REAL ENGINEERING PROBLEMS RATHER THAN THEORY

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Abstract: The aim of this scientific paper is to investigate the impact of research, based on real engineering problems, on the development of students' entrepreneurial abilities. The gap between expected competencies and those provided by education system is widely recognized problem in Montenegro. In Montenegrin Economic Reform Program (2019-2021), the Assessment Commission (Council of the European Union Brussels, 12 April 2019) stated that the skills mismatches are manifested on the level of secondary and higher education, but that the revised law on higher education is also introduced 25% practical learning, which led to increased enrolment and engagement of employers. To improve the performance program and expand its impact on the transition between school and work, this research focused on building the supporting environment for students- the Laboratory for product design and the Laboratory for mechanical testing of materials. The motivation factor for the students was the opportunity to deal with real problems, not theory, and to participate in the creative process. Faculty subjects included practical knowledge, but not only with real enviromental examples, but also laboratory examinations and modeling in those laboratories. Laboratory excersises included students of different years of study which gave the opportunity to monitor the competence and progress of students during the years of study. Statistical data showed results among students, followed by the appropriate evaluation matrix, in order to measure the students' competencies. Measurement of student satisfaction, in terms of the effects of laboratory exercises, was performed by conducting a survey, based on Bloom taxonomy and Likert scale. The result was 3.7 on the scale from 1 to 5. The project, which is a part of this research, seeks to help shift the focus from basic to applied research and overcome industry scepticism towards commercializing the results by consulting industry representatives, engaging them in the design and construction process, and focusing on topics that interest them. In such an environment, young researchers would be encouraged to develop their areas of interests and build their identity in the wider academic community, by conducting research initiated according to the needs of the industry. Science-industry collaboration is one of the main pillars of practical knowledge which is recognized as the main goal of developing experience and satisfaction in achieving business results. Preparing student to be competitive on the market is one of the bigest requirements. Due to the high speed of change, young people will be forced to make even faster adjustments in order to survive in a market where multidisciplinarity will play a major role in the developing of employability.
Keywords: education system, practice, students, engineering, laboratories

1. INTRODUCTION

Research on entrepreneurial skills and the importance of the existence of subjects that develop these competencies are very popular and permeate all areas in which students specialize. Duval-Couetil et al. (2012) conducted a special statistical survey that addressed the involvement, attitudes and outcomes of engineering students in the field of entrepreneurship education. The authors explored students' attitudes and interests regarding entrepreneurship and engineering, then how they recognize and value the techniques they have mastered by listening to these courses and the outcomes they have achieved and related to the activities and courses they have had the opportunity to follow at their universities. The survey was conducted on 501 respondents, at three higher education institutions, which had entrepreneurial programs. The results they obtained represent a good basis for the development of study programs, especially in the field of engineering, because in this field it is often omitted. They concluded that students who have developed entrepreneurial skills tend to process thinking, deeply analyze the market, have better business communication and self-efficacy. Patterson and Mitchell (2007) pointed out that it was important for engineers to understand the business perspective and the rules by which the market operates, in order to increase their productivity, as well as the productivity of people who will work with them. In their work, they developed a certified program, which would import engineering and business students, so that the product developed by engineers could be valorized through the business environment.

Shartrand at al. (2008) developed two appropriate contexts and tools to evaluate the outcomes that entrepreneurship courses and programs had on engineering students. The first tool measures knowledge of technology entrepreneurship terms and concepts, while the second is a way to analyze entrepreneurial thinking at a higher level. The authors point out that an increasing number of engineers are coming to the labor market and who lack knowledge of entrepreneurial skills, in order to maximize their engineering skills. Through these two tools, it is possible to see the learning outcomes provided by higher education institutions and it can be useful to increase the quality of teaching in the courses offered by these institutions.

Fellnhofer (2018) provided a completely new view of entrepreneurship in engineering, through a specific approach - an approach through play, which boosts entrepreneurial thinking, behavior and vision. In her statistical research, she used linear regression to test the hypotheses, which concern the impact of the approach through play on the quality of entrepreneurial education and motivation to think entrepreneurially.

Byers et al. (2013) point out that the responsibility of engineering educators is key to getting their students used to thinking entrepreneurially and acting that way. They also point to a survey conducted at American College, where 41% of students answered that their goal is to "become successful in a business of my own" - which means that having an entrepreneurial mindset and vision for the future is essential.

