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Developing students' aptitudes through University-Industry collaboration

Desarrollo de las habilidades de los alumnos a través de la colaboración entre Industria y Universidad

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ABSTRACT

In addition to the engineering knowledge base that has been traditionally taught, today's undergraduate engineering students need to be given the opportunity to practice a set of skills that will be demanded to them by future employers, namely: creativity, teamwork, problem solving, leadership and the ability to generate innovative ideas. In order to achieve this and educate engineers with both in-depth technical knowledge and professional skills, universities must carry out their own innovating and find suitable approaches that serve their students. This article presents a novel approach that involves university-industry collaboration. It is based on creating a student community for a particular company, allowing students to deal with real industry projects and apply what they are learning in the classroom. A sample project for the German sports brand adidas is presented, along with the project results and evaluation by students and teachers. The university-industry collaborative approach is shown to be beneficial for both students and industry.

Keywords: Student community, multidisciplinary teamwork, creativity, motivation, university-industry collaboration.

RESUMEN

Además de los conocimientos tradicionales sobre ingeniería, durante sus estudios los estudiantes universitarios requieren poder desarrollar una serie de habilidades críticas para su futuro profesional, tales como creatividad, trabajo en equipo, resolución de problemas, liderazgo e innovación. Por esto, es necesario que las universidades generen nuevas innovaciones en las metodologías de enseñanza. Este artículo presenta un avance en este ámbito, considerando una colaboración universidad-empresa. Esta innovación está basada en la creación de un grupo de trabajo de estudiantes para una empresa, con el objetivo de que los estudiantes pongan en práctica los conocimientos y las habilidades adquiridas en clase en proyectos industriales reales. A modo de ejemplo se presentan los resultados de un proyecto piloto para la empresa alemana adidas, además de la evaluación diagnóstica hecha por los estudiantes y los profesores participantes. De estos resultados se puede deducir que la colaboración entre universidad e industria es beneficiosa para los estudiantes y para la empresa.

Palabras clave: Comunidad de estudiantes, trabajo en equipo multidisciplinario, creatividad, motivación, colaboración universidad-industria.

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Introduction

New generations of students are becoming more and more demanding. There is a widely known rule of thumb (Johnstone et al., 1976) that states that students stop paying attention between 10 and 20 minutes into a lecture; this loss of attention leads to boredom and lack of motivation and engagement. Lecturers, then, are faced with the critical challenge of adjusting their approaches to teaching, so that student attention can be retained and their motivation and engagement can be rekindled.

When undertaking to provide a more engaging teaching approach, a key aspect that should be taken into account is creativity. Most degrees, especially technical ones, are very complex and theoretical. It is common for students to feel that the knowledge transmitted in class has nothing to do with physical, real-world phenomena. In addition to this, the problems solved in university are normally rigid, having only one possible solution and one correct way of attaining it. This structure kills creativity. Sir Ken Robinson stated that "creativity now is as important in education as literacy, and we should treat it with the same status" (Robinson, 2009). This means that creativity is not only an essential aptitude for real work –after all, the problems faced by industry do not have just one way of being tackled– but it is also necessary for fostering students' motivation and enthusiasm. A

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student that has freedom in thinking will hardly feel bored. Fortunately, in recent years most developed countries have become aware of the importance of creativity and they are including it in their educational policies (Shaheen, 2010).

There are several approaches in scientific literature that aim to end students' feelings of monotony, and foster their creativity. Smith et al. provide a significant review of some teaching methodologies in (Smith et al., 2005). They refer not only to the traditional way of lecturing, but also to other methodologies such as collaborative learning, project-based learning and combinations of different methodologies. The popular Problem-Based Learning approach (Norman et al. 2000) also appears to be a more challenging, motivating and enjoyable approach to education.

