SCIENCE EDUCATION AS AN ACADEMIC BASIS FOR ENTREPRENEURIAL SKILLS DEVELOPMENT IN HIGH SCHOOL SETTING

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This paper presents the author's methodology for teaching entrepreneurial skills based on science education. In the introduction to the article, we substantiate the chosen subject and give a brief overview of the information and ideas contained in the article. By combining science education and entrepreneurial education, we present a methodology called "Business-cycle science education project ". The project consists of two blocks: 1) Work on the project itself (creation of a product within the framework of studies on science education); 2) Development of operational skills in the enterprise (communication, budgeting, processing of documents, marketing basics, and legal awareness). We also offer a description of pedagogical experiment and case study "Eco-postcards 2019", which was conducted with the participation of Kyiv Junior Academy of Sciences methodologists. Questions about methodology, practice and pedagogical tools for implementing the idea of combining science and entrepreneurial focus in the education process are raised. We also argue the need for an integrated approach to the development of both academic and entrepreneurial skills of high school students. We note the first success in this regard and recall the

need for in-depth study of this issue from different points of view, namely scientific, pedagogical, psychological, social and other tangible branches of knowledge.

Key words: science education, entrepreneurial education, social and economic context of education, project based learning, business simulation teaching activities, business-cycle science education project, creative thinking, critical thinking.

Introduction

This paper seeks to examine science education and entrepreneurial education and the way they can complement each other in the curriculum. Many questions are raised in this article; for some of them we have answers and some of them are still open for discussion and further study. In this article, education is viewed as a milestone of Western civilization and humanity in general. It helps to summarize the knowledge, preserve information and transmit it to next generations, forming intellectual and cultural capital of humanity.

In the first section, we discuss social and economic contexts of education. We ask mainly a rhetorical question of what the education actually is and what the main objectives of education are. In the second section, we examine similarities and differences of entrepreneurial and science education. What is in common and what differs in science and entrepreneurial education? How can education catalyze common development of science, technology, and economy? What does it take to become a successful scientist or inventor? And what does it take to become a successful entrepreneur? What do scientist and entrepreneur have in common? How can these skills and mindsets be developed? In the third section, we examine three main pedagogical approaches, among them are project-based learning, business simulation games, and pieces of training. We also introduce Business-cycle science education project methodology, which we have created not only to teach students science but also to develop entrepreneurial thinking. In the fourth section, by means of the analysis of one case study, we share our experience of entrepreneurial skills development while working on a science project with middle and high school students. We will also invite our readers to think about questions relating to the topic, which are still to be answered in a marketized and globalized educational environment since small number of research has been conducted. In the last section, we offer the conclusions.

Social and economic context of science education

Along with the development of human civilization, knowledge transfer and education were the key factors of our progress and even survival. Therefore, education in general and science education, in particular, cannot exist aside from our society, economy and mental culture. Do we, as educators, always remember about it while preparing for class or choosing materials for students' projects? Do we always remember about the main mission of any class, which is both 1) to prepare the student to real-life context and 2) to give students skills to make difference and

change the overall environment for the better? These questions are rhetorical and very practical at the same time.

At the age of globalization, urbanization, and technologization of society, we should pay close attention to the style and content of education and set clear and attainable goals, for both today and the future. The global community of educators constantly discusses these and related questions. For 'the place of science education within general education, and the place of general education within society' [Longbottom & Butler, 1999] is the crucial problem of pedagogy. In many cases, authors assume that "a major goal of education is … to improve the quality of human existence" [Longbottom & Butler, 1999] and it is difficult to quarrel with this statement.

History of humanity is always accompanied with three interconnected forces, which shape our civilization. It is obviously unfair to state that these are the only three forces, but within this particular paper, we want to focus mainly on them: 1) education, 2) technical progress, and 3) entrepreneurship. Education provides means for the development of new concepts and ideas, technical progress converts these ideas into physical objects and entrepreneurship spreads it to every corner of world and society. Somewhere in the intersection of education and technical progress, we can place science education, but to make sure we provide our students not only with academic and theoretical skills (which are also highly important), we should also pay attention to the development of practical and entrepreneurial skills.

Common components of science education and entrepreneurial education

Globalization has created an educational environment, where practices of corporatization, marketization, and performativity are spreading across the globe. Providing classes and pieces of training, educators should set the goal to create the most effective content, which develops critical and creative thinking, problem-solving competency, ability to set and check hypothesis, plan and manage a project, communicate and share ideas, work in a team etc. Both science education and entrepreneurial education develop these skills but from different angles and with different points of view. Let us examine in detail each of them.

