find alternative solutions to finish the project that has started (Ronis, 2008)	Tolerance to the failure, understand mistakes and try to overcome it	Tolerance to failure (Tan & Frank Ng, 2006)
Innovation (Capraro et al., 2013)	Design a new product	Start new business (Kyndt & Baert, 2015) or create new value	Self-efficacy & confidence

students. Research evidence suggests that personal development is considered as an important factor of motivation that enhances entrepreneurs to proceed (Mitchell, 2004). Drawing upon education through entrepreneurship, non-cognitive competencies could be emphasized during incorporating the entrepreneurial practices into STEM education (Moberg, Vestergaard, Fayolle, Redford, Cooney, Singer, Sailer & Filip, 2014). While STEM practices usually give more focus to innovative cognitive skills such as problem-solving and critical thinking. This chapter discusses ten competencies from each type (cognitive and non-cognitive) that are known to be associated with enhancing entrepreneurial learning. Hence, the acquisition of these competencies is not solely essential for entrepreneurs, but it is also a powerful indicator of the successful social economic because values and ventures created by entrepreneurs may improve standards of livings and provide new job opportunities for others which contribute effectively to a growing economy of any country. The holistic emphasis of these competencies is on "the ability to successfully meet complex demands in a particular context" (Mulder et al., 2007, p. 34). However, many educators prefer to perceive competencies that are needed to enhance entrepreneurial behaviour and mindset in a more specific and analytical oriented manner. Figure 8.1 illustrates the selected competencies that could be developed by incorporating entrepreneurial practices into STEM education.

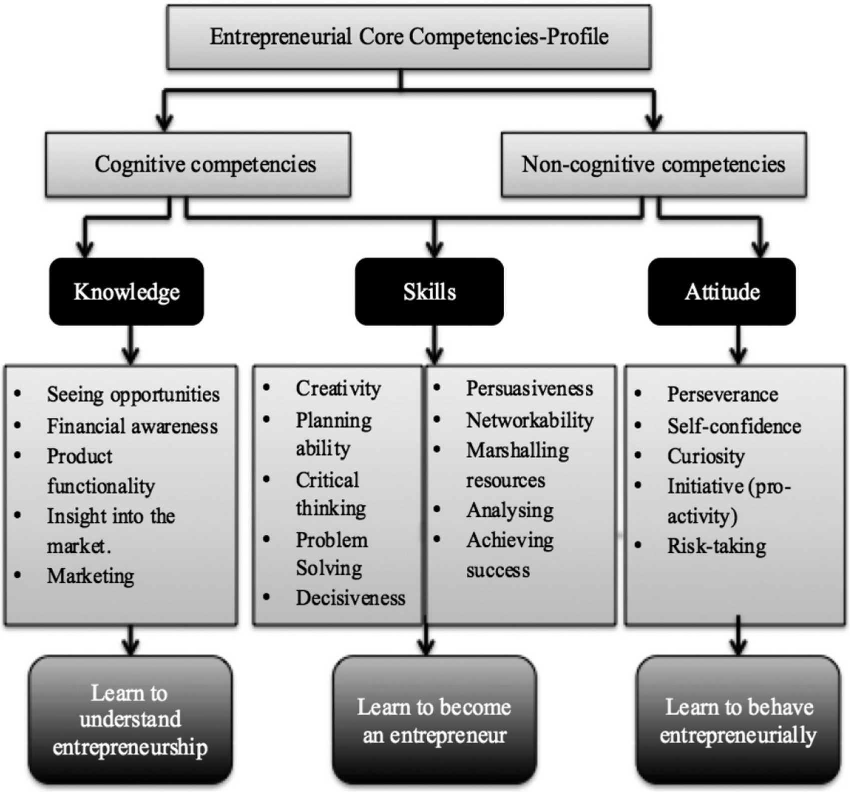

FIGURE 8.1 Student-competency profile of STEM learning

Figure 8.1 introduces twenty entrepreneurial competencies that form the student-competency profile that meant to be targeted through entrepreneurial STEM learning (E-STEM). Entrepreneurial cognitive competencies are some of the desired results of integrating entrepreneurial practices with other disciplines. Thus, cognitive competencies are considered as the necessary knowledge (Heinonen & Poikkijoki, 2006) and entrepreneurial skills needed for enhancing entrepreneurial initiatives. This chapter focuses on the basic cognitive competencies such as financial awareness, product functionality, seeing opportunities, insight into the market and marketing. These competencies are crucial to help students develop an awareness of opportunities as well as constraints about starting up new business (Kyndt & Baert, 2015).

Developing cognitive competencies is essential in an era that launches students in the direction of autonomous learning. An intensive body of research confirmed that STEM education enhances many of students' cognitive competencies that are recognized as fundamental in the labour market such as system thinking, communication, problem-solving and adaptability. However, many other competencies such as creativity, innovation, planning ability, problem-solving, critical thinking and making reasonable and logical decisions are not exclusively related to EE but they can also be developed through STEM education (Elizabeth et al., 2017).

