Project Name: Improving STEM Teaching Process using Digital Transformation - DIGSTEM

Project Number: 22310113

DIGSTEM

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PUBLICATION

Improving STEM Teaching Process using Digital Transformation

University of Pristina in Kosovska Mitrovica
2024

DIGSTEM Publication - Improving STEM Teaching Process using Digital Transformation

2024.

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University of Pristina in Kosovska Mitrovica

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Preface

This publication was created under the framework of project "Improving STEM Teaching Process using Digital Transformation - DigSTEM" (Grant No. 22310113) with cooperation with project partner institutions. The project is supported by the Visegrad Group. The coordinator of the project is the University of Pristina in Kosovska Mitrovica, and the partners are Obuda University, University of Zilina, Lublin University of Technology and Universum College.

The general goal of the project is to improve the application of digital technologies in the educational process of higher education institutions (HEIs) in Western Balkan through the exchange of experiences between HEIs from Western Balkan and the Visegrad region. The project refers to teaching processes in subjects covering STEM (Science, Technology, Engineering and Mathematics). Each of these subjects represents a part of the curriculum. Rather than being taught separately, students learn how these concepts complement each other through an interdisciplinary approach. This concept of education originates from the countries of the European Union and aims to implement STEM skills in all educational institutions and educational levels.

The publication consists of two parts. The first part presents the results and analysis of surveys conducted at all partner institutions among students and teachers. The second part can serve as a guide for the implementation of STEM in education. STEM related topics are based on reports and conclusions from training and webinars organized within the project, as well as examples of good practice from partner institutions from the Visegrad Group.

Project website: https://digstem.pr.ac.rs/

Editors

1. ANALYSIS OF SURVEY RESULTS – UNIVERSITY OF PRISTINA IN KOSOVSKA MITROVICA

As part of the DIGSTEM project, a survey of students and teachers at four higher education institutions was conducted. The questionnaire was prepared to examine the use of STEM education principles during the teaching process. The goal of the research is to see the possibilities and support for teachers for the implementation of STEM education. Over 800 students and over 200 teachers participated in the survey.

1.1. Survey for Teachers

Field of teaching:

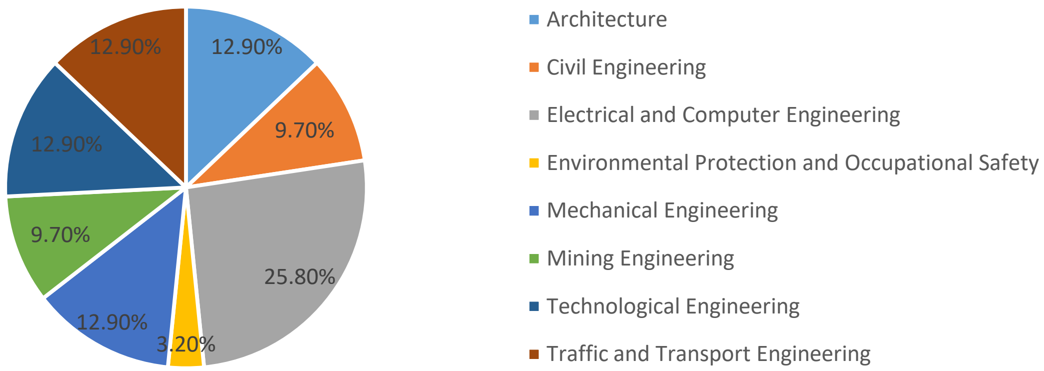


Figure 1.1. Respondents' answers to the question Field of teaching.

Sex:

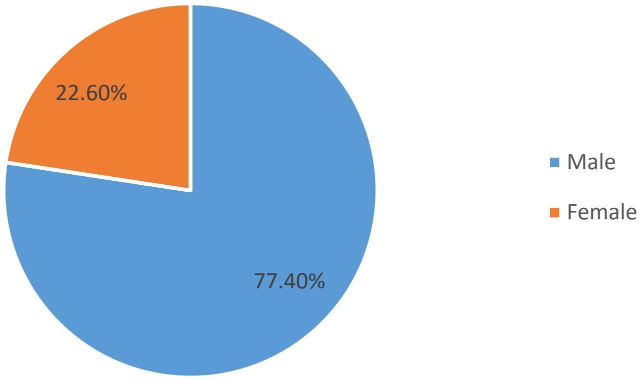


Figure 1.2. Respondents' answers to the question Sex.

Position:

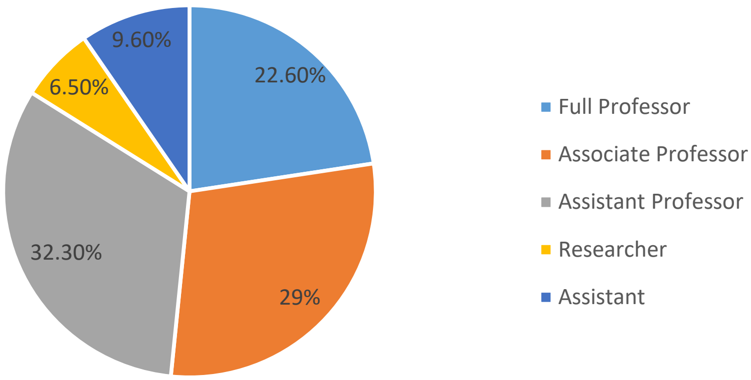


Figure 1.3. Respondents' answers to the question Position.

Teaching experience at university:

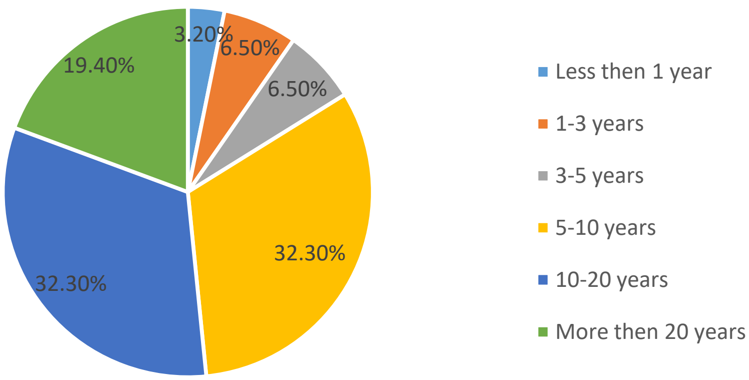


Figure 1.4. Respondents' answers to the question Teaching experience at university.

The survey results show that the largest portion is held by the Electrical and Computer Engineering sector, accounting for 25.80%, indicating a high popularity or demand for professionals in this field. Following this, the sectors of Architecture, Mechanical Engineering, Technological Engineering and Traffic and Transport Engineering each hold a share of 12.90%, suggesting an even distribution of interest or resources among these disciplines. The sectors of Mining Engineering and Civil Engineering each account for 9.70%, while Environmental Protection and Occupational Safety occupies the smallest share at 3.20%.

The majority of respondents are male, comprising 77.4% of the sample, while females account for 22.6%. This indicates a significant gender disparity among the academic staff.

Assistant professors make up the largest proportion at 32.3%, followed by associate professors at 29%, and full professors at 22.6%. Researchers are the smallest group, representing 6.50% of the respondents.

The largest groups are those with 5-10 years of experience (32.30%) and those with 10-20 years of experience (32.30%), indicating a substantial portion of faculty members in their mid-career stage. Respondents with more than 20 years of experience make up 19.40%, reflecting a significant portion of highly experienced faculty. Those with 3-5 years and 1-3 years of experience represent smaller groups, each at 6.50%. The smallest group is those with less than 1 year of experience, at 3.20%.

1.1.1. STEM Education Integration

1.1. Has the Science, Engineering, Mathematics, Technology education been integrated at your faculty?

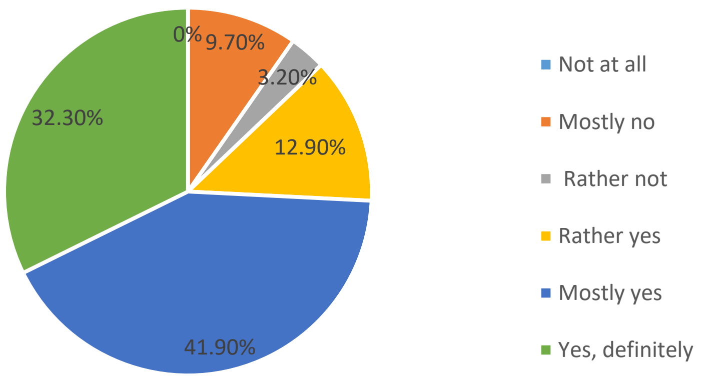


Figure 1.5. Respondents' answers to the question 1.1.

1.2. How much focus does your teaching have on STEM education.

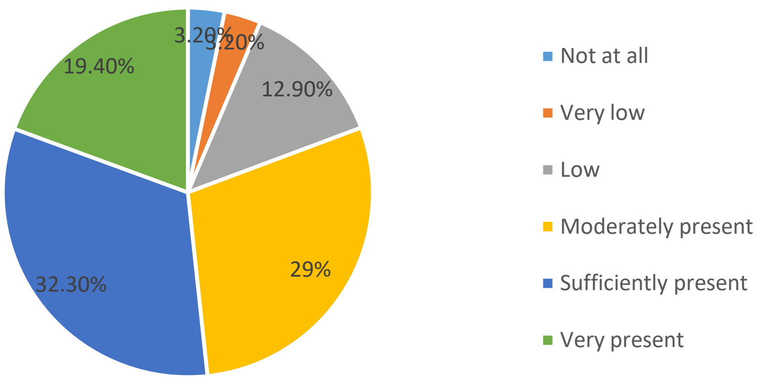


Figure 1.6. Respondents' answers to the question 1.2.

1.3. Do you provide lectures/courses with elements of STEM education? (*answer in percentages from 0-100%, scale 0-5)*

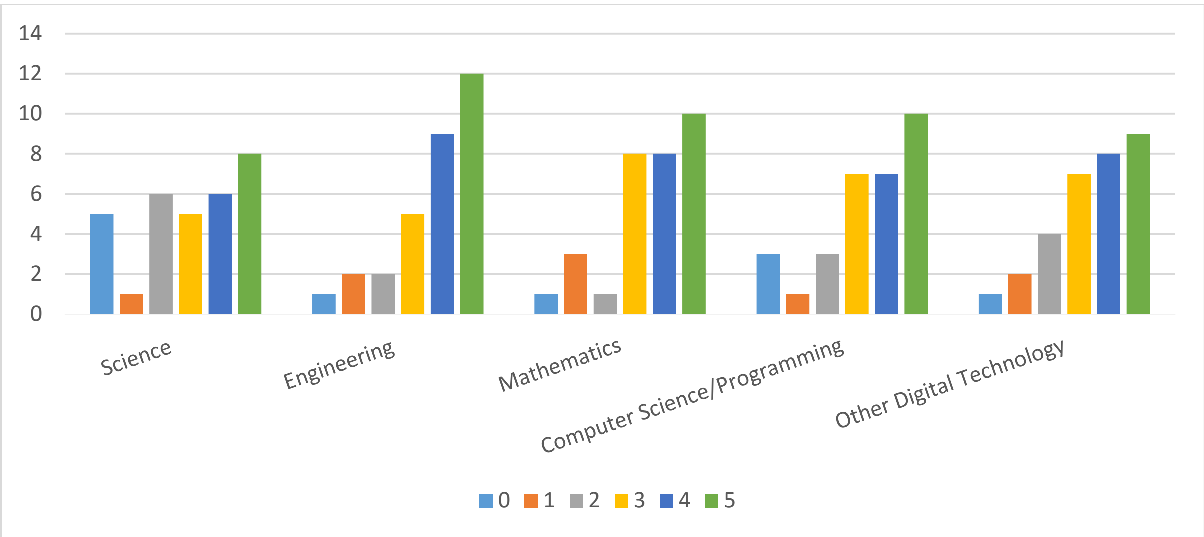


Figure 1.7. Respondents' answers to the question 1.3.

1.4. Is the STEM curriculum at the lectures/courses that you are teaching multidisciplinary and does it include lectures that are integrated (to include science, technology, engineering, and mathematics)?

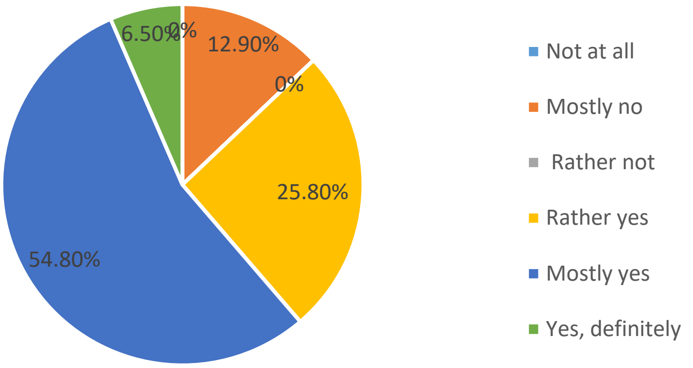


Figure 1.8. Respondents' answers to the question 1.4.

The responses indicate varied perceptions regarding the integration of STEM education at the faculty. The largest group (41.90%) believes that STEM education is "Mostly yes" integrated. This is followed by 32.30% who feel it is "Yes, definitely" integrated. A smaller portion of respondents (12.90%) think it is "Rather yes" integrated, indicating some positive but less definitive integration. Only 9.70% of respondents believe that STEM education is "Mostly no" integrated, while 3.20% feel it is "Rather not" integrated. Notably, none of the respondents believe that STEM education is "Not at all" integrated.

The largest group (32.30%) feels that STEM education is "Sufficiently present". This is followed by 29% who believe it is "Moderately present". A smaller portion of respondents (19.40%) perceive it as "Very present", indicating a high level of focus. Additionally, 12.90% of respondents feel that STEM education is "Low" in focus, while 3.20% believe it is "Very low". Only 3.20% of respondents think there is no focus on STEM education ("Not at all").

STEM elements are present to varying degrees across different subjects. Engineering and digital technology courses appear to have higher ratings for STEM elements, suggesting stronger integration in these areas.

The responses indicate varying perceptions regarding the multidisciplinary nature and integration of the STEM curriculum. The largest group (54.80%) believes that the STEM curriculum is "Mostly yes" multidisciplinary and integrated. This is followed by 25.80% who feel it is "Rather yes" integrated. A smaller portion of respondents (6.50%) consider it to be "Yes, definitely" multidisciplinary and integrated. Additionally, 12.90% of respondents believe that the STEM curriculum is "Mostly no" integrated, while no respondents believe it is "Not at all" integrated or "Rather not".

1.1.2. Professional Development and Experience in STEM

1.5. Which pedagogical approaches do you use in your STEM teaching?

A. Traditional teaching where the teacher gives information, and students learn from it. Traditional direct instruction (lessons are focused on the delivery of content by the teacher and the acquisition of content knowledge by the students).
B. Teaching with experiments (experiments are used in the classroom to explain the subject matter).
C. Project-/Problem-based approach (students are engaged in learning through the investigation of real-world challenges and problems).
D. Inquiry-Based Science Education (students design and conduct their own scientific investigations).
E. Collaborative learning (students are involved in joint intellectual efforts with their peers or with their teachers and peers).
F. Formative assessment, including self-assessment (student learning is constantly monitored and ongoing feedback is provided; students are provided with opportunities to reflect on their own learning).
G. Others……………….*(This is open question)*.

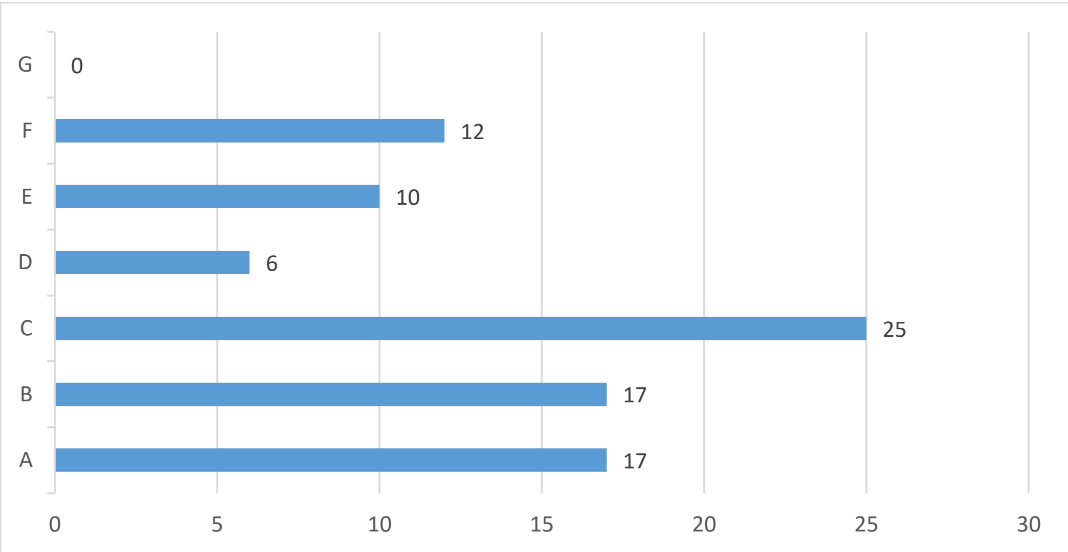


Figure 1.9. Respondents' answers to the question 1.5.

1.6. Please evaluate the STEM implementation in your teaching.

A. I use the STEM approach in teaching.
B. I frequently integrate science, technology, engineering, and mathematics within one curriculum.
C. My STEM approach motivates student for more active learning.
D. STEM approach is for me crucial for preparing students for real challenges in their future careers.
E. I regularly adapt the STEM education system based on the number of students and their knowledge.
F. Preparing for education using STEM methodology is time-consuming for me.
G. I regularly educate myself and explore new possibilities in STEM education methodology.

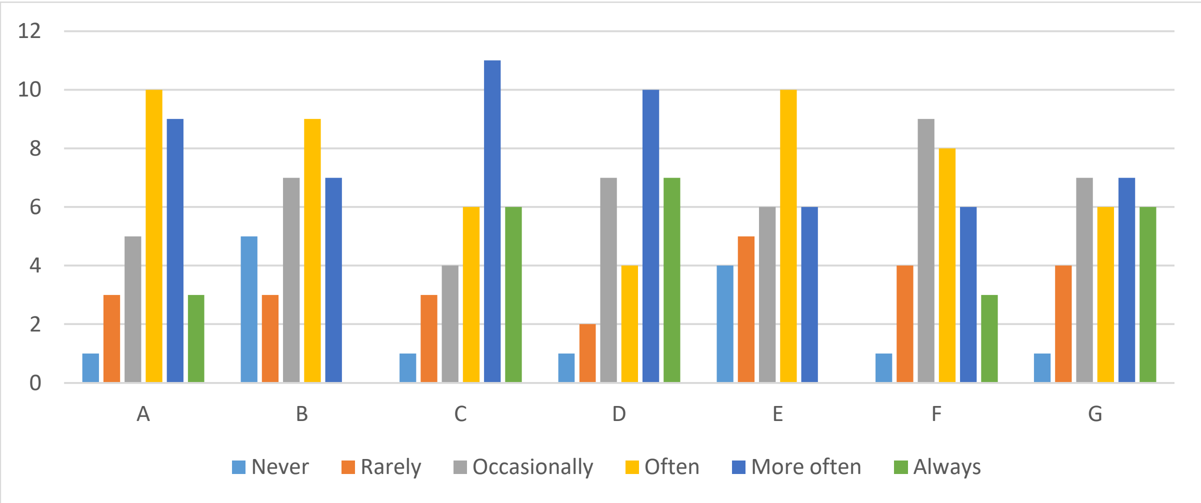


Figure 1.10. Respondents' answers to the question 1.6.

1.7. How would you rate your ability to follow and implement current trends in the STEM (e.g. ICT, team works, project based learning, e.t.c.)?

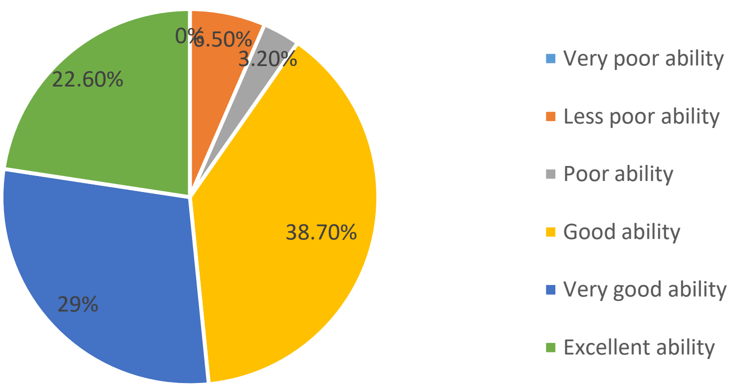


Figure 1.11. Respondents' answers to the question 1.7.

1.8. Would you consider additional training or professional development to better incorporate current STEM trends into your teaching?

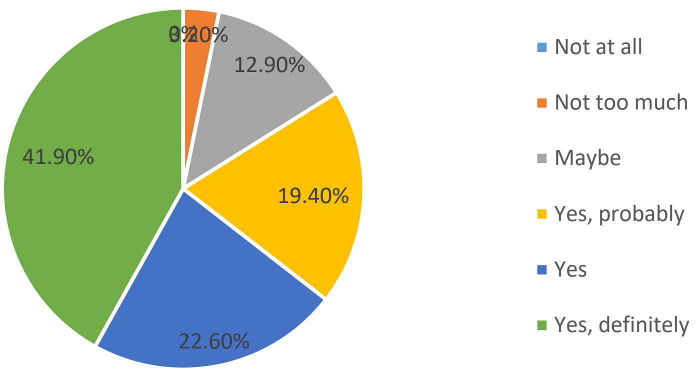


Figure 1.12. Respondents' answers to the question 1.8.

The data reveals that the most favored pedagogical approach in STEM teaching is the project- or problem-based approach, followed by traditional teaching methods and teaching with experiments. Collaborative learning and formative assessment are also significantly used, while inquiry-based science education is less common. The absence of responses for the "Others" category suggests that the provided options encompass the main pedagogical strategies employed by the respondents.

The results indicates that the "Project-/Problem-based approach" and "Collaborative learning" are the most frequently implemented methods, with high frequencies of "Often" and "More often". Traditional teaching and formative assessment are also commonly used but have more varied implementation frequencies. Teaching with experiments and inquiry-based science education are used to a lesser extent but are still significant. The responses for "Other methods" show diverse implementation frequencies. Overall, the data suggests a strong presence of active and collaborative teaching methods in STEM education, with traditional and formative approaches also playing a significant role.

The data shows that a significant majority of respondents believe they have good to excellent abilities to follow and implement current trends in STEM, such as ICT, teamwork, and project-based learning. This suggests a high level of confidence among faculty members in their capability to stay updated with and apply contemporary STEM methodologies. However, there is a small portion that feels less capable, indicating potential areas for professional development and training to enhance these skills further.

The responses indicate a strong interest in additional training or professional development to better incorporate current STEM trends. The largest group (41.90%) answered "Yes, definitely". This is followed by 22.60% who responded "Yes", and 19.40% who said "Yes, probably". A smaller portion of respondents (12.90%) are uncertain and responded with "Maybe". Only 3.20% of respondents answered "Not too much", and no respondents answered "Not at all".

1.1.3. Institutional Support (University, Business and Industry Sector - Partners)

1.9. Are business and industry also included in STEM education at your university related to your courses/subjects?

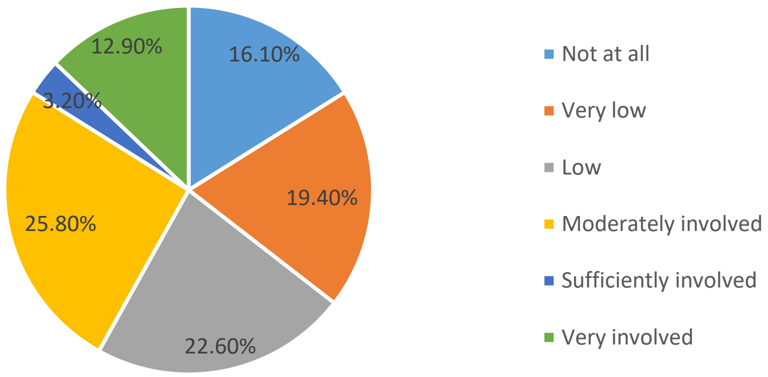


Figure 1.13. Respondents' answers to the question 1.9.

1.10. Please rate university – industry cooperation in STEM education in your teaching.

A. Facilitating company visits.
B. Having STEM professionals at universities (consultations, lectures…).
C. Student Training.
D. Assigning tasks by business/industry sector.
E. Solving tasks for business/industry sector.
F. Financial support.
G. Other…..*(This is open question)*.

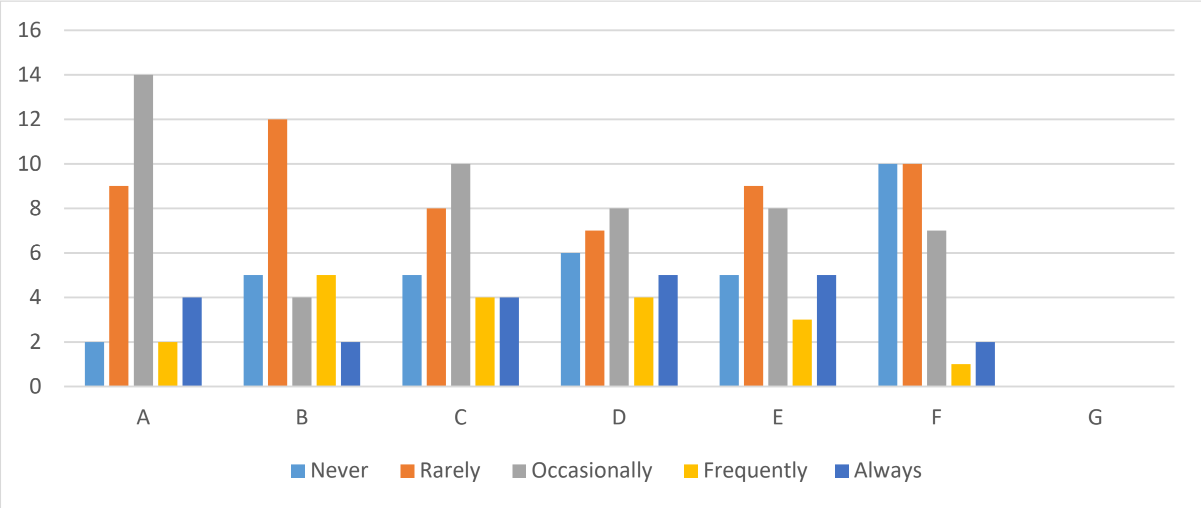


Figure 1.14. Respondents' answers to the question 1.10.

