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Assessment of Students' Benefits Resulting from their Participation in an Innovative Project: A Case Study

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Abstract:

Purpose: *The objective of this paper is to determine the benefits for students of practical training in a multi-sectoral environment, involving practitioners, outside the university.*
Design/Methodology/Approach: *The research was conducted in the scope of an international project based on the following research methods, questionnaires, in-depth interviews and focus group interviews with students from four different countries.*
Findings: *Participation in the experimental practical training outside the university allowed the students to gain additional knowledge and contacts in various milieus. Their soft competences were developed better than their hard competences. The students have become more aware of the determinants of their choice of career path and their educational needs.*
Practical Implications: *The implementation of selected elements of practical training outside the university can bring beneficial results for both students and academic staff.*
Originality/value: *Incorporation of innovative training students by practitioners, outside the university, and in a multi-sector environment – into the academic education system.*

Keywords: *Innovative education, multi-sectoral environment, student competences, open design & manufacturing paradigm, makerspace environments in higher education.*

JEL classification: *A22, A23, I23, I25, O35.*

Paper Type: *Research study.*

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1. Introduction

In traditional educational models (based on directional and formalised education) teamwork, emphasis on independence and creativity, and practical understanding were not sufficiently favoured, which – in view of the contemporary competence revolution (Barth *et al.*, 2007), dynamic socio-economic changes and new challenges of the labour market – translated into the need to look for new solutions. The contemporary didactic explorations form part of traditions such as experiential education, constructionism, Freire's critical pedagogy, creativity pedagogy, and learning by doing, the main features of which are a paradigm shift from classical *teaching* to *learning*, and organising the educational process in a participatory, reflective, and contextual dimension (Blikstein, 2013; Dacko-Pikiewicz and Walancik, 2016).

Nowadays the aim is to link education with practice and with actual challenges, implement projects that consider the needs of the surrounding reality, and combine formalised university education with the specific nature of professional and competence-related challenges of the modern world (Krokhmal and Simutina, 2018). Attention is drawn to the necessity of implementing activities that enable students to solve problems on their own, considering such challenges as multiculturalism, technologization of life, ecology, accessibility policy, and universal design. Creative elements, diagnosis, and research, and the prototyping and creation of artefacts – all of which require evaluative engagement and the use of various technologies – play a special role. One of the allies of contemporary strategies and explorations is the maker movement and makerspaces, which enable the creative development of classical forms of education, while broadening them with highly dynamic and effective forms oriented towards the development of key competences of the 21st century (Rosa *et al.*, 2018).

However, the research gap concerning the impact of the practical, innovative educational activities on the students' competences still exist. Thus, the research problem concerns the assessment of the benefits of practical training of students in a multi-sectoral environment (makerspaces). The objective of this paper is to determine the benefits for students achieved thanks to practical training with practitioners outside the university. The authors briefly present a literature review, methodological approach, and key findings and, following the discussion, they conclude about the changes in knowledge, hard and soft skills as well as the carriers' plan of students participating in the project.

2. Maker Movement vs Modern Educational Challenges

The term 'maker movement' describes a creative social movement – a broad group of stakeholders, enthusiasts, entrepreneurs, craftspeople, amateurs, and innovators, all united by common characteristics such as: the use of new technologies (e.g., 3D printers, CNC machines, 3D modelling, CAD, and IoT) and the incorporation of new technologies and innovative solutions into traditional activities (crafts, manufacturing, and services) (Dougherty, 2012; Hys and Domagała, 2018). The term 'makers' (also referred to as a grassroots innovation movement) has been present in academic discourse since 2010, while 'maker culture' is defined based on the specific values of the movement: the ethos, the types of behaviour and the philosophy of action, including engagement with digital technologies and advocacy of the ideas of open source and the sharing economy, as well as dissemination of the principles of accessibility, equality and freedom (Anderson, 2012).

The popularisation and development of the maker movement has been taking place since the beginning of the 20^{th} century and can be observed across various sectors and fields of manufacturing (Dougherty, 2012). Its popularisation is linked to the development of solutions such as hackerspaces, makerspaces, and fab labs in many urban areas (Niaros *et al.*, 2017). Among other things, they are gaining popularity as places where local entrepreneurs can assemble and collaborate to provide solutions to environmental, social, or economic problems. The term 'makerspaces' describes community-organised and managed places where people can use local manufacturing technologies. These places provide opportunities for practitioners to be active and integrated when developing, testing and implementing collaborative projects, while simultaneously offering access to modern technologies, digital manufacturing tools, and often grants, incubation and promotion mechanisms (e.g., clusters, HUBs and incubators) (Niaros *et al.*, 2017).