Non-cognitive competencies such as communication and information competencies (Dedovets & Rodionov, 2015) are more likely to represent skills and attitudes of the students. There is an emerging body of studies that asserts the critical role of non-cognitive skills in predicting the outcomes of the market. Moreover, Heinonen and Poikkijoki (2006) listed competencies such as proactivity, initiative, independence, self-confidence, curiosity and persistence under the category of attitudes. In addition to risk-taking and the need for success that are considered as the most frequent characteristics of an entrepreneur. The non-cognitive competencies also include essential skills such as persuasiveness, social orientation and marshalling of resources (Foss & Klein, 2012) in order to facilitate turning students' creative ideas into action. When identifying which specific aptitudes are seen critical for new entrepreneurs regardless of their sectors, competencies like having insight into the market and perseverance were considered a positive indicator to perform entrepreneurial behaviour and to become and remain an active entrepreneur in the future (Kyndt & Baert, 2015).

Success is driven by the acquisition of the most relevant and appropriate knowledge, having as many experiences as possible to master the desirable skills and developing a positive attitude to proceed and overcome barriers (Tshikovhi & Shambare, 2015). Therefore, the following sections discuss the selected twenty-inclusive competency set that includes cognitively and non-cognitively oriented competencies. Many of these competencies can be generally developed in the context of STEM education and all specifically in entrepreneurial practices. Thus, STEM students are more likely able to acquire these competencies through applying and practicing the knowledge they learn in the educational setting of the E-STEM learning.

3.1 *Entrepreneurial Knowledge*

Entrepreneurial knowledge refers to "an individual's appreciation of the concepts, skills and mentality expected of an entrepreneur" (Jack & Anderson, 1999, p. 118). It is also perceived as the necessary information and useful experiences that have been learnt and successfully gained while carrying out an entrepreneurial activity in business. Moreover, it was articulated that consistent exposure to entrepreneurial practices help foster the acquisition and the development of this knowledge (Massad & Tucker, 2009). Thus, the role of the education system is to simplify activities that are supposed to be beyond students' capabilities in order to increase high school students' beliefs in their own knowledge and abilities.

Seeing opportunities is the ability to seize suitable opportunities attached to the entrepreneurial process (Rae, 2007). 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. Thus, this competency is related to seeking market opportunities through identifying and assessing them. In STEM education, students can develop this process more effectively as they often collaborate with partners to discuss the pros and cons of each opportunity (Hill, 2016).

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 (Rezaei-Zadeh, Hogan, O'Reilly, Cleary, & Murphy, 2014).

Product functionality is a cognitive entrepreneurial competency that refers to the overall ability or the function of the design made by students. It also refers to how each product facilitates users' tasks and addresses their needs (Tsakiridou & Stergiou, 2014). Developing this competency will help STEM students to identify their needs to implement the 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. Additionally, they will be able to identify the target customers of their products. One of the desirable outcomes expected from crossing the boundaries between EE and STEM is promoting students' design thinking and entrepreneurial attention.

Having insight into a 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 closely related to the students' orientation towards learning. Starting by identifying equivalent products that have been delivered to the market to provide customers with the same service (Kydnt & Baert, 2015). In this essence, students should identify the target audience that represent their customers and know what they are passionate about.

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, posters in or outside school, brochures, newsletters and emails. Furthermore, students should be aware of where they can find their customers in order to introduce their service or sell their STEM products to gain profits. Hence, marketing is regarded as "the management process of identifying and satisfying the requirements of consumers and society in a sustainable way" (Evans, 1995, p. 4).

3.2 *Entrepreneurial Skills*

Identifying instructive competencies for the current work environment is driven by the urgent need to alleviate variances between objectives of the learning process in the educational setting and necessities of the work market (Jamaludin & Hung, 2017). Therefore, a large variety of skills have been recognized in the EE literature as being essential to apply and incorporate entrepreneurial practices into education. Integrating these practices with STEM education can help students identify logical evidence that lead to formulating reasonable conclusions during their learning. Notably, STEM-related skills are progressively relevant to other fields and not exclusively identified with STEM disciplines. As, the framework of NGSS (2013) clarified, "learning about science and engineering involves the integration of the knowledge of scientific explanations (i.e., content knowledge) and practices needed to engage in scientific inquiry and engineering design. Thus, the framework seeks to illustrate how knowledge and practice must be intertwined in designing learning experiences in K-12 science education" (NRC, 2012, p. 11).

The chapter highlights ten entrepreneurial skills that are essential for both STEM education and entrepreneurial learning. The first five competencies are more likely to be considered as cognitive-oriented competencies, which can be successfully developed in the educational setting, while the second five skills are characterized as non-cognitive competencies in the literature, which are usually developed more effectively via real-life communication (Krueger & Sussan, 2017).

Creativity is the ability to imagine and think of new useful ideas. This cognitive skill is vital to design innovative products in the STEM class. Accordingly, teachers are asked to learn how to integrate creativity in their instructions; it is highly relevant to problem-solving strategy that is recommended for effective STEM implementation. Although it is difficult for teachers to teach creativity as a separate topic, it is still possible for them to plan and facilitate the learning process in order to support their students to practice thinking in a creative way.

