electronics

MDPI

Article

Motivation and Engagement of Students: A Case Study of Automatics and Robotics Projects

Iwona Grobelna [1,*] and Anna Pławiak-Mowna [2]

1 Institute of Automatic Control, Electronics and Electrical Engineering, University of Zielona Góra, 65-516 Zielona Góra, Poland
2 Institute of Control and Computation Engineering, University of Zielona Góra, 65-516 Zielona Góra, Poland; a.mowna@issi.uz.zgora.pl
* Correspondence: i.grobelna@iee.uz.zgora.pl

Abstract: Automatics and Robotics students usually engage in some interdisciplinary approaches on their courses at universities, joining the areas of computer science and control theory. During the limited duration of these courses, some knowledge must be acquired by the students. Remote education, temporarily enforced by the COVID-19 pandemic in recent years, has posed new challenges related to the limited contact that students have with academic staff, as well as the limited access students have to hardware facilities. This paper discusses the motivations of students after the COVID-19 pandemic based on a case study of student projects completed at the University of Zielona Gora (Poland). The conducted study was student-centered and highlighted some important aspects of motivation from the point of view of the students, focusing mostly on the emerging challenges, how they have been overcome, and what the students have learned from them. The results indicate that the students, minimally supported by an academic teacher, were able to plan everything by themselves and bring the project to completion according to their own intuition. In comparison to before the COVID-19 pandemic, students are now more independent and self-motivated.

Keywords: Automatics and Robotics; case method; control systems; education; student motivation

Citation: Grobelna, I.; Pławiak-Mowna, A. Motivation and Engagement of Students: A Case Study of Automatics and Robotics Projects. *Electronics* **2024**, *13*, 3997. https://doi.org/10.3390/electronics13203997

Academic Editors: Erik Kučera, Oto Haffner and Peter Drahoš

Received: 12 September 2024
Revised: 5 October 2024
Accepted: 6 October 2024
Published: 11 October 2024

1. Introduction

Students enrolled in Automatics and Robotics courses engage in some interdisciplinary methodologies during their studies. This aspect of education is, for many of them, a great challenge. From the first semester, young people acquire skills related to mathematics, computer science, the basics of electrical engineering, and control theory. Various specialized courses are conducted in the form of lectures, exercises, laboratories, and projects, each with a different scope and allocation of hours. The trend of remote education, enforced a during the COVID-19 pandemic, remains attractive in some situations; it can pose challenges both for educators and students. On the other hand, work-from-home arrangements have become an interesting alternative for graduates. A recent systematic review [1] revealed that many aspects related to remote work affect employee performance and productivity, including the nature of the work, employer and industry characteristics, as well as home settings. However, the majority of studies report a positive impact. Another review paper reported the effects of remote learning during the COVID-19 lockdown on children's learning abilities and school performances [2], highlighting the fact that motivational and behavioral factors influenced the achievements of students. Students' engagement in learning during emergency remote teaching was also discussed in another paper [3]. One of the findings of this study was that there is a need for more research outputs on the topic of student engagement during pandemics in European and African countries. Although the value of student engagement in higher education has been appreciated for a long time [4], continued exploration will increase its value [5–7].

The implementation of student projects in a team setting helps students to develop teamwork skills that are necessary in the labor market. This includes aspects of interpersonal interactions and goal setting. It should be noted that project-based learning prepares students for work that requires problem solving or the integration of specialists from different industries. The valuable aspects of independent work and teamwork skills, among others in a dispersed environment, were particularly highlighted during the COVID-19 pandemic. Researchers created ideas on how to organize students' activities to make the teamwork as effective as possible. In addition, an important feature of constructing academic team activities is related to motivation. At professional conferences on teaching and learning methodologies and aspects of organizing educational systems, there are regular meetings and discussions about research findings related to preparing students for development and professional work. The context of the aforementioned issues is discussed in the next section, in order to provide a state-of-the-art approach.

In our research, we investigated the motivation and engagement of students, basing our findings on a case study involving student projects. The course was completed in the sixth semester (out of seven) of the engineering students' Automatics and Robotics studies. The present study sought to find answers for the following research questions:

RQ 1: Is the level of the students' engagement sufficient to complete the projects?
RQ 2: Is the level of the students' motivation sufficient to complete the projects on their own?
RQ 3: Which skills can be acquired by the students when engaging with the projects?

This research addressed these questions explicitly from the students' perspective. We analyzed feedback from the students after their participation in the course and summarized the obtained results. This paper continues our work on the experimental methods of education, conducted in recent years with the participation of Automatics and Robotics students from the University of Zielona Gora [8,9].

The rest of this paper is structured as follows: Section 2 briefly discusses related works. Section 3 describes the research methodology and milestones in project realization. Section 4 provides the results of the students' projects. Section 5 discusses the challenges and perspectives of this study, focusing much on the subjective opinions of the students. Finally, Section 6 summarizes and concludes this paper.

2. Related Work

Research reports consider the effectiveness of project-based learning and experiential learning in terms of their significant contributions to student development [10,11] and higher education development [12,13]. Project-based learning is currently quite popular [14–18]. The existing literature focuses on the development of soft skills [19], the effectiveness of teamwork [20], and the introduction of project-based (PjBL) and blended (BPjBL) activities into the curriculum of student education. Soft skills usually include interpersonal skills (such as teamwork and leadership) and intrapersonal skills (such as motivation, self-motivation, and self-efficacy). They are essential for future success in the workplace. The topic of teamwork in the context of preparing engineers for the workplace [21–24] is an important element of work that can be encountered in a real work environment. Preparing to work on a multidisciplinary team is a challenge and a team project method is valuable here.

