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ORIGINAL PAPER

STEM leaders and teachers views of integrating entrepreneurial practices into STEM education in high school in the United Arab Emirates

Marwa Eltanahy[1] · **Sufian Forawi**[1] · **Nasser Mansour**[2]

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Abstract

Acting in an entrepreneurial way and exercising entrepreneurial competencies are essential in current society because of its uncertainty and constant change. That is why it is contended that enhancing students' abilities to design innovative products and being able to deliver them to the market become a priority in the educational sector. A sequential exploratory mixed method was conducted to collect both qualitative and quantitative data needed to fulfill the purpose of the study. The theoretical perspective adopted relies on education through entrepreneurship where the aim of interdisciplinary E-STEM learning is to incorporate entrepreneurial practices into STEM education in high school. Focus group interviews were employed to explore STEM leaders' views regarding incorporating entrepreneurial practices into STEM education. Variables identified were used to develop a questionnaire for STEM teachers to investigate their perceptions regarding current STEM practices that enhance students' entrepreneurial skills. Academic leaders believed in infusing entrepreneurial pedagogies into existing STEM curriculum with a constant support of business teachers because they are more aware of entrepreneurial learning activities than other teachers in school. Conclusions from the study argue that competency-based approach is preferable to implement E-STEM learning because it allows for a new situated learning platform where value creation practices could be integrated with project-based problem-solving practices in the UAE.

Keywords STEM education · Entrepreneurial learning · Interdisciplinary approach · UAE

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✉ Marwa Eltanahy
marwatanahy@gmail.com

Extended author information available on the last page of the article

Introduction

Education has a great responsibility in preparing pupils for the workplace, as they may become employers (entrepreneurs) or employees (Okeke 2007). The organization for Economic Cooperation and Development (OECD) (2016) called for enhancing the educational outputs in the United Arab Emirates (UAE) because "the coexistence of high unemployment and skills shortages in much of the Arab world illustrates that producing more of the same graduates cannot be the answer" (p. 3). Accordingly, the Science, Technology and Innovation Policy (STIP) was launched in November 2015 (UAE Government 2019) to emphasize and reflect the purposeful transition toward a knowledge-based economy in UAE (Farah 2012). Thus, UAE National Agenda 2021 set ambitious goals that primarily target science, technology and innovation (STI) as important indicators to support the dynamic government drive. Consequently, students in high school should be trained via meaningful practices that integrate Science, Technology, Engineering and Mathematics (STEM) in order to foster innovation and increase entrepreneurial opportunities among learners (World Bank 2008).

It is worth knowing that curriculum evolution in most Arab countries including UAE has been influenced by the updated educational reform and curriculum development happening in western countries in spite of culture differences between western and non-western countries (Dagher and BouJaoude 2011). STEM is considered a form of interdisciplinary inquiry that emphasizes teaching meaningful knowledge from integrated subjects in a student-centered environment to solve real-life problems (Capraro et al. 2013).

STEM students are provided with learning opportunities that challenge them to generate innovative designs. The question is: What is the point of those STEM initiatives? It seems that such creations could be easily lost unless involving basic understanding of the market (Hershman 2016). This reflects the logic of adding one more E to STEM to become E-STEM. The new E stands for integrating entrepreneurial learning into STEM education to make use of STEM efforts by delivering its outcomes to the market. Therefore, it was recommended to restructure STEM education to include entrepreneurial practices to change the environment of the STEM context to be business-like (Ezeudu et al. 2013). Consequently, there is a growing urgency to close the skills gap by developing the structure of STEM education to better support the economy (Kelley and Knowles 2016). Therefore, STEM educators were invited to embrace a contextualized approach to entrepreneurial learning in the STEM framework to support and expand the larger entrepreneurship ecosystem (Winkler et al. 2015). Thus, understanding actual STEM learning opportunities that are currently available is critical to instilling entrepreneurial mindset in STEM students. Moreover, investigating how entrepreneurial practices can be incorporated into STEM education in UAE is warranted to enhance restructuring STEM education and to promote students' entrepreneurial identity and career choice.