Planning is a cognitive skill referring to the ability of students to structure a certain task. Hence, PBL is the best strategy to be utilized in STEM education where students work on complex as well as ill-structured problems to enhance their cognitive development (Capraro et al., 2013). Planning is an essential practice that allows students to think ahead in the light of specific vision to reduce expected risks (Kydnt & Baert, 2015). Accordingly, this ability is not only needed to solve STEM problems in a learning inquiry environment but also to establish a causal link towards starting a new business (Honig, 2004) because it allows students to organize, analyse data and make judgments regarding weaknesses and strengths of the work done. This ability is highly linked to resource skills that allow students to secure access to the required resources as well as to strategic skills that help them setting priorities and focusing on goals (Fisher et al., 2008).

Critical thinking is a cognitive skill (Harvey, 2018) that is defined as "the intellectually disciplined process of actively and skilfully conceptualizing, applying, analysing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action" (Scriven & Paul, 2007, p. 1). During working on STEM content or problem, students develop this mode of thinking whilst attempting to acquire better critical thinking disposition by applying the intellectual standards of reasoning (Forawi, 2016). Arguments found in the literature refer to the difficulty of teaching critical thinking and suggest applying integrated approaches to enhance the cognitive development of students. Neck and Greene (2011) argued that EE as an applied discipline gives entrepreneurs the opportunity to think and act like designers, requiring many cognitive skills such as critical thinking, creativity and problem-solving.

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 (Muir, Beswick, & Williamson, 2008). Anchored and practical instructions that are guided by project-based science and PBL are the main pedagogical methods utilized in schools to develop students' problem-solving abilities (Cooper & Heaverlo, 2013). Thus, the ability to solve ill-structured challenges is considered a crucial competency for STEM learning (Jamaludin & Hung, 2017) where students usually face unexpected issues to try to address them with a good degree of confidence. The experience of applications is as important as the theoretical knowledge for facing a complex situation in real-life.

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 (Rezaei-Zadeh et al., 2014). When consequences or results are not fully predictable, successful conclusions that lead to the right decisions are not only supported by eliciting information independently but also require experts 'and colleagues' advice whom have deep insights and meaningful experiences that allow them to offer important recommendations (Kydnt & Baert, 2015).

The following entrepreneurial skills with less cognitive characteristics (more non-cognitive) are usually interconnected with students' mindset (Menke, 2018). Additionally, they are also affected by students' inquisitiveness, sociability and adaptability. The literature of personality traits categorized them as agreeableness and openness, all of which can be taught and enhanced in the educational setting (Moberg et al., 2014).

Persuasiveness is a non-cognitive 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 (Oreg & Sverdlik, 2013). In order to develop such a communication competency, it is crucial to identify certain communication objectives that are needed as well as the possible communication methods during the learning process. Dedovets and Rodionov (2015) explained that communication competencies could be successfully acquired via STEM education where students often work independently to prepare a presentation plan in order to display their knowledge, evidence and decisions taken and to describe the obtained results during their STEM projects in an effective persuasive argument.

Networkability is a non-cognitive skill that refers to the social scaffolding dimension internal and external to the educational setting. On the one hand, students can assist and support each other in school through working on an inspirational-social environment to solve authentic problems in education (Gutwill & Allen, 2012) so, it refers to the effective relationships with adults outside the school atmosphere that can support students to create new channels to serve the learning process. Students demonstrate networkability in STEM classes by discussing ideas and offering advice while working on the same project. Building a network of assistance is a key attribute for any successful entrepreneur (Menke, 2018) in order to be provided with consistent facilitative and collaborative support to reach the learning goals.

Marshalling resources is a non-cognitive 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 (Moberg, 2014). It was observed that social capital plays a strong role in this process, which reflects the casual link between networkability and marshalling resources (Karlsson & Honig, 2009). This long process helps students experience managing ambiguity to implement their ideas. The literature of applied science advocated that STEM learning is a multifaceted process that allows students to exploit as ubiquitous resources as possible, such as human resources that require communication tools. Other resources that rely on information technology and tools, such as print-base resources (printers, copiers, fax, etc.), and media or digital resources (TV, smartphones and computers, video recording, internet, electronic mail, etc.), are all valuable to search and select necessary information (Dedovets & Rodionov, 2015). Utilizing all these resources allows students to expand upon the classroom experiences and get access to reliable knowledge from content-expertise (Hora & Oleson, 2017).

Analysing data is perceived as the ability to evaluate information in both inductive and deductive methods. Tsakiridou and Stergious (2014) explained that students who discuss and work together to assess complex situations to make well-balanced choices develop their analytical skills. Thus, the acquisition of these skills requires practices that allow students to collect and visualize data to understand the meaning behind certain facts. Moreover, it could also be the ability to deconstruct information on complex situations to verify the roots behind this challenge and identify its details. This requires the use of all the possible analytical tools such as graphs, tables and previous models that help understand the expected consequences of any decision.