Creed, Suubergi and Crawford from Brown University (2002) designed a two-semester course for students of different types of engineering sciences and external students from other fields, which aims to connect students with the real sector. The idea is for domestic companies to explain a problem they face during their business or to point out their future goals, and the task of students is to cooperate with each other, build a team and by the end of the second semester design their own start-up that could provide a specialized service. which would improve the business of companies in the field or to design a product to market and to sell their idea to companies. This can certainly be one of the models by which the development of entrepreneurial engineering is achieved.

Lury et al. (2007) also emphasize the importance of acquiring entrepreneurial skills in the field of engineering and in their work present their vision of the importance of teaching entrepreneurship, through their experience in implementing NSF-sponsored pilot programs based on collaboration between Stony Brook University and three other major higher education institutions on Long Island. They believe that the following three characteristics must be an integral part of every engineering curriculum: the entrepreneurship program must be compulsory for all engineering students, then the program must import students from different fields and universities and the ultimate goal must be to strengthen competitive behavior and use MIT ideas. which organizes annual competitions, where students will test their ideas and talents.

Mosly (2017) addressed in his research the impact of entrepreneurial education in engineering programs and their effects on students 'perceptions and willingness to change their direction of employment. This study reveals the importance of education to engineering students. Most of the participants in this study strive to start their own business in the future [13].

In his research, Abdulwahed et al. (2013) points out that entrepreneurial education in engineering and technology is lacking in most universities. In his work, he submitted a review of the literature on the topic of entrepreneurship and education in the field of entrepreneurship in engineering. A proposal was also made for a combination of entrepreneurship and engineering in education at various levels of undergraduate and postgraduate studies at the faculties of engineering at the University of Qatar. The envisaged new courses provide a strong link between new technologies and innovation with entrepreneurship (1- GENG 500 Principles of Technology and Innovation Analysis, Market Research, and Entrepreneurship (3 Credits); 2- GENG 540 Advanced Technology Innovation and Entrepreneurship (3Credits)). It also emphasizes the importance of researching real problems through the importance of student participation to participate in local, regional and international competitions in entrepreneurship (general and technological).

2. MATERIALS AND METHODS

Entrepreneurship is defined as the self-employment of an individual by practicing business ownership and dealing with important elements, including risk, control, and reward (Mosly, 2017).

The process of education is a life process, which requires the development of students' abilities that affect their goals and aspirations during career development. Engineering as a science requires a continuous approach, which is upgraded and based on research and solving real problems. As such, engineering requires its further development through entrepreneurship, which contributes to connecting engineering with the market, which would allow students to better understand the world around them.

Entrepreneurship is not only related to work, but also to the way of life, ie. the principles of entrepreneurship can be applied in all areas of life. Also, today's labor market is focused on the development of innovative solutions, which require certain entrepreneurial skills to survive in the market. At this moment, we are witnesses that the largest

companies, which used to be start-ups, have just recognized the real problems and offered a solution for them on the market. Therefore, students are expected to acquire multidisciplinary knowledge, especially in the field of entrepreneurship, in order to eventually become their way of thinking and develop a competitive spirit, which leads to maximizing their abilities, that the market valorizes.

Laboratories are directly involved in the acquisition of practical knowledge of students and its involvement helps in formation of this research. The basic idea behind laboratories is to improve the performance of the Montenegrin economy by creating an environment for technology transfer. Product Design Laboratory - PRODE is an academic and professional center for the development of new products and services which helps students develop entrepreneurial skills throw designing prototypes for market needs.

Another laboratory that we are developing through the IPA project entitled "Research and education based on physical models of real engineering structures" refers to the examination of physical and mechanical characteristics of materials. The project aims to initiate and promote model-based education and education, in order to improve research capacity and bridge the mismatch between skills needed in the labor market and those offered by the education system.

The input parameters for the research were obtained on the basis of a questionnaire called “Real engineering problems rather than theory”, which consists of 12 questions. The questionnaire is divided into two parts: the general part and the special part. In the general part, the questions are related to the year of study, gender and average grade during the study. A special section covers questions about previous experience that students had in relation to laboratory exercises, expectations before and impressions after laboratory exercises. The reasons for potential dissatisfaction and the assessment of the relevance of laboratory research for the development of entrepreneurial skills were also examined. The sample consists of students in the final year of undergraduate studies (third year) and the final year of postgraduate master studies (fifth year). The total number of respondents is 20, of which 14 are respondents of undergraduate studies and 6 are respondents of postgraduate studies.