Science education gives students direct experience and understanding of the physical world around us (environment, materials, physical laws, mechanics and overall principles of world functioning)ю Later it will help to understand nature and basic principles of working with resources in entrepreneurial activities. Students have to think about their hands-on work, move deeper into the subject, discuss it with teacher and peers. Students' thoughts and theories, ideas for designing an investigation and hypothesis, predictions, hesitations, and conclusions need to be explicit, shared and debated orally and sometimes in writing. Science investigation very often requires teamwork and rarely an individual activity, and it helps students to achieve success in communication and teamwork.

Science education requires an inquiry as an inevitable method of studying, but it is impossible to conduct an inquiry without the data from secondary sources such as books, experts' articles, and the Internet. In order to do that, students need to develop analytical and critical thinking to find the information they want. Therefore, they learn how and where to look for it. These and other skills are also of high importance when we are talking about entrepreneurial education [Longbottom, 1998].

Entrepreneurial education is also very important in the context of society. Though the word 'entrepreneurship' appears more and more frequently in different sources (popular books, blog articles, academic texts, and scholarly journals etc.), the essence of the entrepreneurial concept is often misunderstood: "Rather than being used synonymously with concepts such as charismatic leadership or small business, entrepreneurship should be approached as the shifting of resources from areas of low to areas of higher productivity" [Maranville, 1992]. Keeping this in mind, we can state that entrepreneurs are those, who bring change to society transforming its resources to the most effective and efficient condition. It is close to what scientists do while discovering the world, its principles, and laws.

However, there is one question which has to be addressed while aiming to combine science and entrepreneurial education. Science education is easily applied in middle and high schools; and some educators use this approach working with primary school students and even preschoolers. At the same time, entrepreneurial education is usually applied when adult people consciously choose their career or at least decide to attend a course or training to develop entrepreneurial skills and mindsets. Usually, these are courses aimed to provide executive, entrepreneurs, CEOs, and managers of different levels and responsibilities with practical skills or necessary knowledge. We usually speak of entrepreneurial education only in relation to adult, postgraduate education, different professional courses, and pieces of trainings. Therefore, to be more precise and show our awareness of pedagogical age specifications, we will use the term 'entrepreneurial skills development' instead of 'entrepreneurial education'.

Theory and methodology of the research

Since entrepreneurial 'value-addedness' to the science educational curriculum is essential for the successful careers in business, let us discuss some methodological models, which appear to be the most appropriate for this purpose. Mainly we are going to discuss:

- Project based learning;
- Business simulation games and activities.

Project-based learning is a very common teaching strategy in science education, which gives students the possibility to gain knowledge and skills by working on a particular issue, problem or assignment for some period. It is one of the most popular method to organize inquiry-based and science education learning. Usually, there is a clear goal, deadline, working plan and a team. A good example of project-based

learning is TheoPrax methodology developed by German educators [Krause et al., 2007]. This project-based learning is performed in cooperation with an external partner and aims at building strong connection between schools and universities on the one hand, and industry on the other. One of the most important features is that TheoPrax-project is the 'real-life project work' collaborating with different types of industry and businesses. A TheoPrax project often comprises planning and brainstorming, inquiry or statistical survey, building prototypes, testing them out, and completing the project. Many manual and technical skills must be developed and acquired; students usually work in a multidiscipline field, so all of these factors support the learning process. It is also important to mention that students feel extremely responsible and motivated working on "real-life projects". As a result, 'students have the theoretical, methodological, social and personal skills, which are learned and used in a team during the project work' [Krause et al., 2016].

Business simulation games and activities are the second teaching model we are going to discuss in this paper since they play a crucial role in teaching and learning [Goi, 2018]. Through business simulation games students are able to internalize many business concepts, principles, tools, and ways of thinking. As previously stated, there is a need for embedding the components of employability into the curriculum, as well as filling the gap between theoretical knowledge and industry-required skills. To summarize it in a clear and short phrase: knowledge is not a skill. Simulations are based on an extremely effective learning approach - practice, which is a transformational transition between theory and skills. To reach the highest efficiency, a practice needs to take place within a particular context aiming at measurable goal.

All business simulation games and activities can be subdivided into total enterprise simulations (focusing on enterprise development strategy) and strategic management simulations (focusing on operation activity: decisions, marketing, negotiations, accounting, business planning, finance, operations, product design etc.). Since the main goal of simulation is to reproduce and imitate reality, there are different types of activities customized to learning needs: "Functional or total enterprise, competitive or non-competitive, interactive or non-interactive, industry-specific or general, involving an individual or a team, deterministic or stochastic, judged by the degree of complexity, and judged by the time period" [Biggs, 1990]. To conclude, the main goal of the simulation is to teach a specific process within a specific environment, or to put it differently, to acquire certain practice within a particular context.