Attaining personal success relies on the potential need of an individual to become an achiever, which is a non-cognitive competency that 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. A number of key scholars explained that achieving success is usually associated with narcissistic perceptions of entrepreneurs where their self-belief is based on the underlying desire to achieve the required end goals and the ability to recognize the potential challenges that may accompany it (Klyver, Hindle, & Schøtt, 2007).

3.3 *Entrepreneurial Attitude*

All the following competencies related to entrepreneurial attitude, revolve around students' beliefs on their ability to perform a task and face its obstacles. Moreover, researchers of personality attributes categorized these non-cognitive competencies as conscientiousness of individuals (Bengtson, 2013). A key element of these competencies is that they are not static like inherited traits, which means that they can be taught, fostered, developed and adopted through educational practices. It was found that entrepreneurial attitude is positively associated with entrepreneurial activities. Therefore, the acquisition of these entrepreneurial competencies is the key driver of entrepreneurial success (Rașcă & Deaconu, 2018).

Hence, *perseverance* is the process of being persistent when doing a task despite difficulties that might delay achieving the required objectives (Eisenberger, 1992). 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 vague situations (Scherer & Gustafsson, 2015). Moreover, there is no doubt that successful STEM students strive to complete their tasks, projects or designs though they are tired of its procedures. Thus, educational practices should be manipulated in a way that help students develop this strong entrepreneurial attitude to remain steadfast in the face of any adversities (Harris, 1994).

Self-confidence is a competency referring to students' belief in their ability to successfully achieve the task (Fisher et al., 2008). Students with high self-confidence 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 (Sanchez, 2011). Actually, Bandura (1994) explains that this competency cultivated throughout life and schools play a crucial role in its development, which means that learning can help develop students' confidence and justify self-efficacy in order to be able to work in stressful situations and to effectively deal with goal setting. Accordingly, students' confidence in their own capabilities could enhance their willingness to pursue and explore entrepreneurial opportunities (Tsakiridou & Stergiou, 2014).

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 new knowledge independently, and apply it in a different practice to solve its authentic problem. Satisfying your learning curiosity is not a simple process because it requires you to become a highly learning-oriented person who consistently searches for useful knowledge and enhances your overall performance. Moreover, curiosity launches students in the direction of being involved in new development activities in order to be provided by recent knowledge that is relevant to their interest (Lans et al., 2008).

Sense of taking the initiative and being a proactive individual refers to students' ability to turn their ideas into action and to tackle unexpected problems (Pepin, 2012). Having a proactive personality and action-oriented mindset is highly required. It is not only for effective STEM students because it is an indicator of their future performance in the workplace (Rodrigues & Rebelo, 2013), but also for developing students' entrepreneurial attitude towards setting clear targets and doing relevant plans (Guimarães, 2017). Action orientation is increasingly acknowledged by EE researchers as an essential ability that is strongly connected to the ability to recognize business opportunities.

Risk-taking is a competency referring to the propensity and the ability of students to take new risks and persist in intellectualism. STEM education as a creative process of inquiry encourages the approach of learning by doing through what is called "STEM rich-making activities" (Bevan, Gutwill, Petrich,

& Wilkinson, 2017, p. 1). This process is challenging at the school level as well as rewarding because STEM students can take risks to develop their ideas and make their own designs under the supervision of the program staff. Thus, it is a great opportunity for high school students to develop this competency to be able to recognize the probability factor within their decision and to deal more effectively with possible consequences (Kydnt & Baert, 2015).

4 Teaching Approaches of Entrepreneurship Education

Considerable discussion has been found in the literature regarding the ability to teach entrepreneurship. However, the debate was closed by a consensus of agreement on the possibility of teaching and learning its features (Henry, Hill & Leitch, 2005). Educating students to become entrepreneurs is different from educating them on how to act entrepreneurially (Jones & Iredale, 2010). Thus, most recently, however, the new debate has focused on the most appropriate methodology of teaching entrepreneurship to each grade level, which results in a call for a re-evaluation of the current pedagogy to emphasize teaching through an approach that works on students' abilities (Jackson, Scott, & Schwagler, 2015). The diversity of the approaches used across the world to apply entrepreneurial programs does not cause a conflict if they include business basic and focus on entrepreneurial thinking and competencies such as problem-solving and opportunity recognition (Neck & Greene, 2011). Accordingly, one of the core questions in the field of entrepreneurship is how entrepreneurial behaviour and competencies can be taught or developed in education. In this essence, researchers of entrepreneurship differentiated approaches of teaching EE based on learning goals of the organization where the curriculum and its assessment are also influenced by these goals (Pepin, 2012). Thus, EE has mainly focused on the content knowledge at the tertiary level because students can communicate more closely with the labour market. This focus is shifted from content to pedagogy in the lower levels of education to develop students' entrepreneurial skills (Pepin, 2012).