1.10.1. Do you have other types of university-industrial cooperation? *(This is open question)*

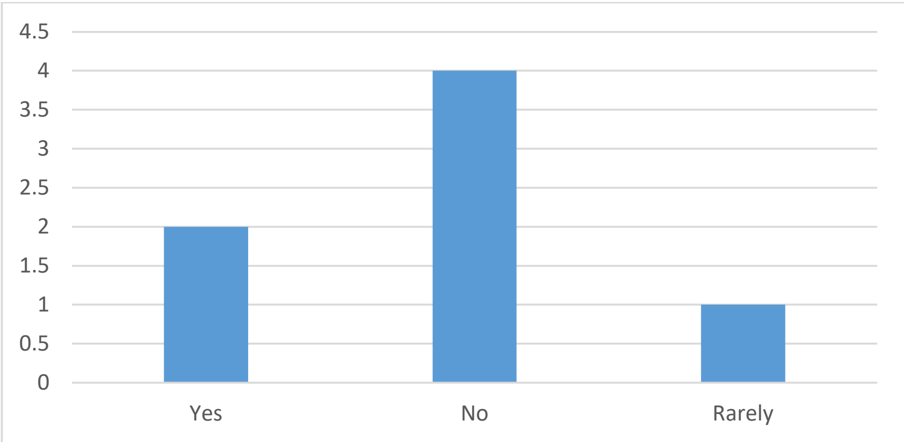


Figure 1.15. Respondents' answers to the question 1.10.1.

1.11. Would you support initiatives that facilitate between industry and universities?

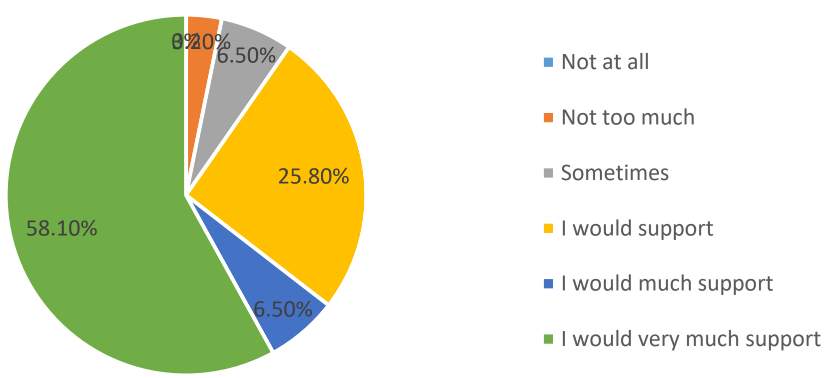


Figure 1.16. Respondents' answers to the question 1.11.

1.12. Do you think that the current support for STEM education from the university is sufficient?

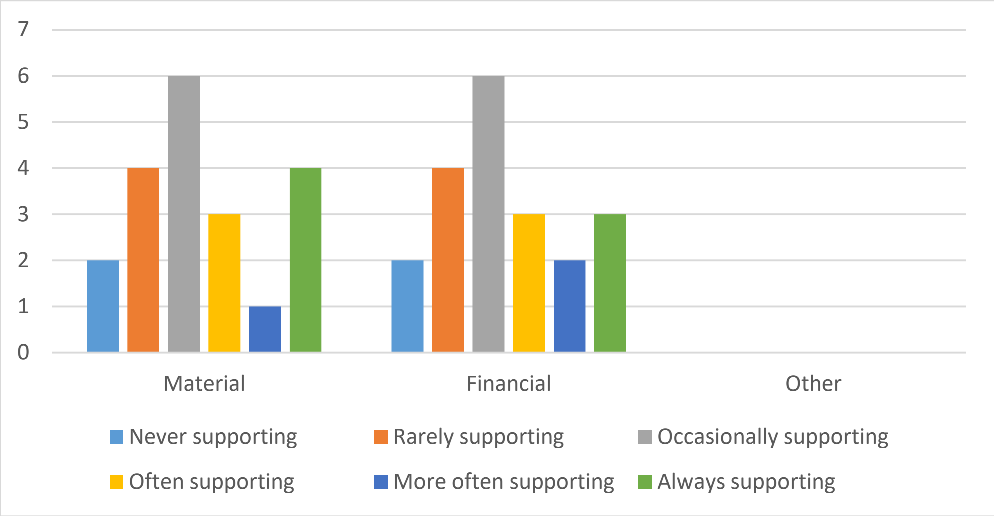


Figure 1.17. Respondents' answers to the question 1.12.

There is a significant level of involvement from the business and industry sectors in STEM education, with most respondents indicating moderate to high levels of involvement.

The data reveals that the most common forms of university-industry cooperation are facilitating company visits and having STEM professionals at universities, though these are often only occasional or rare. Student training, assigning tasks by the business/industry sector, and solving tasks for the business/industry sector also show varied levels of implementation, primarily on an occasional basis. Financial support from industry is notably less frequent, with many respondents indicating it is rare or never provided. This suggests that while there are multiple forms of cooperation between universities and industry, there is significant room for enhancing these partnerships, particularly in terms of financial support and more frequent interactions.

Most respondents do not have other types of university-industrial cooperation beyond what was previously listed. However, there are a few instances where additional cooperation exists, albeit on a limited basis. This indicates that while there may be some unexploited opportunities for further engagement and collaboration with industry, the current scope of cooperation is relatively narrow.

A vast majority of teachers support initiatives that aim at cooperation between industry and universities.

The support of STEM education by the university is perceived as insufficient, particularly in terms of financial support. There is a major gap in financial support, highlighting the need for improved and more consistent support from the university.

1.1.4. Material Support (Financial and Non-Financial)

1.13. How would you rate the current availability of literature and materials to support teaching STEM in your subject.

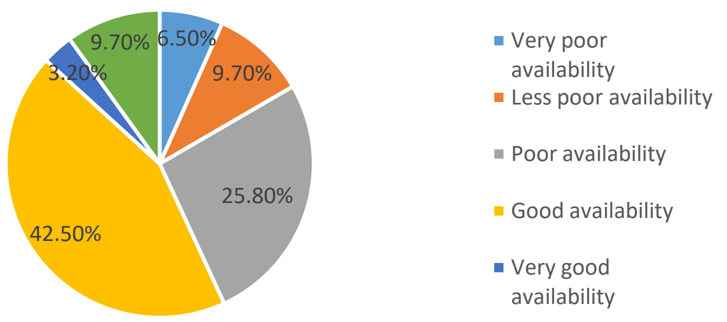


Figure 1.18. Respondents' answers to the question 1.13.

1.14. Do you think the current availability of literature limits the quality of your STEM teaching?

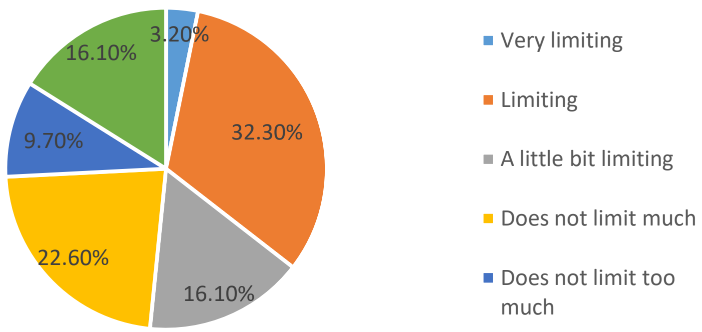


Figure 1.19. Respondents' answers to the question 1.14.

1.15. Are the STEM laboratories at your faculty available for your teaching purposes?

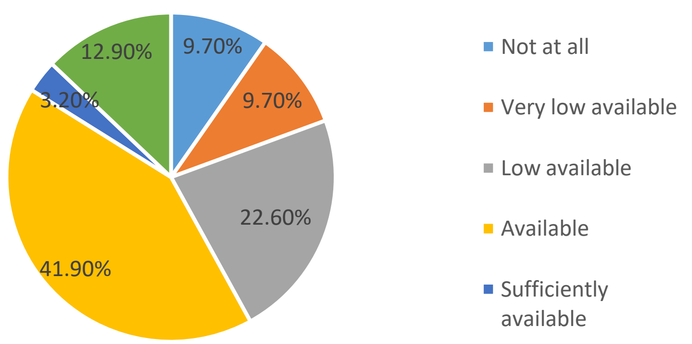


Figure 1.20. Respondents' answers to the question 1.15.

1.16. Do you have sufficient technological support, when implementing STEM education to your subjects?

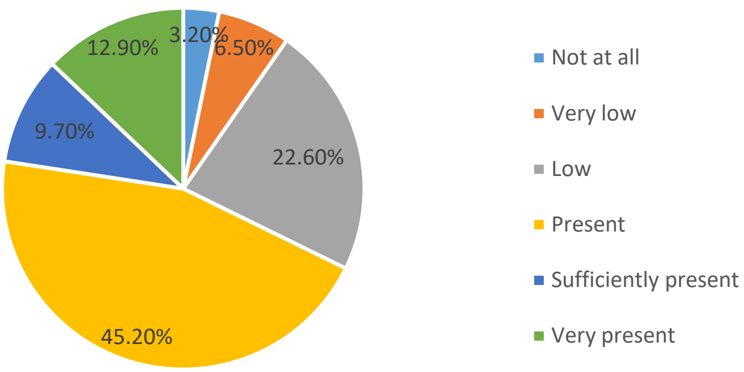


Figure 1.21. Respondents' answers to the question 1.16.

1.17. Do you think the current availability of technological equipment limits the quality of your STEM teaching?

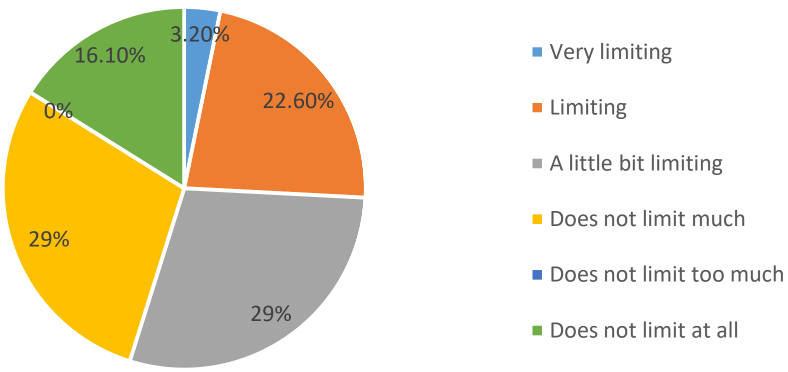


Figure 1.22. Respondents' answers to the question 1.17.

1.18. Is there any non-financial equipment you are missing, that would be helpful for your STEM education?

No comments.

1.19. What teaching resources do you use when implementing STEM education?

A. Presentations.
B. Office tools (word, excel, notepad…).
C. Software.
D. Programming tools (not only PC programming, machine programming…).
E. Applications.
F. STEM-specific software.
G. Audio/video materials.

H. Robots.
I. General digital devices (e.g. laptops, smartphones, tablets, cameras, video game consoles).
J. Online resources (websites, dictionaries, encyclopedias, etc.).
K. Manipulation in an experimental lab.
L. Online collaborative tools (Padlet, Centimetre, Tricorder, Kahoot…).
M. Resources published by private companies operating in STEM fields.
N. Others……. *(This is open question)*.

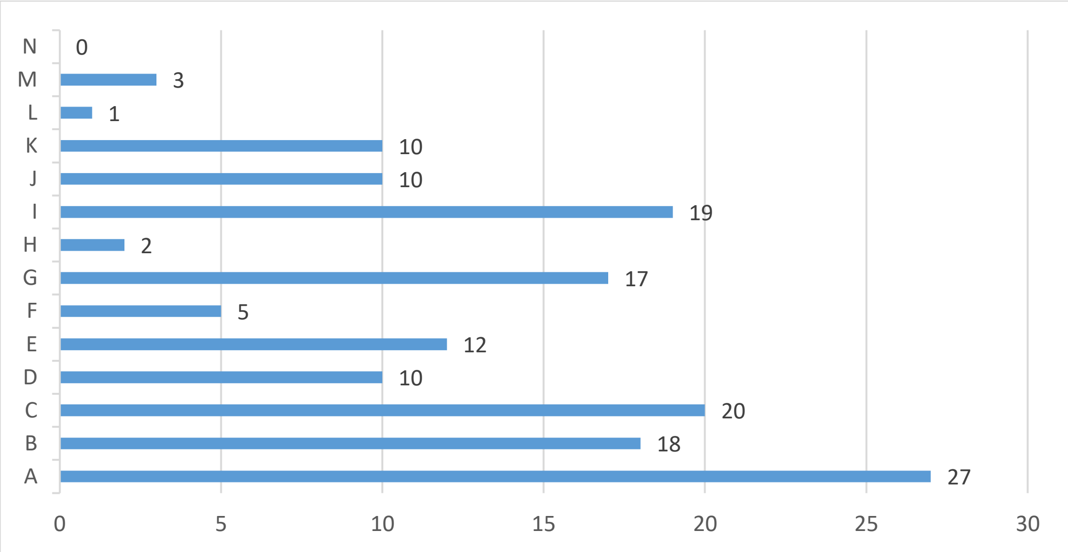


Figure 1.23. Respondents' answers to the question 1.19.

The responses indicate varied perceptions regarding the availability of literature and materials for STEM teaching. The largest group (42.50%) rates the availability as "Good availability". This is followed by 25.80% who consider it "Poor availability". Equal proportions of respondents (9.70% each) feel that the availability is either "Less poor availability" or "Excellent availability". A smaller portion of respondents (6.50%) believe the availability is "Very poor availability", while the smallest group (3.20%) considers it "Very good availability".

Many respondents believe that the lack of literature affects the quality of STEM education.

The availability of STEM laboratories is mixed, with a significant portion finding them low or very low.

While some respondents feel that technological support is present, a notable percentage find it low or very low.

The availability of both literature and technological equipment significantly impacts the quality of STEM teaching, with many respondents indicating varying degrees of limitation.

Presentations, office tools, and online resources are the most commonly used resources, whereas specialized STEM-specific software and robots are notably absent. There is a clear need for increased financial support and time for self-study to better support STEM education.

1.1.5. Student Achievement

1.20. How well do students achieve good results in combined STEM subjects?

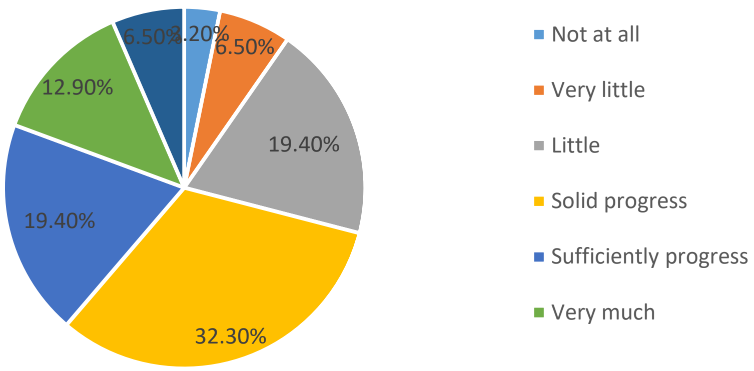


Figure 1.24. Respondents' answers to the question 1.20.

1.21. Is the teaching more difficult for students when using STEM? (Based on student feedback)

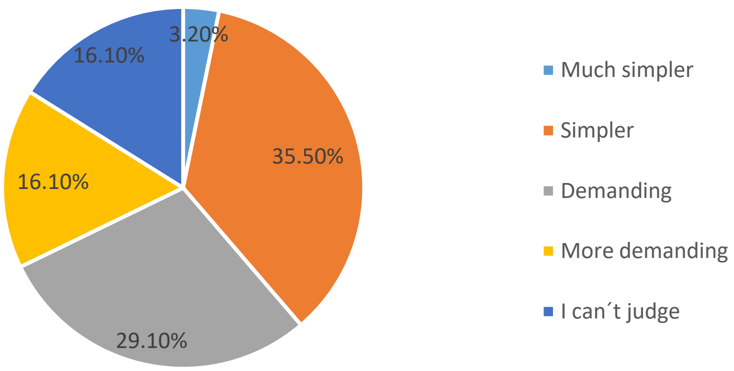


Figure 1.25. Respondents' answers to the question 1.21.

1.22. If you have any other comments, please free to write any comment…… *(This is open question)*

No comments.

The responses indicate varied perceptions regarding student achievement in combined STEM subjects. The largest group (32.30%) believes that students make "Solid progress". Equal proportions of respondents (19.40% each) feel that students achieve "Little" progress or "Sufficiently progress". A smaller portion of respondents (12.90%) believe that students achieve "Very much" progress. The smallest groups, each with 6.50%, feel that students make "Very little" progress or "Not at all".

The data shows that opinions on the difficulty of STEM education for students are mixed. While a significant portion of respondents (35.50%) believe that teaching is simpler or much simpler with STEM, a combined 45.20% feel that it is demanding or more demanding. Additionally, 16.10% of respondents are uncertain and chose "I can't judge". This suggests a diverse range of student experiences with STEM education, indicating that while some students may find STEM approaches easier to grasp, others face challenges, highlighting the need for differentiated teaching strategies to accommodate varying student needs.

1.2. Survey for Students

Field of studies:

Figure 1.26. Respondents' answers to the question Field of studies.

Type of studies:

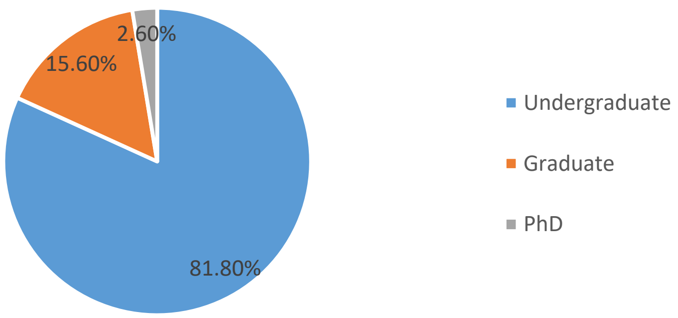


Figure 1.27. Respondents' answers to the question Type of studies.

Finished number of semesters:

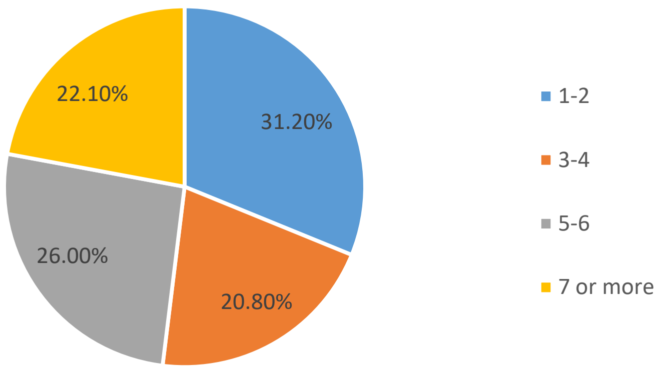


Figure 1.28. Respondents' answers to the question Finished number of semesters.

Sex:

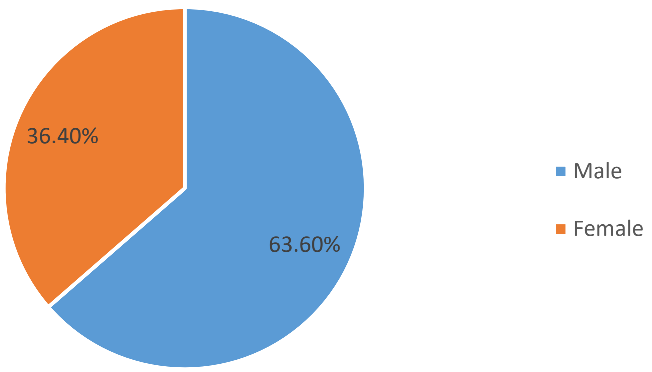


Figure 1.29. Respondents' answers to the question Sex.

Age:

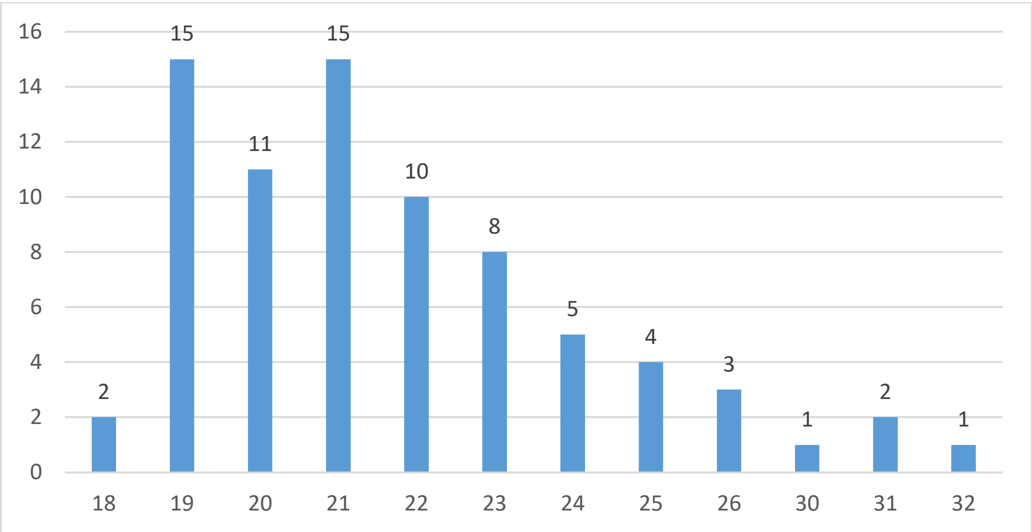


Figure 1.30. Respondents' answers to the question Age.

At the Faculty of Technical Sciences, the survey was completed by students of all field of studies, with the largest percentage from the Electrical and Computer Engineering, 36.4%. They are followed by students from Architecture and Mining Engineering, with percentages of 13% and 10.4% respectively. In almost the same number of 9.1% of the total respondents, students from the fields of Environmental Protection and Occupational Safety, Mechanical Engineering and Technological Engineering responded. There were 7.8% of students from Civil Engineering and 5.1% of students from Traffic and Transport Engineering.

About 10% of the total number of students at the faculty filled out the survey. 81.8% of them are in bachelor studies, while 15.6% are in master's studies, and the rest are in PhD studies.

The largest number of respondents are in the first year of study, ie. 31.2% of students completed 1-2 semesters. Students with completed 5-6 semesters follow in the percentage of 26%. They are followed by those who have completed 7 or more semesters with 22.1% and students with completed 3-4 semesters in 20.8%.

Most respondents are male, 63.6%, and the rest are female. Most of the students are between the ages of 19 and 22.

1.2.1. Familiarity with the Term STEM

2.1. Are you familiar with the term “STEM“ education?

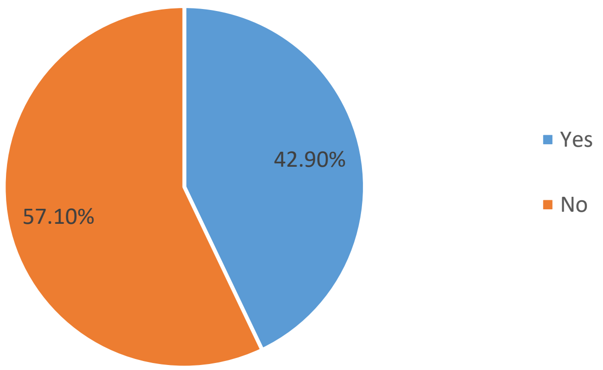


Figure 1.31. Respondents' answers to the question 2.1.

2.2. How many subjects focused on a combination of math, problem solving, technology and science did you have in your studies so far?

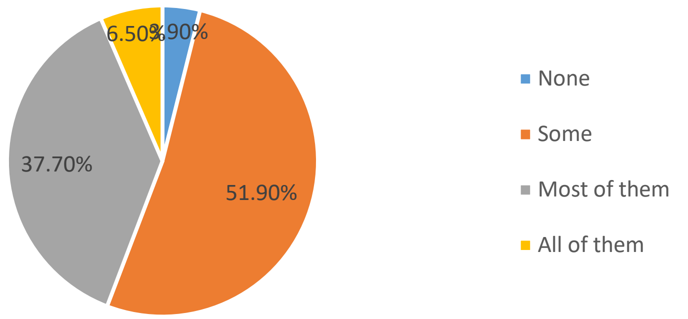


Figure 1.32. Respondents' answers to the question 2.2.

2.3. How many classes (subjects/courses) have you taken in each of these categories so far? (Fill in the ratio of courses for each category).