The education sector has benefited from the popularisation of makerspaces (Halverson and Sheridan, 2014; Sheridan *et al.*, 2014; Vuorikari *et al.*, 2019). It is currently facing major challenges not only because of the rapid pace of change that digitalisation and the development of new technologies impose on society and the labour market, but also because of generational change (Generation Y entering the productive stage). New challenges force education to shift its focus to new competences (Coates and McDermott, 2002) and to change the teaching strategies themselves (moving away from the informative towards the practical/activating forms).

3. Methodological Approach

An innovative approach to practical training was tested on the OD&M course, realised in a multi-sectoral and international environment (makerspaces). The premise of the course is to create and support communities of practitioners grouped around the Open Design & Manufacturing paradigm – that is, to harness the potential of horizontal and cross-sectoral collaboration (between universities and practitioners), multidisciplinary, openness, the sharing economy, challenge-based working methods, and fostering a learning environment for the creation of social innovation (social good-oriented) in design and manufacturing (Tabarés *et al.*, 2020).

According to this approach, the scope and implementation of the curriculum of practical training for students was the joint responsibility of representatives of high and educational institutions (HEIs) and makers, manufacturing businesses, innovation communities of makers, open manufacturing businesses, and start-ups. The idea was to take academic education outside the university space – to makerspaces (mainly fab labs), which are distinguished by their innovative approach to business and technology. Representatives of the multi-sectoral environment, i.e., practitioners (e.g., makers) taught students, university lecturers and traditional manufacturers how to apply OD&M in practice, using the following educational forms: workshops, labs, study visits, implementation projects, and networking meetings. This innovative solution was tested to include elements of education in a real business environment in institutionalised academic education. It can be applied wherever practical training is an element of academic education.

The innovative OD&M course was conducted simultaneously at four universities in the United Kingdom (UK), Italy (IT), Spain (SP) and Poland (PL) within the scope of an international project entitled 'A knowledge Alliance between HEIs, makers and manufacturers to boost Open Design & Manufacturing in Europe', funded by the Erasmus Plus programme, from 2017 to 2020. The aim was to create a trust-based and collaborative framework, with the ability to generate knowledge and the capacity to fully embed open design and manufacturing within the partners' network, and to boost it across the project's stakeholders. Innovation communities are positioned and empowered to act as pivotal hubs of strategic connections between businesses' innovation needs, while HEIs and students are better positioned as actors expressing new skills, new jobs, and new knowledge. Business and third-sector organisations engaged in the project were aware of OD&M and benefited from new opportunities, skills, and knowledge to experiment with new production processes and products in cooperation with the project's participants representing other environments.

The research was conducted in 2018-2019. To solve the research problem, the answers to the following research questions were provided: 1. Did the students expand their knowledge of OD&M and develop their soft and hard competences through participation in the OD&M course? 2. Did participation in the project change the students' educational needs and career plans, as well as their contacts with the multi-sectoral environment? The following research methods were used:

- an electronic questionnaire with closed questions: ex-ante, i.e., before the start of the training (2018), and ex-post, i.e., after the end of the training (2019);
- individual in-depth interviews with open questions (five students from each country);
- focus group interviews (one interview in each country), 2019.

The research sample were respondents representing students participating in the project (50 students at the bachelor's level, each from PL, IT, SP and UK). The research focuses only on assessing the benefits that the innovative approach in question provides to students, while analyses of its impact on other groups involved in the project (e.g., academic staff) are the subject of further research.

4. Empirical Results

The aim of the course testing the innovative approach to practical training was to provide the participants with knowledge about OD&M and to develop the soft and hard competences necessary to use OD&M in practice (for students – in business activities; for academic staff – to improve the quality of lectures and classes at universities). A prerequisite for taking part in the course was a demonstration of basic knowledge of OD&M. The assessment of the students' knowledge of OD&M before and after taking the course is shown in Table 1.