Among these lecturing methodologies, Project-Based Learning (Mills et al. 2003) is a useful tool because, in addition to alleviating student boredom, it also aligns students' views with industry's needs (Chandrasekaran et al. 2013). Project-Based Learning is well developed and implemented in many engineering schools around the world, since it gives students the opportunity to do something closer to what is done in real professional life. Antón et al. (2011) presented a case study where this issue is thoroughly assessed. Diaz et al. (2013) showed the beneficial effects of Project-Based Learning activities for the teaching-learning process in terms of success vs. implementation cost and success vs. implementation time. Moreover, two example cases from Fang (2012) show that this learning approach enhanced some students' technical and professional skills, although it is not always easy to find projects which are beneficial for both students' education and industry.

As mentioned previously, creativity is an essential skill for professional work. Leadership and multidisciplinary teamwork are other capabilities that should be encouraged (Pitso, 2013). Nowadays, companies are increasingly demanding these qualities because engineers who acquire them have proved to be better able to effectively deal with new engineering and business challenges. Universities must therefore promote good practices that foster these capabilities in order to create complete professionals.

The approach presented in this article intends to promote the essential aptitudes of creativity, leadership and multidisciplinary teamwork in students through a University-Industry connection. The objective is to foster student motivation while at the same time making them aware of real world demands. Universities have the duty to provide their students with the knowledge they need in order to competently engage in professional activity after they finish their studies. In order to produce fully competent engineers, it is crucial that lecturers use a suitable educational approach that encompasses both traditional engineering knowledge and experience with the realities of the business environment, and that they create an atmosphere that is engaging and promotes creativity.

Lemons et al. (2010) published a study based on the model building lecturing approach. They introduced an interesting fact: students develop new ideas more easily when they physically manipulate artefacts. The kinaesthetic activity of hands-on building makes students modify their initial ideas by helping them clarify these ideas, generate new ones, combine them, etc. Drawing models is a useful skill, but sketches do not fully make sense to students until they build a prototype. This fact was taken into account in the present study, and the approach presented also includes the building of prototypes.

There are a number of ways to connect universities and industry, many of which are based on the tradition of having students work on industry-related projects during certain courses (Ursache et al. 2013), complete final year projects, visit different firms or take on a summer internship. Hess et al. (2013) summarize different experiences in collaboration between industry and academia and conclude that, although these projects are in general beneficial for the undergraduate students, they have to be carefully planned and usually come with several challenges.

In this article, a new way of immersing university students in the business side of engineering is proposed: creating a student community that collaborates with industry. This community consists of a multidisciplinary group of students from the Tecnun School of Engineering who work as a team to develop new products, services and experiences for a given company. The objective is to enhance their teamwork and creative abilities, in addition to demonstrating the importance of multidisciplinary collaboration.

The first part of the article explains the educational approach used by this particular university-industry partnership and the different phases that a project should have. The second part of the article deals with the results obtained from a real project done with a group of five students for adidas, the German sports clothing manufacturer. At the end of the article, a double evaluation of the project is presented, both from the students' and the teachers' perspectives, and the conclusions reached during this study are listed.

Educational approach

Collaborations between industry and academia have increased during the last decade (Diaz et al., 2013; Hess et al., 2013), and have become very beneficial for both the participating businesses and for the students and their education. However, students often face a number of limitations when working on these projects, in the sense that on most of the projects they are required to do certain tasks in a specific way in order to meet the project milestones. This means that certain important capabilities, such as leadership and creativity, are often not encouraged, which leads to a gap in the students' education.

In order to fill this gap, a novel way of immersing students in an engineering environment was established. The method consists of a unique collaboration between an engineering school (Tecnun) and a company. The idea is to create a community of students that can develop new ideas, projects and products. By doing so, the potential of the

students is tapped and an "idea bank" is created, providing a meeting point where ideas can be exchanged between students and companies. This type of collaboration gives future engineers the opportunity to create and develop new concepts that can be launched into the market.

In order to determine the degree to which participating in this type of community is a major step forward in student education, the educational advantages of the proposal need to be analysed. Figure 1 shows a schematic diagram of the different benefits that this proposal offers to the students.