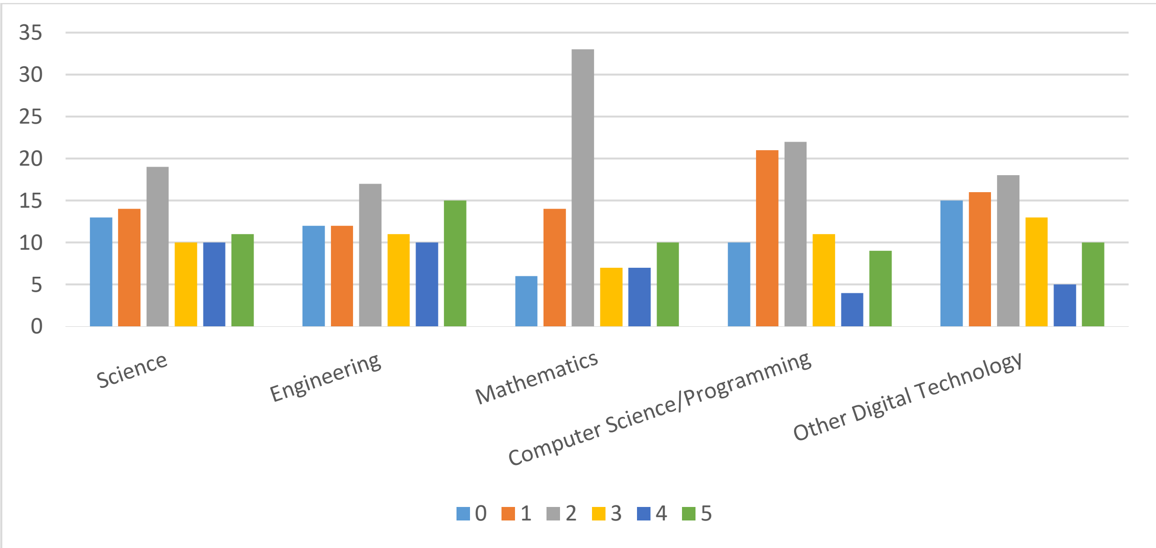


Figure 1.33. Respondents' answers to the question 2.3.

2.4. Does your school offer engineering courses or projects? Engineering (any with problem solving).

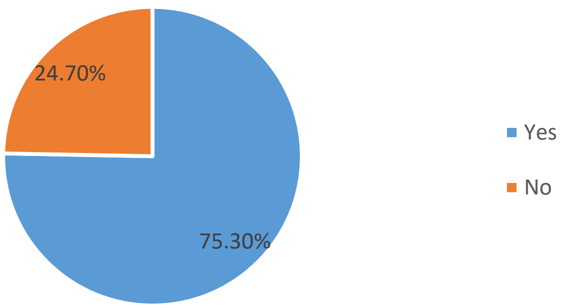


Figure 1.34. Respondents' answers to the question 2.4.

The majority of students, more precisely 57.1%, are not familiar with the term STEM education.

They said they had a few (51.9%) to most (37.7%) subjects focused on a combination of math, problem solving, technology and science. 3.9% of students said they did not have any subjects, while 6.5% said all subjects were STEM-focused.

To the question How many subjects have they taken in each of these categories, the students answered that they attended mostly about 30-40% of subjects in each of the categories: science, engineering, mathematics, computer science. Most of them had the same answer for mathematics.

The majority of students (75.3%) answered that the faculty offers engineering courses or projects.

1.2.2. Business and Industry Partners Involvement in STEM Education

2.5. Are business and industry also included in your STEM education?

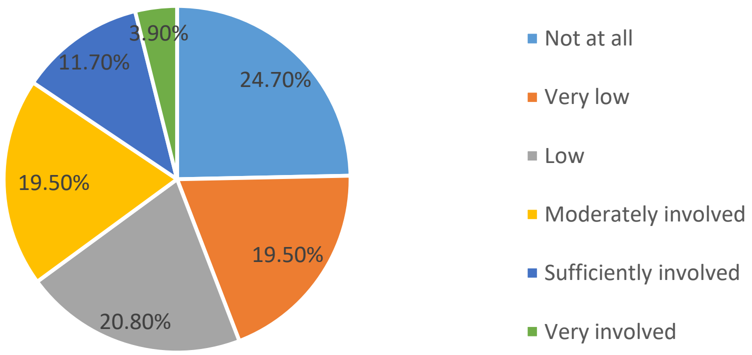


Figure 1.35. Respondents' answers to the question 2.5.

2.6. Do you implement projects assigned by industry partners in your school tasks?

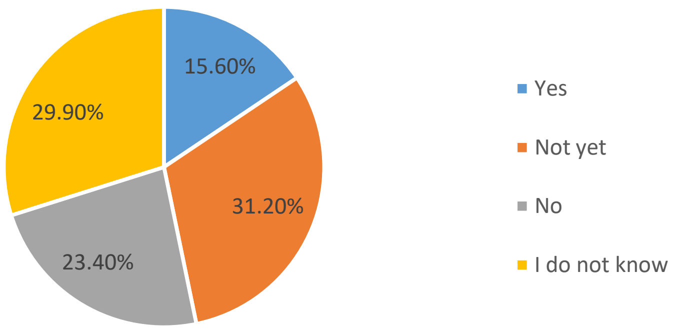


Figure 1.36. Respondents' answers to the question 2.6.

2.7. In your education, do you often deal complex problems that are similar to problems in practice?

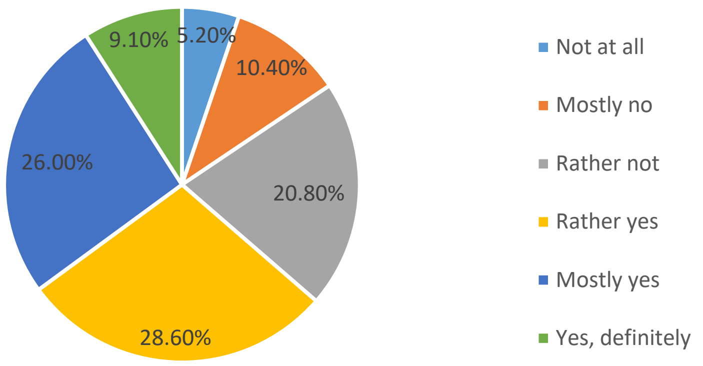


Figure 1.37. Respondents' answers to the question 2.7.

The largest number of students agree that business and industry is low involved or not at all in STEM education at the faculty. About 19.5% think that they are moderately involved, while the rest say that they are significantly (11.7%) and very (3.9%) involved.

Therefore, most students do not implement projects with industrial partners (23.4%) or have not yet started (31.2%). 29.9% do not even know about it, they have no information, while 15.6% of them are already implementing such projects.

More than 63% of students confirm that in their education they often deal with complex problems that are similar to problems in practice. The others answered in the negative.

1.2.3. Technology Used Throughout STEM Education

2.8. Do you have classes in the computer classroom?

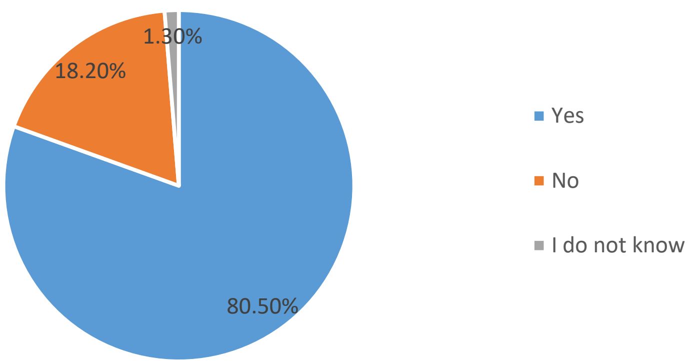


Figure 1.38. Respondents' answers to the question 2.8.

2.9. Do you have classes in specialised laboratories (no computer classroom)?

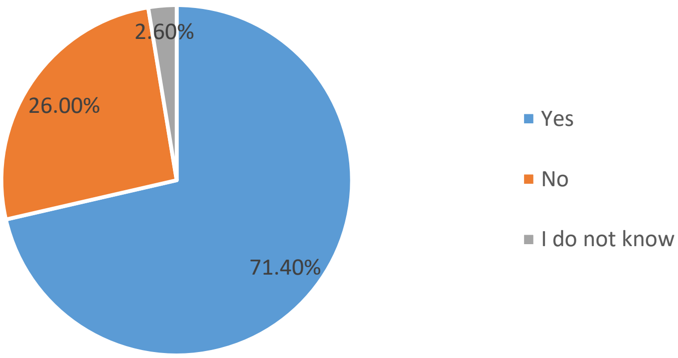


Figure 1.39. Respondents' answers to the question 2.9.

2.10. What percentage of courses/subjects do you use digital technologies (PC, tablet, mobile phone)

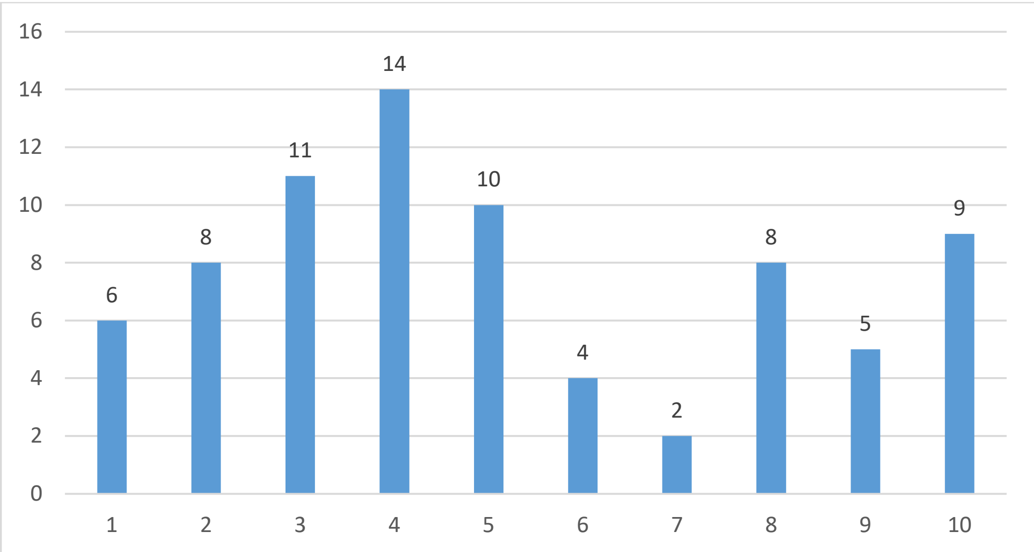


Figure 1.40. Respondents' answers to the question 2.10.

Between 70-80% of students have classes in computer classroom or specialised laboratories. The majority of them said that about 30-50% of the courses/subjects in which they use digital technologies, such as PC, tablet, mobile phone.

1.2.4. Future Vision

2.11. In a future, I plan to continue in STEM education. Science (any where science is applied – physics, chemistry, meteorology, economy...), Engineering (any with problem solving), Mathematics, Computer Science/Programming, Other Technology.

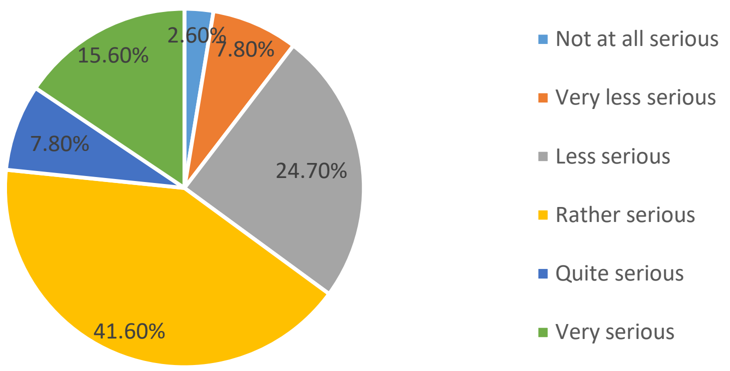


Figure 1.41. Respondents' answers to the question 2.11.

2.12. I see myself in STEM a career (in the future)

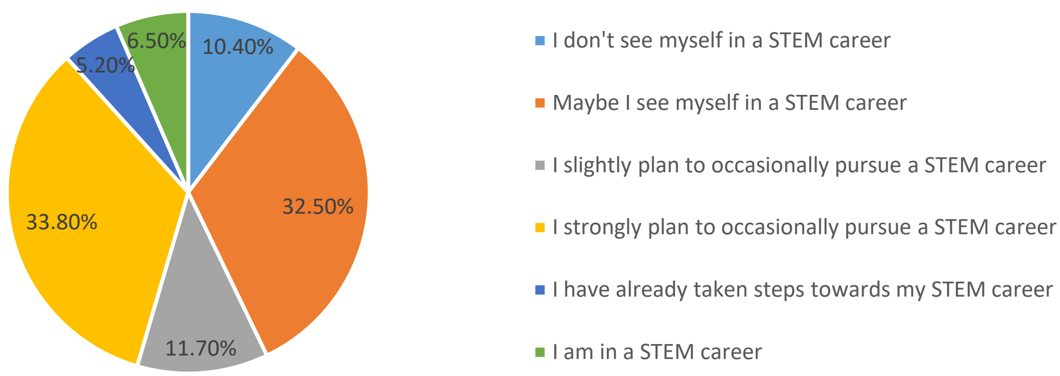


Figure 1.42. Respondents' answers to the question 2.12.

Majority of students plan to continue in STEM education rather (41.6%) or very (23.4%) seriously in the future, while 24.7% of them plan to continue less seriously. Only 2% of students do not want to continue in STEM education.

Also, the majority of students see themselves in a stem career, and 6.5% of them are already engaged in it. 32.5% of respondents see themselves in a STEM career, and 10.4% of them answered the opposite. About 40% of them plan to occasionally pursue a STEM career, while 5.2% have already taken steps towards their STEM career.

1.2.5. Increasing STEM Skills

2.13. I would appreciate more chances to learn STEM.

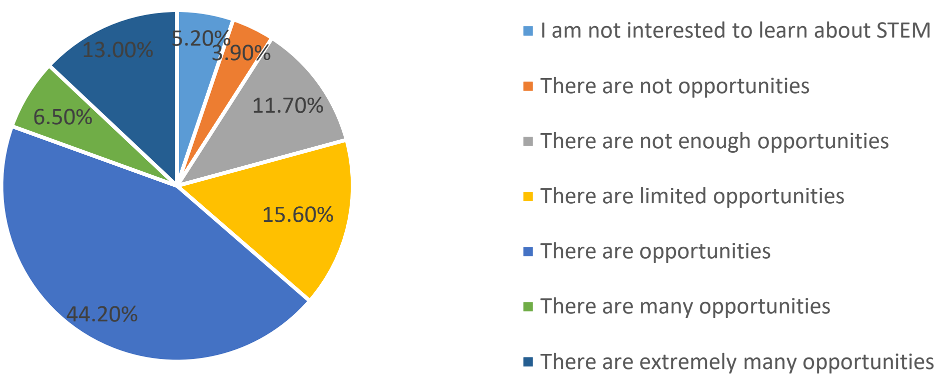


Figure 1.43. Respondents' answers to the question 2.13.

2.14. Rate (evaluate) your skills obtained during your study so far.

A. I can solve some equation and work with variables (in my field of study).
B. I am able to think logically.
C. I can analyze complex problems.
D. I can solve a problem.
E. I can come up with creative idea.
F. I can do the critical analysis.
G. I am open to learn new technologies.
H. I can use digital devices such as computer, tablet, smartphone.
I. I understand basic software applications.
J. I can use and evaluate information from digital sources.
K. I understand the basics of cybersecurity.

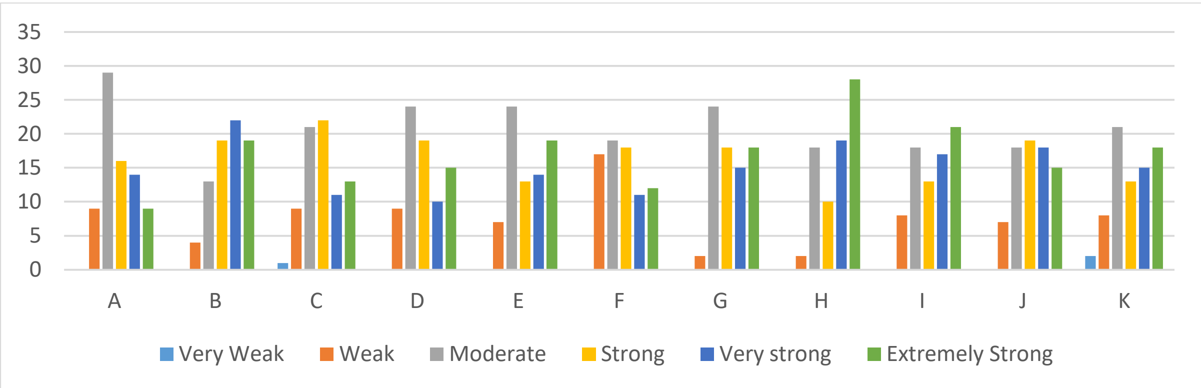


Figure 1.44. Respondents' answers to the question 2.14.

2.15. If you have any other comments, please free to write any comment…… *(This is open question)*

No comments.

Students generally say they would appreciate more chances to learn STEM. The majority think that there are opportunities for learning (44.2%), and about 20% of them think there are really many opportunities. 15.6% believe that opportunities are limited, while 11.7% say that there are not enough opportunities. A very small percentage believes that there are no opportunities (3.9%). Also, there are few who are not at all interested to learn about the STEM (5.2%).

One of the important questions was the self-evaluation of their skills obtained during study so far. In solving equations and working with variables, 29 students rate themselves as moderate, 16 as strong, 14 as very strong and 9 as extremely strong. Only 9 of them consider themselves weak in this. Most answered that they think they are "strong" at logical thinking, as well as that they can analyze complex problems. They also think that they are creative with ideas. While opinions are divided about critical analyses. 17 of them think they are weak in this, 19 that they are at a moderate level, and 41 that they are strong in doing critical analyses. Most students are open to learning new technologies. Most of the responses "extremely strong" were for the use of digital devices such as computer, tablet, smartphone. There is approximately an equal number of responses between moderate, strong, very and extremely strong for using and evaluating information from digital sources, as well as for understanding basic software applications. Only 7-8 students think they are weak in it. 21 of them understand the basics of cybersecurity at a moderate level, 46 of them is at a strong to extremely strong level, while 10 students have a weak understanding of cybersecurity.

Students believe that more emphasis should be placed on the impact of the economy on engineering. Also, they think that the transition from theoretical to practical work and their content itself should be better conceived.

2. ANALYSIS OF SURVEY RESULTS – OBUDA UNIVERSITY

2.1. Survey for Teachers

Field of teaching:

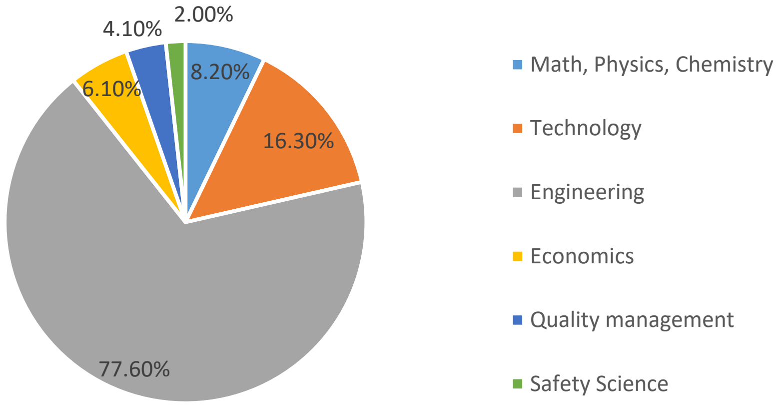


Figure 2.1. Respondents' answers to the question Field of teaching.

Sex:

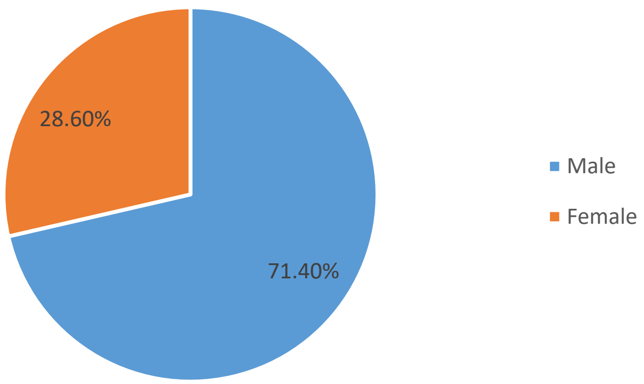


Figure 2.2. Respondents' answers to the question Sex.

Position:

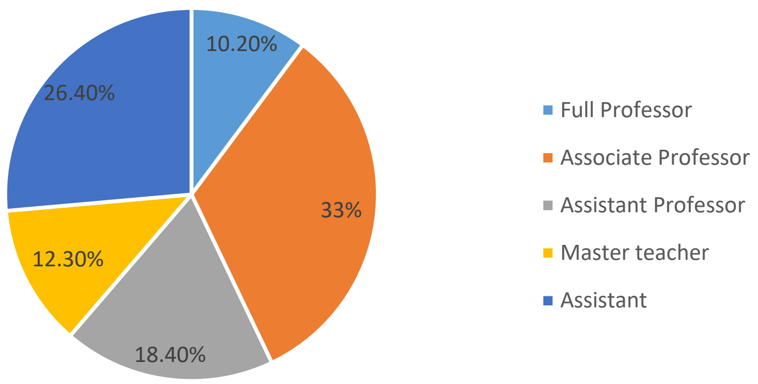


Figure 2.3. Respondents' answers to the question Position.

Teaching experience at university:

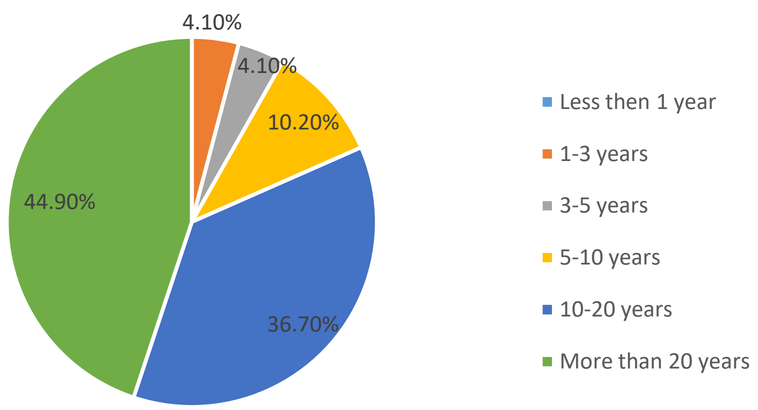


Figure 2.4. Respondents' answers to the question Teaching experience at university.

A large proportion of the teachers who responded to the survey teach in engineering, technology and mathematics. Some of the respondents do not teach STEM subjects, but economics, quality assurance or safety science. There is a significant gender difference in the number of lecturers, with the vast majority of respondents being male, which is in line with the proportion at Óbuda University. Most respondents teach as associate professors, but a large number of assistant professors and adjunct professors also appear. A very small number of researchers appear among the respondents, as Óbuda University has a very low proportion of people engaged only in research. Within the teaching field, there is a significant number of experienced teachers, with no responses with less than one year of experience.

2.1.1. STEM Education Integration

1.1. Has the Science, Engineering, Mathematics, Technology education been integrated at your faculty?

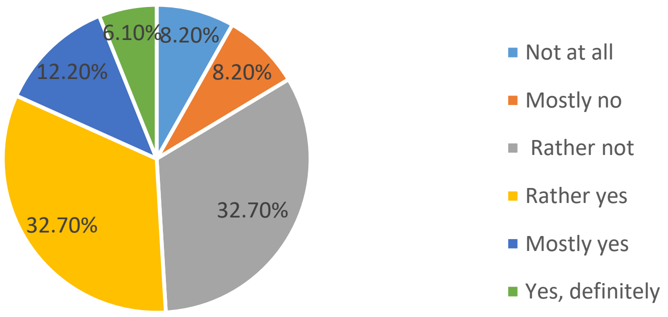


Figure 2.5. Respondents' answers to the question 1.1.

1.2. How much focus does your teaching have on STEM education.

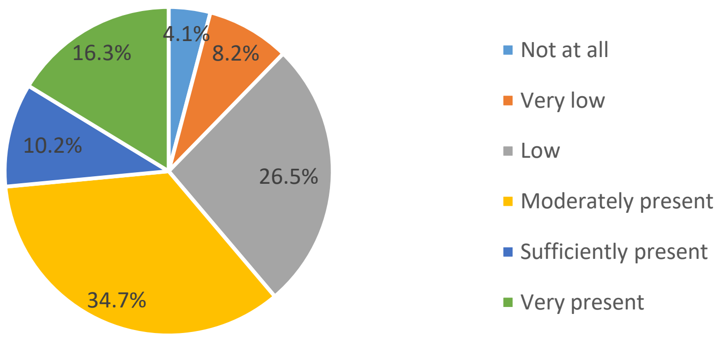


Figure 2.6. Respondents' answers to the question 1.2.

1.3. Do you provide lectures/courses with elements of STEM education? (*answer in percentages from 0-100%, scale 0-5)*

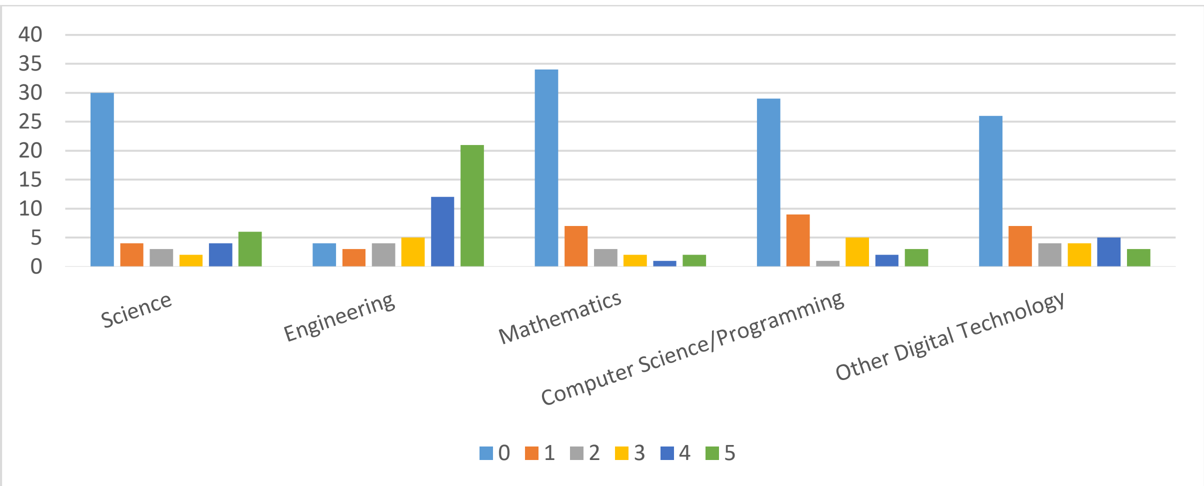


Figure 2.7. Respondents' answers to the question 1.3.