Two leaders in the field of entrepreneurial pedagogy emphasized, "the analytical approach of teaching opportunity evaluation, feasibility analysis, business planning and financial forecasting is the cornerstone for most entrepreneurship curricula today" (Neck & Greene, 2011, p. 57). However, many scholars within this field strongly argued that structuring the learning process is the most effective method to enhance the entrepreneurial characteristics of the students (Hannon, 2006). The argument revolves around whether the attention should be given to the content knowledge or pedagogical knowledge

TABLE 8.2 Differences between education for and through entrepreneurship

Differentiated elements	Education for entrepreneurship	Education through entrepreneurship
Perspective	Content-oriented perspective	Pedagogy-oriented perspective (Jones & Iredale, 2010)
Purpose	Enrich declarative knowledge (Larson, 2000)	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 (Johannisson, 2010)
Outcomes	Knowledge about how to start a venture and how to make a business plan (Cunha & Heckman, 2010)	Social and character qualities 'attentiveness, sociability, self-esteem, perseverance, motivation & forward-thinking behaviour'
Teaching method	Lecture-based education (Mwasalwiba, 2010)	Practice-based education
Foster	Cognitive entrepreneurial skills	Non-cognitive entrepreneurial skills
Enhance (Moberg, 2014)	Negative engagement of students in the learning process	Positive engagement of students in the learning process

(Jones & Iredale, 2010) that is whether the emphasis should be on 'education for entrepreneurship or education through entrepreneurship' (Hannon, 2005). Therefore, the extent to which students are close to the workplace is an important factor that should be considered while selecting the appropriate teaching approach of EE.

Table 8.2 differentiates the two approaches of EE according to Moberg (2014). The first approach reflects the possibility of teaching entrepreneurship in isolation as an educational discipline, while the second approach emphasizes integrating entrepreneurial practices in order to promote entrepreneurial initiatives through developing students' competencies.

Having said that educators and policymakers have been concerned for quite a long time about supporting the student' acquisition of the necessary aptitudes and knowledge required to function effectively in a world that is progressively oriented to and affected by technology, science and innovation (Epstein & Miller, 2011). Acting in an entrepreneurial way and exercising entrepreneurial competencies are essential in the current society because of its uncertainty and constant change. As a result, it was contended that enhancing students' abilities to think about innovative ideas and being able to carry them out in creative ways should become a priority in the educational sector whether those ideas are capitalized as creating a new venture and working on its consistent success or innovative attempts within established organization (Foss & Klein, 2012). However, incorporating entrepreneurial climate into 1scientific disciplines that has a reality-based focus to meet the rigors in academia is challenging to apply in a learning experience environment (Solomon, 2007). Therefore, communication with actual practitioners of the teaching and learning approach can positively impact reform efforts in education and eliminate its challenges (O'Sullivan, 2015). EE does not have a stereotypical form for its measurement. Therefore, the learning focus, objectives and expected outcomes of EE are varied for each age group applying its practices. In this essence, Lackéus (2015) designed the graph in Figure 8.2 to illustrate the focus of EE in each learning stage in education.

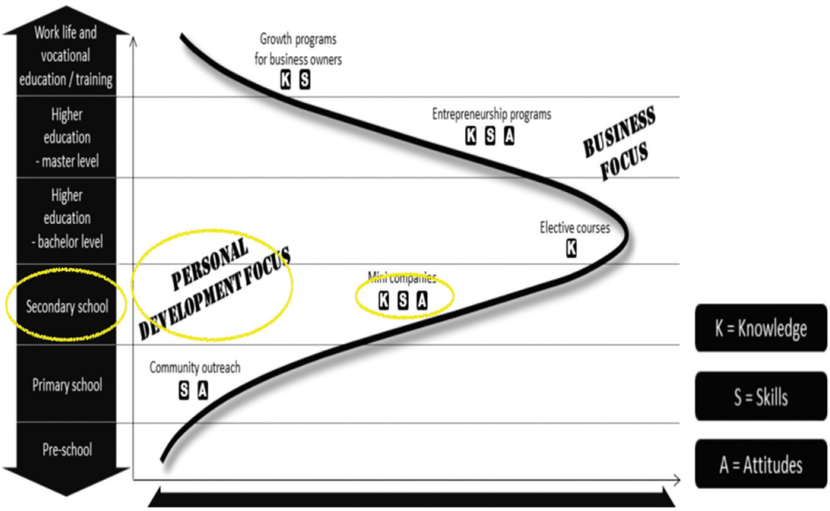

FIGURE 8.2 The focus of entrepreneurship in different educational stages (from Lackéus, 2015, p. 8)

Figure 8.2 illustrates that the main focus of entrepreneurial learning in the stage of secondary school (circled in yellow), 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 high school stage through experiential learning activities to be prepared for the EE as an elective course in higher education (Lackéus, 2015).