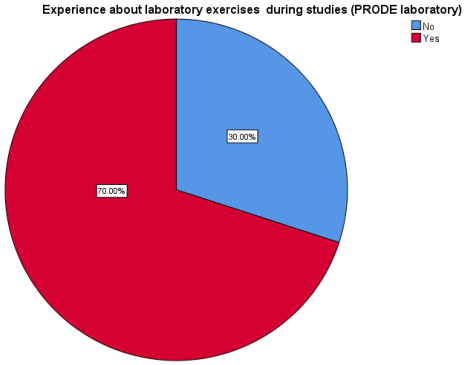
3. RESULTS AND DISCUSSION

This questionnaire seeks to collect data on the importance of solving real engineering problems during studies, as well as their relevance in application in a real work environment after studies.

The analysis of the results consists of 75% of the respondents being female, and the rest being male. Of the total number of registered respondents, 70% are students from undergraduate studies and 30% from postgraduate studies. In this study, 70% of respondents had an average grade over 8 (average includes grades 5 to 10).

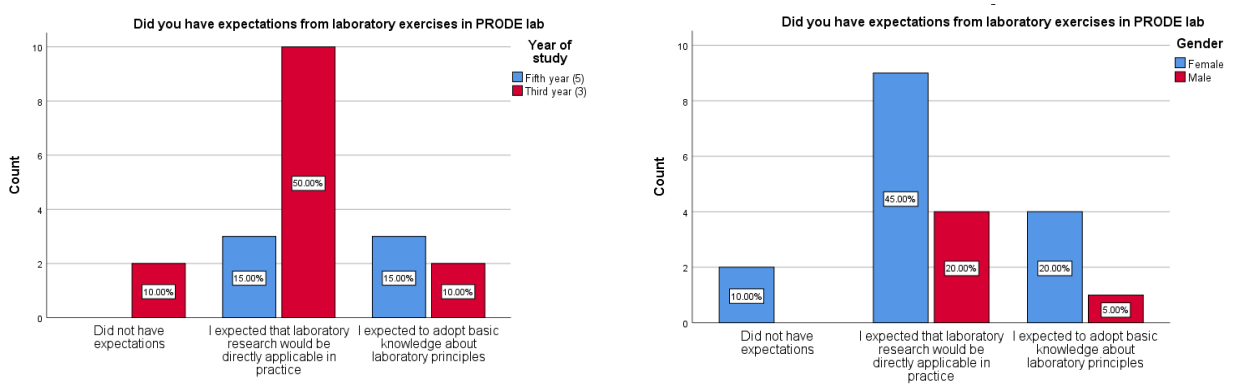
As stated in the general part of the research, the previous experience of students in relation to laboratory research was also examined. 70% of students encountered laboratory research during their studies, while the rest had no experience with it.

Chart 1. Experience about laboratory exercises during studies



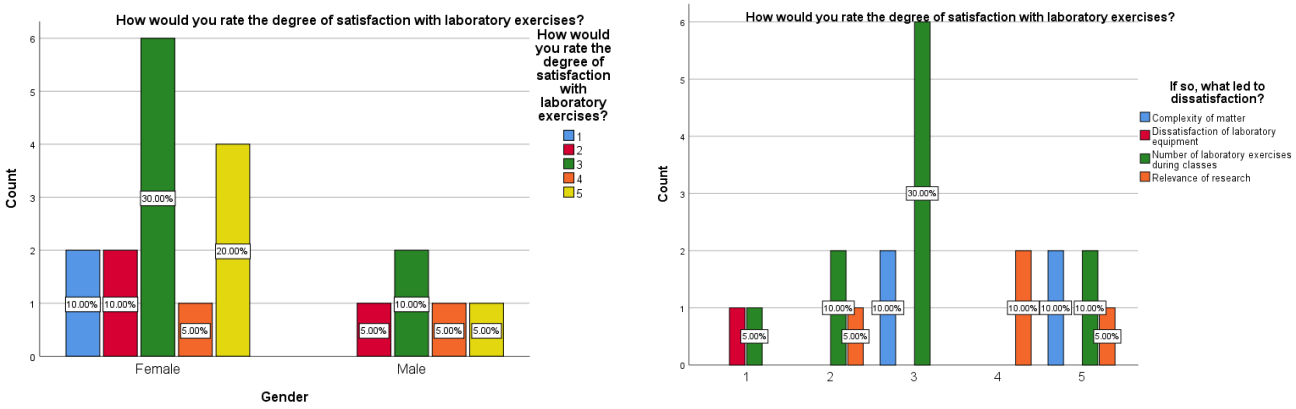
The analysis obtained from the questionnaire shows a comparative report among third and fifth year students showing their previous experience in laboratory exercises during their studies. According to the research, the percentage of students who had experience with laboratory exercises during studies is 70%, which leaves 30% of those respondents that did not have this experience before. The reason why some of the students from the fifth year responded that they did not have laboratory exercises is because they signed in postgraduate studies at Faculty of Polytechnics from another University. When we examine students from the third year, the reason may be that those students did not report subjects that include laboratory exercises. The results are presented in the pie chart 1.