1.4. Is the STEM curriculum at the lectures/courses that you are teaching multidisciplinary and does it include lectures that are integrated (to include science, technology, engineering, and mathematics)?

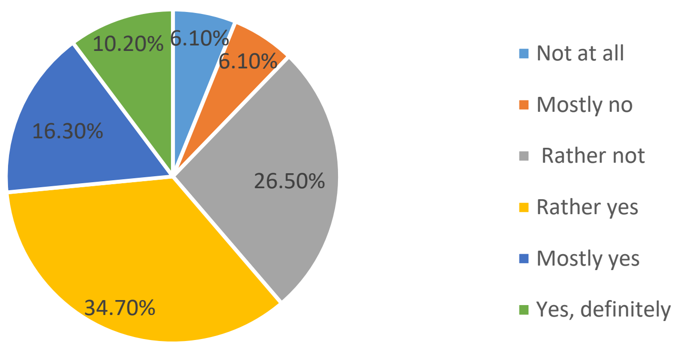


Figure 2.8. Respondents' answers to the question 1.4.

Almost half of respondents said that integration of STEM fields is not happening, while the other half said it is. Almost 1/3 of respondents do not favour STEM integrated teaching in their education. Breaking the question down further, a higher proportion of teachers educate engineering, a very few of them teach science, math, computer science/programming, or other digital technologies. The majority of instructors integrate STEM education into their courses.

2.1.2. Professional Development and Experience in STEM

1.5. Which pedagogical approaches do you use in your STEM teaching?

A. Traditional teaching where the teacher gives information, and students learn from it. Traditional direct instruction (lessons are focused on the delivery of content by the teacher and the acquisition of content knowledge by the students).
B. Teaching with experiments (experiments are used in the classroom to explain the subject matter).
C. Project-/Problem-based approach (students are engaged in learning through the investigation of real-world challenges and problems).
D. Inquiry-Based Science Education (students design and conduct their own scientific investigations).
E. Collaborative learning (students are involved in joint intellectual efforts with their peers or with their teachers and peers).
F. Formative assessment, including self-assessment (student learning is constantly monitored and ongoing feedback is provided; students are provided with opportunities to reflect on their own learning).

G. Others……………….*(This is open question)*

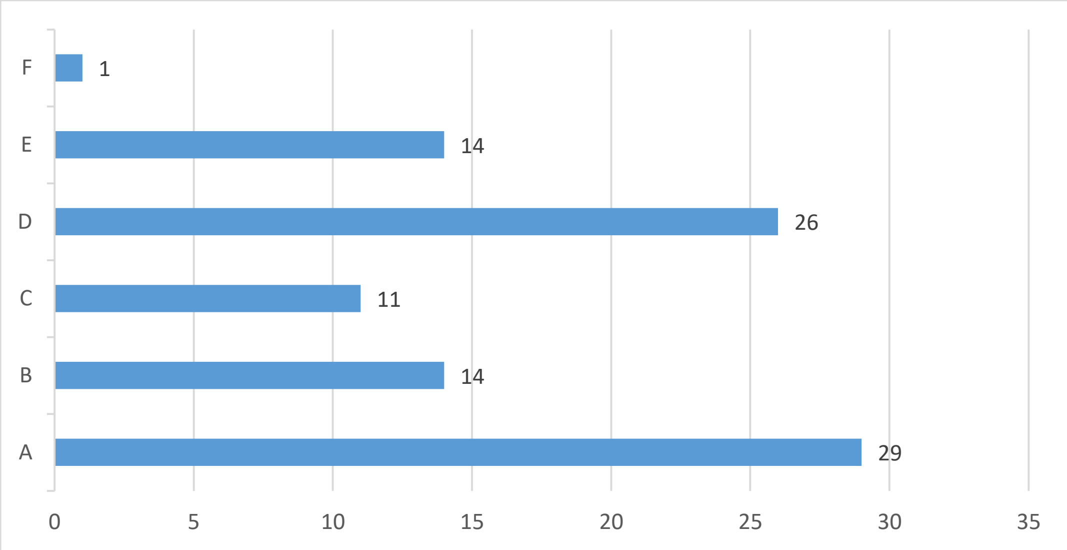


Figure 2.9. Respondents' answers to the question 1.5.

1.6. Please evaluate the STEM implementation in your teaching.

A. I use the STEM approach in teaching.
B. I frequently integrate science, technology, engineering, and mathematics within one curriculum.
C. My STEM approach motivates student for more active learning.
D. STEM approach is for me crucial for preparing students for real challenges in their future careers.
E. I regularly adapt the STEM education system based on the number of students and their knowledge.
F. Preparing for education using STEM methodology is time-consuming for me.
G. I regularly educate myself and explore new possibilities in STEM education methodology.

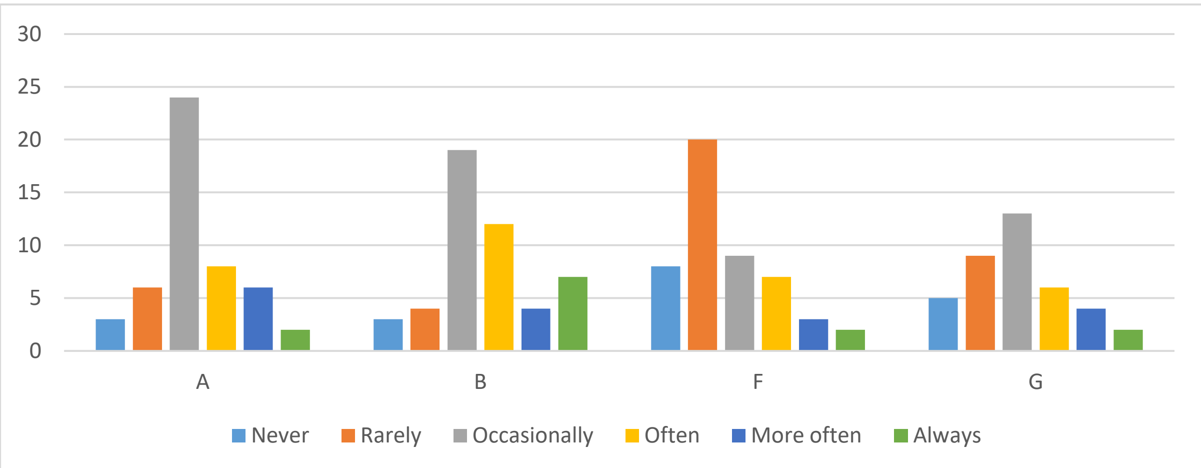


Figure 2.10. Respondents' answers to the question 1.6.

1.7. How would you rate your ability to follow and implement current trends in the STEM (e.g. ICT, team works, project based learning, e.t.c.)?

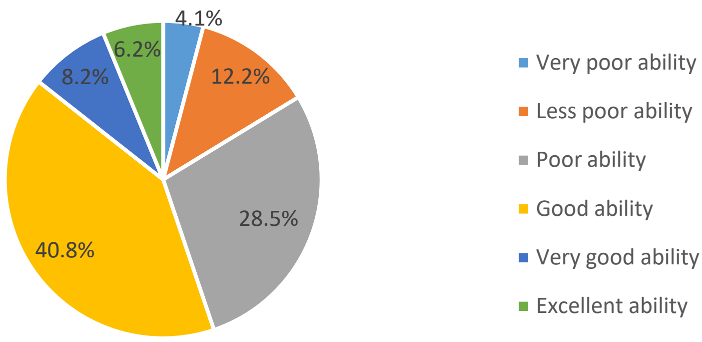


Figure 2.11. Respondents' answers to the question 1.7.

1.8. Would you consider additional training or professional development to better incorporate current STEM trends into your teaching?

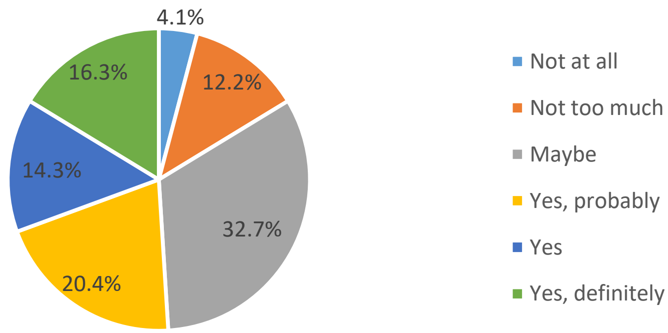


Figure 2.12. Respondents' answers to the question 1.8.

In teaching, traditional teaching is still the most common method used by the colleagues at Óbuda University, where the teacher gives information to the students in a one-sided way. Inquiry Based Science Education is the second most common. The STEM approach is used more occasionally by lecturers, for the most part, they often integrate STEM within the curricula. Preparation for STEM subjects is generally not time-consuming based on the answers. Some teachers train regularly, and some do not. Just over half of respondents can only keep up with current trends in STEM. Nearly 16% think they would not like to receive further training on the use of the STEM approach, 1/3 are undecided on this issue, the remaining respondents are open for development.

2.1.3. Institutional Support (University, Business and Industry Sector - Partners)

1.9. Are business and industry also included in STEM education at your university related to your courses/subjects?

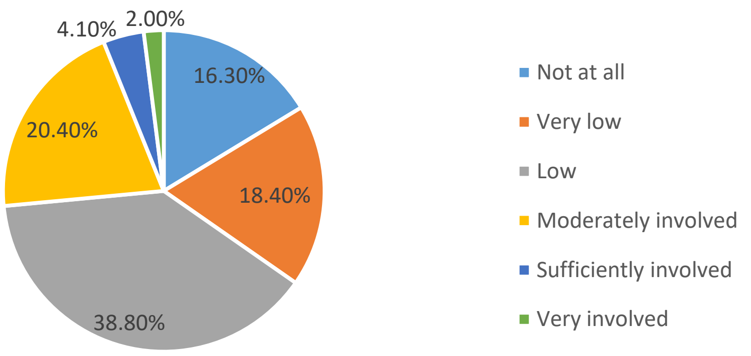


Figure 2.13. Respondents' answers to the question 1.9.

1.10. Please rate university – industry cooperation in STEM education in your teaching.

A. Facilitating company visits.
B. Having STEM professionals at universities (consultations, lectures…).
C. Student Training.
D. Assigning tasks by business/industry sector.
E. Solving tasks for business/industry sector.
F. Financial support.
G. Other…..*(This is open question)*.

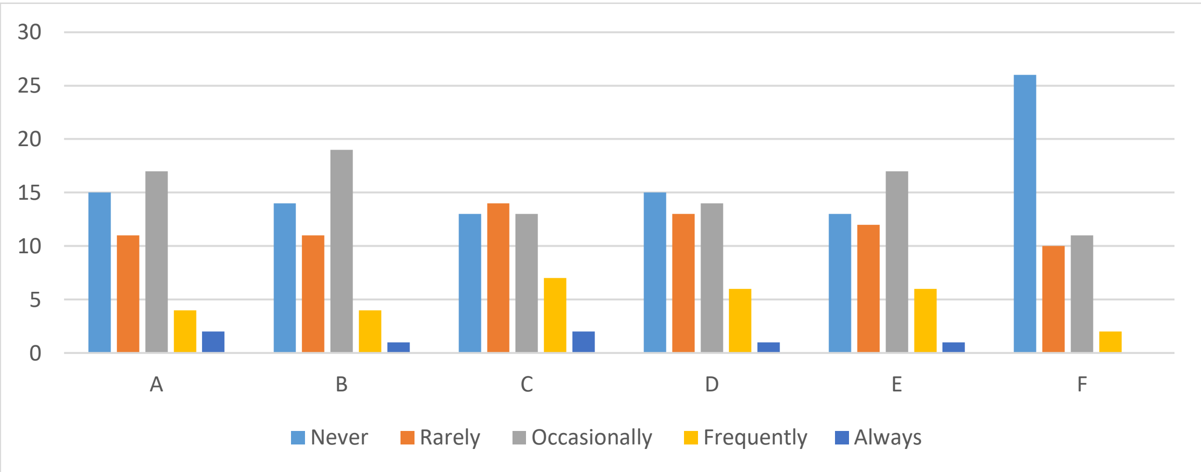


Figure 2.14. Respondents' answers to the question 1.10.

1.10.1. Do you have other types of university-industrial cooperation? *(This is open question)*

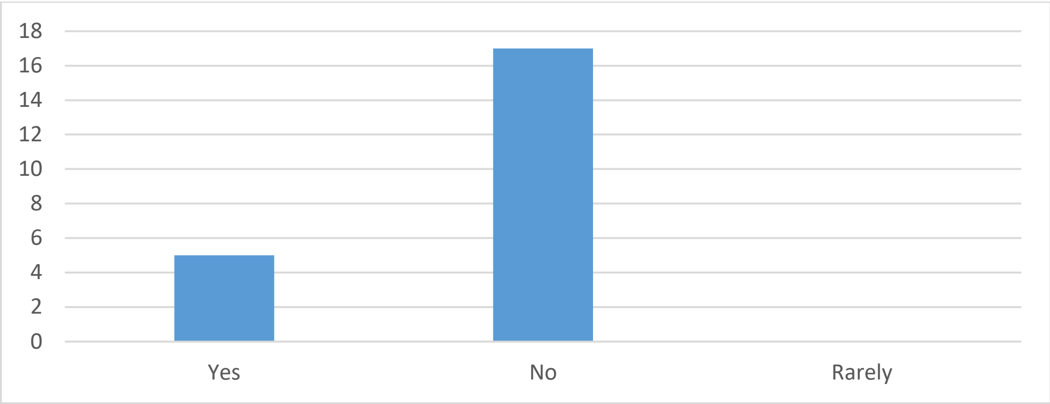


Figure 2.15. Respondents' answers to the question 1.10.1.

The university-industry cooperation at Óbuda University is at a very low level, only one respondent named a company (Bosch), and 4 teachers have some cooperation related their research field.

1.11. Would you support initiatives that facilitate between industry and universities?

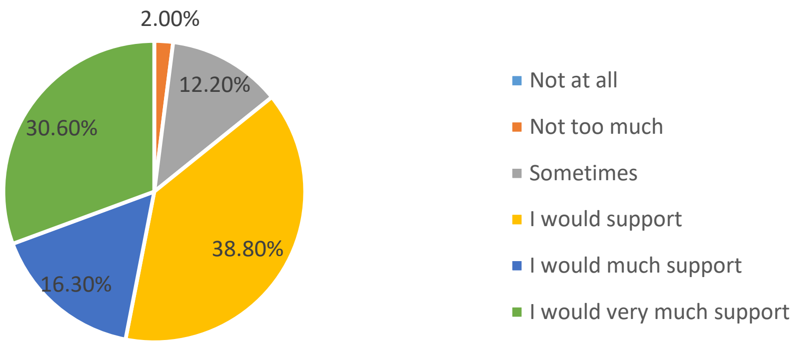


Figure 2.16. Respondents' answers to the question 1.11.

1.12. Do you think that the current support for STEM education from the university is sufficient?

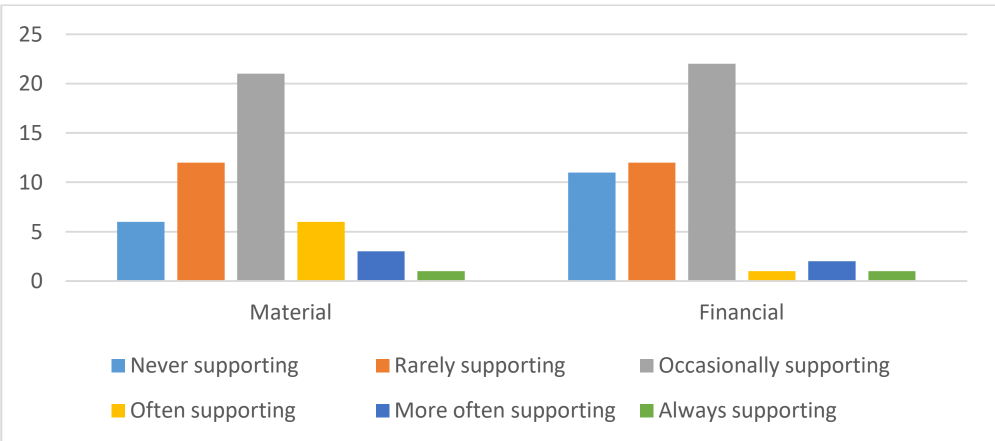


Figure 2.17. Respondents' answers to the question 1.12.

According to the answers given by the teachers, there is little or no link between the Óbuda University and industry based on their experience. The figures show that industry does not provide financial resources to use the STEM education, but other opportunities (factory visits, STEM professionals, etc.) are not significantly present at the Faculty. 85% of the teachers would support initiatives that aim at cooperation between industry and Óbuda University. The support of STEM education by the university is not sufficient, neither in terms of material nor financial, the major gap is seen in financial support.

2.1.4. Material Support (Financial and Non-Financial)

1.13. How would you rate the current availability of literature and materials to support teaching STEM in your subject.

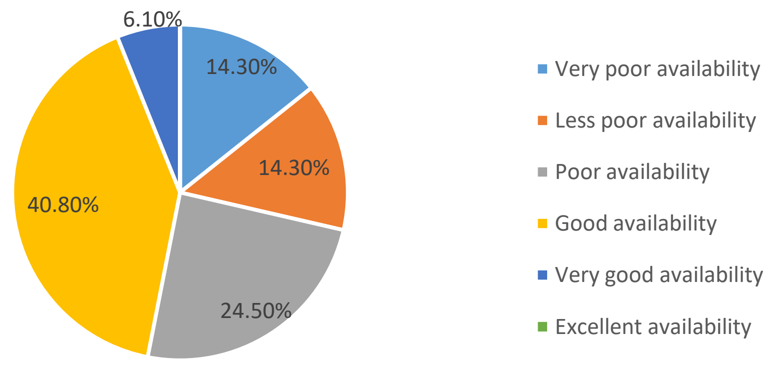


Figure 2.18. Respondents' answers to the question 1.13.

1.14. Do you think the current availability of literature limits the quality of your STEM teaching?

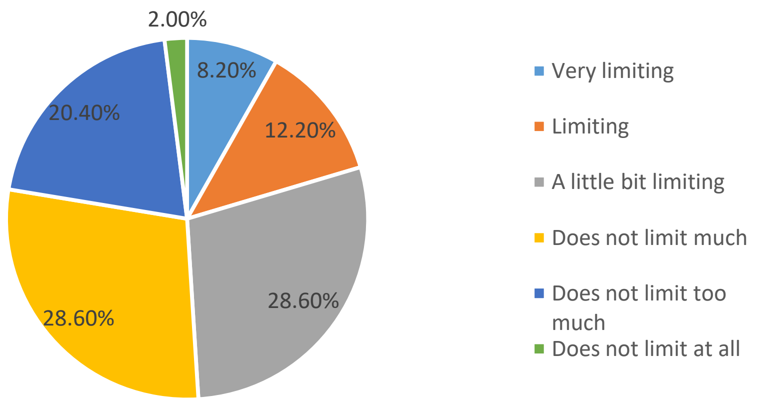


Figure 2.19. Respondents' answers to the question 1.14.

1.15. Are the STEM laboratories at your faculty available for your teaching purposes?

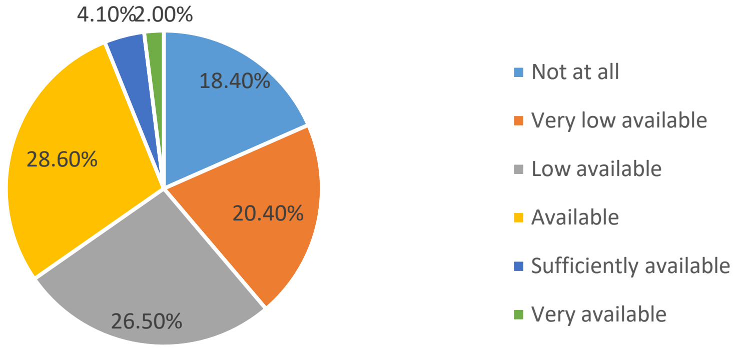


Figure 2.20. Respondents' answers to the question 1.15.

1.16. Do you have sufficient technological support, when implementing STEM education to your subjects?

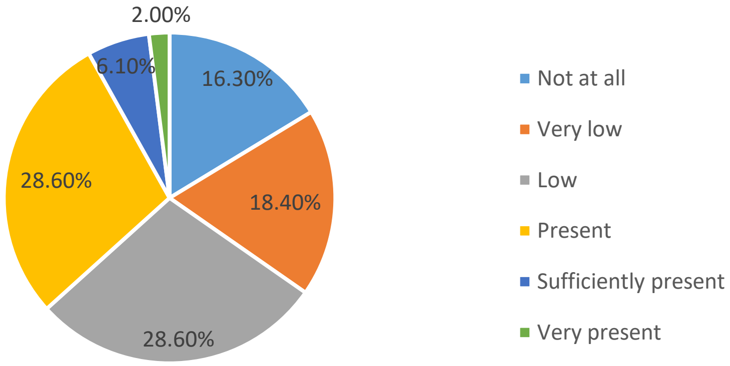


Figure 2.21. Respondents' answers to the question 1.16.

1.17. Do you think the current availability of technological equipment limits the quality of your STEM teaching?

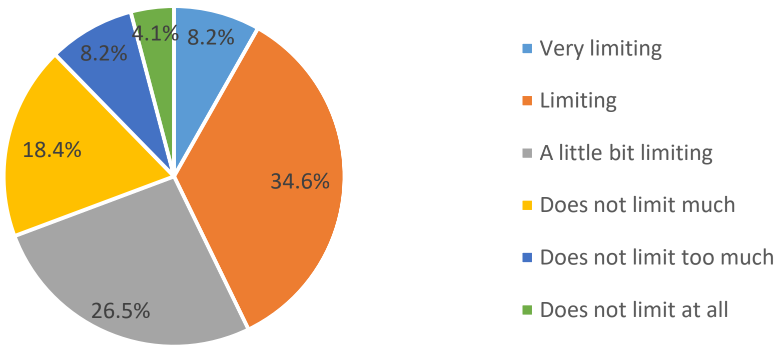


Figure 2.22. Respondents' answers to the question 1.17.

1.18. Is there any non-financial equipment you are missing, that would be helpful for your STEM education?

- Training

1.19. What teaching resources do you use when implementing STEM education?

A. Presentations.
B. Office tools (word, excel, notepad…).
C. Software.
D. Programming tools (not only PC programming, machine programming…).
E. Applications.
F. STEM-specific software.
G. Audio/video materials.
H. Robots.
I. General digital devices (e.g. laptops, smartphones, tablets, cameras, video game consoles).
J. Online resources (websites, dictionaries, encyclopedias, etc.).
K. Manipulation in an experimental lab.
L. Online collaborative tools (Padlet, Centimetre, Tricorder, Kahoot…).
M. Resources published by private companies operating in STEM fields.
N. Others……. *(This is open question)*.

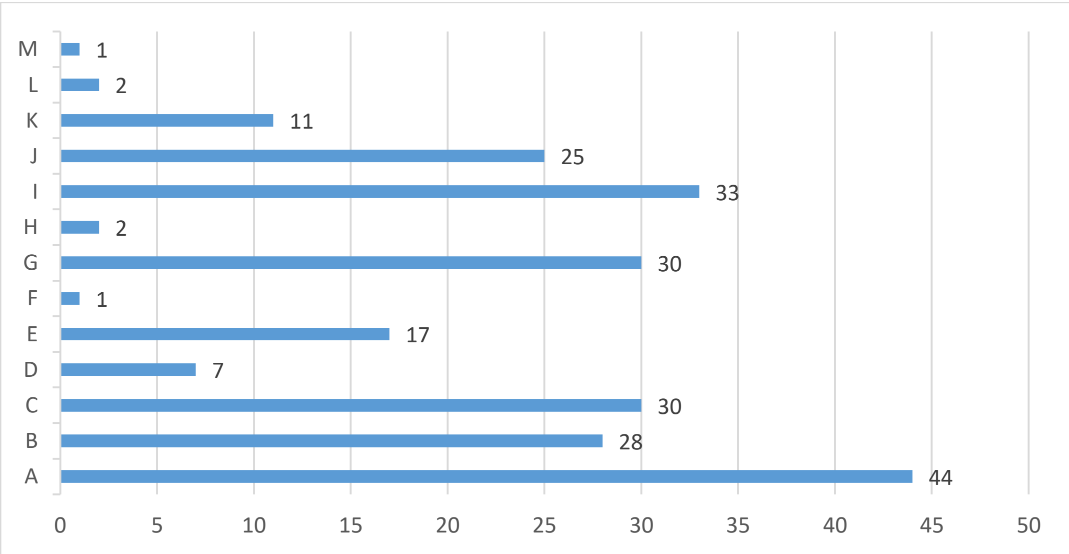


Figure 2.23. Respondents' answers to the question 1.19.

Literature and other teaching materials are available according to half of the respondents. There are some teachers who believe that the possible lack of literature does not affect STEM education. There are no laboratories in the Faculty that could be used for STEM education according to 2/3 of the respondents. 37% say that there is technological support for STEM teaching, 30% of respondents say that this does not limit the introduction of STEM. When integrating STEM education, the following methods are most used at the Óbuda University: presentations, general digital tools, software, video materials, as well as online resources and websites.