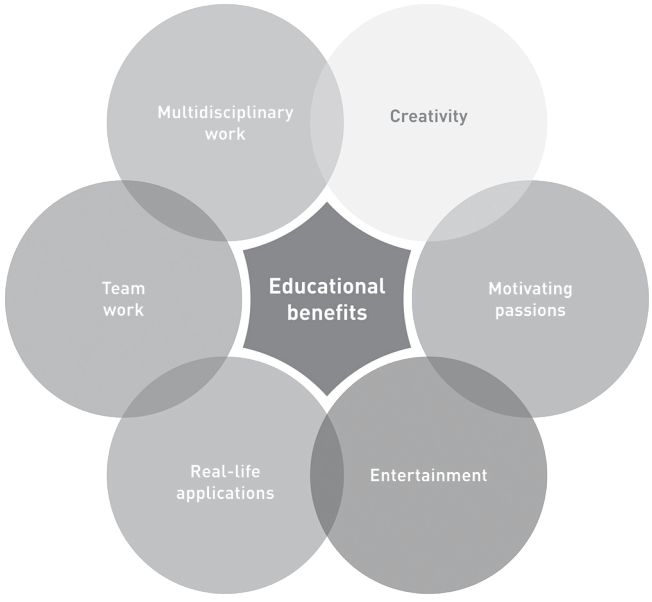

Figure 1. Benefits of the proposal.

One of the main benefits of the community is that students could feel free to develop their creativity not only by creating new ideas but also by learning how to make them more coherent and how to grow them into something that could be applied in the real world. To that end, it would be convenient for students to participate with members of the company in brainstorming and other creativity sessions so they could learn about the new technology trends and services that are being developed. Since this close collaboration, however, is difficult to achieve, we decided to first carry out an example project that could then be sent to the company in order to convince them of the benefit of collaborating in this way.

This approach also encourages two other critical aspects of undergraduate education: teamwork and multidisciplinary work. Teamwork is a basic requirement in any engineering company. The ability to work and create synergies with other people is essential in order to carry out complex engineering projects. In addition, multidisciplinary work is becoming essential in many companies. Projects that combine different branches of knowledge require teams that are made up of engineers from several branches of engineering, such as mechanical and electrical engineers, and other scientists such as physicists or mathematicians. Therefore, the student community would be composed of students from different degrees programmes such as mechanical engineering, product design & development engineering, electrical engineering, management & production engineering and even biomechanical engineering. This diversity of sciences and points of view gives the students the possibility of mutual enrichment, a broader perspective and opens their mind while avoiding excessive fragmentation of knowledge.

In addition, students would be able to apply real engineering and design tools and the methodologies learned in class to real-life applications, such as the design of new products and services or participating in projects that could be proposed by the company. Students would also be able to try new products as beta testers in order to assess the possibility of introducing them in the market; this would not only be entertaining and engaging, but it would also demonstrate how innovative concepts can be directly applied to new products.

In the case of a company like adidas, it is also important to take into account the benefits that this unique type of collaboration could offer to a multinational corporation that already has a top class and very productive R&D department. At the same time, given that the target market for most of adidas' products is young and athletic people, having the help of a community of young, athletic and creative people who are able to produce a great flow of ideas about what they would like to improve or design in terms of sports products could be helpful for adidas, in order to complement previous engineering and user experience inputs. Moreover, another benefit for such companies in this sort of cooperation could be helping their recruitment of young talent.

The project

We asked ourselves how a university could contact adidas and convince them of the idea's feasibility and suitability. For this purpose, a group of students was selected in order to produce an example project of what the undergraduate students at Tecnun could do for adidas. This example project was also meant to validate the suitability of the student community and demonstrate that this proposal could be highly beneficial for the students' undergraduate education.

The project consisted of the re-design of an existing adidas product. The product selected was micoach, a personal trainer that consists of 3 different devices that measure the users' activity while practicing sports. The purpose was not only to re-design the physical product but to also offer a whole new experience.