Nisula and Pekkola reviewed the use of enterprise resource planning (ERP) used on teaching and learning. They identified that ERP is widely used to support experiential learning, especially focusing on business process orientation, understanding business functions and integration, understanding enterprise systems, and improving IT skills [Nisula & Pekkola, 2012]. However, the number of research is still limited.

Skills-forming pieces of training is the third method used in business education.

It is very effective learning activity to form certain skills and knowledge. The advantage and disadvantage of training as a teaching activity is in focusing only at one skill at a time.

Business-cycle science education project. We live in a time of startups, when technological inventions emerge nearly every morning and young people very often try to launch new Facebook, Apple, WhatsApp or Grammarly. Many ideas become successful while many fail to survive, which is often due to poor professional knowledge and skills.

In order to develop business skills on the academic basis of science education, we decided to combine those approaches within an education project. As a result, we started the development of business-cycle science education project. This project imitates full-cycle of interaction between service provider and client and helps to understand how real business works and what it takes to provide excellent service to a real customer. It is a problem-solving and project-based type of learning, which reproduces interaction, operation, and communication.

Business-cycle science education project is a project of "full entrepreneurial cycle" or "full business cycle". It starts when client makes an order; its main period is when the client is being served by business and service provider satisfies the demand. Now, when the customer gets what he or she needs and service provider gets compensation, this cycle is deemed completed.

Since science education is the milestone and students are usually working on some tasks related to STEM subjects, it is crucial to have an experienced, enthusiastic and open-minded teacher to get the success with the project. The teacher has to be not only a good expert in science, but must also possess good skills in project managing, communication, team building etc. Usually, a team of students and science teacher is working on some technical or technological solution and it is an enriching experience for all of them.

In business-cycle science education project, as in any business, there are two core components:

1) Product;
2) Operational processes.

Product development is a core process and it is performed under the supervision of a science teacher. It takes science approach since science education is 'in charge' of creating the product. But a product is not the only player on the market, in an enterprise, and in a project-based training simulation. A product can be developed only in a certain operation process environment, which engages all necessary resources. This environment consists of team, project management, communication, finance, collaboration and interaction of different experts, market placement and sales (if we mean the real-world setting).

There are three main parties involved in the educational process:

Table 1. *Main parties involved in the educational process*

No.	Main parties	Detailed description
1	Client	A real-life company, a governmental or public institution, which has a problem to be solved or task to be completed.
2	Providers of business services	Team of students (3-10).
		A competent and experienced teacher in science.
3	Coordinator	A person, who coordinates the process, provides communication between client and service provider and manages operational activities.

'Full cycle' project-based course is completed by additional pieces of training in:

- Sales, marketing and promotion;
- Basic finance;
- Basic legal literacy;
- Business communication skills (negotiation & delivering a presentation);
- Other project related skills and knowledge.

The main objective of our pedagogical experiment was to examine and observe how our hypothesis and methodology of the business-cycle science education project work on practice. We understand that the entrepreneurial type of thinking might be developed only within an appropriate context along with real experience.

Case study of business-cycle science education project 'Eco-CARDS 2019'

In November 7, 2018, a 'full-cycle' educational course 'Eco-CARDS 2019' started. This project imitates cooperation between an IT company and a publishing house while creating customized New Year cards. The application of scientific method is essential here, because the students had to produce first the paper, on which cards were printed, using recycled materials, which was only possible under the supervision of a chemistry teacher. They needed to learn the technology of paper recycling and improve it to achieve high efficiency of the process and high quality of produced paper.

The educational project was a simulation of the real business cooperation between the Client and the Business services provider. The Client was GMDH Streamline, an IT company, which provides demand and inventory planning software worldwide, and the Provider of business services was a team of 8 students lead by the teacher of chemistry. There was also a coordinator involved, whose main responsibilities were to enable good communication between two parties, provide students with all necessary resources, and make sure the order will be delivered to the Client exactly in time. Of course, in real-life setting, some delays are possible,

but we did our best to finish the project in time for two main reasons:

1) We want our students to learn time management and respect the client's time;

2) Since our Client ordered Christmas cards, the order had to be completed strictly due the December 13, for Christmas cards must be delivered before festive season and it takes some time for delivery. For the project it means - no delays are allowed.