2.1.5. Student Achievement

1.20. How well do students achieve good results in combined STEM subjects?

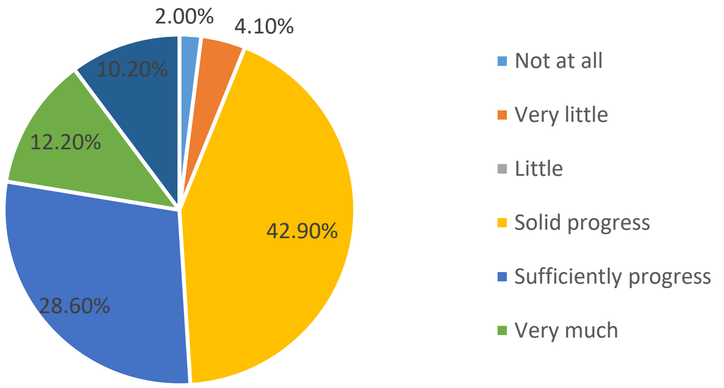


Figure 2.24. Respondents' answers to the question 1.20.

1.21. Is the teaching more difficult for students when using STEM? (Based on student feedback)

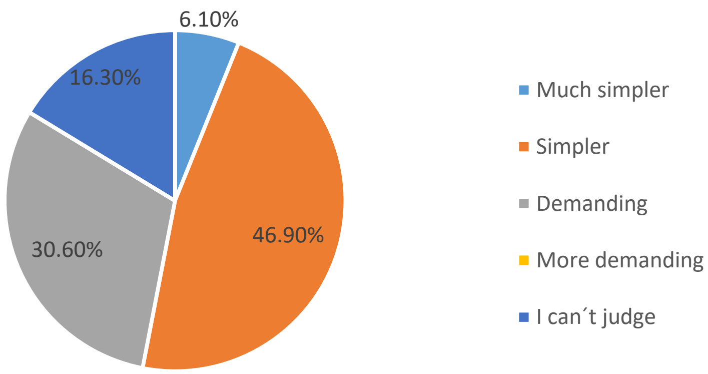


Figure 2.25. Respondents' answers to the question 1.21.

1.22. If you have any other comments, please free to write any comment…… *(This is open question)*

- There are cases where we cannot or do not want to use a STEM tool because of time constraints. Some are due to software shortages.
- Because you get positive feedback from students, it's much easier to teach and motivate them. But a targeted training of trainers would be good for the faculty!

- More information is needed on the elements and methodology of the system.
- I still think it is wrong to force a more paper-based practice-oriented education in a situation and curriculum where the trend is to displace the basic subjects (merging of former mechanics semesters, continuous shortening of the mathematics curriculum). It is possible that a student will learn to use a piece of software but will be less and less able to evaluate its results. Unless we leave that to the software...

In combined STEM subjects, students perform better according to the vast majority of respondents. Of those who were able to judge, around 2/3 think it is easier to teach with STEM education.

2.2. Survey for Students

Field of studies:

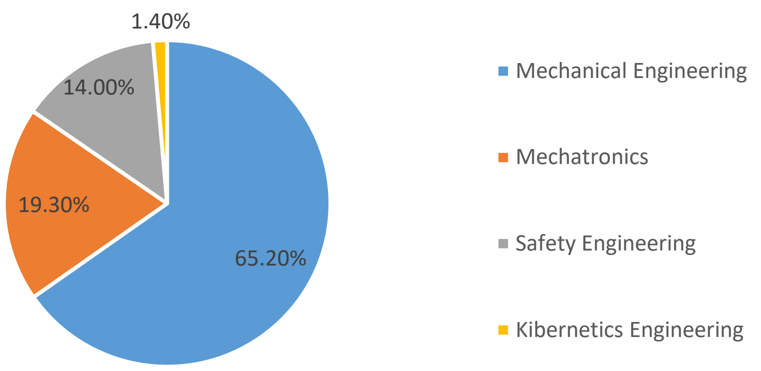


Figure 2.26. Respondents' answers to the question Field of studies.

Type of studies:

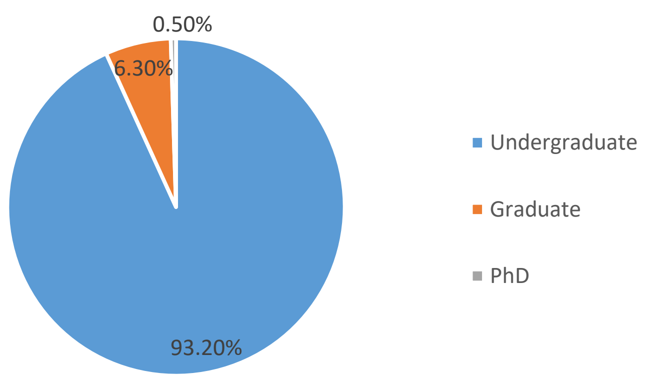


Figure 2.27. Respondents' answers to the question Type of studies.

Finished number of semesters:

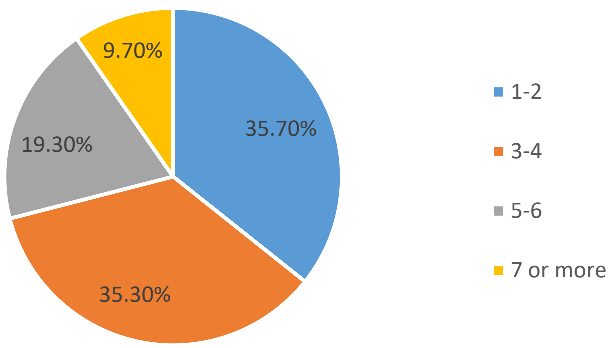


Figure 2.28. Respondents' answers to the question Finished number of semesters.

Sex:

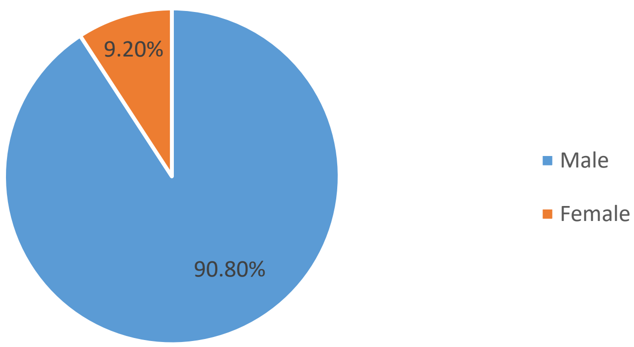


Figure 2.29. Respondents' answers to the question Sex.

Age:

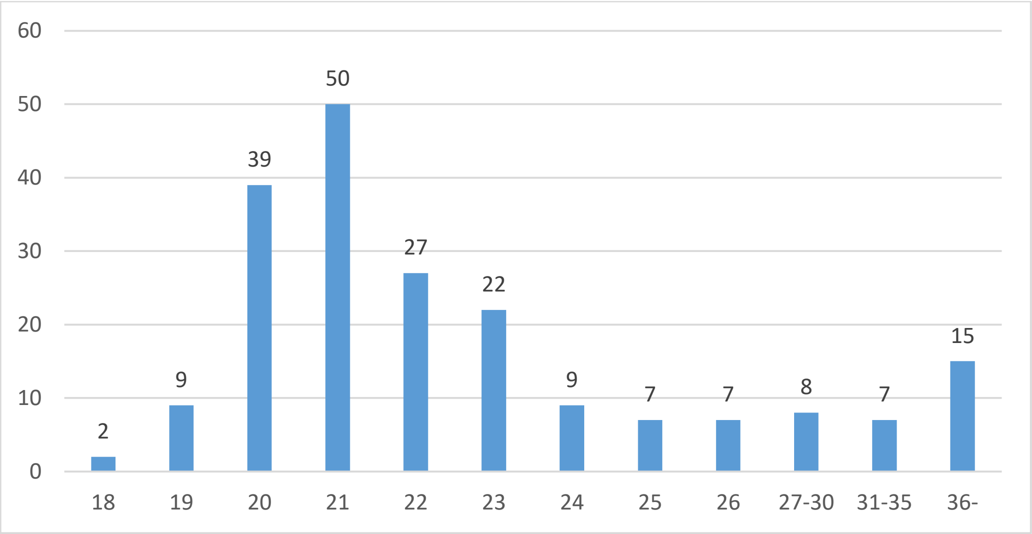


Figure 2.30. Respondents' answers to the question Age.

A total of 207 students from the Bánki Donát Faculty of Mechanical and Safety Engineering, Óbuda University completed the questionnaire. The majority are mechanical engineering students, but there are also students of mechatronics, safety engineering and cyber engineering. 93% of the respondents are BSc students and 90% are male. 1/3 of the respondents have completed 1-2 semesters and 1/3 have completed 3-4 semesters, which means that the vast majority of respondents are in the middle of their bachelor's studies. The age distribution is more likely to be under 23, but there are also students up to 36 years old.

2.2.1. Familiarity with the Term STEM

2.1. Are you familiar with the term "STEM" education?

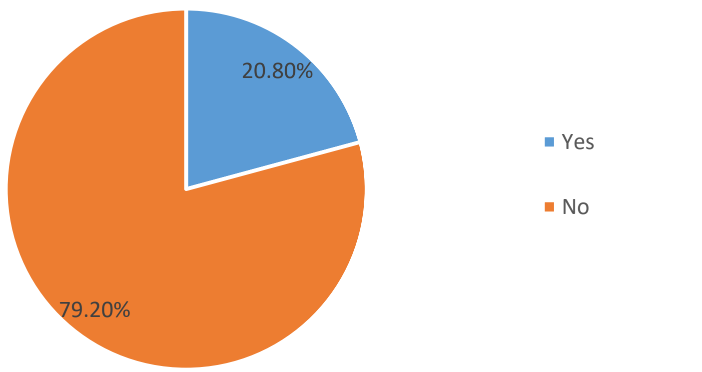


Figure 2.31. Respondents' answers to the question 2.1.

2.2. How many subjects focused on a combination of math, problem solving, technology and science did you have in your studies so far?

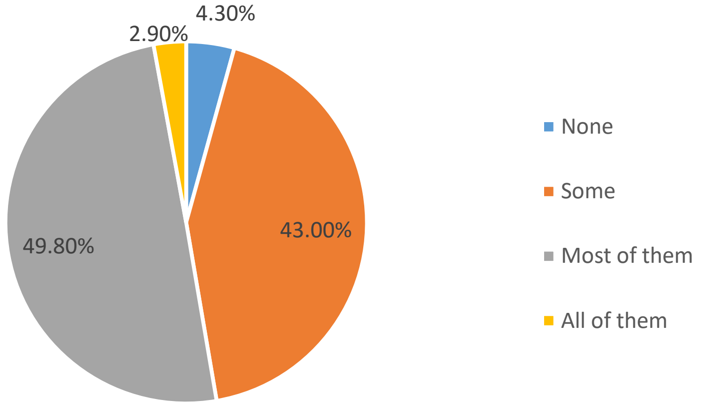


Figure 2.32. Respondents' answers to the question 2.2.

2.3. How many classes (subjects/courses) have you taken in each of these categories so far? (Fill in the ratio of courses for each category).

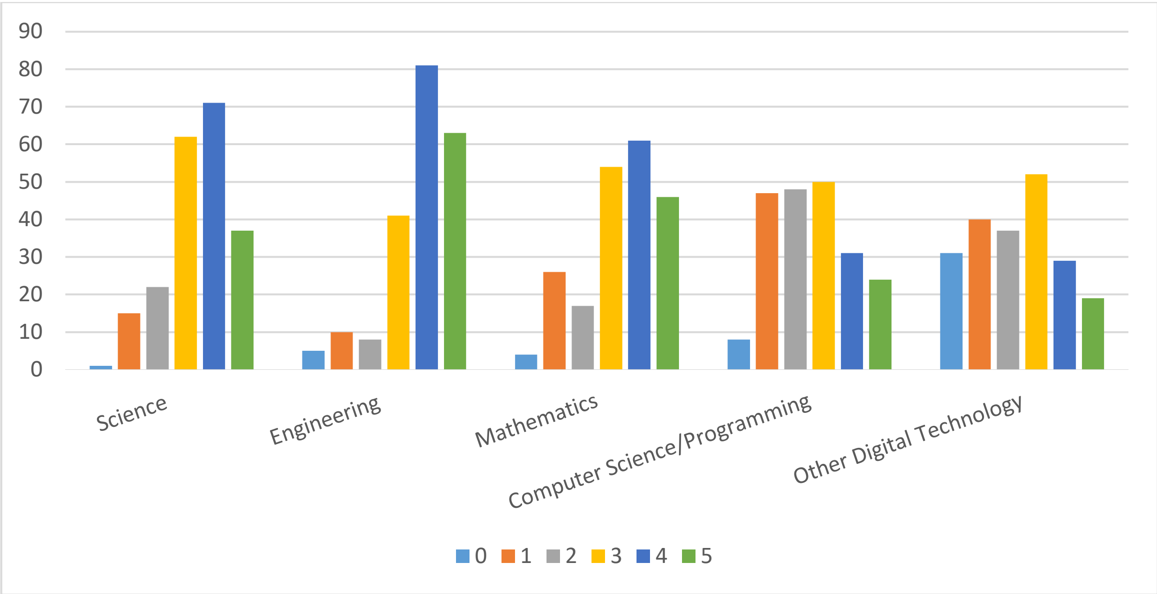


Figure 2.33. Respondents' answers to the question 2.3.

2.4. Does your school offer engineering courses or projects? Engineering (any with problem solving)

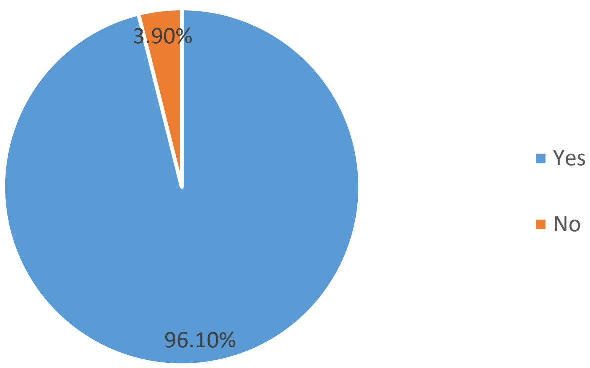


Figure 2.34. Respondents' answers to the question 2.4.

Almost 80% of students have never heard of STEM education, but nearly 90% of subjects include maths, problem solving, technology and science. The majority of students' subjects are in science, engineering and maths. The University offers engineering and problem solving related subjects, although there are some students who say they do not (4%).

2.2.2. Business and Industry Partners Involvement in STEM Education

2.5. Are business and industry also included in your STEM education?

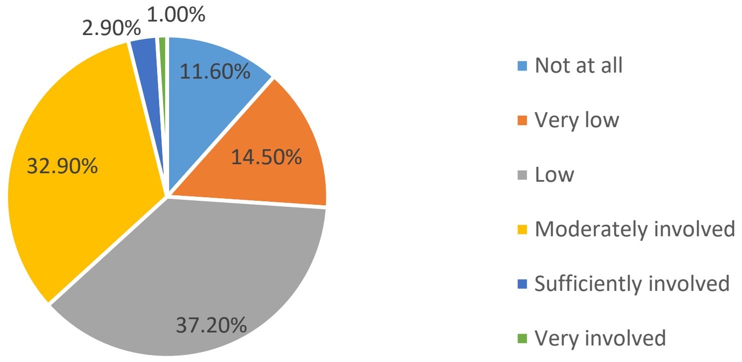


Figure 2.35. Respondents' answers to the question 2.5.

2.6. Do you implement projects assigned by industry partners in your school tasks?

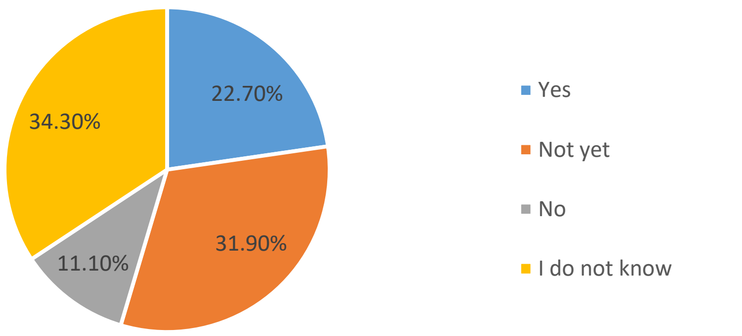


Figure 2.36. Respondents' answers to the question 2.6.

2.7. In your education, do you often deal complex problems that are similar to problems in practice?

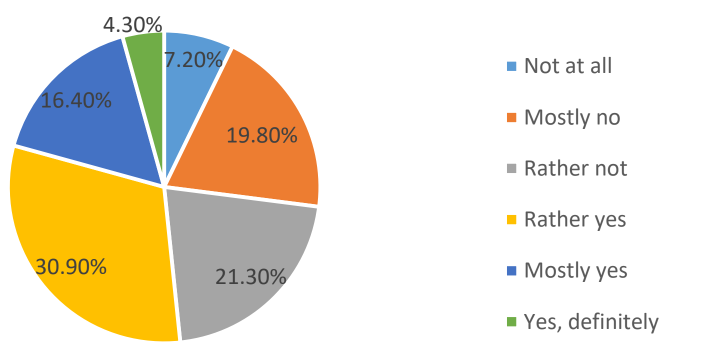


Figure 2.37. Respondents' answers to the question 2.7.

2/3 of students say that there is no link between industry and university in education at Óbuda University. 80% of students say there are no industrial projects in university education or they do not know about these. There are topics related to practical problems that students solve as assignments.

2.2.3. Technology Used Throughout STEM Education

2.8. Do you have classes in the computer classroom?

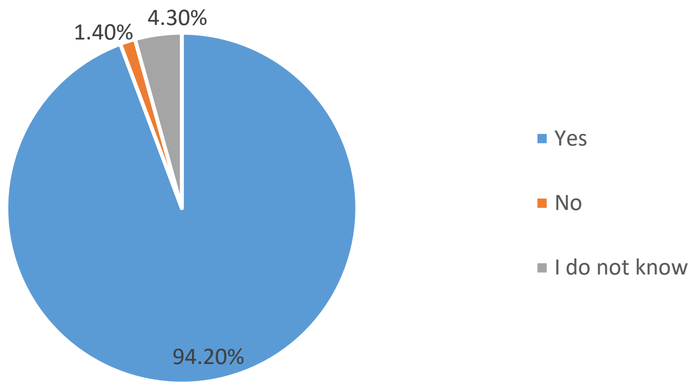


Figure 2.38. Respondents' answers to the question 2.8.

2.9. Do you have classes in specialised laboratories (no computer classroom)?

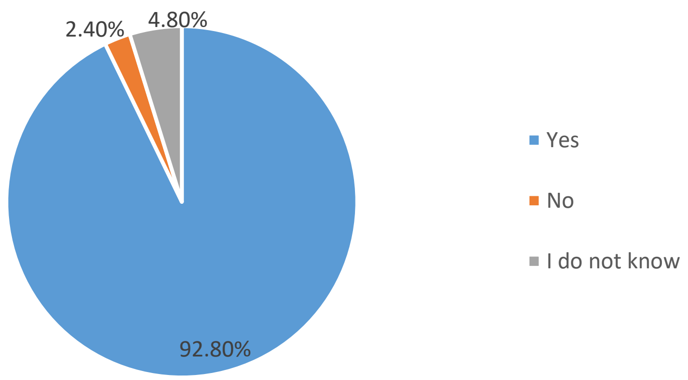


Figure 2.39. Respondents' answers to the question 2.9.

2.10. What percentage of courses/subjects do you use digital technologies (PC, tablet, mobile phone)

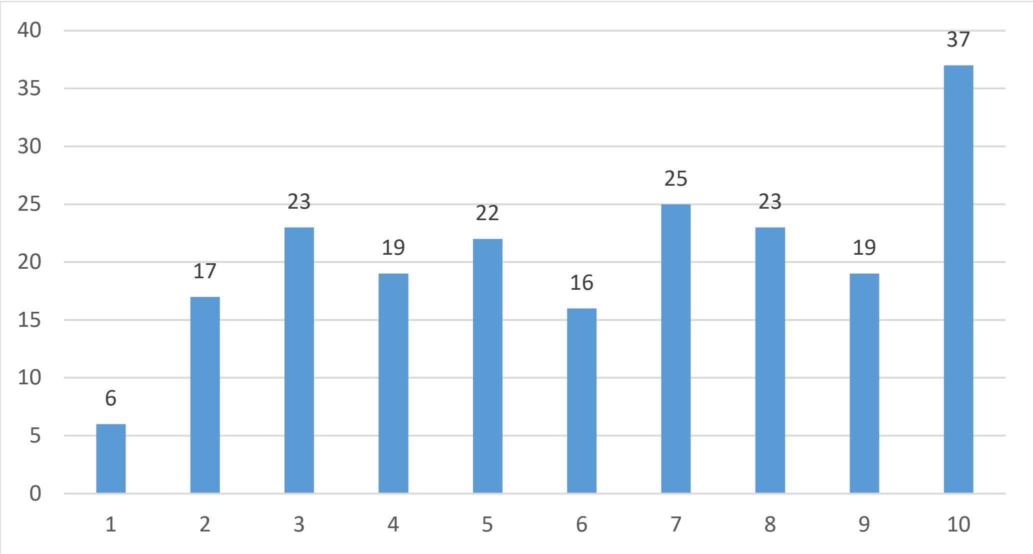


Figure 2.40. Respondents' answers to the question 2.10.

At Óbuda University, 94% of respondents said they have classes in a computer classroom and a specialised laboratory. 120 students (out of 207) use digital tools more than 60%.

2.2.4. Future Vision

2.11. In a future, I plan to continue in STEM education. (Science (any where science is applied – physics, chemistry, meteorology, economy...), Engineering (any with problem solving), Mathematics, Computer Science/Programming, Other Technology.

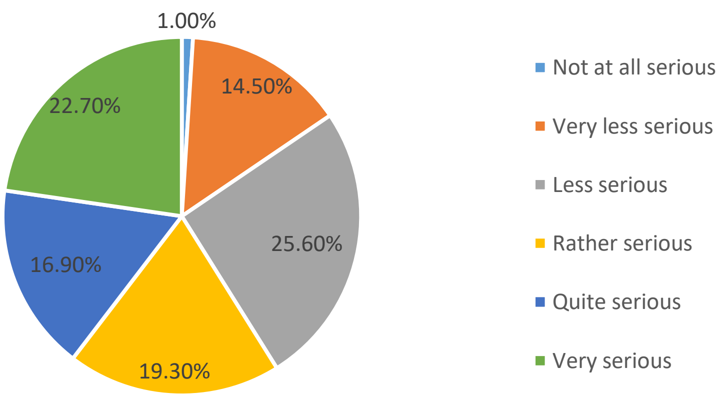


Figure 2.41. Respondents' answers to the question 2.11.

2.12. I see myself in STEM a career (in the future)

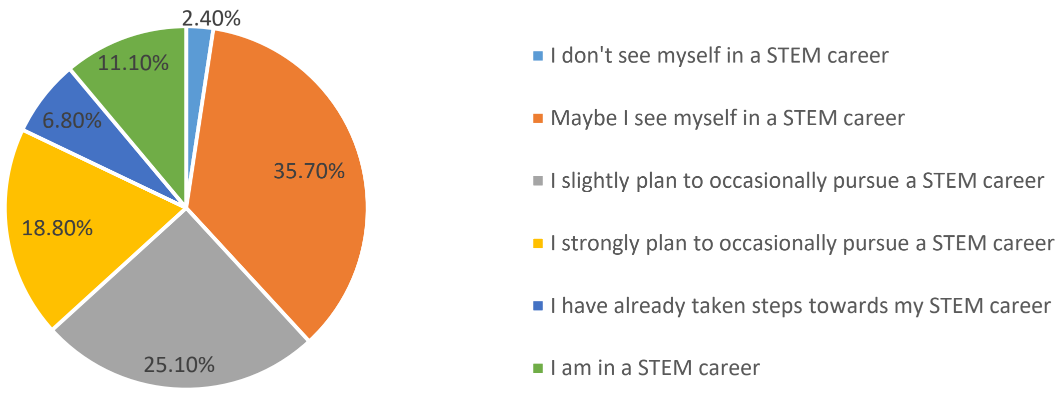


Figure 2.42. Respondents' answers to the question 2.12.

More than half of students prioritise STEM education in their further studies. Only a small proportion of students (2.4%) do not choose a STEM field as their future career, with the majority envisaging some form of STEM career.

2.2.5. Increasing STEM Skills

2.13. I would appreciate more chances to learn STEM.

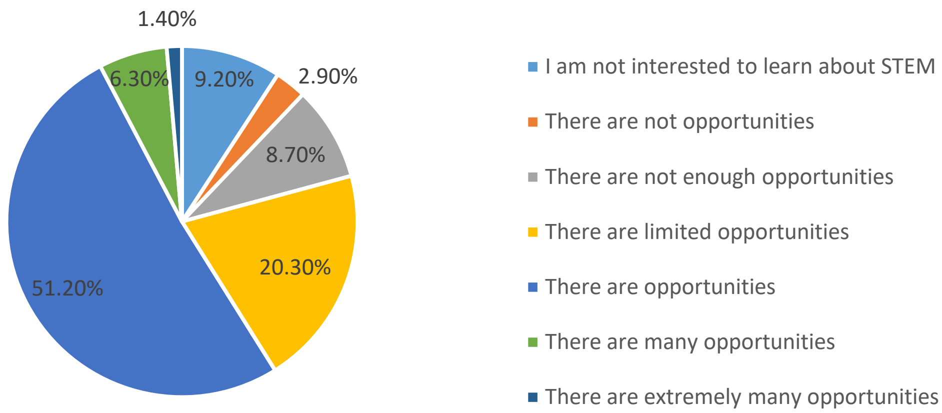


Figure 2.43. Respondents' answers to the question 2.13.