Table 1. *The students' knowledge of OD&M*

No.	Scope and moment of assessment	Self-assessment of the students participating in the project (in %, by national groups)			
1.	Level of the students' knowledge before the course:	PL	IT	SP	UK
	- low	2.0	6.0	14.0	4.0
	- average	12.0	40.0	52.0	48.0
	- high	84.0	54.0	34.0	48.0
2.	Change in level of knowledge after the course:				
	- knowledge has broadened	100.0	92.0	100.0	100.0
	- knowledge has not broadened	0.0	8.0	0.0	0.0
	- difficult to say	0.0	0.0	0.0	0.0

Source: *Surveying the students by means of an electronic questionnaire: 2018 and 2019.*

Even before the course, many students declared a high level of knowledge of OD&M. Polish and Italian students had relatively greater knowledge than students from Spain and the United Kingdom in relative terms. The reasons for those differences may be, among others, the differences between the educational curricula at the universities surveyed, or the students' level of preparation for recruitment. More importantly, most of the students increased their knowledge of OD&M through participation in the project.

The individual in-depth interviews confirmed that the scope of knowledge gained during the course was linked to the high level of the students' knowledge of OD&M even before the course. The following factors were also identified as significantly influencing the level of knowledge the students gained during the course, the readiness of practitioners to share knowledge with students; the alignment of the scope of the course curriculum with the duration of the course; and the convergence of the course curriculum with the knowledge and skills that the students had acquired during their previous education. The students also assessed how their participation in the course had changed the levels of their soft and hard competences. The results are presented in Tables 2 and 3.

Table 2. *Changes in the level of soft competences of the students participating in the course*

Type of competences assessed	Assessment of soft competences of the students before the course				Percentage of students who improved their soft competences during the course			
	PL	IT	SP	UK	PL	IT	SP	UK
1. problem-solving	4.11	3.77	3.33	3.24	58.00	92.00	100.00	76.00
2. teamwork	3.70	3.42	3.56	3.81	86.00	92.00	90.00	100.00
3. leadership	3.80	3.36	3.14	2.65	84.00	60.00	52.00	76.00
4. entrepreneurship	3.05	2.54	3.01	2.52	86.00	70.00	66.00	50.00
5. communication	3.85	3.68	3.92	2.72	100.00	70.00	58.00	100.00
Grading scale of the competences before the course, from 0 – no competences to 5 – very high competences; weighted average								

Source: *Survey of the students by means of an electronic questionnaire: 2018 and 2019.*

The students starting the course presented varied levels of soft and hard competences. The students from Poland (3.70), Spain (3.39) and Italy (3.35) assessed their soft competences as above average, while the students from the United Kingdom (2.41) assessed their soft competences as below average. Thanks to the participation in the project, the largest number of students in each country improved their teamwork competences (92% of the students on average) and communication competences (82% of the students on average).

Table 3. *Changes in the level of hard competences of the students participating in the course*

Type of competences assessed	Assessment of hard competences of the students before the course				Percentage of students who improved their hard competences during course			
	PL	IT	SP	UK	PL	IT	SP	UK
1. Open-Source Hardware	2.88	1.60	2.46	1.89	86.00	24.00	8.00	84.00
2. The Internet of Things	0.84	1.15	1.87	1.47	100.00	22.00	34.00	66.00
3. Computer-Aided Design and Manufacturing	0.40	2.45	3.50	3.40	76.00	8.00	100.00	34.00
4. Rapid Prototyping Method	2.57	2.33	2.66	2.94	72.00	24.00	100.00	44.00
5. Crowdsourcing and digital communication	3.05	2.95	2.46	2.35	42.00	38.00	66.00	42.00
Grading scale of the competences before the course, from 0 (no competences) to 5 (very high competences); weighted average								

Source: *Survey of the students by means of an electronic questionnaire: 2018 and 2019.*

An overwhelming number of students in all four countries also noted improvement in the other competences analysed (leadership and entrepreneurship 68% each; and problem solving 60.75%). Before the course, hard competences were assessed much lower than soft competences. Average grades were as follows: Spain 2.59; United Kingdom 2.41; Italy 2.10; Poland 1.95. There were changes in the level of hard competences because of participation in the course, however, the results achieved are quite diverse. The greatest differences concern the competences related to Open-

Source Hardware & Computer-Aided Design and Manufacturing. For both competences, there was a very significant improvement in some countries (for more than three-quarters of the students) and little improvement in others (e.g., for only 8% of the students). Also, for the other hard competences surveyed, the differences in assessment are quite significant.