The topic of undertaking education on project teams is the subject of the analysis of this study in the context of its usefulness. The research group in Belwal et al. [25] formulated the following conclusions: "*The students benefited largely on behavioral skills and abilities such as communication, self-confidence, (. . .), planning, thinking, and time management skills. Altogether, project-based learning offered them a different skillset beyond what they usually acquire in the conventional teaching and learning environment*". A team of researchers from Riga Technical University [26] presented the results of a study on two methods of organizing group projects in the educational process. One of the projects was implemented as an optional project, while the other was a group project with pre-tests for the students, which were mandatory. The authors concluded that, according to the students, the classes allowed them to improve their communication skills and the practical implementations of group work, and they gave them the opportunity to learn about the real aspects of teamwork. The researchers emphasized that the introduction of the tasks to the teams was perceived by the students as a learning experience. In the implementation of the educational process, it is necessary to introduce aspects of teamwork, experiment with approaches for selecting teams to carry out the project, and determine the project's optimal form. The effectiveness of the PjBL method has been studied, both for desktop projects [27–29] and for online classes [23].

An overview of empirical research in the field of PjBL is presented by Guo et al. [14]. The following question is asked: "*How do PjBL students cope with assessments in higher education?*" The authors identify four categories and seven subcategories of student learning outcomes in PjBL in higher education and eight instruments to measure them. As the researchers point out, "*only a few studies investigated the influence of PjBL on student learning related to either cognitive (e.g., knowledge) or affective outcomes (e.g., motivation)*". The BPjBL method is an interesting subject for research and analysis [30–33]. Researchers make conclusions about the impact of using the BPjBL model on student achievement, stating that it "*is more effective in increasing student achievement compared to traditional learning models*" [30], noting "*the potential of PjBL to revolutionize traditional educational methods, equipping students with skills engagingly and effectively*" [31]. Some of the researchers analyze the level and type of engagement and motivation. The achievement of learning outcomes is directly related to the level of engagement [34].

This article focuses on the motivational aspect of teamwork. The results of teams performing assigned tasks in the context of increased student self-efficacy and in the aspect of motivation during group work using the project method are presented. Similar results have been reported by Raza et al. [35], where the authors concluded that there is a positive relationship between case-based learning and the level of engagement. That study was conducted among university students in Pakistan. Dasi et al. [34], based on project management reports, attempted to determine the correlation between skills, motivation, and team capability factors and project performance. The authors determined which combinations of factors are best for projects of varying complexity. The authors expressed the following opinions: (1) "*teams working with simple tasks and under time pressure are more focused on solving the immediate tasks at hand*"; (2) "*in complex projects, the greatest improvements in project performance can be achieved by increasing motivation. In addition to its own positive effect, this will amplify the effects of ability and opportunity*".

Recent papers also focus on the use of selected project management methodologies in the context of student team performance [11,36–40]. Topics covered in this manuscript also include student-centered learning, flipped classroom implementation [23], and team-based problem solving [41]. The presented material covers issues in the areas of developing teamwork skills in the context of motivation and self-organization [42], teamwork during the implementation of flipped classroom [43,44], and the organization of project work in a flipped project management environment. Research results are presented that focus on the implementation of project classes and teamwork outcomes in relation to motivation, collaborative problem solving [45], and self-organization of teamwork for the situation in which the academic teacher acted as a mentor. The latter aspect fills a research gap in this area.

3. Materials and Methods

The study was performed in the summer semester of the academic year 2022/23 at the University of Zielona Gora, Poland. The course lasted 75 h and was realized in the sixth semester (out of seven) towards gaining an engineer's degree. It has 6 ECTS (*European Credit Transfer and Accumulation System*) points awarded, which makes it the highest-scoring subject in that semester. The study involved 23 students, all of them being males with an average age of around 21 years. The research did not include any personal or sensitive data and involved only anonymized case studies of the students' projects.

The study is fully based on the experience gained during the realization of the course, i.e., the student projects. The course itself has been scheduled in a way that enabled students' motivation and attitudes towards the projects to be tracked, while also monitoring any problems and the attempts that were made to solve them. The participants divided themselves into smaller groups, each containing a maximum of six members. The four teams were then asked to realize their own projects, while following the general, pre-planned milestones. The students were responsible for making decisions on the distribution of tasks and the time schedule for their project. The milestones planned in the project, and therefore also the important steps of the study, are schematically presented on a timeline in Figure 1; these are described in detail in the following subsections. Weekly all-day meetings were timetabled; during these meetings, the students could conduct collaborative work or problem solve within their groups, enabling them to review their progress and to discuss any unforeseen situations and future tasks.

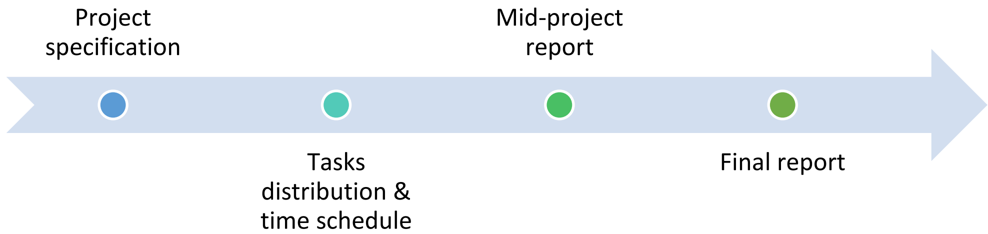


Figure 1. Milestones in the project realization.