Project planning

The project lasted for approximately 3 months, with a total of 63 working days. The first thing that was done once the project had started was to fully plan out the various phases. The whole process was planned following the Design Thinking methodology (Brown, 2009) and its seven stages

(define, explore, ideate, prototype, select, implement, review). Since this methodology combines benchmarking, user research, creativity, prototyping and technological and revision skills, we considered it to be the best way to combine engineering, teamwork and creativity in our project.

Selection of students

As mentioned above, a team of five students, which were supervised by two of the article authors during two-hour-weekly meetings, was put together for this particular project. From the evaluated students, the most appropriate were selected.

Keeping in mind our aim of promoting teamwork and multidisciplinarity, the goal was to select one person with strong sketching and creative techniques, one student with a focus on user research, one with a holistic approach to product design, one with expertise in industry management and finally a student whose expertise was mechanical engineering. In selecting students, we analysed different aspects: their grades, interpersonal skills, previous performance during other projects when they were our students in different subjects and other achievements such as professional experience and awards. After this initial evaluation, we interviewed several students and chose five for the final team: two from the mechanical engineering degree and three from the industrial design and product development engineering degree (all of them were students from final years of their 4-year-degrees). During the interviews, the project and the idea of the student community were described, and the expected level of commitment was clarified. It is important to remark that even though students were not offered any type of reward or remuneration and the project was carried out during their holiday time, all of them responded with a definite yes when asked to join the team. Although their participation in this project was not part of their undergraduate degree, they were very interested in taking part in a side project that could complement their education.

Project execution

Once the project plan had been set and the five students had been selected, the team started going through each of the seven stages of the process. In the following sections, a brief explanation of the work undertaken in each stage can be found, along with different images of the output obtained during each of those stages.

Define

As mentioned previously, the project was defined before the team was selected. The student team was given a briefing in which we defined the product to be redesigned and the kind of redesign that we wanted to attain (redesign of all the micoach products and the micoach website). We also defined the final output expected for the project according to the kind of proposal we wanted to send to adidas. This output included: Project storyboard; 3D models and mock-ups of the new micoach product range; Renderings of the new micoach product range; Screenshots for the new features on the micoach website; Handbook with a full explanation of the project; Design of the packaging for the proposal.

Explore

During the Explore stage, which is mostly an informative phase in which the team gathers information for the future project, the students went through two main phases.

Firstly, they got to know adidas as a brand, learning about its history, principal milestones and achievements, mission, vision, and values; they also studied the different brands inside adidas and their particularities.

Secondly, the team carried out broad research on users (including field studies) to identify their needs while practicing different sports (running, cycling, surfing, aerobics and tennis). For this purpose, the team used five different tools, including three user research tools:

- Activity Analysis: split the activity into smaller entities (stages, phases, milestones, stakeholders, places, etc.) in order to analyse and get to know each of them.
- Error Analysis: identification of all the possible errors, failures, human mistakes, etc. that can take place during an activity.
- Surveys & Questionnaires.
- Rapid Ethnography: observation of users engaged in the activity analysed (doing the different sports for this particular project).
- Try it Yourself: the team tries the product while doing the different sports analysed in this project.

The Explore stage produced four different outputs, according to the different tools used.

First, the team developed two different conceptual maps for the activity analysis. The first map was related to adidas as a brand, and the second was a complete analysis of micoach. The second output from this stage was a big map of all the possible failures and errors associated with micoach. For this case, the team developed a timeline of the typical stages in the use of micoach. In each of these stages, the team identified all the possible errors. Thirdly, all the information of Surveys & Questionnaires was recorded using tables. The fourth and final output from this stage was a collection of pictures, notes and videos from users practicing different sports. This output helped the team identify new needs for micoach users.

Ideate

Based on all the information gathered during the Explore stage, the team started to generate ideas through several brainstorming sessions. While this stage took place, all the pictures, maps and notes from the Explore stage were spread across the workplace, and the team reviewed the videos and the information from the Surveys & Questionnaires.