5 The Relationship between Entrepreneurship and STEM Education

Although entrepreneurial practices in STEM education may not be as well integrated or incorporated as they could be, the existence of many of the key entrepreneurial competencies arise in STEM research (Hill, 2016). Nonetheless, Atkinson and Mayo (2010) explained that entrepreneurial practices in the US have been recognized as an important mechanism within STEM classes to help accelerate students' entrepreneurial behaviour. Generally, research on entrepreneurial learning has shown that students who study entrepreneurship-related disciplines have more opportunities to develop an entrepreneurial intent than other students who do not have the chance to practice entrepreneurial learning in education (Hallam et al., 2015). The reason behind this fact is that students tend to gain positive entrepreneurial attitude if they have had past entrepreneurial experience in adding value or starting a business that provide them with the basic knowledge regarding the process of entrepreneurship and its prioritization as well. Thus, these educational experiences about entrepreneurial learning can place pupils ahead of market competitors lacking this valuable practice. In addition to providing students with the essential knowledge and skills, educational experiences about entrepreneurship help reduce students' anxiety regarding the ambiguous issues associated with launching new business. According to that, an empirical study found that the entrepreneurial intent is more among learners who studied business and were exposed to entrepreneurial events than students who solely studied STEM (Hallam et al., 2015). Therefore, it was suggested to integrate entrepreneurial practices into STEM education to launch STEM students in the direction of the entrepreneurial path (Ezeudu, Ofoegbu, & Anyaegbunnam, 2013; Winkler et al., 2015). Without this integration, the likelihood that STEM students will develop entrepreneurial thinking or pursue a clear entrepreneurial direction is low. Accordingly, researchers in education have argued that students should be provided with the new learning opportunities that help engage them in a wide range of integrated learning tasks and activities outside school in order to develop the core competencies needed for the workplace (Asghar, Ellington, Rice, Johnson, & Prime, 2012).

The literature explained that there are many educational practices that have been proven to be successful in infusing entrepreneurial activities into STEM education. Prior results of these empirical studies have mentioned in order to build upon. The complexity level of the application of a maple-seed robotic flier (MRF) in STEM classes enhances students' development of their designs and encourages entrepreneurship (Aslam et al., 2014). Furthermore, learning through STEM-rich tinkering has positive effects on enhancing the STEM workforce and advancing entrepreneurship. A previous study identified three important phases for enhancing entrepreneurial initiatives that are exploration, evaluation, and exploitation in which certain skills are associated with each phase. The exploration phase requires creative ability in order to identify proper opportunities while planning ability and financial awareness are needed for the evaluation phase. Finally, the exploitation phase requires resource marshalling, teamwork and managing ambiguity or uncertainty (Moberg et al., 2014). More interestingly, it was argued that entrepreneurial STEM instructors prevail with regards to making imaginative and transformative learning situations, both inside and outside their own particular classrooms, to such an extent that the quality and amount of STEM learning results are uniquely superior in comparison to outcomes of the traditional educational setting (Abd-El-Khalick, Gaffney, Price, Koehler, & Martin, 2011).

6 E-STEM Best Pedagogies

The best pedagogies of E-STEM learning require reference to the associated pedagogies for STEM education as well as EE.

In general terms, teaching is perceived and interpreted as the effective act of supporting a student to learn (Kolb & Kolb, 2005). According to Johnson et al. (2014), the discussion about teaching paradigms has been shifted from how knowledge is presented and transferred from a teacher to learners to how knowledge taught is perceived by the learners. In order to achieve this endeavour, the focus of the pedagogical relation in teaching has to be changed from a teacher-student-relation in which the content knowledge is the only transported product or the medium of this relationship to a student-subject-relation in which the teacher or the instructor is the facilitator of this relationship. The literature gives special importance to the pedagogical relationship between the main elements of the teaching and learning process, which are the teacher and the students as well as the content knowledge or the subject taught. In this regard, the teacher-student-relation is usually emphasized in the deductive teaching methods that focus on raw knowledge, facts and principles. Whereas student-subject-relation takes place more successfully in the inductive teaching methods that give emphasis to values, experiences and skills that solve real problems (Sidhu et al., 2015). Thus, the "didactic triangle" (Johnsson et al., 2014,

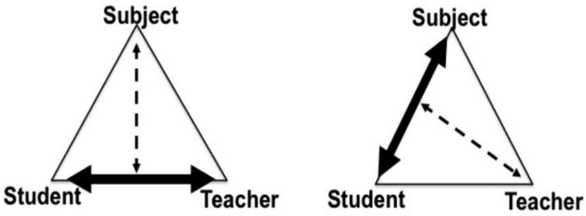

FIGURE 8.3 Didactic triangle to show the transferred focus of the teaching paradigm

as cited in Aaltio & Eskelinen, 2016, p. 338) was introduced to illustrate how the teaching paradigm was shifted in Figure 8.3.

Figure 8.3 demonstrates how the emphasis of teaching paradigm was shifted from students-teacher (the left triangle) to student-subject (the right triangle) to generate more independent learners who can address workplace challenges. The STEM literature introduces a wide range of pedagogical approaches including strategies, models and frameworks that are used to apply STEM in the classroom. Three main approaches (silo, embedded and integrated) are currently being applied to teach STEM in schools. The degree of STEM content used is the measurement of the distinction between these methods.

First, the silo STEM approach refers to isolated instruction that gives more focus to knowledge acquisition and depth of understanding of each subject through a teacher-driven classroom (Dugger, 2010). Second, embedded STEM instruction emphasizes the acquisition of knowledge through problem-solving of different real-life contexts. However, it might lead to fragmented learning because if students do not have prior knowledge regarding the embedded course content, the teacher must cover this lack of knowledge separately (Hmelo & Narayanan, 1995). Third, the integrated approach where all course contents are taught as one subject (Breiner, Harkness, Johnson, & Koehler, 2012). Moreover, specific standards from each subject matter that have been incorporated with the STEM implementation to solve a real-life problem should be evaluated in an experiential learning environment (Sanders, 2009).