In order to explain the differences in the level of soft and hard competences among the students participating in the course, the results of individual in-depth interviews were used. They confirmed that the development of the students' soft and hard competences was influenced by the same factors that affected the changes in the level of knowledge they acquired. Participants in the interviews considered practical training in a real working environment to be more effective than training at university laboratories. They highly appreciated the opportunity to engage in specific projects and assignments that they carried out during the makerspace's courses.

Participation in the course allowed the students to develop soft competences better than hard ones, which was facilitated by contact with the maker culture and the multi-sectoral environment. In the students' opinion, the development of hard competences requires more time than the development of soft competences; therefore, they did not have the opportunity to develop both types of competences to a similar extent. It is worth noting that before starting the course, the students assessed their hard competences much lower than their soft competences.

Table 4 shows the professional plans of the students participating in the course. After the course, the percentage of students from Poland, Spain, and the UK planning to work in a traditional company increased. At the same time, the percentage of students declaring their intention to work in a maker environment decreased in all countries. There was little change in the students' interest in working independently as makers or freelancers, as well as in their interest in running their own businesses. The interviewed students confirmed that they had become aware of the advantages and disadvantages of employment in that sector through direct contact with the maker environment. As a result, some of the students changed their minds and opted for careers in traditional companies.

Table 4. *Professional plans of the students participating in the course*

Type of professional plans assessed	Declarations concerning future professional plans before the course (answers in %)				Declarations concerning future professional plans after completing the course (answers in %)			
	PL	IT	SP	UK	PL	IT	SP	UK
1. work in a traditional company	10.0	0.0	6.0	10.0	30.0	0.0	16.0	30.0
2. work in an open design & manufacturing company	46.0	54.0	33.0	34.0	30.0	34.0	26.0	16.0
3. as a maker, freelancer	10.0	10.0	23.0	18.0	8.0	16.0	26.0	18.0
4. starting own business	30.0	24.0	34.0	34.0	30.0	34.0	10.0	34.0
5. other	2.0	0.0	2.0	2.0	0.0	16.0	10.0	2.0

6. no answer	2.0	12.0	2.0	2.0	2.0	0.0	12.0	2.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: *Surveying the students by means of an electronic questionnaire: 2018 and 2019.*

Focus group interviews identified the most important learning needs of the students taking part in the course (linking the theory and practice in studying and training; development of soft and technical skills; joining the innovation community). The above elements are at the core of the innovative approach to practical training. The students considered them values to be incorporated into institutionalised forms of academic education. Another element subject to assessment, i.e., 'development of entrepreneurial education in training' was not considered important. Only some students plan to develop their own businesses after completing their academic education; not everyone is interested in doing so.

Studying in a multi-sectoral environment, which results in diverse contacts, is very helpful for students in their future careers. It extends the possibilities of training different technical and soft skills not only in the academic environment, but also with representatives of innovative communities – for example in hybrid teams. Students are interested in cooperation with global organisations and as well as smaller ones, both commercial and public. This depends on their interests and plans regarding their future careers. Most of the students would like to keep in touch with the innovative communities' representatives, practitioners, specialists, and makers whom they met.

The students are aware that being involved in a community is vital and brings opportunities. They also know that there is no need to be in touch with many different organisations at the same time. The students noticed an increase in the number of contacts with the following entities: networks of innovators, innovative communities, companies based on the OD&M paradigm, university staff (professors and enablers), research and development entities, and makers.

5. Discussion and Conclusions

The paper serves to assess the benefits that practical training outside the university, in a multi-sectoral setting, provides to students in a real business environment – which is an innovation in relation to existing academic practice. The research shows that most of the students increased their knowledge of OD&M through participation in the project, although many of them declared a high level of knowledge of OD&M before the project started. The students' initial level of knowledge of OD&M was considered an important factor influencing the level of knowledge gained during the course. At the beginning of the course the students presented the varied levels of soft and hard competences. At the initial stage the students assessed their hard competences much lower than soft competences.

As a result of participating in the course, more than half of the students improved their soft skills in most of the areas analysed. At the same time, progress in hard skills development was smaller and very diverse. The students' practical training in a maker environment is effective when:

- the students are aware of the benefits of this form of education;
- the students are adequately prepared for this form of education.