3.1. Project Specification

The teams were assigned to imagine their own prototype system with a control process implementation. The only requirements were as follows:

(1) The prototype should be built manually by the students using the commonly available materials (wood, plastic, paper, Lego bricks, etc.).
(2) The control process should be implemented using a simple device (e.g., Arduino platform).
(3) Many abstractions were acceptable in the process design, as long as the prototype accurately simulates the real process.

The students were asked to prepare a specification of the envisaged project (What will the final product be?). They were required to explain their motivation for their decisions (Why such a project?), write an informal description of the control process (What will be achieved or simulated?), and define some general assumptions (How will the prototype be built? Which hardware platform will be used?).

3.2. Task Distribution and Time Schedule

After the specification phase, each team had to choose a leader whose role was to supervise the execution of the project. This aspect was especially important as it is reflective of the working conditions in companies, while ensuring that the students felt responsible for their projects. It should be highlighted that the teacher only observed the on-going work and kept an eye on the progress, being available in case of any questions, but they did not provide critique, nor did they influence any decisions. They just acted as a mentor.

The teams had to define the particular tasks for the whole project, assign them to individuals, and create a time schedule for their completion. This was treated as a milestone, because it was kept as a reference for progress in bringing the project to its realization. Any deviations from the plan had to be reported and justified. Additionally, students had to implement a catch-up plan on an ongoing basis.

3.3. Mid-Project Report

In the middle of project, the students were asked to prepare a mid-project report, which was required to cover the following aspects:

(1) An evaluation of the progress of the project (in a percentage, where 100% would mean project completed).
(2) A discussion of the so-far-encountered problems and their solutions.
(3) A risk analysis.

The participants had to think about which (hitherto unforeseen) situations might occur, how they might minimize the probability of such events and—if it is not possible to avoid them—how to mitigate their effects.

While the first and second parts of the report were related to the facts (What is working? Were there any problems? How were they solved?), the last part required a deeper analysis and a forward-thinking approach. The aim of this part was to make the students more aware of the real risks related to execution of the project.

3.4. Final Report

At the end, the students had to provide a full report of the project's realization. It had to be prepared as a four-page document with a marketing description of the product, some background information on similar solutions, the concept, and the technical implementation details.

The students were also asked to present the prototypes in front of the class and answer some questions from their colleagues.

Finally, regardless of the topic and project, all students were asked to subjectively summarize the course and identify what they had learnt (no specific application form was used, students had complete freedom as to the content and form of their feedback). This feedback was especially important in developing an understanding of the students' perspectives and the core elements of the study.

4. Results

In the following section, the four projects will be briefly introduced, focusing on the milestones of the study and on the attitudes of the students. For the remainder of the paper, the projects will be referred to as follows:

Project A: Bread-baking and vending machine.
Project B: Automatic greenhouse.
Project C: Metal detection in production processes.
Project D: Smart parking.

4.1. Project Specification

4.1.1. Project A: Bread-Baking and Vending Machine

The idea of the project was to create a simple prototype of a vending machine that bakes and sells fresh bread. High-tech vending machines are becoming popular worldwide [46]. Arduino was chosen as a target hardware platform to control the system, mostly because of its simplicity. It is suited even for primary education students [47] and is often used in various practical applications in many domains, including a chocolate vending machine [48], an innovative smart blind stick for people with vision loss [49], and patient health monitoring [50].

The students described the project as follows: "We noticed that on weekends, in the morning or after returning from the second shift at work, often one cannot buy fresh bread. Apart from bakeries, we can only buy pre-baked and chemically strengthened bread. Our solution addresses these problems. Thanks to our vending machines, one can have fresh, fragrant bread at any time and in any place".

4.1.2. Project B: Automatic Greenhouse

The purpose of the project was to create a small portable greenhouse for the preparation of plant seedlings with automatic watering. The topic fits into the trend of greenhouses automation [51,52]. The chosen hardware platform to control the system in this project was also Arduino. The project included the planned use of humidity, temperature, and soil moisture sensors.

The students described the project as follows: "We focused on automation in the area of agriculture by automating the process of watering and maintaining the right temperature and humidity of the air and lighting, optimal for growing plants. The greenhouse is small in size and it is convenient to move it wherever necessary".

4.1.3. Project C: Metal Detection in Production Processes

The prototype was intended to detect metal elements in products on conveyor belts. It might be useful in any production system, especially ones related to the food industry, where this aspect is of special interest [53]. A program for the Arduino platform was planned to read and interpret signals from the sensor and take appropriate action if the presence of metal is detected.

The students described the project as follows: "The task was to create a conveyor belt that moves a product. A self-made inductive sensor is placed under it to detect metal. It will enable the detection of dangerous contamination during production".

4.1.4. Project D: Smart Parking

The aim of the project was to create a physical mock-up of an intelligent car park with the use of LED diodes, buttons, and an LCD display using the Arduino platform. The system should allow for automatic selection and detection of available parking spaces, as well as the dynamic assignment of these places to incoming cars. It was intended that the prototype should enable the simulation of a real car park, but at another scale (toy cars). The topic of smart parking has great potential nowadays [54,55], as city centers are becoming more and more crowded.

The students described the project as follows: "Main functionalities are automatic detection and selection of available parking spaces, dynamic assignment of these spaces to users, and real-time parking monitoring. By using the Arduino platform, our system provides flexibility, scalability, and the possibility of further development".

4.2. Task Distribution and Time Schedule

After the detailed specification of the projects, the groups were asked to prepare a time schedule and distribute the tasks between team members. Initially, the division of working hours to particular students was assumed to be even, but in reality, it was not. Some of the more engaged students took on more tasks than the others. The process of task assignment itself took more time than expected. Firstly, this was because of the necessity of defining the tasks. Secondly, this was because the students had to decide who would undertake which tasks. Incorrect task definition and distribution could negatively affect the task realization time.