2.14. Rate (evaluate) your skills obtained during your study so far.

A. I can solve some equation and work with variables (in my field of study).
B. I am able to think logically.
C. I can analyze complex problems.
D. I can solve a problem.
E. I can come up with creative idea.
F. I can do the critical analysis.

G. I am open to learn new technologies.
H. I can use digital devices such as computer, tablet, smartphone.
I. I understand basic software applications.
J. I can use and evaluate information from digital sources.
K. I understand the basics of cybersecurity.

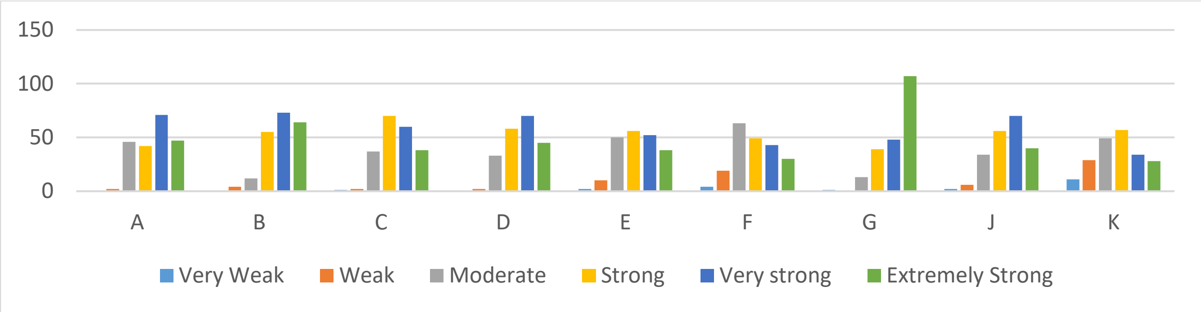


Figure 2.44. Respondents' answers to the question 2.14.

2.15. If you have any other comments, please free to write any comment…… *(This is open question)*

- My skills listed in the question 2.14 were not studied at university.
- I'm supposed to be on a practical course, but so far 95% of my learning has been from presentations and the university continues to promote itself as practical to prospective students.
- The use of more visual tools, visual elements in teaching would be necessary.

Nearly 10% of students are not interested in STEM education at all, 1/3 say there are few opportunities to learn about STEM, and more than half of students perceive that they have opportunities to participate in STEM education. Students are open to learning new technologies and are able to think logically. The majority of respondents perceive their knowledge of cyber security as weak.

3. ANALYSIS OF SURVEY RESULTS – UNIVERSITY OF ZILINA

3.1. Survey for Teachers

Field of teaching:

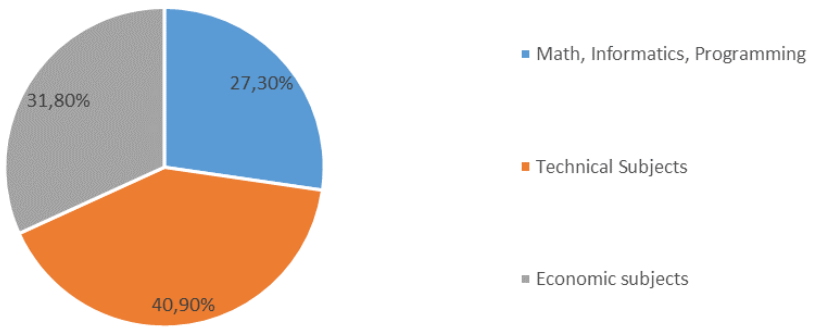


Figure 1.1. Respondents' answers to the question Field of teaching.

Sex:

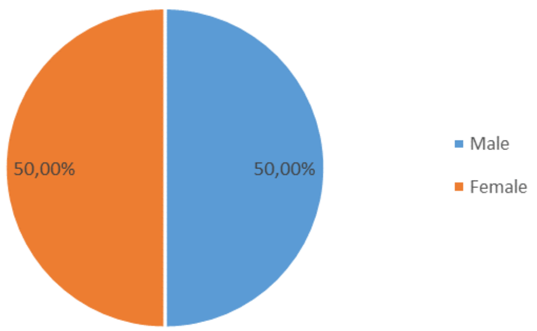


Figure 1.2. Respondents' answers to the question Sex.

Position:

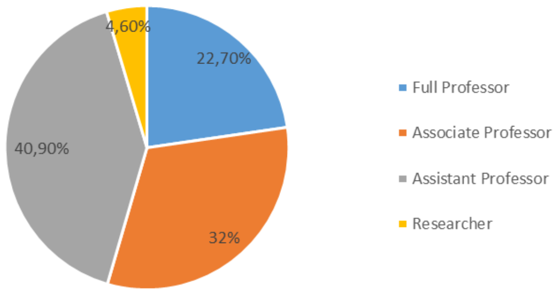


Figure 1.3. Respondents' answers to the question Position.

Teaching experience at university:

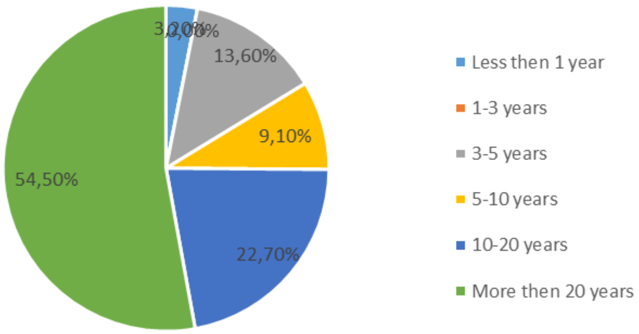


Figure 1.4. Respondents' answers to the question Teaching experience at university.

A significant number of academic professionals are engaged in technical subjects, followed by economic subjects, and then math, informatics, and programming. There is an equal gender distribution among the academic professionals surveyed. Assistant professors make up the largest proportion of academic ranks, followed by associate professors, full professors, and researchers. Most of academic professionals have over 20 years of experience, with a significant portion having 10–20 years of experience. There are relatively few professionals with less than 5 years of experience.

In summary, the data indicates a balanced gender representation, with a significant number of professionals specializing in technical subjects. Most academic professionals hold positions at the assistant or associate professor level and have extensive experience, with more than half having over 20 years in their respective fields.

3.1.1. STEM Education Integration

1.1. Has the Science, Engineering, Mathematics, Technology education been integrated at your faculty?

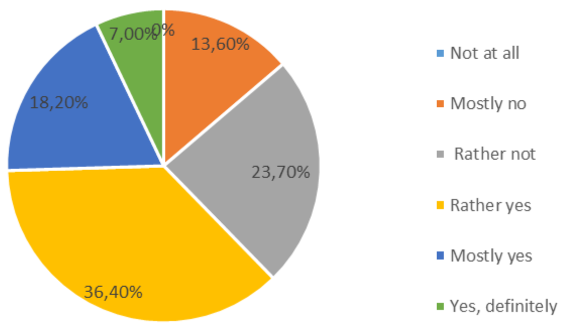


Figure 1.5. Respondents' answers to the question 1.1.

1.2. How much focus does your teaching have on STEM education.

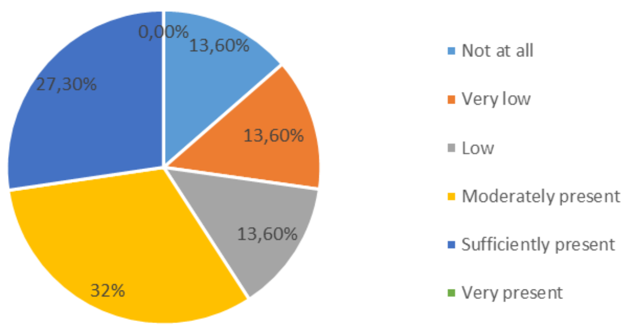


Figure 1.6. Respondents' answers to the question 1.2.

1.3. Do you provide lectures/courses with elements of STEM education? (*answer in percentages from 0-100%, scale 0-5)*

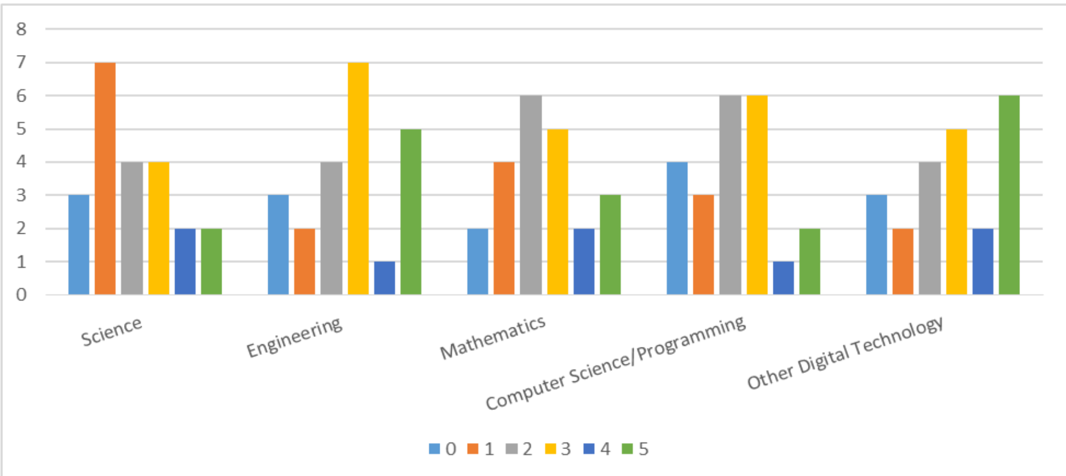


Figure 1.7. Respondents' answers to the question 1.3.

1.4. Is the STEM curriculum at the lectures/courses that you are teaching multidisciplinary and does it include lectures that are integrated (to include science, technology, engineering, and mathematics)?

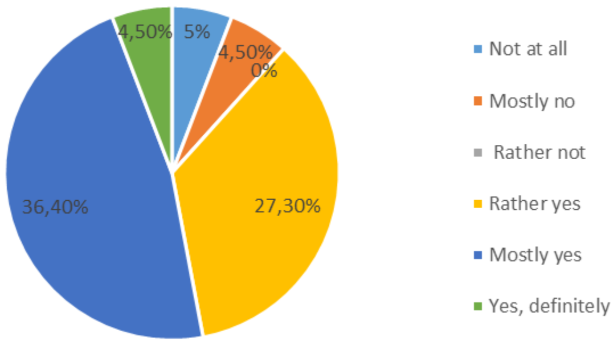


Figure 1.8. Respondents' answers to the question 1.4.

The integration of STEM education appears to be somewhat varied. While a small portion (7%) of respondents believe that STEM education is “definitely integrated,” the largest group (36.4%) feels it is "rather" integrated. A combined 37.3% of respondents, however, lean towards less integration, indicating room for improvement. When it comes to the emphasis placed on STEM education in teaching, a significant portion (32%) considers it to be moderately present, and 27.3% find it to be sufficiently present.

However, no respondents rated the focus as "very present," and a notable combined percentage (40.8%) rated it from "not at all" to "low." The data suggests that while there is some level of integration and focus on STEM education within the faculty, it is not universally high. Efforts to enhance the presence and emphasis of STEM education could be beneficial, as there is a substantial portion of faculty members who perceive the current level as insufficient.

The survey results provide insights into the inclusion of STEM elements in lectures/courses and the multidisciplinary nature of the STEM curriculum. Respondents were asked to rate the extent to which their lectures/courses include elements of STEM education on a scale of 0 to 5, with 0 being no elements and 5 being fully integrated elements. The results are as follows: From these results, STEM elements are present to varying degrees across different subjects. Engineering and digital technology courses appear to have higher ratings (4 and 5) for STEM elements, suggesting a stronger integration in these areas. Respondents were also asked if the STEM curriculum in their lectures/courses is multidisciplinary and includes integrated elements of science, technology, engineering, and mathematics. The data indicates a moderate integration of STEM elements in courses, with engineering and digital technology courses showing a higher level of integration. Regarding the multidisciplinary nature of the curriculum, the significant number of respondents (63.7%) feel that their courses are at least "rather" multidisciplinary, with 36.4% saying "mostly yes" and 4.5% saying "yes, definitely." However, there is still a small percentage (12.2%) who feel that multidisciplinary integration is lacking.

Overall, while there is a positive trend towards integrating STEM education and multidisciplinary approaches, there remains potential for further development and enhancement in these areas.

3.1.2. Professional Development and Experience in STEM

1.5. Which pedagogical approaches do you use in your STEM teaching?

A. Traditional teaching where the teacher gives information, and students learn from it. Traditional direct instruction (lessons are focused on the delivery of content by the teacher and the acquisition of content knowledge by the students).
B. Teaching with experiments (experiments are used in the classroom to explain the subject matter).
C. Project-/Problem-based approach (students are engaged in learning through the investigation of real-world challenges and problems).
D. Inquiry-Based Science Education (students design and conduct their own scientific investigations).
E. Collaborative learning (students are involved in joint intellectual efforts with their peers or with their teachers and peers).
F. Formative assessment, including self-assessment (student learning is constantly monitored and ongoing feedback is provided; students are provided with opportunities to reflect on their own learning).
G. Others..................*(This is open question)*.

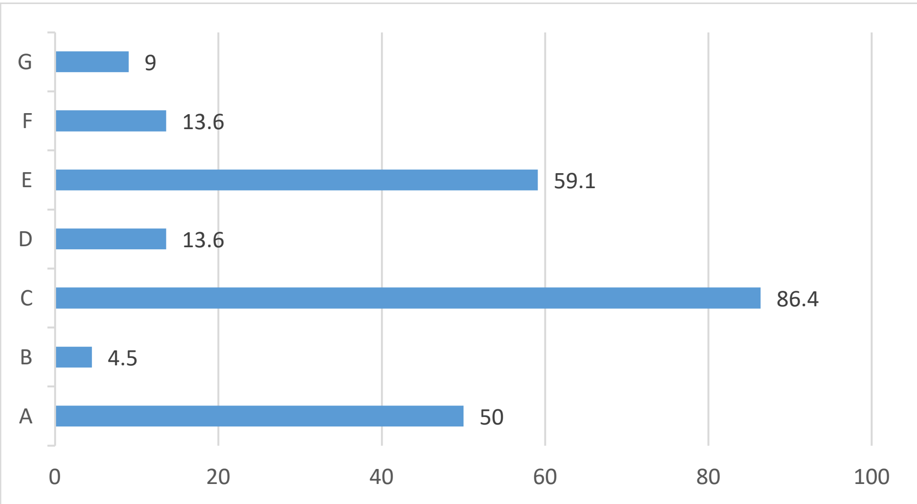


Figure 1.9. Respondents' answers to the question 1.5.

1.6. Please evaluate the STEM implementation in your teaching.

A. I use the STEM approach in teaching.
B. I frequently integrate science, technology, engineering, and mathematics within one curriculum.
C. My STEM approach motivates student for more active learning.
D. STEM approach is for me crucial for preparing students for real challenges in their future careers.
E. I regularly adapt the STEM education system based on the number of students and their knowledge.
F. Preparing for education using STEM methodology is time-consuming for me.
G. I regularly educate myself and explore new possibilities in STEM education methodology.

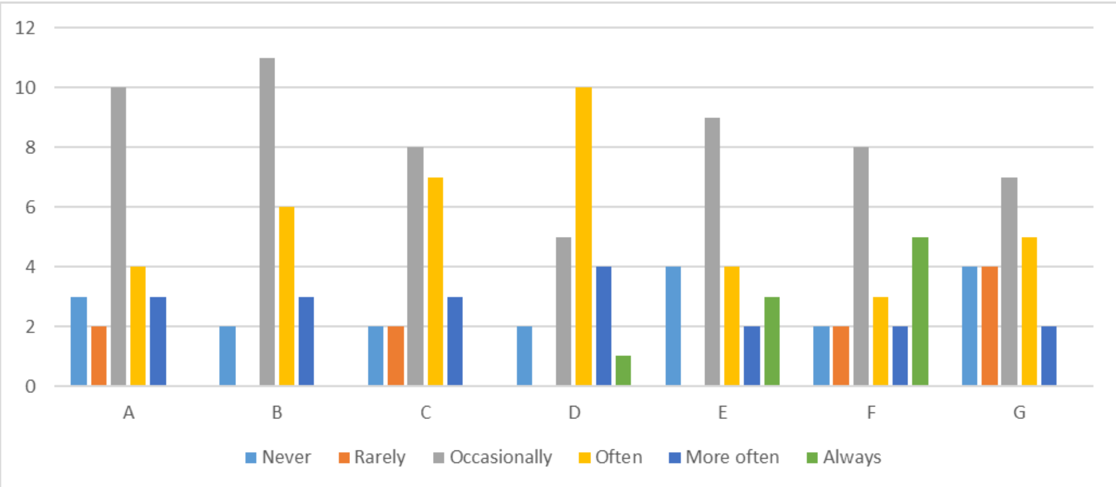


Figure 1.10. Respondents' answers to the question 1.6.

1.7. How would you rate your ability to follow and implement current trends in the STEM (e.g. ICT, team works, project based learning, e.t.c.)?

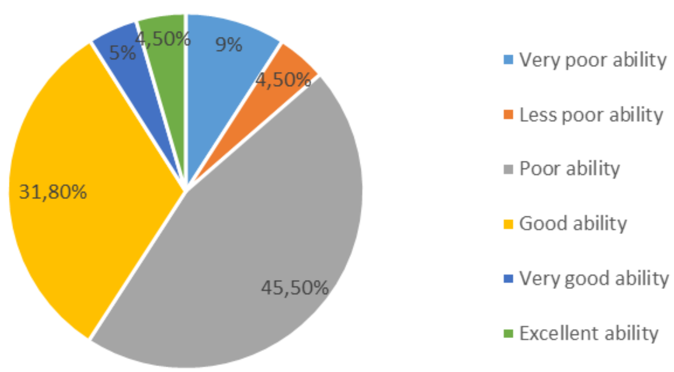


Figure 1.11. Respondents' answers to the question 1.7.

1.8. Would you consider additional training or professional development to better incorporate current STEM trends into your teaching?

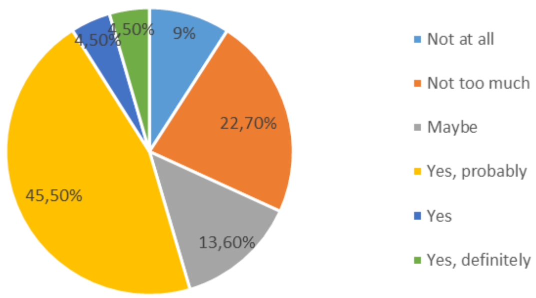


Figure 1.12. Respondents' answers to the question 1.8.

The data indicates a strong preference for project- or problem-based learning and collaborative learning, while traditional teaching methods are also commonly used.

Preferred Pedagogical Approaches: Project- or problem-based learning and collaborative learning are highly favoured, while traditional direct instruction remains prevalent.

STEM Implementation Frequency: STEM approaches are occasionally used, but rarely implemented, indicating room for improvement.

Impact on Student Motivation and Preparation: STEM approaches are seen as valuable for preparing students for real-world challenges, though the motivational impact is mixed.

Challenges and Adaptations: Preparing STEM lessons is often seen as time-consuming, and educators regularly adapt their methods based on student needs.

Self-Education and Current Trends: Many educators feel they have poor to moderate abilities to follow current STEM trends, but a significant number are open to further training and professional development.

Overall, there is a positive inclination towards enhancing STEM education, though there is a clear need for additional support and training to fully integrate and benefit from current STEM methodologies.

3.1.3. Institutional Support (University, Business and Industry Sector - Partners)

1.9. Are business and industry also included in STEM education at your university related to your courses/subjects?

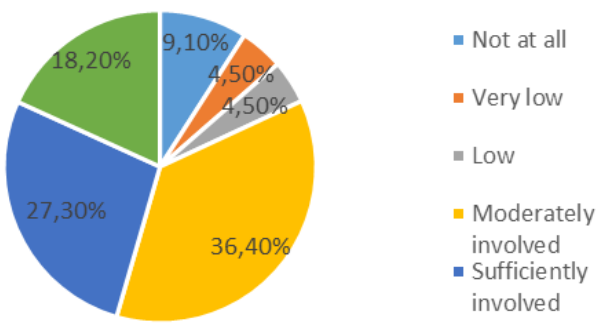


Figure 1.13. Respondents' answers to the question 1.9.

1.10. Please rate university – industry cooperation in STEM education in your teaching.

A. Facilitating company visits.
B. Having STEM professionals at universities (consultations, lectures…).
C. Student Training.
D. Assigning tasks by business/industry sector.
E. Solving tasks for business/industry sector.
F. Financial support.
G. Other…..*(This is open question)*.

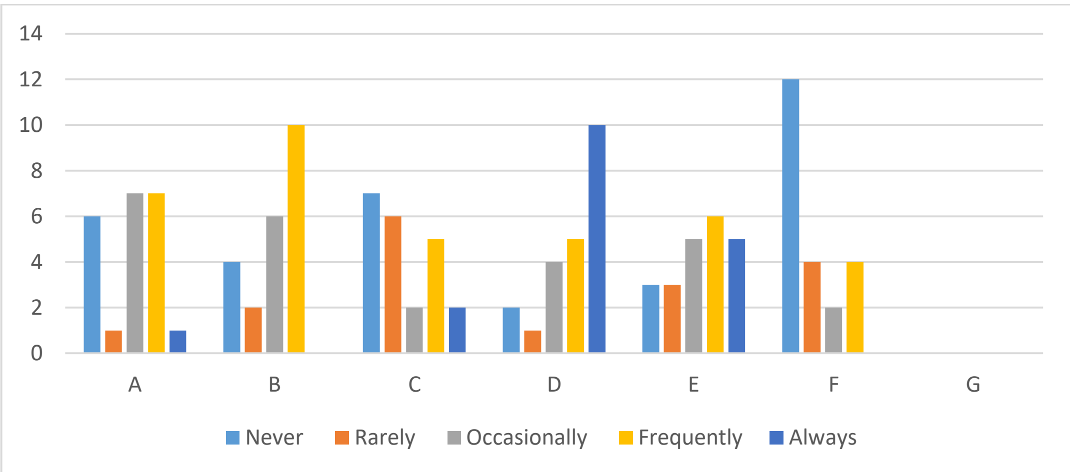


Figure 1.14. Respondents' answers to the question 1.10.

1.10.1. Do you have other types of university-industrial cooperation? *(This is open question)*

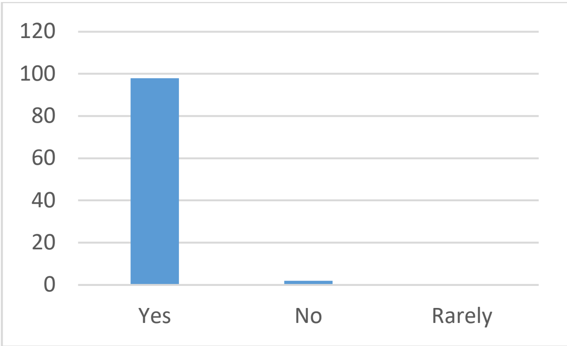


Figure 1.15. Respondents' answers to the question 1.10.1.

1.11. Would you support initiatives that facilitate between industry and universities?

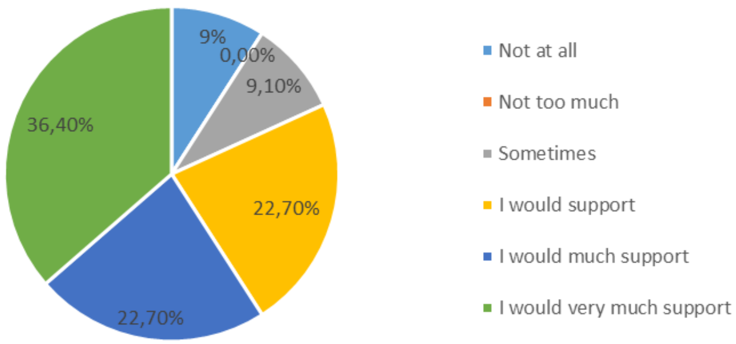


Figure 1.16. Respondents' answers to the question 1.11.

1.12. Do you think that the current support for STEM education from the university is sufficient?

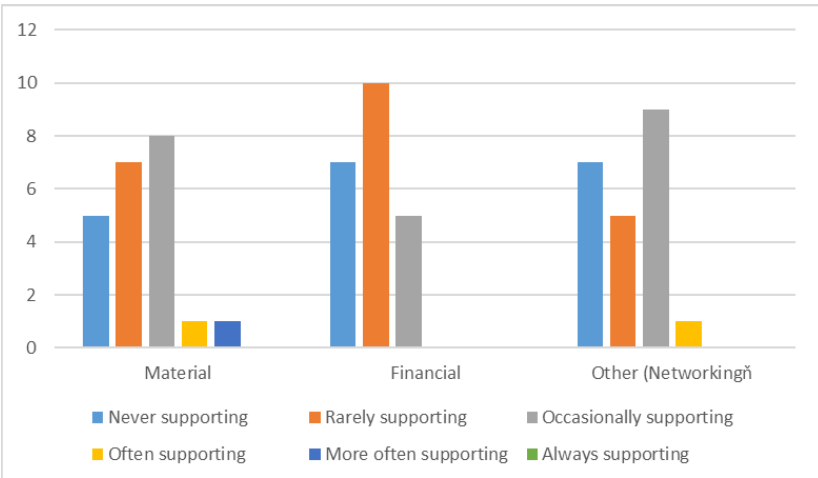


Figure 1.17. Respondents' answers to the question 1.12.