The total duration of this project was 6 weeks. It started with the meeting of student's team and Streamline CEO. During the conversation, the majority of questions related to the final order have been discussed: How are Christmas Cards supposed to look? What style is to be used? How many cards are supposed to be prepared? When should the Cards be ready and what is a due day for the product to be ready? Who is responsible for the communication? What text is to be used on the Cards?

The next day after receiving an assignment, the Team of students conducted brainstorm session to create a mind map of the project. During this session student suggested their roles and responsibilities in the project, discussed the budget, worked through the time management and planning and many other things related to the project management. Considering all above, before even starting to work on the main product, which means to work with literature, conduct research, build a hypothesis, and create prototypes, student first improved their skills in project management, team building, and communication.

Similarly, as any business comprises two main components, (product or service production and operation support); our educational project consists of two focuses in the curriculum. First component is aimed at the production of recycled paper and study this process from the scientific point of view. At the beginning, the Team had no idea how to do it exactly, and paper samples were rather unsuitable for printing at all (the texture of the paper was not smooth and flat, it was full of small pieces ready to fall down, and difficult to work with because due to its fragility). There was a problem not only with a texture but also with the paper color. It was not white, or even yellowish; it was rather gray with different spots, stains, letters, lines, and numbers, and sometimes we were even able to read an old text on it.

Approximately, in the middle of the project, within the week 3, the Team has invited an expert in this industry to understand the technological secrets of recycling and producing paper. An expert was very helpful, explaining that the main secret is in putting the paper into water and grinding it with blender until smooth consistency with subsequent special frames to get the shape. By adding peroxide water, the Team whitened the material and reached a soft ivory color, which was very nice for printing on it. The next step following technology improvement was the launching and scale of paper production. Each sheet of paper was handmade so it was time- and effort-consuming process. While some students were busy with paper production, others created the design. For this purpose, we invited a professional graphic designer who conducted several workshops on using Photoshop, working with text, picture, and composition.

Since our idea and methodology was aimed at connecting science and entrepreneurial education, we used business simulation method to develop and improve students' legal literacy. We had several pieces of training and learned about what a contract is, what its constituent parts are, how the contract can be checked, etc. The students discuss the contract, check it and sign with their Client. So, following the agreement and completing the order in time is a part and a very important part of a business simulation studying activity.

Table 2. *Main components of an education project*

Main components of an education project	**Detailed description**
The Client	GMDH Streamline, IT company, which provides demand and inventory planning software worldwide
The Provider of business services	Team of 8 students lead by the teacher of chemistry, Junior Academy of Sciences of Ukraine
The Coordinator	Natalie Panasenko; author of business-cycle science education project, Junior Academy of Sciences
Project duration	6 weeks
Main project	Recycling paper production
Additional activities	Brainstorming; • budget settlement; • team building; • training in communication; • training in design; • training in Legal Literacy "THE GENERAL SERVICE AGREEMENT" • preparing and signing a contract between the Client and the Service Provider etc.
Final product	Unique New Year Cards with corporate Streamline logo printed on a recycled paper
Students age: 13-16	Number of cards: 17
Fields of science education	Biology, Chemistry

During the project, there were some issues, which had to be solved by students and quite often in a very short time. Considering the fact that the project was completed in time and was done very well, we can state the fact that many professional skills

and competencies were developed. First, we can talk about communication skills, presentation skills, collaboration, engagement, interaction, discussion of ideas and the ability to negotiate as well. Again, it is worth mentioning a problem-solving ability, challenges and competitions resistance, the ability to process and explore information in a nonlinear fashion, critical and creative thinking. Growth mindset is a crucial component of constant and efficient development of students' skills and abilities [Dweck, 2007]. Of course, during the project, we wanted to cultivate decision-making ability, organizational thinking, strengthen a sense of responsibility and leadership skills, and certainly increase planning experience in students. We also wanted to improve classroom teaching in emerging production paradigms and at the same time to complete it with fun, enjoyment and the sense of achievement for students[12].

Reviewing the literature, we have examined a list of entrepreneurial traits suggested by a group of Harvard Business School academics as critical in business. While improving methodology of business-cycle science education project we are going to create an activity for developing all of these features. However, in the current business-cycle science education project students gained experience in 7 out of 11 skills suggested by Butler (2017):

Table 3. *Skills and psychological characteristics of business oriented people*

No.	Skills and psychological characteristics of business oriented people	Detailed description	Were developed in project
1	Identification of Opportunities	Measures skills and behaviors associated with the ability to identify and seek out high-potential business opportunities	+
2	Vision and Influence	Measures skills and behaviors associated with the ability to influence all internal and external stakeholders that have to work together to fulfill a business vision and strategy	
3	Comfort with Uncertainty	Measures skills and behaviors associated with the ability to move a business agenda forward in the face of uncertain and ambiguous circumstances	+