The relationship between entrepreneurial learning and STEM

Entrepreneurship education (EE) has mainly considered as a stand-alone subject that is usually offered as an elective course to learners in business-related studies. Thus, diffusing entrepreneurial activities to be accessible to all students of different streams in high school is a real challenge that requires interdisciplinary approach to raise students' awareness of the entrepreneurial act (Wilson 2008). Mayer (2004) explained that integrating knowledge from different subjects provides students with better learning environment. There is an ongoing discussion in EE literature about how to incorporate entrepreneurial applications into existing course framework because it acts as a catalyst for economic growth. Oganisjana et al. (2014) conducted a qualitative study through implementing "holistic interdisciplinary teaching and learning entrepreneurship promoting methodology" (p. 447) that proved the appropriateness of this pedagogical strategy on facilitating entrepreneurial culture among school students. Furthermore, it was statistically proved that Emirati students from both girls and boys have equal desire to scientific and mathematics-oriented careers. However, educators should assist students who have lack of motivation and job aspiration through creating new educational tools that are able to explicate links between educational coursework and future career goals (Forawi 2014).

Teaching approaches of entrepreneurial learning

Hence, educating students to become entrepreneurs is different from educating them to act entrepreneurially (Jones and Iredale 2010). Researchers of EE differentiated the approaches of teaching its practices based on the learning goals of the organization where both curriculum and assessment are influenced by these goals (Deuchar 2004). In the tertiary level, EE has mainly focused on content knowledge of entrepreneurship that launches students in the direction of being entrepreneurs who are able to establish a new venture because students can communicate more closely with the labor market (Katz 2008), whereas the primary focus of EE is shifted from content to pedagogy in lower levels of education to develop students' entrepreneurial skills (Pepin 2012) because it is not easy for high school students to convey entrepreneurial content to the market. Scholars within this field strongly argued that structuring the learning process is the most effective method to enhance entrepreneurial characteristics of students (Hannon 2006). The proponents of education for entrepreneurship have the content-oriented perspective, which encourages education to introduce entrepreneurship to students in higher education to motivate them to consider a career as self-employed, which requires teaching entrepreneurship in a separate subject. Conversely, the pedagogy-oriented perspective is usually for the proponents of education through entrepreneurship (Johannisson 2010) where the focus is mainly on developing core entrepreneurial competencies of the students (Mahieu 2006) through integrating entrepreneurial practices with other disciplines. Essentially, entrepreneurial learning should be taught to students as a method not as knowledge.

Core entrepreneurial competencies

Competencies have been perceived as the aptitude helps apply a combination of skills and information in a specific professional context (Lans et al. 2011). Dedovets and Rodionov (2015) explained how the interdisciplinary approach in STEM increases authentic learning opportunities that enhance students' creative abilities and cognitive skills. Beyond the acquisition of disciplinary knowledge, STEM education enhances students' intra-disciplinary skills such as creativity, problem solving and critical thinking skills (Murphy et al. 2018) that all are essential to create new value in order to serve the community in an entrepreneurial endeavor. Conversely, the implementation of entrepreneurial practices, such as making a business plan, collecting and analyzing relevant information, considering benefits and relative costs and applying alternative solutions to solve unexpected problems, is critical influences that help develop personal competencies of students. Drawing upon education through entrepreneurship, non-cognitive competencies should be emphasized during incorporating entrepreneurial practices into STEM education (Moberg 2014), whereas STEM practices usually give more focus to cognitive innovative skills such as problem solving and critical thinking (Branes et al. 2014).