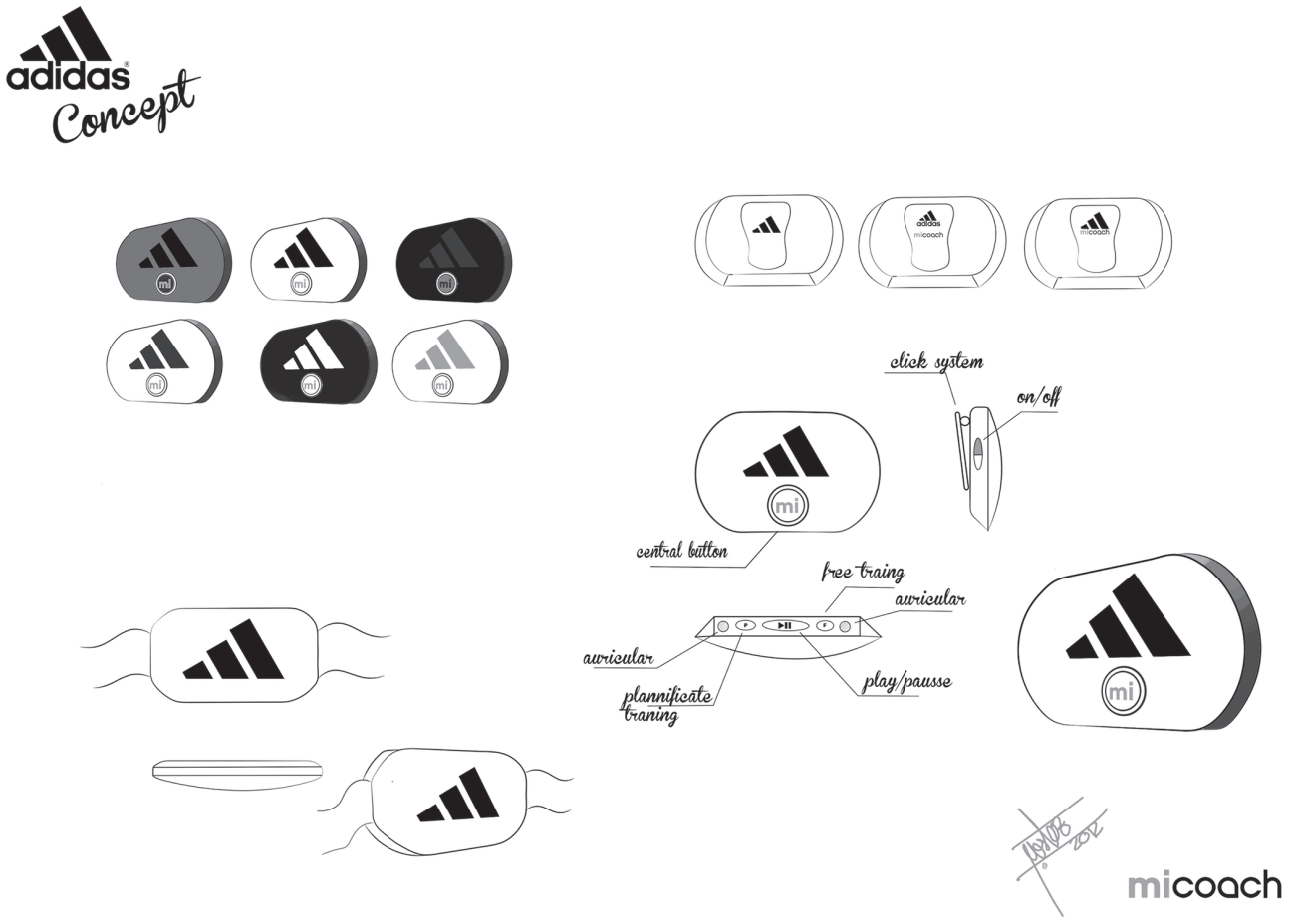

Figure 2. Example of a preliminary sketch of the micoach products,

Prototype

Although several different prototypes were developed throughout the process in order to view the various ideas proposed, the most remarkable ones were those developed during the Implement stage of the project (see Implement section).