Figures 1 & 2. Expectations from laboratory exercises



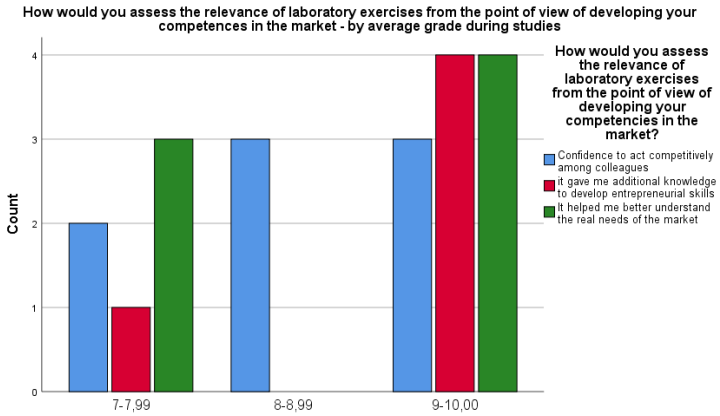
Figures number 1&2 show the percentage display of students' expectations from laboratory exercises by year of study and by gender. According the results, most students in both years of study and both gender expected that laboratory exercises would be directly applicable in practice which shows that they understand the importance of practical knowledge during studies, especially from undergraduate students who are willing to learn as much as they can to adopt relevant knowledge that can be used in the market.

Figures 3 & 4. Degree of satisfaction with laboratory exercises



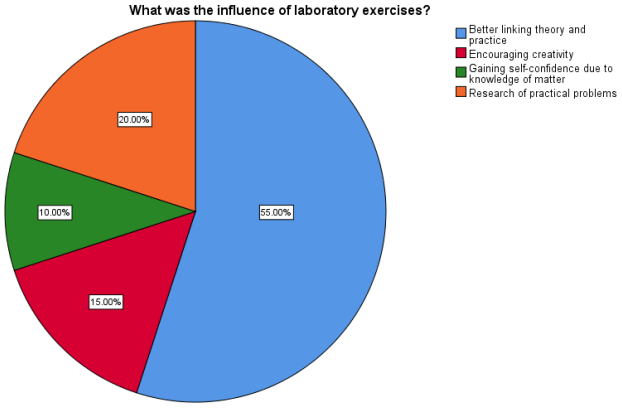
On the other hand, this research tends to measure the degree of satisfaction with laboratory exercises among students in order to improve and adjust to the curriculum. The rate of satisfaction can be seen the the following figures number 3 & 4, which shows that mostly female students share their plesure during those excercises. The reason may be their devotion and entrepreneurship when it comes to the study activities. As can be seen on the diagram number five, the dissatisfaction with laboratory exercises led in 30% due to the small number of laboratory exercises planned in the curriculum. This encourage us to develop the new ways of introducing laboratory exercises into teaching.

Figure 5. Relevance of laboratory exercises from the point of view of developing competences in the market



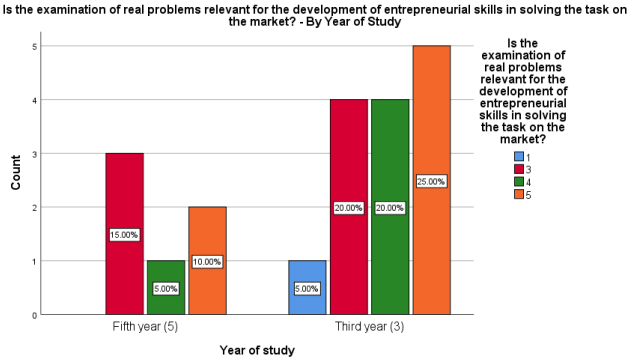
Since this questionnaire seeks to collect data on the importance of solving real engineering problems during studies, as well as their relevance in application in the real work environment after studies, the following figure number 5 seeks to show numerical results of the relevance of these laboratory exercises from the point view of developing students' competence in the market. The diagram shows that students with the highest average grade during studies recognize the link between real engineering in the market with practical knowledge during studies. It also shows that most students realized that laboratory exercises helped them develop entrepreneurial skills as one of the most important characteristics in the working environment.