Theoretical framework

Incorporating entrepreneurial practices into STEM education is supported by both interdisciplinary, social constructivist and situated cognition theories because they provide an educational foundation of constructing new knowledge through integration in a social learning environment. This will guide the path of the study to focus on structures that emerge from integrated knowledge-based social learning experience. Interdisciplinary theory refers to integrating knowledge of different disciplines that are related to a particular issue (McGrath 1978) in order to address challenges that are too complex to be properly tackled by a single field (Jacobs 1989). A wealth of interdisciplinary literature asserted that implementing interdisciplinary approach promotes students' ability to produce innovative ideas in both business field (Razmak and Belanger 2016) and STEM field (Jong et al. 2014). Furthermore, Vygotsky (1987) explained that social environment is a critical factor to construct new knowledge through effective learning experiences. Social constructivist theory emphasized many pedagogical elements such as construction, cognitive skills, authentic tasks and collaboration that can be translated into educational practices (Lin and Hsieh 2001). Accordingly, many pedagogical approaches were derived such as project-based learning (PjBL) and problem-based learning (PBL) where learning is best experienced through hands on activities that enhance students' skills (Ronis 2008).

Purpose of the study

The main purposes of this inquiry are to explore educational leaders' views about incorporating entrepreneurial practices into STEM education in UAE, and to explain effective practices within STEM classes to enhance this incorporation in light of STEM teachers' perceptions. Accordingly, the current study is carried out to answer the following questions:

- What are educational leaders' views about incorporating entrepreneurial practices into STEM education in the UAE?
- What are STEM teachers' perceptions regarding effective practices within STEM education that enhance entrepreneurial learning in the UAE?

STEM Context in the UAE

UAE's system of education has three main sectors (public, private and higher education). Majority of public schools adopt the Arabic curriculum and few of them implement science and mathematics curricula in English, whereas 17 of different types of curricula are implemented in different private schools. Ministry of education (MOE) as a federal government authority governs all UAE private schools except those in Abu Dhabi (regulated by ADEC) and in Dubai (regulated by KHDA). Both of the regulators ADEC and KHDA are not federal but emirate-level government authorities. However, all of these three powerful educational bodies (ADEC, MOE and KHDA) emphasize the education reform and keep UAE cultural identity, local principles and valuable tradition preserved. The vision of UAE was outlined in 2010 for the next eleven years and stated that UAE aims to stand as one of the best countries all over the world (UAE Vision 2010). In order to achieve this great ambition, science, technology and innovation were considered as a remarkable policy in the National Innovation Agenda of UAE where main national priorities were identified to witness significant economic revolutions. Education has to work harder to support the new vision of UAE economy where promoting both technology and innovation has perceived as the main cornerstone in the transition of the economy from oil-based to knowledge-based. Owing to this emphasized vision, education was identified as the most significant sector in UAE that carries the responsibility of building a competent human capital in order to support economic development.

UAE believes that innovation is driven by continuous improvement that requires curiosity, taking risks and inquiries (MOE 2010). Consequently, Abu Dhabi education announced its move to a unified STEM curriculum in a group of public schools that puts more emphasis on STEM subjects to meet the demand of UAE labor market (Pennington 2017). It was found that UAE students were excited in learning scientific concepts through inquiry learning instruction to prompt their learning skills (Eltanahy and Forawi 2019). In spite of being an engineer and physician were at the top five preferable future career choices determined by UAE students, they desire to finish all education stages before deciding on pursuing a profession. Thus, it was suggested to enrich students' learning experiences to inspire their future choices (Forawi 2014). Accordingly, Eltanahy (2018) argued that an explicit STEM policy is needed as a unified guide for private and public schools in UAE in order to implement STEM more successfully. It was recommended to connect learning outcomes of high school students to real job tasks in spite of being distant to the employment or work responsibilities (European Commission 2003).

Methodology

A mixed method approach was carried out to collect data needed to fully answer the research questions. Through exploratory sequential design, data were collected in two phases in order to develop E-STEM model that incorporates entrepreneurial practices into STEM education. Six public schools in different emirates were recruited to contribute to the current inquiry because they implement the unified STEM curriculum.