Select

After generating ideas, the team started synthetizing these for the final concept. For this purpose, the team evaluated the most important user needs and the desired product features, and then selected the ideas that best met those needs and features.

During this stage, the team decided to design an additional concept for micoach, apart from the re-design of the range of physical products and the website. The additional feature that the team developed was a micoach in-store service that included the re-design of the physical stores and the shopping experience.

Implement

The Implement stage ran the longest. During this stage, the team developed the selected concept into the final proposal that was sent to adidas.

At the beginning of this stage, one member of the team started creating sketches for the physical range of products (Figure 2). Two members of the team designed what would be the new micoach webpage. The rest of the team planned and sketched what the new adidas store should be like in order to adapt it to the new micoach in-store service.

All the sketches, website designs and store plans were evaluated by the full team so as to find improvements in the overall functionality (product functionality, manufacturability, etc.) and aesthetics. The goal was to obtain a consistent family of micoach products.

After this evaluation, the final 3D models were created using Rhinoceros 3D and printed using 3D printing technologies. After being printed, the team painted them in order to show the real aspect of the new micoach (Figure 3). The website designs and store plans were saved as a series of pictures. Additionally, the whole project and the goal of the proposal were captured in a small book. The prototypes, the book and all the information generated during the project were put in a box also designed and manufactured by the team and then sent to adidas.

Review

Once the project was finished, the last step was to review

it. In this case, the review was considered to be the adidas' response to the project.

After initial contact with adidas, the company told the team that they could not facilitate their postal address for security reasons. Nonetheless, they encouraged the team to send some drawings and documents about the project via e-mail. The team sent different drawings and product renderings to adidas. People at adidas were impressed by the project, and they provided the team with a postal address so that they could send the whole project.

Currently, adidas is studying the proposal in order to evaluate the possibility of creating a student community at Tecnun.

Figure 3. Micoach mock-ups.

Results: students and teachers perspectives

Although the feedback from adidas was rather positive and encouraging, it was also necessary to carry out two different assessments of the work done in order to determine whether this idea is beneficial for the students from an educational point of view. For this purpose, two different assessments were performed: the first one was a questionnaire answered by the students that participated in the experience, and the second encompassed the perspective of the three teachers (who are also the authors) who guided the students throughout the project.

Questionnaire

The purpose of the questionnaire, which was anonymous, was to obtain information from the students about several educational issues related to the project, focusing on the idea of analysing whether this type of project and the proposal for adidas is beneficial for the students' education. Table 1 shows the mean values and standard deviation results of the questionnaire, considering values from 1 (poor) to 10 (excellent).

Results from the above table show that, in general, most of the students found that the project and the proposal to adidas were very positive for their education (question 5). In fact, one of the highest ranked questions was question 2, where students were asked about the benefits of working with people from other disciplines. Two students also indicated in their responses that their creativity and innovative skills had been significantly improved during the projects, whereas nearly all of them thought that their teamwork abilities were greatly increased by working with students from other disciplines (question 1).

Table 1. Mean values and standard deviation from the five student assessments.

	Question	Mean	SD
1	Has the project been useful in encouraging teamwork?	8.2	1.6
2	Do you think working with students from other disciplines is good for your education?	8.6	1.9
3	Has the project been useful in encouraging your creativity and innovation skills?	8.2	1.8
4	Have you found the project entertaining?	8.6	1.5
5	Do you think that this project has been valuable for your education?	8	2.1
6	Do you find the synergy of engineering and sport motivating or inspiring?	8.2	1.6
7	Have you found the project useful for applying what you have learned in class to a real-life application?	7.4	1.5
8	Do you think this kind of project helps you understand industry's needs?	6.6	1.4
9	Do you think this kind of project is a good way to approach companies and collaborate with them?	8.4	1.4
10	Do you think that the "student community" could be beneficial for students' education?	8.4	1.7
11	Would you take part in this student community for adidas?	8.4	1.4
12	Have your teachers been helpful during the project, set achievable goals and been good advisers?	9	1.5

In terms of motivation, most of them found the synergy between sport and engineering to be very motivating (question 6) as well as entertaining (question 4), facts that are key in motivating students to learn.