4.3. Mid-Project Report

Each group prepared their own mid-project report, providing the information about project progress, problems encountered so far, their solutions, and a risk analysis for the second half of the project duration. The reports are summarized in Table 1 (all data provided directly by the students). Although the topics were very different, the problems were quite similar, referring mostly to time aspects (longer time than expected for the realization of particular tasks, waiting for the delivery of some additional elements) and to hardware issues (possible damage of elements, calibration, precision).

Table 1. Chosen information from the mid-term reports (all data provided by the students).

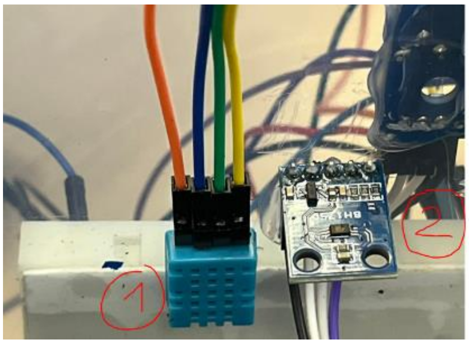
	Project A	Project B	Project C	Project D
Progress	65%	70%	65%	60%
Problems	Time underestimation; little experience in the chosen applications	Long delivery time of additional elements	Incorrect control algorithm; calibration problems	Problems with the quality of 3D printing; unavailability of some team members; problems with hardware synchronization
Risk	Not completing the project on time	Missing elements (still waiting for delivery); damage of elements during realization	Matching of elements; lack of precision	Damage of elements during manufacturing
Action	Increasing time devoted to the strategic tasks; decreasing time devoted to the minor tasks	More careful implementation of physical elements	Use of 3D modeling; extensive testing	Increasing the time schedule flexibility; testing of separate hardware elements

All the students were engaged in the realization of the projects. The mid-term reports additionally included some subjective feedback concerning the initial vision. Although the progress in all projects was estimated to be above 50% (the mid-term report was prepared exactly in the middle of the dedicated time period), two groups indicated that they underestimated the time needed for the particular tasks. The team of Project A stated the following: "*We thought that it would be much easier. The work has been going much slower and the project progress is small*"; the team of Project D stated the following: "*We also encountered problems related to the organization of working time of project team members, which had a negative impact on the realization of the schedule*". The two other groups had no problems with proper time estimation. The team of Project B stated the following: "*The team worked cohesively and consistently, which is why the implementation schedule was maintained*"; the team of Project C stated the following: "*The team was able to maintain control over the progress of the work and adapt the action plan to the changing conditions*".

Considering the risk evaluation, the students (both from "under-estimated" time-scheduled projects and from those running on time) were afraid that they might not complete the project within the given time. However, the "time-critical" groups self-adjusted the time schedule and increased the time spent on working on strategic stages, regarding hours spent outside of the university: Project A stated that "*We reduce the amount of work on less important stages of work (details)*" and Project D stated that "*To avoid problems related to the organization of working time and team members, we will be more careful about setting realistic deadlines and increase the flexibility of the schedule*".

4.4. Final Report

All final reports included a marketing description of the product and a short discussion of similar solutions available on the market. The mandatory sections (analogously to scientific papers) were the introduction, methodology, some implementation details, simulations/tests, and conclusions, with indication of possible improvements. Some sample implementation details are shown in Figure 2. In order to keep to the deadline, the reports could be submitted up to two weeks after the final presentation (all data were provided by the students).

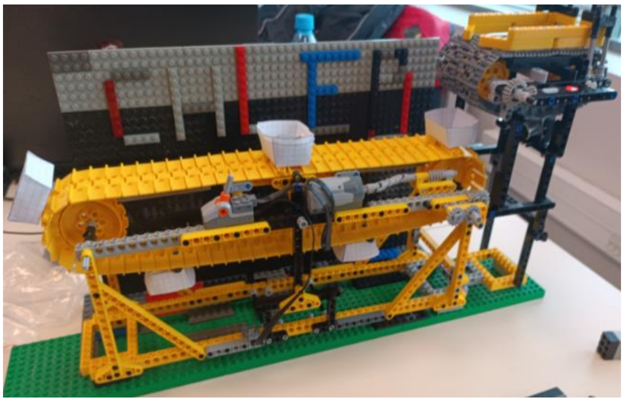


Temperature and humidity sensor (1) and light level sensor (2)

Soil moisture sensor

Figure 2. Implementation details (Project B).

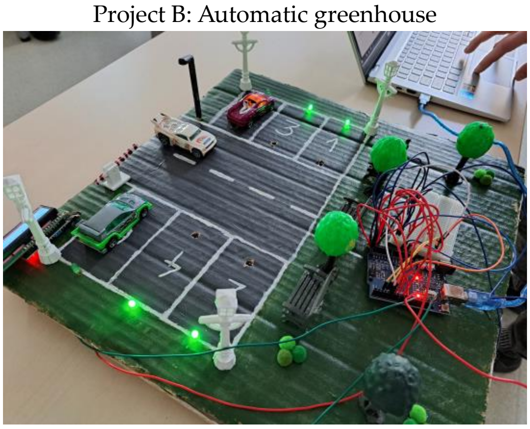
Just before the final report, the students presented their solutions in front of their classmates. Each group had 10 minutes available for the presentation. Afterwards, there was also some time for questions from the other students (those not involved in the particular project being presented). The questions were mostly related to some implementation details, ways of working, or future expansion possibilities. The students greatly enjoyed introducing their projects. The completed prototypes are shown in Figure 3.