First, qualitative data were collected through semi-structured interviews in light of the "constructivist grounded theory" (Mills et al. 2006, p. 26). Two focus group settings were conducted with twelve of STEM leaders and curriculum developers who work for a group of campuses distributed among six emirates in UAE. These interviews sought to explore STEM leaders' views regarding how entrepreneurial practices could be incorporated into STEM education. Interview participants were selected purposefully through a snowball sampling technique to identify variables in relation to the proposed incorporation. In the first meeting, seven female leaders volunteered including lead teachers of mathematics, science, engineering and technology as well as a curriculum developer. Based on data given at this meeting, two lead teachers from business department (male and female) were recruited to attend the second meeting who included another three female academic leaders from mathematics and technology departments.

Interviews

The interview protocol consisted of four primarily open-ended questions that were posed earlier to guide the interview path and to keep participants focused on the phenomenon being discussed (Kvale and Brinkmann 2009). Each interview sitting averaged between 70 and 85 min in length to allow for probing and to encourage leaders to provide the maximum amount of appropriate and useful information. To enhance the internal reliability of the qualitative data analysis, the transcript was given to another academic researcher to work independently in order to capture salient themes of responses (Ajzen 1991). Accordingly, qualitative data were analyzed by coding and recoding to answer the first study question; then, results were expanded in the second quantitative phase.

Second, quantitative data were collected through a paper-based questionnaire for STEM teachers in participating schools to be recruited conveniently. Variables identified were used to develop this questionnaire that aimed to explain current effective STEM practices that enhance incorporating entrepreneurial learning in STEM classes. Thus, 154 eligible responses were received from participating schools. The quantitative data collected were analyzed descriptively through measuring the frequency and percentages of its elements to answer the second study question.

Questionnaire

The questionnaire consists of two main sections. The first section asked about 3 demographics including gender, emirate and subject taught, followed by another section to investigate current STEM practices with 14 standardized elements measured by a 5-point Likert scale (5 = always applied, 4 = often applied, 3 = occasionally applied, 2 = rarely applied and 1 = never applied). Items from 1 to 11 aimed to investigate the extent to which teachers emphasize applying PBL/PjBL practices in their STEM classes to promote entrepreneurial learning in addition to three items that focus on current practices concerning value creation.

Validity and reliability

A pilot study was conducted as a simple scale methodological test where 39 science, technology and mathematics teachers were employed conveniently to respond to the questionnaire. Thus, SPSS was used to measure the reliability of this new instrument to indicate high consistency with Cronbach's Alpha 0.804. Moreover, an educational expert evaluated the appropriateness of the instruments format to enhance content validity. Additionally, all ethical dilemmas were considered. A consent letter was given to the head office of participating schools to explain the main purpose, objectives, significance of the study in order to enhance research accessibility. Research participants were informed that anonymity is kept confidential and they have the right to withdraw anytime from the study (Creswell 2009).

Data analysis

Both qualitative and quantitative types of data were analyzed separately. Methods of data analysis were selected based on the nature of each type.

Qualitative data analysis

Analyzing qualitative data collected from the constructivist grounded theory began immediately with initial contact with STEM academic leaders to answer the first study question and to explore variables of the phenomenon being studied. Then it continues with the progress of the grounded theory development, which means that activities of gathering qualitative data and analyzing them were continual and concurrent. The study adopted the interactive model for Miles and Huberman (1994) to analyze qualitative data. The model consists of three fundamental components that are data reduction, data display and drawing/verifying conclusion that were used to analyze the initial dataset from the academic leaders' interview in order to identify main themes to be utilized to develop the questionnaire for the second stage of data collection.

Quantitative data analysis

The quantitative data of the teachers' questionnaire were analyzed descriptively through measuring the mean, standard deviation and percentages of all items of the instrument to answer the second question. Furthermore, an examination of differences was applied among the main three demographic variables.

Findings

Qualitative results of educational leaders interview

Four open-ended questions were asked in the interviews. Accordingly, themes were identified by coding and recoding to elicit variables needed to develop the questionnaire for teachers.