[12] *To learn more about our project, please visit: https://www.facebook.com/EcoCards2019*

4	Assembling and Motivating a Business Team	Measures skills and behaviors required to select appropriate team members and motivate such team to accomplish business goals	+
5	Efficient Decision Making	Measures skills and behaviors associated with the ability to make effective and efficient business decisions, even in the face of insufficient information	+
6	Building Networks	Measures skills and behaviors associated with the ability to assemble necessary resources and create the professional and business networks necessary for establishing and growing a business venture	
7	Collaboration and Team Orientation	Measures skills and behaviors associated with being a strong team player who is able to subordinate a personal agenda to ensure the success of the business	+
8	Management of Operations	Measures skills and behaviors associated with the ability to successfully manage the ongoing business operations	+
9	Finance and Financial Management	Measures skills and behaviors associated with the successful management of all financial aspects of a business venture	+
10	Sales	Measures skills and behaviors needed to build an effective sales organization and sales channel that can successfully acquire, retain, and serve customers, while promoting strong customer relationships and engagement	

11	Preference for Established Structure	Measures preference for operating in more established and structured business environments rather than for building new ventures where the structure must adapt to uncertain and rapidly changing business context and strategy.	

Discussion

All new ideas and projects need discussion in order to be improved and then implemented. The business-cycle science education project is no exception from this rule, especially considering the fact that it is a new educational approach. Further research is needed to understand the existing influential factors and their effect on the development of an effective learning process. In our future investigations, we are going to study many different aspects of the teaching process:

- Pedagogical method
  How to improve the learning process?
  How to implement such activities into the curriculum? Are they supposed tobe held during classes or after classes' time?
  What other activities should be used in order to develop entrepreneurial skills?
  How to improve the effectiveness of teaching and learning?
- Progress monitoring
  How to check progress?
  Can the timely completion of a product be assumed as an overall success?
  Shall we have some additional tests and papers to track the progress?
- Communication
  How to maintain communication between different parties (educators, students, and clients)?
  How to communicate with business representatives?
  How to settle conflicts between students?
- Motivation and self-confidence
  How to keep teacher's and student's motivation high?
  How to improve self-confidence in students?
  What factors stimulate students to become proactive?
- Social aspects
  How to overcome misperceptions of entrepreneurship and science in society?
  How to spread the idea of purposeful teaching and learning worldwide?

Conclusions

We believe that scientists and entrepreneurs have many things in common. They have a common goal, which is to improve reality, solve different problems, find new solutions etc. In order to be successful, they should possess many common skills and mindsets, among which are creative and critical thinking, problem solving, project management, presentation skills, the ability to share ideas, and many others. We were looking for and trying to identify optimal teaching methods to achieve the most effective learning outcome in terms of science and entrepreneurial education [Butler & Timothy, 2017]. Since each approach covers usually either business or science, we decided to combine them. We also point out that, despite the common features of science and entrepreneurial education, there is one significant difference: different age categories [Maranville & Steven, 1992]. If science education is usually taught from the middle school age, and sometimes earlier, entrepreneurial education is more typical for adults. Therefore, in the context of school education, we propose the use of the term 'entrepreneurial skills development' instead of 'entrepreneurial education' and adapt certain teaching methods to the corresponding age.

We assume that education has two main tasks: 1) to develop students and prepare them to real-life situations; 2) to provide students with knowledge, tools, and skills for improving society. To achieve these objectives, we combine different teaching methods and mainly:

- Project-based learning;
- Business simulation games and activities;
- Skills-forming pieces of training.

Combining all the above we have invented business-cycle science education project. It is a scientifically based way to teach students how business and relationships between the Customer and the Service provider work. Since the design of the project is based on real-world and complex contexts, it is a great opportunity for science education to become very popular among students.

Business-cycle science education project affects students' motivation, self-fulfillment, and self-respect in a very positive way. Students enjoy studying; they are completely engaged, interested, and deeply involved in the activities. Such 'growth' mindsets enable them to extract the most from school lessons experiences and motivate them to apply the skills and knowledge in real-life situations [Dweck, 2007].

Technology and entrepreneurship are concepts, which are deeply connected and which shape our society in cooperation and interconnection. In Business-cycle science education project, we tried to reproduce this cooperation in educational process, which lead to amazing results in terms of students' motivation, acquiring academic knowledge and new skills. We plan to further develop this idea conducting new researches and implementing new projects, aiming to make this teaching method the most effective.

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