Project A: Bread-baking and vending machine

Project B: Automatic greenhouse

Project C: Metal detection in production processes



Project D: Smart parking

Figure 3. Prototypes of completed student projects.

5. Discussion

The self-motivation of the students (intrinsic motivation when the students engage because they enjoy it and are satisfied with their work) played a significant role in the success of the project. The study aimed to check whether the students are able to self-organize their work, supervise it, and finalize the project within the given time framework.

The role of the teacher was to observe the progress and to be available for any questions. However, the students were encouraged to first try to find the answers by themselves, leaving the help of the mentor as the last option. The organization of the work allowed the researcher to keep track of the students' motivation levels.

The completed projects were similar to the average graduation thesis (first cycle of studies), which is frequently prepared at the end of the first cycle of Automatics and Robotics courses. The size of the prototypes as well as the scope of work was also quite similar. The only difference was that the diploma thesis is prepared individually, while the students worked in groups for these projects. However, the students had no previous experience in conducting such works, and the course aimed to prepare them to write their own diplomas in the near future.

The subjective opinions of the students made it possible to find out what they thought about the course. Although there were no specific questions (the students were asked to write any comments they wanted about what they had learnt and how they liked the course), some common aspects appeared in many of their notes. During data analysis, we carefully reviewed all the feedback. The most frequently mentioned advantages were that the students learned to work in a group and to gain experience in time management. A time- and person-related aspect is task assignment, where both factors have to be taken into account. Finally, they practiced communication with other team members and—surprisingly—future thinking. The most frequently appearing keywords (picked up from the provided feedback and summarized) are illustrated in Figure 4 (the larger the font size, the more often a given keyword appeared in student feedback). Based on these results, we assume that the most relevant acquired skills in the examined project-based learning were so-called *soft skills*.

Figure 4. Keywords appearing in students' feedback ("What I have learnt?").

We carefully analyzed the feedback of the students after their participation in the course. The specific comments referred, again, to the time aspect ("*I have learnt how important it is to plan the work and stick to the plan*" and "*I have learnt that any delays in plan realization must be immediately removed*"). Other aspects are related to soft skills, namely creativity and stress resistance ("*I was able to develop my creativity*" and "*I have learnt to cope with stressful situations*").

This strongly suggests that the students recognized the value of responsibility and felt self-motivated to finish the projects. Their level of intrinsic motivation was sufficient for realizing all tasks to be carried out during the course.

In the literature, issues related to student-centered learning have been a topic of research in recent years. Technological developments and a changing environment keep the research topic relevant [14,56,57]. Optimally, students take control of their own learning and define their learning paths in a student-centered approach [58]. As indicated in the advantages of student-centered learning, these include a focus on learning objectives, student participation in learning activities, student collaboration, use of technology, and generation of a real-world product [59]. This method also has the advantage that students play an active role in the learning process and take responsibility for organizing, analyzing, and generalizing.

The present article adopts the following definition of project-based learning: "a teaching method that confronts students with problems that are unfamiliar or complex, with stages of problem orientation, setting learning objectives, conducting a series of scientific investigations, collaborating, using learning technologies and creating a product" [59]. A student-centered learning environment is defined as follows: "provides interactive, complementary activities that enable individuals to meet their unique interests and learning needs, discover content at multiple levels of complexity, and deepen their understanding" [60,61].

The obtained results confirm the effectiveness of using a student-centered teaching method. The conclusions formulated in [58–60] coincide with the research results presented in the present article. The results are focused on the implementation of project activities and teamwork. The presented concept of a self-organizing project [62,63], in which an academic teacher acted as a mentor, fills a research gap. However, further research in this area is necessary. Moreover, the aspect of critical thinking indicated by the students requires, according to the authors, additional attention and study.

6. Conclusions

The aim of the present study was to find the answers to certain research questions surrounding students' motivation and engagement. Here, we summarize the obtained results and answer the questions posed at the beginning.

The first research question (RQ 1) referred to the level of engagement: *Is the level of the students' engagement sufficient to complete the projects?* The study shows that students successfully completed the projects by themselves. Although they were initially not fully aware of the complexity of the imagined projects (the application areas and project sizes were quite diverse depending on the team), they were able to modify the scope of the work during the execution of the projects. Finally, all projects were completed on time.

The second research question (RQ 2) referred to motivation: *Is the level of the students' motivation sufficient to complete the projects on their own?* The research clearly confirms that (in general) the self-motivation of students (intrinsic motivation) was high enough to bring the projects to completion. However, it was observed that a few students had withdrawn slightly, which meant that the more motivated team members had to partially take over their duties. Although the reasons for their withdrawal were not analyzed, this seems to be related to motivation levels, which were observable during the classes.

The third research question (RQ 3) referred to acquired skills: *Which skills can be acquired by the students when engaging with the projects?* We were interested in finding out which skills were most important to the students. Was it technical skills? Or was it perhaps soft skills, such as group work/teamwork, communication, forward thinking, individual assignments? From the feedback provided at the end of the course by the students, it can be concluded that they acquired time management, teamwork, task assignment, communication, and future-thinking skills (listed from the most common to the least common answers). The mid-term report also confirmed that time-related aspects were a big challenge during the course of the project (underestimation of time, concerns about the deadline). All of the acquired skills that were identified by the students are soft skills. What surprised us is the fact that students treated the technical issues (problems with hardware, getting to know some new software, building a physical prototype) simply as "tools" to carry out the projects.

The results of the study revealed that most students were able to identify their role in the execution of the project. They were motivated and involved in the tasks without the intervention of a mentor.