E-STEM advantages

All participating lead teachers who were from business, mathematics, science, technology and engineering departments believed that STEM practices can assist in accomplishing learning outcomes of entrepreneurial activities. Moreover, it can promote the entrepreneurial intention of students because they usually acquire many competencies in STEM classes that are strongly needed for entrepreneurial learning. It was explained that "both practices of STEM and EE enhance innovation. Additionally, their curricula are highly supported by integrating knowledge from different disciplines, so incorporating their practices will dual benefit to learners." Interestingly, science lead teachers were so proud of their STEM students and identified them as the future inventors, and they clarifying their opinions saying "During STEM classes, students acquire many primary STEM abilities that all are considered as entrepreneurial competencies such as critical thinking, problem solving, communication, perseverance, independence, collaboration, creativity and innovation. Many of STEM students are inventors but their inventions are easily lost unless they become able to take them to the market." "Although self-employment is not a direct aim of STEM education, engaging STEM students in entrepreneurial practices could enhance the impact of education because it will produce a new generation of entrepreneurs who are scientifically, mathematically and technologically literate which in order will upgrade their abilities from being only inventors to become inventors and entrepreneurs."

Business integration

Thus, all participating leaders responded positively toward the possibility of incorporating entrepreneurial practices into STEM education in UAE. However, they strongly suggested involving the business department to enhance integrating entrepreneurial practices. The academic developer assumed that "infusing entrepreneurial practices into STEM education for high school students can be successful, only if the focus of STEM education is broadened to situate STEM practices or curriculum elements within a business context. Moreover, the objective of STEM activities is not limited to the proposed disciplines 'S, T, E, M' that form this abbreviation. Thus, knowledge and application among new academic disciplines can also be engaged effectively." Furthermore, "integrating technological applications, mathematical thinking and scientific inquiry to create new designs is not enough to act entrepreneurially." That is why, "involving business teachers is an appropriate methodology because they can guide students not to waste their time designing STEM products that are not needed for anyone." Moreover, they can "help enhance the entrepreneurial terminology among other subject teachers such as venture enterprise and business plans that are basics for better entrepreneurial practices."

E-STEM effective practices

STEM lead teachers elucidated that the characteristics of the learning environment needed for both STEM and EE are relatively similar, which enhance the possibility of this integration through experiential learning strategies. Thus, "the combination of PjBL and PBL to form project-based problem solving (PjBPS) is the most important strategy that allows students investigate real-life problems and provides them with multiple opportunities to collaborate to take responsibilities of their learning, identify problems, pose their own questions, collect data and investigate new inquiries in order to promote different cognitive skills." However, "Collaborative groups are not equivalent because sometimes, students with the same abilities work together and do not understand the importance of working in heterogenous groups." Also, the school emphasizes utilizing the PjBPS strategies because "the MOE recommended them to support the National Agenda of the UAE." Furthermore, STEM practices emphasize "interdisciplinary approach as the main approach used to promote integrated practices." Furthermore, they asserted that E-STEM practices should be carried out through experiential learning that focus on business opportunities, applying technology, solving problems, engaging in logical reasoning process, students' reflection on their learning and using teachers' feedback for improvement. These activities will develop many of the cognitive entrepreneurial competencies of students, which make this incorporation easy and interesting for them."

Value creation practices

Although, STEM students cooperate to achieve all the previous activities, all of this is not enough to generate new entrepreneurs, “value creation practices should be conducted in order to facilitate this incorporation to make entrepreneurial learning be partially taught in STEM classes.” Accordingly, the lead teachers agreed with this incorporation because “entrepreneurial learning will contribute to STEM education, by helping students to become more selective when they brainstorm their ideas to focus on product functionality, cost of materials, studying the market and prototyping to introduce their projects to the community and ensure that they are needed.” Unfortunately, all of these activities are not implemented in STEM classes. However, “high school students usually get very few opportunities to apply some entrepreneurial practices in separate business courses to allow them to experience success and failure, however, these isolated practices are not enough to develop entrepreneurial competencies.”