Although in this particular case they found it a little difficult to understand industry's needs (question 8) through the project, they felt, in general terms, that they could apply what they had learned in class, since it was not an academic but a real-life example (question 7).

It is also important to underline that the students agreed that this type of project and proposal to industry could be beneficial for their education (question 10) and that they would definitely like to become part of a future student community like the one proposed to adidas (question 11).

Nevertheless, one of the students did not seem to be as satisfied as the others, as the results of the questionnaire show. However, this student's comments were not in accordance with his/her assessment of the project:

"It was a nice team and an interesting project, we had a lot of fun. It was inspiring to work for a company like adidas. Many thanks for the opportunity".

Comments from the rest of the students were positive, underlining the idea that the project was very motivating and a good opportunity to apply what they learn in class to a real-life application:

"The synergy between sport and engineering has made me see that engineering can be applied to everything".

"I have been very motivated from the beginning of the project because of the aim of the project."

"The opportunity to check that what I have learned in three years can be applied in real life is an extra incentive for working hard during the rest of my degree".

"The motivation and enthusiasm shown by the teachers was transmitted to the team, which was really helpful and motivating".

Another student reported that:

"I enjoyed the experience of being a part of a student team and carrying out a project all together. We had the opportunity to develop other skills and it was a good way to approach companies".

As can be concluded from the students' answers, the overall assessment was very positive since the project and the idea of the proposal clearly engaged the students, helped them to develop skills for teamwork and creativity by gathering together students from different engineering disciplines. Moreover, they agreed that it was a valuable asset to their undergraduate education.

Teachers perspective

The most remarkable fact about this project from the point of view of the teachers was the motivation and availability of the students. Since the beginning they were clearly engaged with the project and the idea of the proposal, and they worked very hard to carry out the project (it is important to note that everything took place during their holiday time and they were not rewarded in any way for this work).

The idea of putting different profiles on the same team was very beneficial for the students since they were continuously learning new techniques and different ways of approaching the same problem, and they showed great interest in learning from each other. It was also really interesting for them to perform field studies, try the products themselves and, above all else, experience that many things that they learn in class can be applied to real-life applications like this project.

Nevertheless, it is also true that it was sometimes difficult to maintain the student focused during some of the more creative activities. Since they were students from different degrees, each of them had a completely different perspective when proposing new ideas. This fact made them argue more, but at the same time it was an enriching experience for the team. However, the difficulty of staying focused can be overcome if the supervisors have some experience in these kinds of activities.

From the point of view of the authors, the venture confirmed that it is possible to carry out this type of project with engineering students, with the idea of implementing the student community with a sports brand like adidas. The results from the project showed that this community could be beneficial for both the industry and the students' education, especially with the potential to motivate that the synergy between sports and engineering brings.

Conclusions

This article presents a new educational approach focused on fostering creativity, as well as other aptitudes demanded by industrial companies such as teamwork, problem solving, leadership and the capacity to generate innovative ideas. The approach consists in creating a student community for university-industry collaboration that benefits both the company and the students' education.

The sample project presented here serves as a validation of the educational approach taken. In collecting and analysing the teachers' and students' feedback on what they liked and did not like about the approach, the positive response from the students shows that they are enticed by innovative projects with real-life applications that help them develop important skills such as creativity, teamwork and multidisciplinary work. The teachers also have a positive view of the student community and find that it is a good tool for enhancing motivation while developing important skills.

Moreover, future strategies should take into account that similar pilot projects could also be performed for smaller companies in order to find out if these companies are more suitable for implementing a student community rather than larger ones, due to the difficulties to reach them. In addition, when implementing these projects, lecturers' time management should be taken into account and agreed with the industry partners, in order to maximize the community performance according to the lecturers' availability.

Finally, the positive response from the adidas team in Germany is encouraging and could lead to a possible future implementation of the adidas student community at the Tecnun School of Engineering.

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