The present study has some limitations. Firstly, the sizes of the groups participating in the experiment were quite limited. However, the research focused on qualitative rather than quantitative data; therefore, this aspect did not have much influence the general conclusions. Secondly, more formal reporting forms (such as surveys or self-rating scales) could have been used to gain information about certain aspects that arose during the project work. On the other hand, this might then have led to bias in students' responses, potentially leading them to be more polite or seeking social approval. Finally, the choice of application areas of the prototypes and their design influenced the level of difficulty.

The study also uncovers some new questions for future research: Would the results be similar in another related field of study (e.g., computer science)? What would be the attitude of students in earlier semesters? Would they take up the challenge? What makes some students more engaged than others? While the first question is now under investigation (we are conducting a complementary study among students of Computer Science at the University of Zielona Gora), the remaining questions are open. Additionally, an interesting research direction would be to conduct a long-term study with more formal tools that could allow some quantitative analysis to be conducted and might provide more objective conclusions.

Author Contributions: Conceptualization, I.G.; literature overview: A.P.-M.; methodology, I.G.; investigation, I.G.; writing—original draft preparation, I.G. and A.P.-M.; writing—review and editing, I.G.; visualization, I.G.; supervision, I.G.; project administration, I.G.; funding acquisition, I.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The original contributions presented in the study are included in the article; further inquiries can be directed to the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

1. Anakpo, G.; Nqwayibana, Z.; Mishi, S. The Impact of Work-from-Home on Employee Performance and Productivity: A Systematic Review. *Sustainability* **2023**, *15*, 4529. [CrossRef]
2. Cortés-Albornoz, M.C.; Ramírez-Guerrero, S.; García-Guáqueta, D.P.; Vélez-Van-Meerbeke, A.; Talero-Gutiérrez, C. Effects of remote learning during COVID-19 lockdown on children's learning abilities and school performance: A systematic review. *Int. J. Educ. Dev.* **2023**, *101*, 102835. [CrossRef] [PubMed]
3. Yang, D.; Wang, H.; Metwally, A.H.S.; Huang, R. Student engagement during emergency remote teaching: A scoping review. *Smart Learn. Environ.* **2023**, *10*, 24. [CrossRef]
4. Coates, H. The Value of Student Engagement for Higher Education Quality Assurance. *Qual. High. Educ.* **2005**, *11*, 25–36. [CrossRef]
5. Collaço, C.M. Increasing student engagement in higher education. *J. High. Educ. Theory Pract.* **2017**, *17*, 40–47.
6. Serrano, D.R.; Dea-Ayuela, M.A.; Gonzalez-Burgos, E.; Serrano-Gil, A.; Lalatsa, A. Technology-enhanced learning in higher education: How to enhance student engagement through blended learning. *Eur. J. Educ.* **2019**, *54*, 273–286. [CrossRef]
7. Shafiq, M.; Parveen, K. Social media usage: Analyzing its effect on academic performance and engagement of higher education students. *Int. J. Educ. Dev.* **2023**, *98*, 102738. [CrossRef]
8. Grobelna, I.; Mazurkiewicz, M.; Janus, D. Help students learn interpreted Petri nets with Minecraft. *Inform. Educ.* **2022**, *22*, 257–276. [CrossRef]
9. Grobelna, I. Scratch-Based User-Friendly Requirements Definition for Formal Verification of Control Systems. *Inform. Educ.* **2020**, *19*, 223–238. [CrossRef]
10. Balleisen, E.J.; Howes, L.; Wibbels, E. The impact of applied project-based learning on undergraduate student development. *High Educ.* **2024**, *87*, 1141–1156. [CrossRef]
11. Bojanova, I. Development of a reliable, valid, multi-dimensional measure of student engagement in group projects. In Proceedings of the IEEE Frontiers in Education Conference, Oklahoma City, OK, USA, 23–26 October 2013; pp. 239–245. [CrossRef]
12. Baviera, T.; Baviera-Puig, A.; Escribá-Pérez, C. Assessing Team Member Effectiveness among higher education students using 180° perspective. *Int. J. Manag. Educ.* **2022**, *20*, 100702. [CrossRef]
13. Masood, F.; Ghobakhloo, M.; Syberfeldt, A. An Interpretive Structural Modeling of Teamwork Training in Higher Education. *Educ. Sci.* **2019**, *9*, 16. [CrossRef]
14. Guo, P.; Saab, N.; Post, L.S.; Admiraal, W. A review of project-based learning in higher education: Student outcomes and measures. *Int. J. Educ. Res.* **2020**, *102*, 101586. [CrossRef]
15. Louise, H.J. Interdisciplinary Project-Based Learning As a Means of Developing Employability Skills in Undergraduate Science Degree Programs. *J. Teach. Learn. Grad. Employab.* **2019**, *10*, 50–66.
16. Balemen, N.; Keskin, M.Ö. The effectiveness of project-based learning on science education: A meta-analysis search. *Int. Online J. Educ. Teach.* **2018**, *5*, 849–865.
17. Lawrence, J.; Dimashkie, B.; Centea, D.; Singh, I. The Learning Factory: Self-directed Project-Based Education. In *Visions and Concepts for Education 4.0. ICBL 2020. Advances in Intelligent Systems and Computing*; Auer, M.E., Centea, D., Eds.; Springer: Cham, Switzerland, 2021; Volume 1314. [CrossRef]