Entrepreneurial competencies

Lead teachers mentioned that “in spite of the confidence that STEM students gain when they collaborate to complete their STEM projects,” they do not practice taking financial risks properly. All STEM practices are secured and controlled under the school supervision. Besides, cognitive entrepreneurial competencies such as marketing and seeing opportunities as well as non-cognitive competencies like marshaling resources, networkability and being initiative are not emphasized in STEM classes.” On the other side, mathematics teachers who proudly defined their practices in the STEM classes as “competency-based learning practices” gave more details about the purpose of their instruction saying, “teaching that target competencies focuses mainly on the consistent development of learning skills, content knowledge and students’ attitudes.” Therefore, “practices of PjBPS are essential to enhance students’ cognitive skills such as problem solving, critical thinking, planning abilities, creativity and decisiveness” in addition to “the development of some non-cognitive competencies such as perseverance, self-confidence, and persuasiveness through STEM practices.”

Quantitative results of STEM teachers

Section 1: Demographic information of participating teachers Figure 1 demonstrates the main demographic information of the participating STEM teachers that include gender, emirate, STEM subject taught. Six emirates represented the geographic location of the participating teachers in UAE where percentages of responses were Ajman 27%, Abu Dhabi 22%, Dubai 20%, Sharjah 16%, Ras al-Khaimah 8% and Umm-al Qaiwain 7% who are teaching the four main disciplines of STEM with percentages

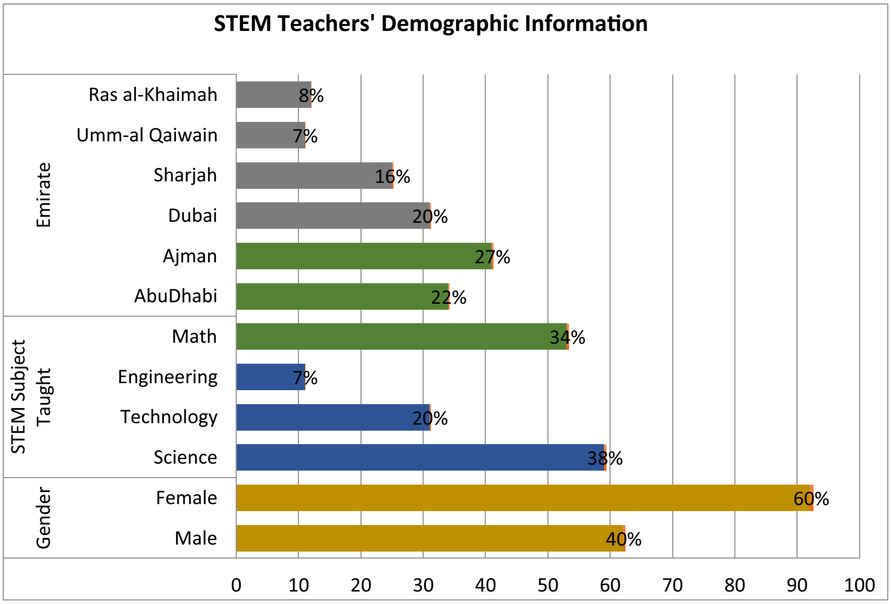

Fig. 1 Demographic information of participating teachers

(science 38%, mathematics 34%, technology 20% and engineering 7%). Moreover, responses from female teachers (60%) came higher than from males (40%).

Section 2: Results of effective practices in the STEM classes that enhance entrepreneurial learning in light of teachers' perceptions The questionnaire asked the STEM teachers about the current effective practices that enhance entrepreneurial learning in STEM classes. According to the qualitative results, teachers' practices were divided into two main sections, which are PjBPS and value creation practices.

Table 1 shows the descending order of the mean and the percentages of the current practices applied in the STEM classes to enhance entrepreneurial learning. Thus, percentages of current practices with highest rate implementation are 96–89%, where students more consistently cooperate in STEM teams, apply technology, integrate information from different disciplines to design a new product, discuss and present their projects and plan for their inquiries. However, practices with medium rate of implementation came with percentage 88–80%, where students take responsibilities of their own learning, reflect on their experiences, evaluate their project using a rubric, consider teachers' feedback, identify the problem for investigation and finally be engaged in reasoning process to solve a problem. On the other hand, 49% of teachers encourage students to use their STEM designs to add value to the society or gain a profit. The lowest rate of implementation (29–26%) came for studying the market to understand its needs and calculate the costs of the proposed STEM project. Accordingly, it is apparent that teachers currently give more focus on the practices of PjBPS strategies in their STEM classes than value creation practices.