The key motivators for encouraging students to undertake practical training outside the university are the universal benefits they can gain, regardless of their future career paths:

- linking theory and practice in studying and training;
- development of soft and technical skills;
- joining the innovation community.

This form of practical training is intended for students who exhibit the minimum required level of knowledge and competence necessary to continue their studies in direct cooperation with practitioners. It is particularly important to match the curriculum with the expected soft and hard competences that students wish to acquire in a practical environment. Research has shown that despite the implementation of the same range of courses, the learning outcomes of the students varied from country to country. This may be due to the different content level of teaching (e.g., differences in the way the content is conveyed, differences in the selection of case studies and project topics, etc.). Therefore, the pedagogical background of the practitioners teaching the students is particularly important. They should adjust the pace and curriculum of classes to a given student's abilities, focusing on practical forms of education (e.g., projects, labs and workshops).

Participation in the course changed the students' approach to career development, but only partially encouraged them to seek employment in a maker environment (generally more students were interested in working in traditional companies, less of them were interested in working in a maker environment). In the case of some students participating in the course, establishing contact with the future professional environment, and becoming acquainted with the real conditions of employment resulted in a change of their professional plans, i.e., no longer intending to develop their professional careers in a maker environment. This confirms that students' ideas about their future work in a specific profession are often false or incomplete.

From this point of view, the tested solution should be considered worthy of inclusion in institutionalised academic education. Students should have the opportunity to fully understand their future professional environment before completing their education. This is not always ensured by work placements, while such an approach may protect students from rashly choosing their career paths.

An important aspect of the tested solution was to provide students studying outside the university with contacts with representatives of various sectors, both traditional and innovative. This gave them the possibility of gaining a broader understanding of career opportunities in cooperating sectors. Thanks to the course, students extended the relations in a maker environment. Due to the specific nature of the modern labour market, the ability to build relationships, as well as flexibility and adaptability, are important soft competences that should be developed to the same degree as hard competences to prepare well for one's future career. An important aspect of this research is the involvement of academic staff representatives in education outside the university. It is commonly believed that a significant shortcoming of academic education is its detachment from practice. The equipment in academic labs is often outdated compared to that which student encounter in innovative companies.

Academic teachers who are not practitioners often lack ongoing contact with the environment in which their students will find employment. By delivering a fixed curriculum, they are not able to keep up to date with technological trends and changes in the labour market. Thanks to the course students realized the added value of education outside the university and in cooperation with academics. Involving academic staff in practical training of students outside the university is an important element of the analysed solution, which also ensures the possibility of improving the quality of lectures and classes conducted at universities.

The study presented here is unique but fits into the research on the practicalities of makerspaces. Makerspace structure, layout, and use have been fairly well researched, and the results confirm the benefits described above (Mersand, 2021). The impact of makerspaces on student learning is understudied, however, due to a lack of tools to measure student learning in that space. The research conducted so far mainly consists of case studies and analyses of the functioning and efficiency of specific solutions (Horton, 2017), relationships within makerspace communities (Schrock, 2014), and the specific nature of the collaborative and partnership-oriented culture being created (Sheridan *et al.*, 2014; Benjes-Small *et al.*, 2017).

By contrast, around researching the attitudes and competencies of makerspaces participants, Barton (2016) reached similar conclusions, indicating that student engagement, or investment, in makerspace activities may be affected by the structure or framing of the activities regardless of technologies. The study found that making connections to problems youth identified as relevant in their communities contributed to perseverance in creating potential solutions. Similarly, it was indicated that framing makerspace activities to connect with the community increased motivation, persistence, and interest in the activities (Holbert, 2016).

Hughes and Morrison (2018) also found significant correlations between students' makerspace activities and work engagement and the development of attitudes based on innovation and conceptual activities. Nevertheless, in the long run, the topic requires further research, especially studies considering the international context and using standardised comparative tools. A successful attempt (piloting) in this respect has been, for example, a survey tool to assess students' perceptions and learning in makerspaces, considering levels of students' motivation, professional identity, engineering knowledge, and belongingness in the context of makerspaces (Lanci *et al.*, 2018). However, this type of research is formally limited by the narrow, low-formalised, and distributed dimension of educational activities, which are carried out according to the OD&M paradigm, as well as by the difficult access to research samples and their limited size.

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