Chart 2. Influence of the laboratory exercises



In general, the participants expressed that the main impact of laboratory exercises is a better connection between theory and practice, which is actually the main goal. But there are 20% of participants who find out that laboratory exercises influence them to explore practical problems which is important for building entrepreneurial skills. Laboratory exercises also have an important impact on encouraging creativity (15%) and gaining self-confidence due to knowledge of matter.

Figure 6. Relevance of examining real problems for the development of entrepreneurial skills



Students had the opportunity to answer the following question on scale from 1 (not relevant) to 5 (very useful): "Is the examination of real problems relevant for the development of entrepreneurial skills in solving the task on the market?". The majority of students (35%) who participated in this research pointed out that it is very useful to examine real problems, which is part of laboratory research. Only 5% of students who rated it as irrelevant participated. According to this question, students understand the importance of this question and the importance of examining real problems for the development of entrepreneurial ability.

4. CONCLUSIONS

This research aims to show the importance of examining real problems in the laboratory on the development of students' entrepreneurial abilities. The charts and graphs, previously presented, claim that students have recognized this influence and need more laboratory tests in the study process. Therefore, this project seeks to help innovate study programs from theory to practice, which will be a part of improved curriculum. The next steps of this research

will have a multidisciplinary effect on the abilities and skills of students needed in the market. Science-industry collaboration is one of the main pillars of practical knowledge which is recognized as the main goal of developing experience and satisfaction in achieving business results. Preparing student to be competitive on the market is one of the bigest requirements. Due to the high speed of change, young people will be forced to make even faster adjustments in order to survive in a market where multidisciplinarity will play a major role in the developing of employability.

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REFERENCES

Abdulwahed, M., Hamad, A., & Hasanain, M. (2013). Entrepreneurship Education in Engineering: A Literature Review, and an Integrated Embedment Proposal.

Byers, T., Seeling, T., Sheppard, S., and Weilerstein, P. (2013). Entrepreneurship: Its Role in Engineering Education. The Bridge, 43, pp. 35–40

Creed, C.J., Suuberg, E.M. & Crawford, G.P. (2002), Engineering Entrepreneurship: An Example of A Paradigm Shift in Engineering Education. Journal of Engineering Education, 91: 185-195. https://doi.org/10.1002/j.2168-9830.2002.tb00691.x

Duval-Couetil, N., Reed-Rhoads, T., & Haghighi, S. (2012). Engineering Students and Entrepreneurship Education: Involvement, Attitudes and Outcomes*. *International Journal of Engineering Education, 28*, 425-435.

Fellnhofer, K. (2018). Game-based entrepreneurship education: impact on attitudes, behaviours and intentions. *World Review of Entrepreneurship, Management and Sustainable Development*, *14*(1/2), 205–228. https://doi.org/10.1504/wremsd.2018.10009001

Luryi, S., Tang, W., Lifshitz, N., Wolf, G., Doboli, S., Betz, J. A., Maritato, P., & Shamash, Y. (2007, October). Entrepreneurship in engineering education. *2007 37th Annual Frontiers In Education Conference - Global Engineering: Knowledge Without Borders, Opportunities Without Passports*. https://doi.org/10.1109/fie.2007.4418174

Mosly, I. (2017). The Significance of Including an Entrepreneurship Course in Engineering Programs. *Higher Education Studies*, *7*(4), 9. https://doi.org/10.5539/hes.v7n4p9

Patterson, P., & Mitchell, R. (2007, September). *Innovation and Entrepreneurship: Merging Engineering and Business*. International Conference on Engineering Education – ICEE 2007, Coimbra, Portugal.

Shartrand, A., Weilerstein, P., Besterfield-Sacre, M., & Olds, B. M. (2008, October). Assessing student learning in technology entrepreneurship. *2008 38th Annual Frontiers in Education Conference*. https://doi.org/10.1109/fie.2008.4720627