The survey results highlight the involvement of business and industry in STEM education at the university, the level of university-industry cooperation, and the perceived sufficiency of university support for STEM education. Most respondents indicate moderate to very high involvement of business and industry in STEM education, suggesting a significant partnership. Most respondents (98%) indicate other types of university-industrial cooperation, suggesting a broad engagement with industry. The survey results reveal several key points regarding the involvement and support for STEM education:

Business and Industry Involvement: There is a significant level of involvement from the business and industry sectors in STEM education, with most respondents indicating moderate to high levels of involvement.

University-Industry Cooperation: University-industry cooperation manifests in various forms, such as facilitating company visits, involving STEM professionals in teaching, student training, and assigning tasks by industry. However, financial support from industry is less frequent.

Other Types of Cooperation: Nearly all respondents report other forms of university-industrial cooperation, indicating a broad and diverse engagement.

University Support: Material and financial support from the university for STEM education is perceived as insufficient, with many respondents indicating that support is either never or rarely provided. Networking support is slightly better but still not adequate.

Need for Improvement: The data suggest that while there is considerable engagement with industry, there is a need for improved and more consistent support from the university, particularly in financial and material resources, to enhance STEM education.

3.1.4. Marterial Support (Financial and Non-Financial)

1.13. How would you rate the current availability of literature and materials to support teaching STEM in your subject.

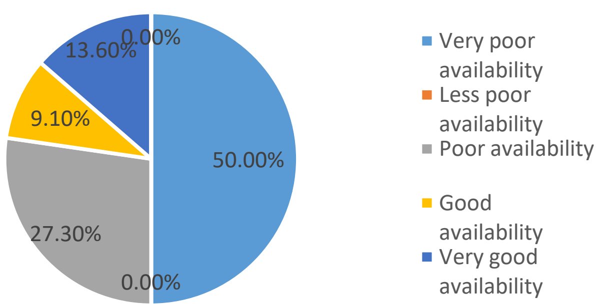


Figure 1.18. Respondents' answers to the question 1.13.

1.14. Do you think the current availability of literature limits the quality of your STEM teaching?

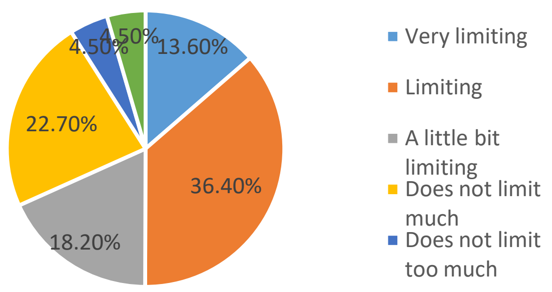


Figure 1.19. Respondents' answers to the question 1.14.

1.15. Are the STEM laboratories at your faculty available for your teaching purposes?

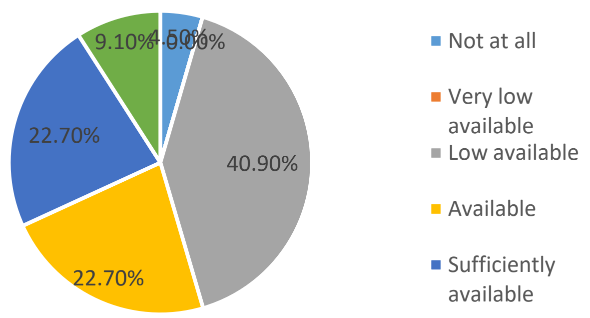


Figure 1.20. Respondents' answers to the question 1.15.

1.16. Do you have sufficient technological support, when implementing STEM education to your subjects?

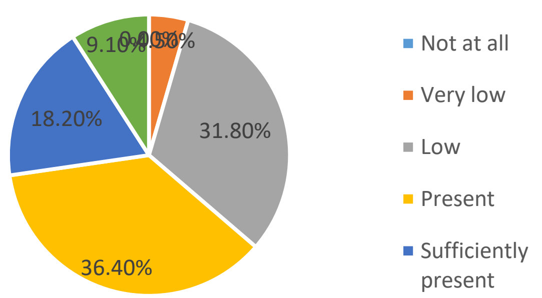


Figure 1.21. Respondents' answers to the question 1.16.

1.17. Do you think the current availability of technological equipment limits the quality of your STEM teaching?

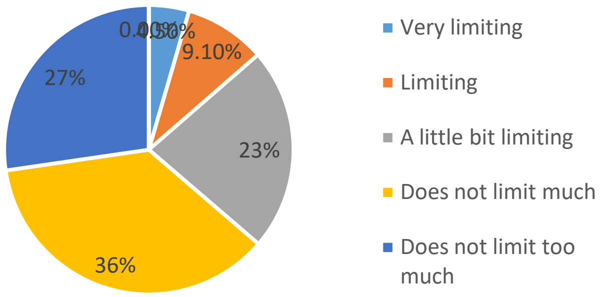


Figure 1.22. Respondents' answers to the question 1.17.

1.18. Is there any non-financial equipment you are missing, that would be helpful for your STEM education?

- Respondents indicated any missing non-financial equipment that would be helpful for their STEM education, highlighting financial support and lack of time for self-study as significant issues.

1.19. What teaching resources do you use when implementing STEM education?

A. Presentations.
B. Office tools (word, excel, notepad…).
C. Software.
D. Programming tools (not only PC programming, machine programming…).
E. Applications.
F. STEM-specific software.
G. Audio/video materials.
H. Robots.
I. General digital devices (e.g. laptops, smartphones, tablets, cameras, video game consoles).
J. Online resources (websites, dictionaries, encyclopedias, etc.).
K. Manipulation in an experimental lab.
L. Online collaborative tools (Padlet, Centimetre, Tricorder, Kahoot…).
M. Resources published by private companies operating in STEM fields.
N. Others……. *(This is open question)*.

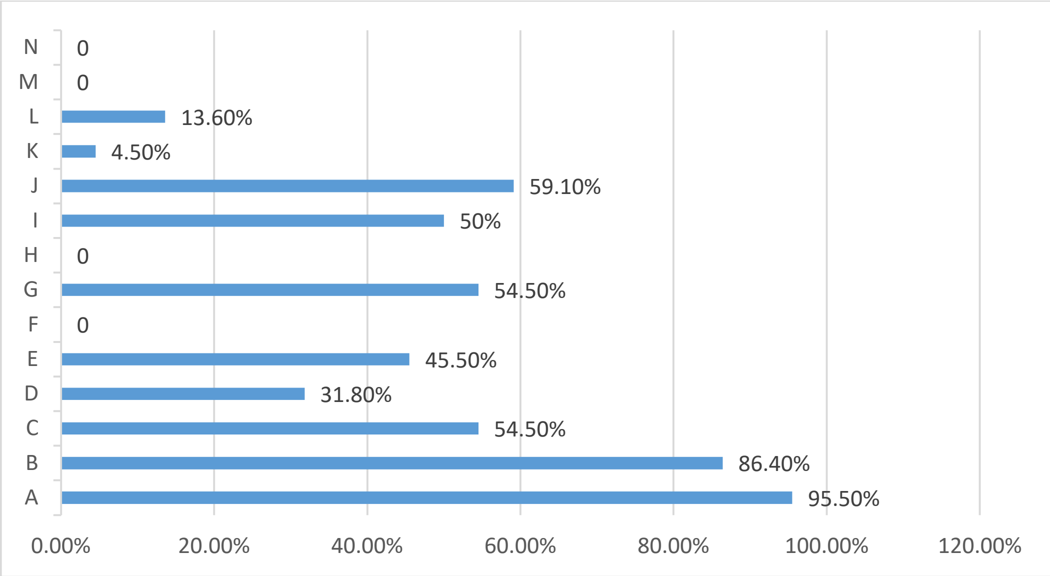


Figure 1.23. Respondents' answers to the question 1.19.

Overall, the data suggest that while some resources are available, there are significant gaps in material and technological support that need to be addressed to enhance the quality of STEM education. The survey results illustrate several key points regarding material and technological support for STEM education:

Literature Availability: A significant portion of respondents (77.3%) rated the availability of literature as poor to very poor, with many feelings this limits the quality of their teaching.

Laboratory Availability: Availability of STEM laboratories is mixed, with 40.9% rating it as low and only 31.8% finding them sufficiently to very available.

Technological Support: While some respondents feel that technological support is present or sufficiently present (54.6%), a notable percentage (36.3%) find it low or very low.

Impact on Teaching Quality: The availability of both literature and technological equipment significantly impacts the quality of STEM teaching, with many respondents indicating varying degrees of limitation.

Teaching Resources: Presentations, office tools, and online resources are the most commonly used resources, whereas specialized STEM-specific software and robots are notably absent.

Need for Support: There is a clear need for increased financial support and time for self-study, indicating areas where the faculty and university could improve to better support STEM education.

3.1.5. Student Achievement

1.20. How well do students achieve good results in combined STEM subjects?

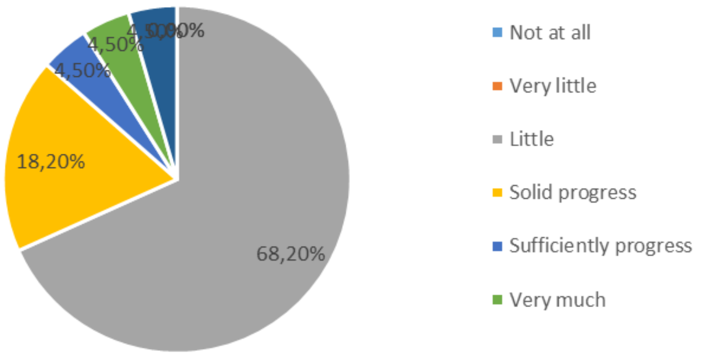


Figure 1.24. Respondents' answers to the question 1.20.

1.21. Is the teaching more difficult for students when using STEM? (Based on student feedback)

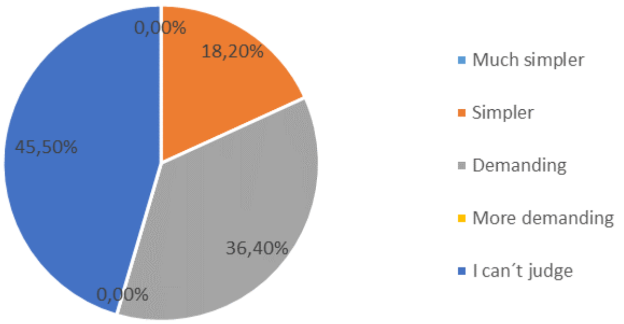


Figure 1.25. Respondents' answers to the question 1.21.

1.22. If you have any other comments, please free to write any comment…… *(This is open question)*

No comments.

The survey results highlight several key points regarding student achievement and the perceived difficulty of STEM education:

Student Achievement: The significant number of respondents (68.2%) believe that students achieve "little" progress in combined STEM subjects. Only a small percentage see "solid progress" (18.2%) or "sufficient progress" (4.5%). This suggests that there may be challenges in student performance in integrated STEM curricula.

Perceived Difficulty: According to student feedback, 36.4% of respondents find STEM education "demanding" for students. Interestingly, 18.2% find it "simpler," while a significant portion (45.5%) cannot judge the difficulty. This mixed feedback may reflect diverse student experiences and the varying complexity of STEM subjects.

Combination of STEM Subjects: A small percentage (4.5%) of respondents do not combine STEM subjects in their teaching, indicating that most educators are attempting to integrate these disciplines.

The data suggest that while there are efforts to integrate STEM subjects, achieving high levels of student success remains a challenge. The perceived difficulty of STEM education varies, highlighting the need for tailored teaching approaches and possibly additional support for both educators and students. To improve student outcomes, institutions might consider:

Enhanced Support: Providing more resources, training, and support for educators to effectively combine STEM subjects.

Student Feedback: Continuously gathering and analyzing student feedback to identify specific areas of difficulty and adjust teaching methods accordingly.

Targeted Interventions: Implementing targeted interventions and support mechanisms for students struggling with STEM subjects to ensure they can achieve better outcomes.

Overall, these insights point to a need for continuous improvement and support in STEM education to enhance both teaching effectiveness and student achievement.

3.1.6. Conclusion

The survey highlights several areas where STEM education can be improved. There is a moderate level of STEM integration and focus on teaching, but there is room for enhancing its presence and emphasis. Increased financial and material support from the university is needed to enhance the quality of the quality of STEM education. This includes better availability of literature, laboratories, and technological equipment. There are challenges to student performance in integrated STEM curricula. Tailored teaching approaches and additional support for educators and students could improve outcomes. While business and industry involvement are significant, financial support from these sectors could be improved. There is a need for more resources, training, and time for self-study to better support STEM education. Enhanced support for educators to integrate and focus on STEM subjects effectively is crucial. By addressing these gaps and leveraging the strengths identified, institutions can enhance the effectiveness of STEM education and improve student achievement and engagement in these critical fields.

3.2. Survey for Students

Field of studies:

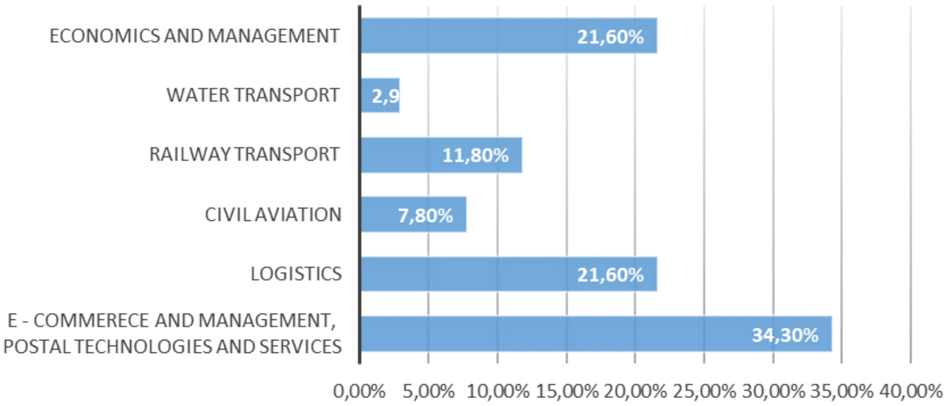


Figure 1.26. Respondents' answers to the question Field of studies.

Type of studies:

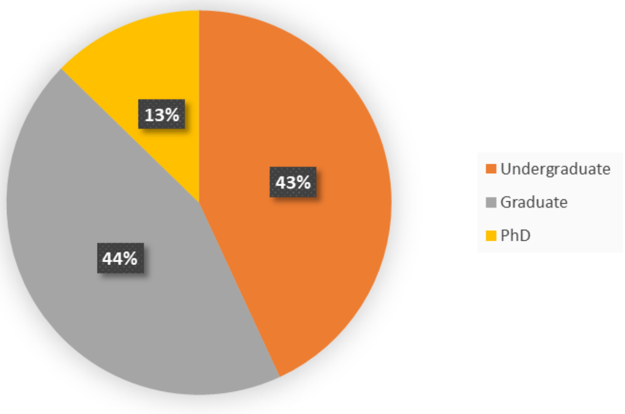


Figure 1.27. Respondents' answers to the question Type of studies.

Finished number of semesters:

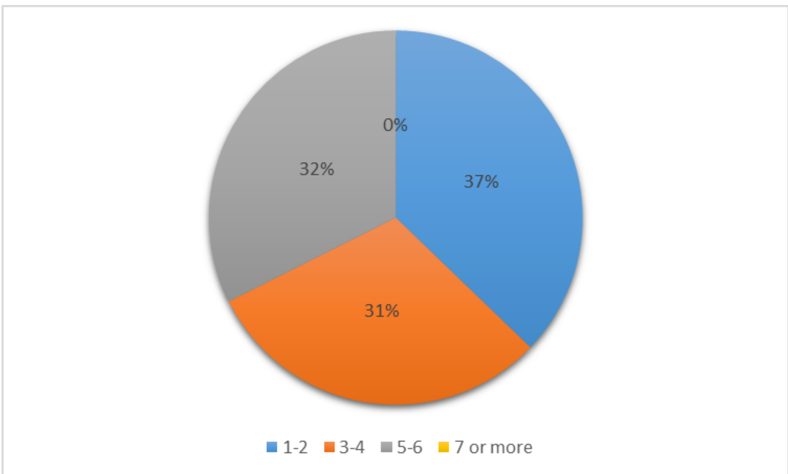


Figure 1.28. Respondents' answers to the question Finished number of semesters.

Sex:

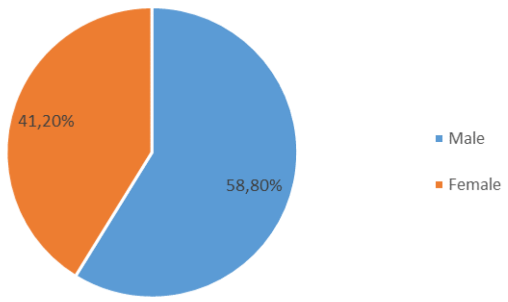


Figure 1.29. Respondents' answers to the question Sex.

Age:

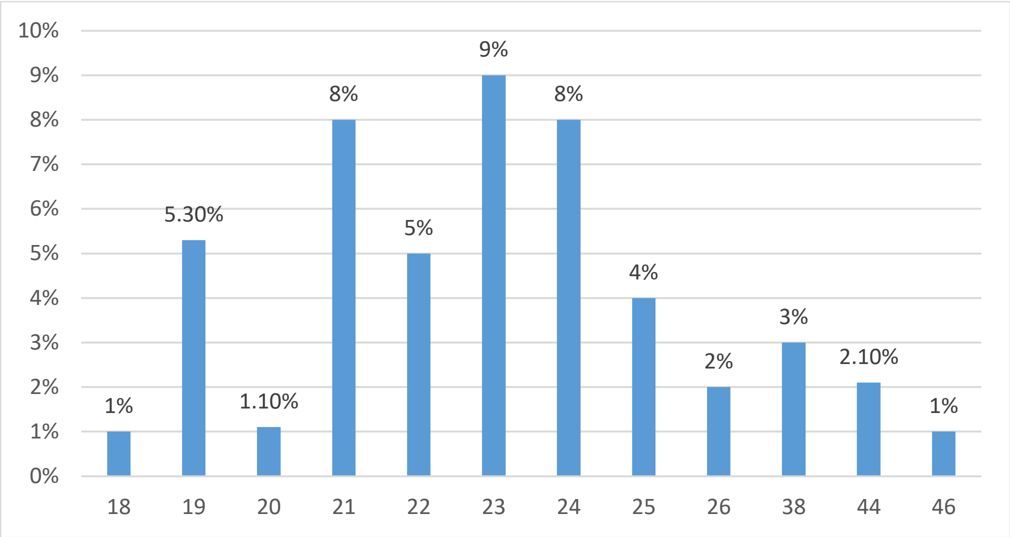


Figure 1.30. Respondents' answers to the question Age.

The most of students are enrolled in E-commerce and Management, Postal Technologies, and Services, which makes up about a third of the respondents. The other fields, such as Railway Transport, Civil Aviation, and Water Transport, have smaller representations. The distribution between undergraduate and graduate students is balanced, with a slight edge towards graduate students. A smaller, yet significant, portion of the respondents are pursuing PhD degrees. Most students have completed between one to six semesters, with none having completed seven or more semesters. This suggests that the respondents are primarily in the early to mid-stages of their academic programs. The gender distribution shows a higher percentage of male students compared to female students, with males making up almost 60% of the respondents.

3.2.1. Familiarity with the Term STEM

2.1. Are you familiar with the term “STEM“ education?

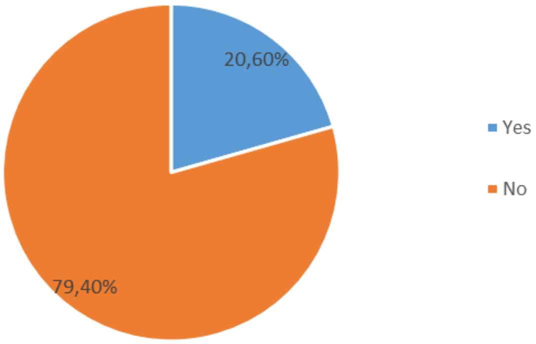


Figure 1.31. Respondents' answers to the question 2.1.

2.2. How many subjects focused on a combination of math, problem solving, technology and science did you have in your studies so far?

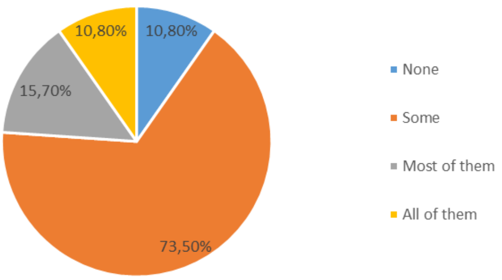


Figure 1.32. Respondents' answers to the question 2.2.

2.3. How many classes (subjects/courses) have you taken in each of these categories so far? (Fill in the ratio of courses for each category).

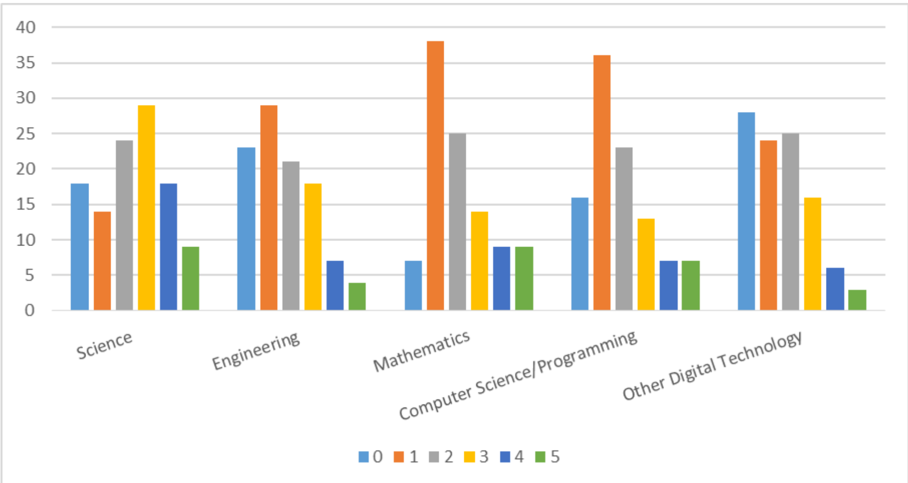


Figure 1.33. Respondents' answers to the question 2.3.

2.4. Does your school offer engineering courses or projects? Engineering (any with problem solving)

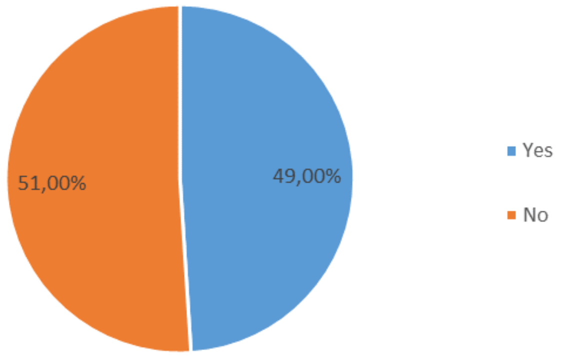


Figure 1.34. Respondents' answers to the question 2.4.

A significant percentage of students (79.40%) are not familiar with the term "STEM" education. This indicates a need for increased awareness and education about STEM, given its importance in contemporary education and career paths. Most students (73.50%) have encountered some subjects that focus on a combination of math, problem-solving, technology, and science. A smaller portion of students have had either most or all their subjects focused on these areas, indicating varying levels of STEM integration in their curricula. The distribution of classes taken across STEM categories shows that while there is some exposure, it is uneven. Notably, a higher number of students have taken multiple science and mathematics courses compared to engineering and computer science/programming. Slightly more than half of the respondents (51.00%) indicated that their school does not offer engineering courses or projects, which highlights a gap in providing comprehensive STEM education.

Low Awareness of STEM: The overwhelming majority of students are not familiar with the term "STEM" education. This indicates a need for awareness programs to highlight the importance and opportunities within STEM fields.

Moderate Exposure to STEM Subjects: While a significant number of students have some exposure to STEM-related subjects, there is room for improvement. Universities should aim to integrate more STEM-focused courses into their curricula to ensure comprehensive education in these critical areas.

Varied STEM Class Distribution: There is a noticeable variation in the number of classes taken across different STEM categories. More emphasis may be needed on engineering and digital technology courses to balance the exposure across all STEM fields.

Engineering Course Availability: With nearly half of the respondents indicating that their universities do not offer engineering courses or projects, there is a clear opportunity for educational institutions to expand their offerings in this area. Providing more engineering courses could enhance problem-solving skills and better prepare students for careers in STEM.

Overall, the results suggest a need for increased focus on STEM education, both in terms of awareness and curriculum development, to better prepare students for the demands of modern industries and technological advancements.

3.2.2. Business and Industry Partners Involvement in STEM Education

2.5. Are business and industry also included in your STEM education?

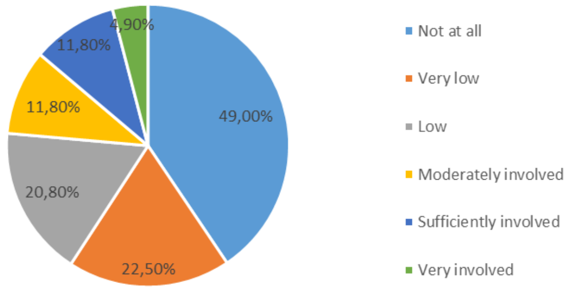


Figure 1.35. Respondents' answers to the question 2.5.

2.6. Do you implement projects assigned by industry partners in your school tasks?

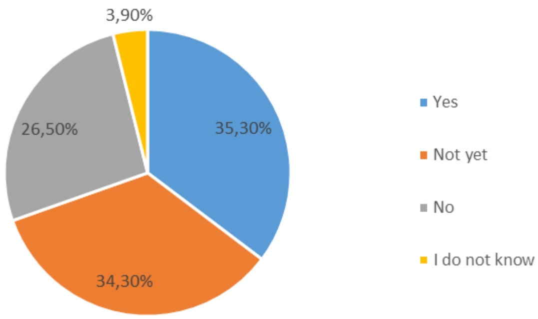


Figure 1.36. Respondents' answers to the question 2.6.