Proponents of STEM reform suggested that an integrated approach is the most effective instructional approach because it helps students to develop valuable learning competencies through PBL/PjBL practices in a multidisciplinary or interdisciplinary integration (Wang, Moore, Roehrig, & Park, 2011). Thus, interdisciplinary integration is defined as a common approach of integrative instruction that, "focuses students' attention on a problem and incorporates content and skills from a variety of fields" (Roberts & Cantu, 2012, p. 113), while multidisciplinary integration requires connecting or linking content knowledge from different disciplines at different time in different learning settings (Wang et al., 2011). It should also be taken into consideration that teacher quality is an important determinant that impacts students' learning because their qualifications including knowledge, beliefs and practices that they bring to the educational field are positively related to students' outcomes (Hedges et al., 1994).

In this essence, it was argued that teachers' pedagogical training is required to help them master the integrative approach-based instruction as they often face difficulties in implementing its practices (Williams, 2011). Consequently, negative effects that eliminate students' understanding such as the potpourri effect or polarity effect may occur as a result of teachers lack structure in the classroom. The potpourri effect of ill-structured instruction takes place when teachers incorporate or integrate different knowledge from different disciplines, while they are not able to identify a common learning intention or to create one objective. Furthermore, the polarity effect appears when teachers become marginalised over explicit course content restricting the consolidation of other disciplines' content (Jacob, 1989). In order to avoid such negative effects, teachers should be trained to be able to select the appropriate teaching instruction and implement its features successfully (Roberts & Cantu, 2012).

The historical perspective of integration clarifies that integrated curriculum was primarily connected to PjBL in the 1920s, and then it was perceived in conjunction with PBL in the 1940s and finally linked with experience-based practices, which refers to experiential learning. However, educational researchers believed that "There is no unique or single pedagogy for integrative interdisciplinary learning" (Klein, 2005). Since the thinking paradigm was shifted from single teaching method to integrative learning practices either through content integration or process integration in order to support the educational reform (Taylor, 1969). Accordingly, the literature demonstrated the distinctive features of the experiential learning that differentiate its instruction from traditional formal methods.

Table 8.3 identifies the main aspects of differentiation according to Moon (2004). Hence, effective implementation of STEM activities takes place through different learning pedagogies that include either PBL (Sari et al., 2018) or PjBL in the school setting. While integrating entrepreneurial practices required involvement in the field of the market to create new value or to start new business in order to achieve the anticipated objectives of this incorporation (Lackéus, 2015). In this regard, incorporating entrepreneurial practices into STEM education can be instructed more successfully with integrative approach-based experiential practices like project-based problem solving with the help of business teachers (Eltanahy, Forawi, & Nasser, 2020).

TABLE 8.3 The main differences between experimental and traditional learning instructions

Differentiated elements	**Experiential learning instruction**	**Traditional learning instruction**
Technique	Unusual and creative	Formal and conventional
Nature	Learning by doing and discovering	Learning by listening and following
Learning responsibility	Students are more responsible about the learning process	Instructors are fully responsible about the learning process
Learning context	In the classroom as well as in different real-life contexts	Only in the classroom
Resources	Unlimited sources of knowledge	Only academic textbooks
Expected outcomes	Different for each student	The same for all students
Reflection	Is highly required	Rarely needed

PBL used in education today as an example of experiential learning strategies was originally developed from innovative health sciences curricula to improve medical education in North American. Thus, the need for applying a hypothetical-deductive reasoning process to learn the required content knowledge through PBL was recognized as a method of teaching medical students to cope with the rapid changes in scientific knowledge, theories and practices (Barrows, 2000). In this regard, Anderson (1980) explained that the process of solving problems is a significant cognitive activity because it requires conducting a sequence of cognitive operations to achieve a certain goal.

There is no certain sequence to represent the implementation of PBL. However, the characteristic of the structure of PBL was outlined by educational researchers and implemented recently in an empirical research study in the field of STEM education (Sari et al., 2018). Five stages are emphasized to implement effective STEM project-based problem solving (STEM PjBPS) that are problem Identification, data collection, research process, transferring and designing, and communication.

Prominent researchers investigated the nature of the problem required in the interdisciplinary STEM education, and their results recommended using complex scenarios to enhance students' acquisition of advanced skills such as analytical and critical thinking, metacognition, creativity, collaboration, innovation and self-directed learning (Asghar et al., 2012). PBL strategy is highly supported by the constructivist theory because it allows collaborative students to work independently and build on their own knowledge (Vygotsky, 1978). Accordingly, the educational philosophers advocated the strong relationship between PBL implementation and successful STEM learning and explained that PBL is one of the most effective pedagogical strategies in teaching and learning STEM concepts (Capraro et al., 2013). According to Roberts and Cantu (2012), this strategy is called a "design-based problem-solving process" (p. 111).