18. Wijnia, L.; Noordzij, G.; Arends, L.R.; Rikers, R.; Loyens, S. The Effects of Problem-Based, Project-Based, and Case-Based Learning on Students' Motivation: A Meta-Analysis. *Educ. Psychol. Rev.* **2024**, *36*, 29. [CrossRef]
19. Escudeiro, N.F.; Escudeiro, P.M. The Multinational Undergraduate Teamwork Project: An Effective Way to Improve Students' Soft Skills. *Ind. High. Educ.* **2012**, *26*, 279–290. [CrossRef]
20. Palmer, S. Framework for Undergraduate Engineering Management Studies. *J. Prof. Issues Eng. Educ. Pract.* **2003**, *129*, 92–99. [CrossRef]
21. Panagiotis, A.; Taggart, J.; Schwartz, R.X. Creating Effective Project-Based Courses: Personal Relevance and Its Relations to Successful Group Work. *Eur. J. Eng. Educ.* **2023**, *48*, 1165–1185. [CrossRef]
22. Çiloglugil, B.; Balci, B.; Uslu, N.A. Acquisition of teamwork competence in a hardware course: Perceptions and co-regulation of computer engineering students. *Int. J. Eng. Educ.* **2020**, *36*, 388–398.
23. Karabulut-Ilgu, A.; Madson, K.; Miner, N.; Shane, J.; Burzette, R. Analysis of teamwork skill development in a flipped civil engineering course. *Comput. Appl. Eng. Educ.* **2024**, *32*, e22680. [CrossRef]
24. Sperling, J.; Mburi, M.; Gray, M.; Schmid, L.; Saterbak, A. Effects of a first-year undergraduate engineering design course: Survey study of implications for student self-efficacy and professional skills, with focus on gender/sex and race/ethnicity. *Int. J. STEM Educ.* **2024**, *11*, 8. [CrossRef]
25. Belwal, R.; Belwal, S.; Sufian, A.B.; Al Badi, A. Project-based learning (PBL): Outcomes of students' engagement in an external consultancy project in Oman. *Educ. Train.* **2020**, *63*, 336–359. [CrossRef]
26. Uhanova, M.; Prokofyeva, N.; Katalnikova, S.; Ziborova, V. Possibilities for Organizing Group Work for Computer Science Students. *Procedia Comput. Sci.* **2023**, *225*, 1407–1414. [CrossRef]
27. Hanney, R. Doing, being, becoming: A historical appraisal of the modalities of project-based learning. *Teach. High. Educ.* **2018**, *23*, 769–783. [CrossRef]
28. Hanney, R. Making Projects Real in a Higher Education Context. In *Applied Pedagogies for Higher Education*; Morley, D.A., Jamil, M.G., Eds.; Palgrave Macmillanl: Cham, Switzerland, 2021. [CrossRef]
29. Kuppuswamy, R.; Mhakure, D. Project-based learning in an engineering-design course –developing mechanical—Engineering graduates for the world of work. In Proceedings of the 30th CIRP Design 2020, Procedia CIRP, Pretoria, South Africa, 5–8 May 2020; Volume 91, pp. 565–570.
30. Suyantiningsih; Badawi; Sumarno; Prihatmojo, A.; Suprapto, I.; Munisah, E. Blended Project-Based Learning (BPjBL) on Students' Achievement: A Meta-Analysis Study. *Int. J. Instr.* **2023**, *16*, 1113–1126. [CrossRef]
31. Marta, R.; Riyanda, A.R.; Samala, A.D.; Dewi, I.P.; Adi, N.H. Innovative Learning Strategies: Project-Based Learning Model for Excelling in Visual Programming. *TEM J.* **2024**, *13*, 581–589. [CrossRef]
32. Tong, Y.; Wei, X. Teaching design and practice of a project-based blended learning model. *Int. J. Mob. Blended Learn.* **2020**, *12*, 33–50. [CrossRef]
33. Mursid, R.; Saragih, A.H.; Hartono, R. The Effect of the Blended Project-Based Learning Model and Creative Thinking Ability on Engineering Students' Learning Outcomes. *Int. J. Educ. Math. Sci. Technol.* **2022**, *10*, 218–235. [CrossRef]
34. Kuh, G.D. Assessing What Really Matters to Student Learning Inside The National Survey of Student Engagement. *Change Mag. High. Learn.* **2001**, *33*, 10–17. [CrossRef]
35. Raza, S.A.; Qazi, W.; Umer, B. Examining the impact of case-based learning on student engagement, learning motivation and learning performance among university students. *J. Appl. Res. High. Educ.* **2020**, *12*, 517–533. [CrossRef]
36. Chen, S.H.; Lu, H.P. Application of the Scrum project management framework in a software engineering course with peer assessment. *Interact. Learn. Environ.* **2019**, *27*, 1072–1087.
37. Chang, S.C.; Wongwatkit, C. Effects of a Peer Assessment-Based Scrum Project Learning System on Computer Programming's Learning Motivation, Collaboration, Communication, Critical Thinking, and Cognitive Load. *Educ. Inf. Technol.* **2024**, *29*, 7105–7128. [CrossRef]
38. Chien, Y.H.; Tsai, C.C. The effects of using a Scrum project-based approach on learning motivation and project performance in a programming course. *Learn. Media Technol.* **2018**, *43*, 1–18.
39. Li, Y.; Shu, Y.; Chen, H. Peer review of group project in software engineering education based on Scrum. *J. Educ. Technol. Dev. Exch.* **2020**, *13*, 1–12.
40. McLeod, P.L.; Orta-Ramirez, A. Effects of Collective Efficacy, Teamwork Attitudes, and Experience on Group Project Performance: Comparisons Between 2 Food Science Courses. *J. Food Sci. Educ.* **2018**, *17*, 14–20. [CrossRef]
41. Hmelo-Silver, C.E.; Linn, M.C.; Eylon, B.S. Using peer assessment to promote collaborative problem-solving in computer science education. *Interact. Learn. Environ.* **2020**, *28*, 369–383.
42. Nguyen, T.H.; Nguyen, V.H.; Vo, H.H.; Le, N.T.; Nguyen, T.T.P.; Vo, H.K. Emotional Intelligence and Teamwork Results of Vietnamese Students. *J. Organ. Behav. Res.* **2022**, *7*, 171–187. [CrossRef]
43. Park, S.; Kaplan, H.; Schlaf, R. Interdisciplinary flipped learning for engineering classrooms in higher education: Students' motivational regulation and design achievement. *Comput. Appl. Eng. Educ.* **2018**, *26*, 589–601. [CrossRef]
44. Sevillano-Monje, V.; Martín-Gutiérrez, Á.; Hervás-Gómez, C. The flipped classroom and the development of competences: A teaching innovation experience in higher education. *Educ. Sci.* **2022**, *12*, 248. [CrossRef]
45. He, S.; Shi, X.; Choi, T.H.; Zhai, J. How do students' roles in collaborative learning affect collaborative problem-solving competency? A systematic review of research. *Think. Ski. Creat.* **2023**, *50*, 101423. [CrossRef]