Table 1 Current practices applied in STEM classes to enhance entrepreneurial learning

	Current practices in STEM classes	Mean	%
	PjBPS practices		
1	Collaborate in a STEM team	4.47	96
2	Students apply technology strategically	4.76	95
3	Integrate STEM disciplines to design a model	4.52	90
4	Discuss, argue and present their projects	4.47	89
5	Students plan for their inquiry	4.46	89
6	Students take responsibility of their learning	4.39	88
7	Reflect on their learning process	4.32	86
8	Evaluate their projects through a design rubric	4.3	86
9	Use feedback to improve their products	4.28	86
10	Identify the problem and pose a question	4.19	84
11	Engaged in logical reasoning	3.98	80
	Value creation practices		
12	STEM outcomes are used to create value or gain profits	2.46	49
13	Students calculate the costs of their project designs	1.29	26
14	Study the market to know if their products are needed	1.47	29

Discussion and implications

Academic leaders believed in infusing entrepreneurial pedagogies into STEM curriculum through experiential learning practices with a constant support of business teachers because they are more aware of the entrepreneurial learning activities than other teachers in school. This view corresponds to the opinion of the European Commission (2003) that suggested integrating entrepreneurial practices with different disciplines as a general learning attitude that can be implemented in school activities to foster students' entrepreneurial spirit. The current STEM instruction of participating teachers gives more focus on PjBPS practices than value creation practices because entrepreneurial practices are not included in their curriculum. Thus, the focus of STEM education should be broadened and expanded to situate STEM curriculum elements within a business context (Ezeudu et al. 2013) to provide students with E-STEM learning opportunities, which is consistent with Winkler et al. (2015)'s suggestion of incorporating entrepreneurial practices into STEM education. This incorporation is beneficial because interdisciplinarity approach-based learning experiences will give more attention to variety of practices such as business opportunities, applying technology, solving problems, engaging in logical reasoning process, students' reflection on their learning and using teachers' feedback for improvement. These findings suggest connecting 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.