Similarly, student-centred learning is a main feature for PjBL but with more explicit guidance by the teacher. However, product creation is needed to solve authentic problems (Savery, 2006). The literature asserted that combining PjBL with STEM education can foster the effectiveness of the learning process and influence students' positive attitudes because of the meaningful learning opportunities that are offered to them through the implementation of this approach (Tseng et al., 2011). Moreover, PjBL is considered as one of the important approaches in STEM learning because it helps scholars to implement better academic rigor (Edmunds, Arshavsky, Glennie, Charles, & Rice, 2017). Through applying project-based instruction, students are guided to employ integrated STEM knowledge in unique ways to represent a model that achieves the learning objectives. Therefore, this instruction empowers learners to promote scientific and mathematical thinking by refining their pre-existing understanding, applying innovative technologies and discovering new concepts and principles in a project-based environment (Wilhelm et al., 2013).

IBL is built on posing and investigating a certain scientific question; however, it may not really be guided by any problems or result in designing a product (NRC, 1996). However, scientific inquiry can be linked to STEM education by formulating or posing questions to be answered through applying the features of effective inquiry process to inform learners before they become engaged in the STEM design that solves a certain problem (Kennedy & Odell, 2014).

Johnson (1993) explained that student' intentions are not influenced by applying abstract principles in the classroom setting. Rather, more engagement in real-life problems is highly effective in developing reasoning skills that are needed to generate future decision makers. More recently, a study conducted to identify the skills needed to become an entrepreneur recommended rethinking about the pedagogical approaches implemented in education regarding entrepreneurship to focus more consistently on real-life situations through PjBL and PBL practices (Sousa, 2018). Furthermore, the literature explained that EE is not excluded from business start-up. However, it refers to all successful walks of life that lead to inspiring learners to be more creative, innovative and opportunity oriented. In this regard, the ability of students to create value for others is considered as the common core of entrepreneurship, while business start-up is viewed as one of the several diverse ways for creating value. Accordingly, Lackéus (2015) suggested focusing on the value creation when infusing entrepreneurial practices into education to be able to identify students who show positive aptitude and develop interest in order to motivate and launch them in the direction of starting-up new business. More interestingly, the results of Birdthistle, Costin and Hynes (2016) recommended engendering entrepreneurial competencies in secondary students through experiential learning activities that emphasize entrepreneurial practices.

The current discussion suggests that "entrepreneurship is when you act upon opportunities and ideas and transform them into value for others. The value that is created can be financial, cultural, or social" (Moberg et al., 2012, p. 14). This definition is grounded in the emphasis on value creation as a key concept of entrepreneurial learning as well as the main goal for learners. In this essence, Lackéus was inspired by the notion of 'Learning by doing', John Dewey labelled the entrepreneurial learning approach a "Learning-by-creating-value" (Lackéus, 2015, p. 11) to emphasize the main objective of incorporating the entrepreneurial learning in order to help teachers realize and apply the best pedagogical intervention that help students learn to add value for the community. The notion of entrepreneurial value creation could result in the development of entrepreneurial competencies because it enhances students to learning knowledge, acquiring skills, motivating attitudes that all can be used to facilitate business start-up (Bruyat & Julien, 2001).

7 Conclusion

Several competencies discussed within this chapter are associated with entrepreneurial behaviours, share resemblance with competencies acquired in STEM classes as well as competencies, which are emphasized as essential to create a value for others and/or to start a new business. The literature suggests that incorporating entrepreneurial practices into STEM education can better develop the key entrepreneurial competencies of STEM students by turning their innovative ideas into economic impacts. Nevertheless, this might not always be the case because it is not a prerequisite for high school students to run their own business. Thus, value creation is the main emphasis during education in high school.

Hence, it was noticed that intentionality could drive learning for better outcomes. There is no doubt that learning and practicing entrepreneurial activities during STEM classes in the school stage is crucial to increase students' awareness of developing a purpose by turning their attention to the need of their STEM designs instead of wasting their valuable time making useless products that are not needed in the real market. Project-based problem solving is the best pedagogy to implement interdisciplinary E-STEM learning in an experiential learning environment to enhance students' entrepreneurial competencies. According to this, the objectives from designing STEM products will be shifted from broadly educative goals to more concrete purposes which will help students to commit themselves to life-long practice launch them in the direction of self-improvement.

At the same time, implementing integrated practices of both entrepreneurship and STEM education help accelerate students' understanding of entrepreneurship and promote their ability to achieve an entrepreneurial mindset. Accordingly, the development of a practical model of E-STEM learning to incorporate entrepreneurial practices into STEM education is needed. Thus, educational models of E-STEM should be inherently interdisciplinary because during its implementation, students should know the nature of materials used (science), they should search and present their work progress (technology), they should design their own products (engineering), they should use measurements and proportions (mathematics) and they should create values or deliver their products to the market (entrepreneurship). This incorporation can foster students' entrepreneurial behaviour in their life journey and motivates them towards self-employment in the future in order to enhance the economic competitiveness of the country.

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