46. Sibanda, V.; Munetsi, L.; Mpofu, K.; Murena, E.; Trimble, J. Design of a high-tech vending machine. *Procedia CIRP* **2020**, *91*, 678–683. [CrossRef]
47. García-Tudela, P.A.; Marín-Marín, J.-A. Use of Arduino in Primary Education: A Systematic Review. *Educ. Sci.* **2023**, *13*, 134. [CrossRef]
48. Desai, S.S.; Jadhav, S.M.; Patil, P.S.; Giri, N.S. Automatic Chocolate Vending Machine By Using Arduino Uno. *Int. J. Innov. Res. Comput. Sci. Technol.* **2017**, *5*, 2. [CrossRef]
49. Rajesh, P.; Sairam, R.; Kumar, M.D.; Eswar, P.K.; Keerthi, Y. Arduino based Smart Blind Stick for People with Vision Loss. In Proceeding of the 7th International Conference on Computing Methodologies and Communication (ICCMC), Erode, India, 23–25 February 2023; pp. 1501–1508. [CrossRef]
50. Alsayaydeh, J.A.J.; bin Yusof, M.F.; Halim, M.Z.B.A.; Zainudin, M.N.S.; Herawan, S.G. Patient Health Monitoring System Development using ESP8266 and Arduino with IoT Platform. *Int. J. Adv. Comput. Sci. Appl.* **2023**, *14*, 617–624. [CrossRef]
51. Gazieva, L.; Belyaeva, E.; Kosulin, V. Effectiveness and profitability of automation technologies in greenhouse productivity and food security. *E3S Web Conf.* **2023**, *451*, 02012. [CrossRef]
52. Alsayaydeh, J.A.J.; bin Yusof, M.F.; Hern, C.K.; Ahmad, M.R.; Shkarupylo, V.; Herawan, S.G. Greenhouse Horticulture Automation with Crops Protection by using Arduino. *Int. J. Adv. Comput. Sci. Appl.* **2023**, *14*, 114–123. [CrossRef]
53. Liu, B.; Zhou, W. The research of metal detectors using in food industry. In Proceedings of the International Conference on Electronics and Optoelectronics 2011, Dalian, China, 29–31 July 2011; IEEE: Piscataway, NJ, USA, 2011; Volume 4. [CrossRef]
54. Diaz Ogás, M.G.; Fabregat, R.; Aciar, S. Survey of Smart Parking Systems. *Appl. Sci.* **2020**, *10*, 3872. [CrossRef]
55. Barriga, J.J.; Sulca, J.; León, J.L.; Ulloa, A.; Portero, D.; Andrade, R.; Yoo, S.G. Smart Parking: A Literature Review from the Technological Perspective. *Appl. Sci.* **2019**, *9*, 4569. [CrossRef]
56. Chen, C.-H.; Tsai, C.-C. In-service teachers' conceptions of mobile technology-integrated instruction: Tendency towards student-centered learning. *Comput. Educ.* **2021**, *170*, 104224. [CrossRef]
57. Dunbar, K.; Yadav, A. Shifting to student-centered learning: Influences of teaching a summer service learning program. *Teach. Teach. Educ.* **2022**, *110*, 103578. [CrossRef]
58. Murphy, L.; Eduljee, N.B.; Croteau, K. Teacher-centered versus student-centered teaching: Preferences and differences across academic majors. *J. Eff. Teach. High. Educ.* **2021**, *4*, 18–39. [CrossRef]
59. Krajcik, J.S.; Shin, N. Project-based learning. In *The Cambridge Handbook of the Learning Sciences*, 2nd ed.; Sawyer, R.K., Ed.; Cambridge University Press: New York, NY, USA, 2014; pp. 275–297.
60. Hannafin, M.J.; Land, S. The foundations and assumptions of technology-enhanced, student-centered learning environments. *Instr. Sci.* **1997**, *25*, 167–202. [CrossRef]
61. Hannafin, M.J.; Hannafin, K.M.; Land, S.; Oliver, K. Grounded practice in the design of learning systems. *Educ. Technol. Res. Dev.* **1997**, *45*, 101–117. [CrossRef]
62. Shmurygina, N.; Bazhenova, N.; Bazhenov, R.; Nikolaeva, N. Self-organization of Students: Realities and Development Prospects. *Procedia-Soc. Behav. Sci.* **2015**, *214*, 95–102. [CrossRef]
63. Heitmann, G. Project-oriented Study and Project-organized Curricula: A Brief Review of Intentions and Solutions. *Eur. J. Eng. Educ.* **1996**, *21*, 121–131. [CrossRef]