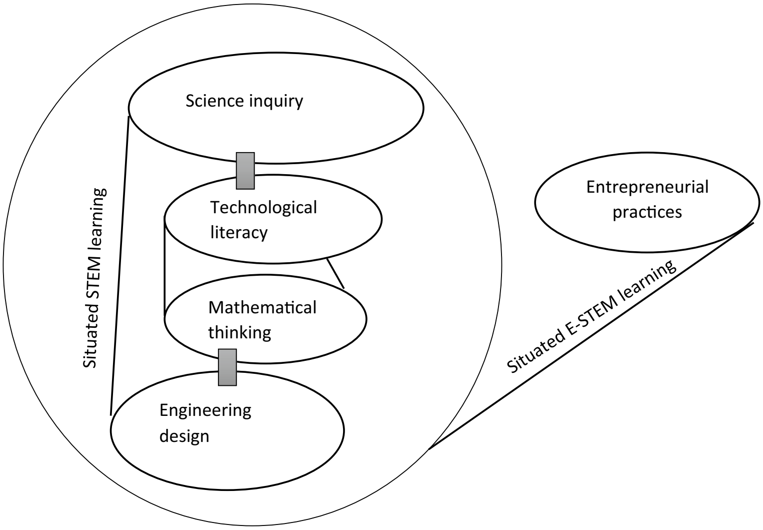

Fig. 2 The main pulley system of the interdisciplinary E-STEM learning

Figure 2 illustrates a new pulley system of the interdisciplinary E-STEM learning after integrating the Kelley and Knowles's STEM system with entrepreneurial practices. This pulley system shapes the building blocks of E-STEM learning where entrepreneurial practices are incorporated into the integrated pulleys of STEM disciplines in a situated learning environment. E-STEM learning activities can provide high school students with authentic opportunities to make use of their STEM designs by aligning them to the market needs. This will produce a new generation of future entrepreneurs who are scientifically, mathematically and technologically literate to focus not only on inventing but also marketing. Engaging students in a project-based problem-solving practices that allow them to collaborate, integrate technology, plan, discuss, conclude, design, reflect and evaluate their outcomes is beneficial because it gives them the basics skills needed to be engaged in a situated entrepreneurial learning experience. According to that, the developmental perspective on E-STEM learning assumes that integrated disciplines-based practices during appropriate task can promote entrepreneurial learning of STEM students. In this essence, incorporating entrepreneurial practices into STEM education is a great contribution that support STEM reform because helping students to become more selective when they brainstorm their ideas to focus on product functionality, cost of materials, studying the market and prototyping to introduce their projects to the community and ensure that they are needed to add value to the community.

Moreover, the finding shows that competency-based approach is an appropriate method to integrate EE with existing STEM course curriculum because it allows for incorporating value creation practices along with PjBL practices to target competencies focuses mainly on the development of learning skills, content knowledge and students' attitudes to entrepreneurship in high school. Accordingly, different entrepreneurial competencies could be developed through E-STEM learning including cognitive (problem solving, critical thinking, planning abilities, creativity, decisiveness, marketing and seeing opportunities) and non-cognitive (perseverance, self-confidence, persuasiveness, marshaling resources, networkability and initiative) competencies to form a student-competency profile that should be emphasized in an education through entrepreneurship environment (Pepin 2012).

The results of this study have a direct implication for STEM teaching and learning as they suggested that incorporating entrepreneurial practices into existing STEM course can broaden the aim of STEM outcomes to accommodate business practices. It is important to note that STEM alone does not produce entrepreneurs. Rather, in order to enhance long-term development of entrepreneurial competencies in STEM classes, integrated practices should support students to design STEM projects to meet the market needs in a situated E-STEM learning platform. The results discussed here are also essential for professional development programs as it has been shown that teachers do not focus on value creation practices in STEM classes because they are not fully aware of them in comparison to business teachers in UAE schools. Furthermore, curriculum developer can work on integrating PjBPS and value creation practices to enhance E-STEM learning instruction by providing students with better learning opportunities that allow them to act entrepreneurially.

Conclusion

There is a constant need to enrich STEM teaching and learning to serve diverse learners and ensure that they are equipped with the competencies needed for their future careers. In light of knowledge-based economy, one of the considerable goals of UAE is to enhance the academic performance of students to achieve competitive levels internationally. Although STEM education can positively contribute and develop some entrepreneurial skills of students, teaching STEM courses or programs that do not incorporate entrepreneurial practices into STEM are not enough to produce entrepreneurs. STEM students should be nurtured more effectively by providing them with authentic entrepreneurial experiences to become the future scientific, mathematical and technological entrepreneurs, which is critical to support UAE national agenda. The current study recommends restructuring STEM education to infuse entrepreneurial pedagogies through competency-based approach in an experiential learning environment in UAE high schools where education through entrepreneurship is appropriate to enhance the E-STEM learning outcomes. This incorporation requires involving business teachers to be able to integrate successful and relevant entrepreneurial value creation practices with PjBPS practices that are applied in UAE high schools. Conclusions from the study argue that incorporating entrepreneurial practices into STEM education is applicable through developing the available STEM course curricula to be more business-like.

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Affiliations

Marwa Eltanahy[1] · Sufian Forawi[1] · Nasser Mansour[2]

Sufian Forawi
sufian.forawi@buid.ac.ae

Nasser Mansour
N.Mansour@exeter.ac.uk

[1] The British University in Dubai, Dubai International Academic City (DIAC), P.O. Box 345015, Dubai, UAE

[2] University of Exeter, St. Luke's Campus, Heavitree Road, Exeter EX1 2LU, UK