2.7. In your education, do you often deal complex problems that are similar to problems in practice?

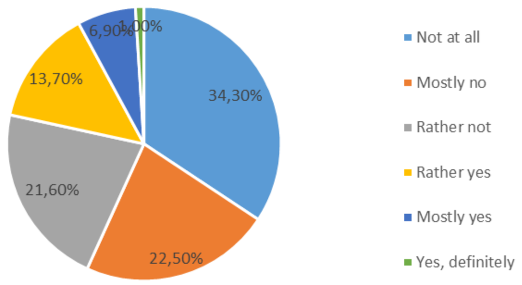


Figure 1.37. Respondents' answers to the question 2.7.

Nearly half of the respondents (49.00%) report that business and industry are not at all involved in their STEM education. When combined with those who report very low (22.50%) and low (20.80%) involvement, it is evident that there is minimal engagement from industry partners in many cases. Only a small fraction (16.70%) feel that industry involvement is moderate to very high. Approximately a third of students (35.30%) have implemented projects assigned by industry partners, while a similar proportion (34.30%) have not yet had the opportunity but may expect to in the future. A notable portion (26.50%) have not engaged in such projects, and a small percentage (3.90%) are unsure about this aspect. A significant number of students (34.30%) indicate that they do not deal with complex, practical problems in their education at all. When combined with those who answered, "mostly no" (22.50%) and "rather not" (21.60%), it shows that over three-quarters of students are not frequently exposed to practical problem-solving scenarios. Only a small minority (21.60%) report that they are rather, mostly, or engaged in dealing with complex problems akin to those encountered in practice.

Low Industry Involvement: The data reveals that business and industry involvement in STEM education is minimal for most students. This suggests a significant opportunity for educational institutions to increase partnerships with industry to enhance the practical aspects of STEM education.

Project Implementation by Industry Partners: While a third of the students have had the opportunity to implement industry-assigned projects, a similar number have not yet, and a quarter have not engaged in such projects at all. Increasing the integration of industry projects into the curriculum could provide valuable hands-on experience and better prepare students for the workforce.

Lack of Practical Problem-Solving Experience: Significant number of students report little to no engagement with complex, real-world problems during their education. This highlights a critical gap in the current educational approach that could be addressed by incorporating more problem-based learning and industry collaboration.

3.2.3. Technology Used Throughout STEM Education

2.8. Do you have classes in the computer classroom?

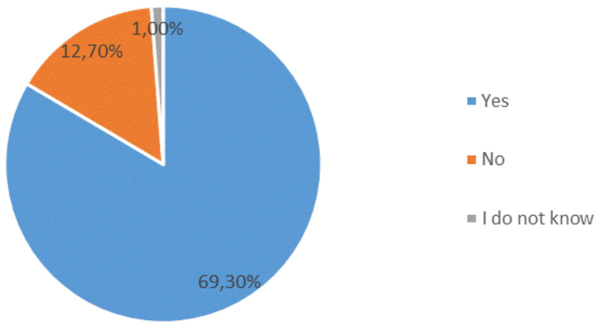


Figure 1.38. Respondents' answers to the question 2.8.

2.9. Do you have classes in specialised laboratories (no computer classroom)?

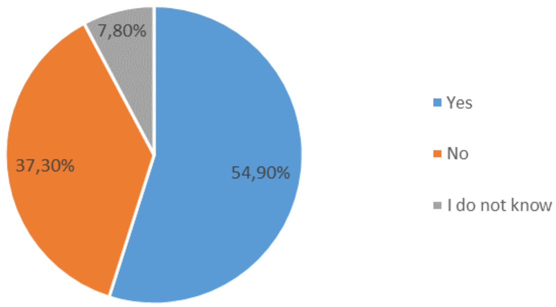


Figure 1.39. Respondents' answers to the question 2.9.

2.10. What percentage of courses/subjects do you use digital technologies (PC, tablet, mobile phone)

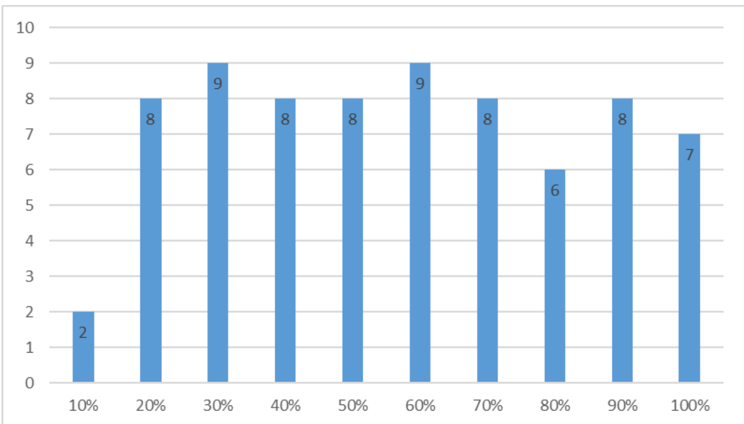


Figure 1.40. Respondents' answers to the question 2.10.

69.30% have classes in computer classrooms, indicating good access to digital tools and resources. However, 12.70% of students do not have this access, and 1.00% are unsure, highlighting some gaps in the provision of technological infrastructure. More than half of the students (54.90%) have access to specialized laboratories, suggesting that practical, hands-on experience is integrated into their education. However, a significant portion (37.30%) do not have access to these facilities, and 7.80% are unsure, indicating room for improvement in providing comprehensive laboratory experiences. The use of digital technologies in courses varies widely among students. The distribution suggests a moderate to high integration of digital tools in education, with most students using digital technologies in 30% to 90% of their courses. A smaller number of students use digital technologies in nearly all (100%) of their courses.

High Access to Computer Classrooms: Most of students have access to computer classrooms, indicating that digital learning environments are well-integrated into their education. However, the small percentage of students without access suggests a need for ensuring that all students benefit from this technology.

Moderate Access to Specialized Laboratories: While over half of the students have access to specialized laboratories, a significant number do not. Increasing access to these facilities could enhance the practical learning experiences of more students.

Variable Integration of Digital Technologies: The use of digital technologies across courses is variable but generally high. Efforts should be made to ensure consistent and effective use of these technologies across all courses to maximize their educational benefits.

3.2.4. Future Vision

2.11. In a future, I plan to continue in STEM education. (Science (any where science is applied – physics, chemistry, meteorology, economy...), Engineering (any with problem solving), Mathematics, Computer Science/Programming, Other Technology.

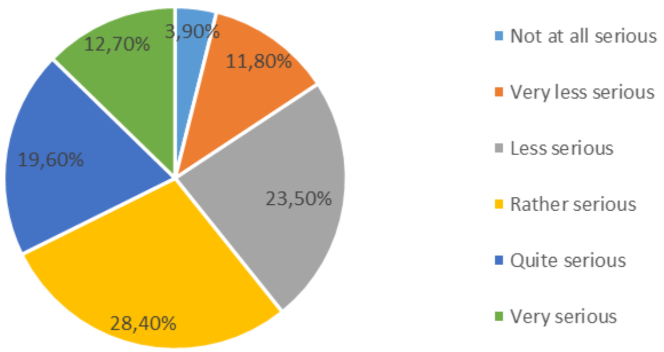


Figure 1.41. Respondents' answers to the question 2.11.

2.12. I see myself in STEM a career (in the future)

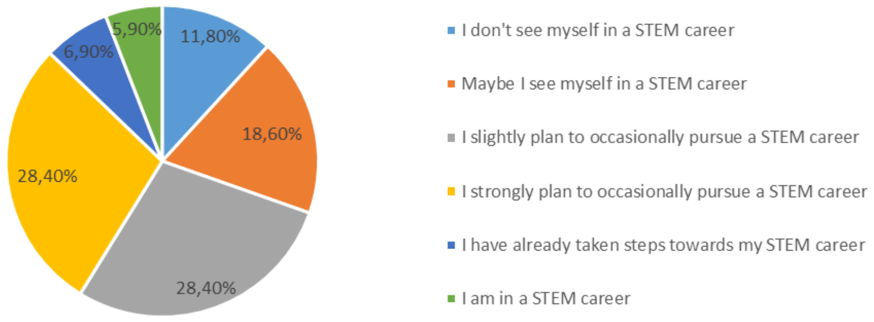


Figure 1.42. Respondents' answers to the question 2.12.

The results show that most students have a serious interest in continuing their education in STEM fields. Specifically, 60.70% of students fall into the categories of "rather serious," "quite serious," and "very serious." A smaller portion of students (39.20%) are less serious about continuing in STEM education. When it comes to pursuing a career in STEM, 56.80% of students show varying degrees of commitment (from slight to strong interest) in occasionally pursuing a STEM career. Additionally, 12.80% have either already taken steps towards or are currently in a STEM career, indicating a proactive approach by a smaller group. Conversely, 30.40% of students are either uncertain or do not see themselves in a STEM career at all.

Strong Interest in Continuing STEM Education: Many students are inclined to continue their education in STEM fields. This indicates a positive outlook towards STEM education among students, with many considering it a serious pursuit for their future studies.

Moderate Commitment to STEM Careers: While a significant number of students are considering or have plans to pursue STEM careers, there is a notable percentage that remains uncertain or uncommitted. This reflects a moderate overall commitment to STEM careers, with some students still in the exploratory phase of their career planning.

3.2.5. Increasing STEM Skills

2.13. I would appreciate more chances to learn STEM.

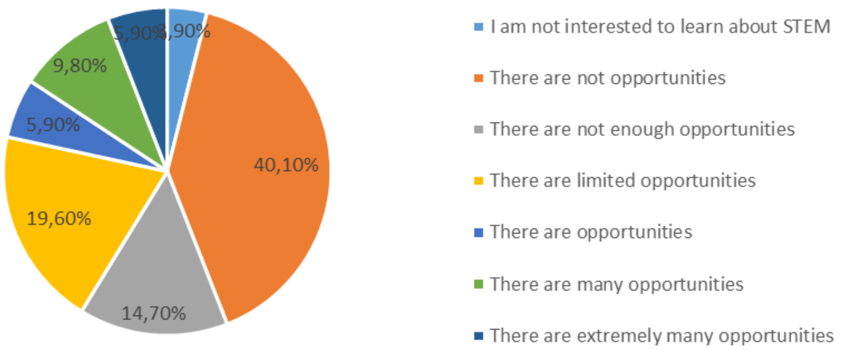


Figure 1.43. Respondents' answers to the question 2.13.

2.14. Rate (evaluate) your skills obtained during your study so far.

A. I can solve some equation and work with variables (in my field of study).
B. I am able to think logically.
C. I can analyze complex problems.
D. I can solve a problem.
E. I can come up with creative idea.
F. I can do the critical analysis.
G. I am open to learn new technologies.
H. I can use digital devices such as computer, tablet, smartphone.
I. I understand basic software applications.
J. I can use and evaluate information from digital sources.
K. I understand the basics of cybersecurity.

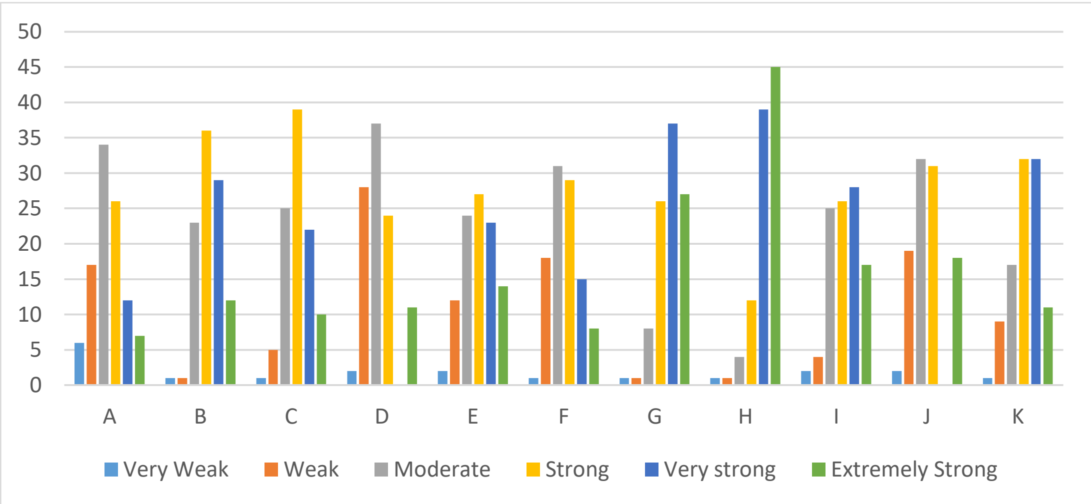


Figure 1.44. Respondents' answers to the question 2.14.

2.15. If you have any other comments, please free to write any comment…… *(This is open question)*

No comments.

A significant portion of students (74.40%) feel there are inadequate or no opportunities to learn STEM, indicating a need for increased availability and accessibility of STEM learning resources and programs. Only a small percentage (21.60%) believe there are sufficient to many opportunities available, highlighting a disparity in perceived access to STEM education.

Need for More STEM Learning Opportunities: A significant number of students feel there are insufficient opportunities to learn STEM. Addressing this gap is crucial for enhancing STEM education and engagement.

Skill Development Varies Widely: Students report a wide range of competency levels in key STEM skills. While many students feel confident in using digital devices and learning new technologies, there are areas like critical analysis and cybersecurity where confidence varies more widely.

Logical and Analytical Skills: Most students rate their logical thinking and ability to analyze complex problems as moderate to strong, indicating these are well-developed areas within the current curriculum.

Room for Improvement in Problem-Solving and Creative Thinking: Although students show a moderate to strong ability in problem-solving and creative idea generation, there is a noticeable number who feel weaker in these areas, suggesting room for improvement.

3.2.6. Conclusion

Universities should actively seek and establish partnerships with businesses and industries to involve them in curriculum development, guest lectures, internships, and collaborative projects. This can provide students with insights into real-world applications of their studies.

Integrating projects assigned by industry partners into the academic curriculum can bridge the gap between theoretical knowledge and practical application. This approach can also help students build networks and gain valuable experience that is directly relevant to their future careers.

Focus on Practical Problem Solving: Educational programs should incorporate more complex, real-world problem-solving tasks into their courses. This can be achieved through case studies, project-based learning, and simulations that mimic industry challenges, thereby better preparing students for practical work environments.

Awareness and Promotion of STEM: Given the low familiarity with STEM education, efforts should be made to promote awareness and understanding of STEM fields, emphasizing their importance and the career opportunities they offer. This can include workshops, seminars, and collaboration with industry professionals to highlight the relevance of STEM in various sectors.

Ensure Universal Access to Technology and Laboratory Access: Higher education institutions should aim to provide universal access to computer classrooms and digital tools. This may involve investing in more computer labs and ensuring that all students are aware of and can use these resources. Increasing the number of specialized laboratories and ensuring all students have opportunities to use these facilities can enhance hands-on learning experiences. Partnerships with industry to provide equipment and resources could be beneficial.

Standardize Digital Technology Use: Standardizing the integration of digital technologies across all courses can help provide a consistent learning experience. Faculty training on the effective use of digital tools and incorporating these technologies into the curriculum can support this goal.

Promote Digital Literacy: Given the high use of digital technologies, promoting digital literacy among students is crucial. Workshops and courses on how to effectively use digital tools for learning and research can be beneficial. By addressing these areas, educational institutions can better align their STEM programs with industry needs, thereby enhancing student readiness for the job market and contributing to the development of a skilled workforce, ensuring that students are well-prepared for the digital demands of the modern workplace.

Higher education institutions should enhance career counseling services to help students navigate their STEM career options. Providing information on various STEM career paths, mentorship opportunities, and industry connections can help students make informed decisions about their future. To increase commitment to STEM careers, it is essential to demonstrate the real-world impact and applications of STEM fields. This can be achieved through guest lectures, industry visits, internships, and showcasing successful STEM professionals and projects. Higher education institutions should encourage students to take early steps towards their STEM careers by offering workshops on resume building, interview preparation, and networking skills. Facilitating internships and cooperative education programs can provide practical experience and a clearer career vision.

For students who are uncertain about their future in STEM, creating exploratory programs or offering courses that combine STEM with other interests might help. Providing platforms for interdisciplinary projects can also illustrate the diverse opportunities within STEM fields. By focusing on these areas, Higher educational institutions can better support students in their STEM education journey and career planning, ultimately fostering a more committed and prepared future STEM workforce.

Integrating STEM with other disciplines can make learning more engaging and show students the diverse applications of STEM skills. Interdisciplinary projects and courses can foster creativity and broader thinking. By implementing these recommendations, educational institutions can better support students in developing strong STEM skills and preparing for future careers in these critical fields.

4. ANALYSIS OF SURVEY RESULTS – UNIVERSUM COLLEGE

4.1. Survey for Teachers

Field of teaching:

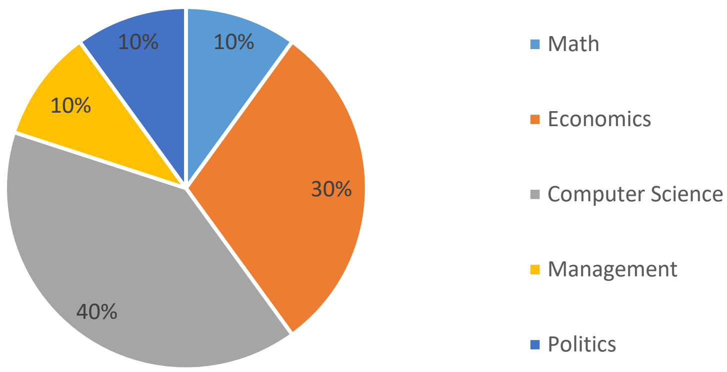


Figure 4.1. Respondents' answers to the question Field of teaching.

Sex:

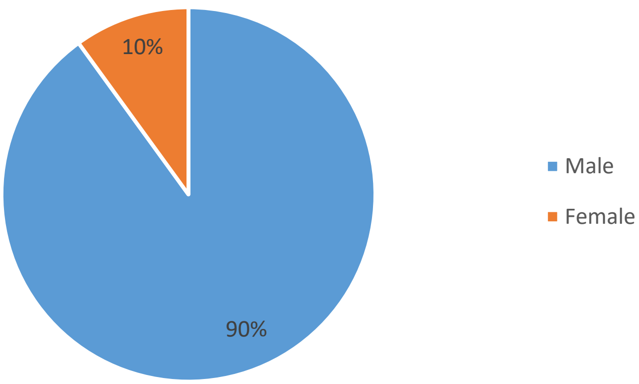


Figure 4.2. Respondents' answers to the question Sex.

Position:

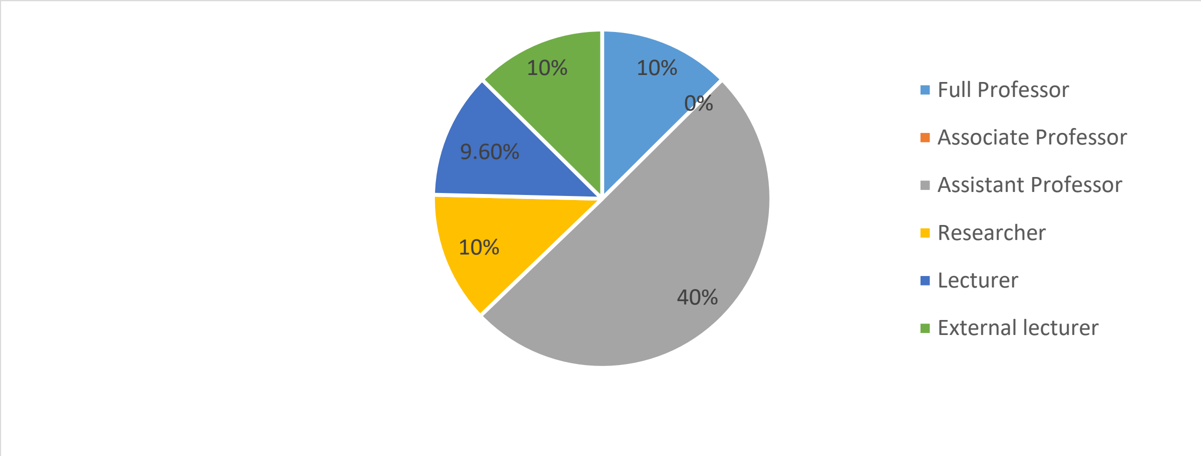


Figure 4.3. Respondents' answers to the question Position.

Teaching experience at university:

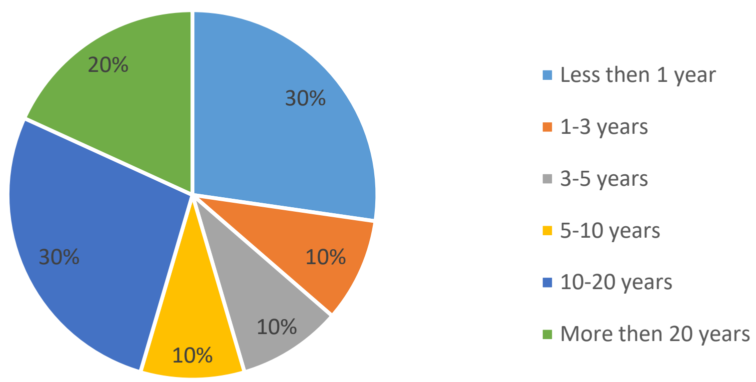


Figure 4.4. Respondents' answers to the question Teaching experience at university.

The staff survey reveals a predominantly STEM-focused faculty, with strong expertise in Computer Science and Economics. Most respondents hold teaching positions, with a significant presence of Assistant Professors and Lecturers. The teaching experience varies, however they all have quite the experience at the college.

4.1.1. STEM Education Integration

1.1. Has the Science, Engineering, Mathematics, Technology education been integrated at your faculty?

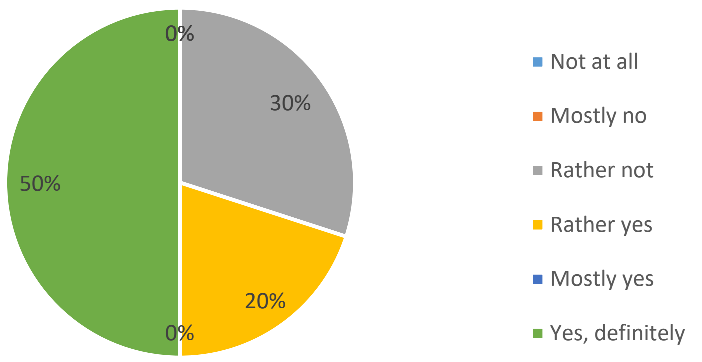


Figure 4.5. Respondents' answers to the question 1.1.

1.2. How much focus does your teaching have on STEM education.

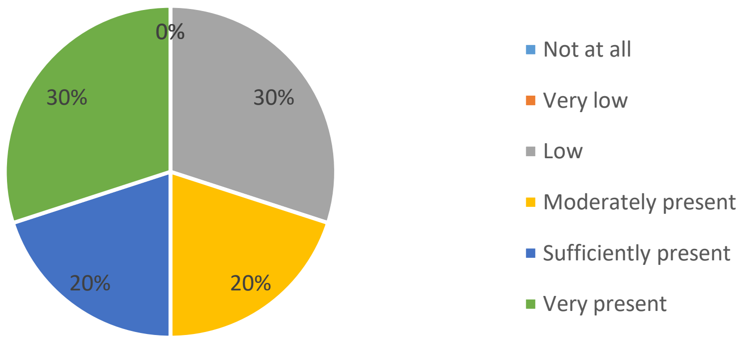


Figure 4.6. Respondents' answers to the question 1.2.

1.3. Do you provide lectures/courses with elements of STEM education? (*answer in percentages from 0-100%, scale 0-5)*

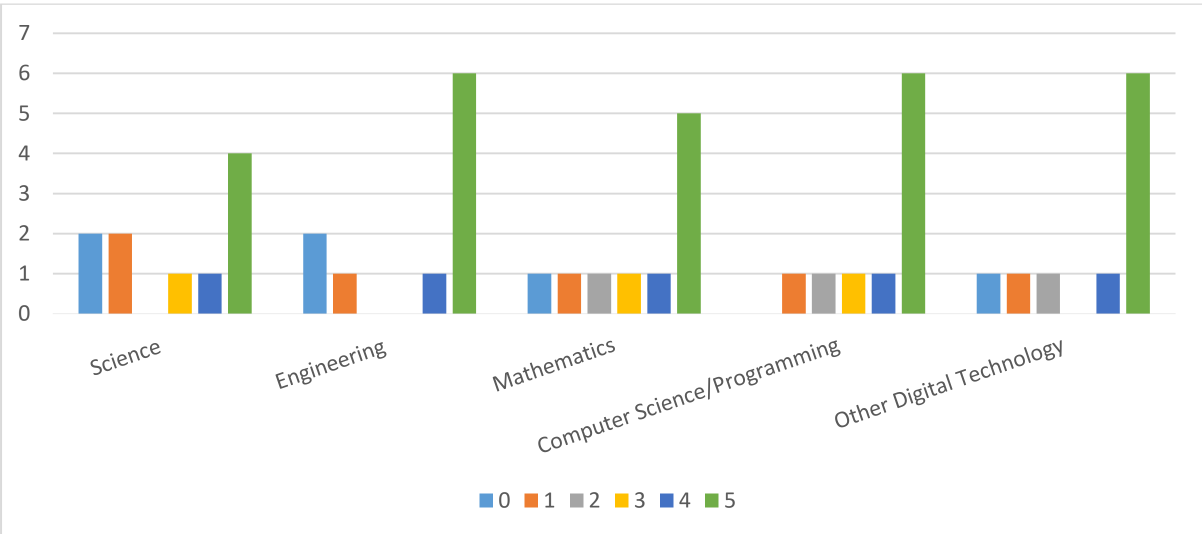


Figure 4.7. Respondents' answers to the question 1.3.

1.4. Is the STEM curriculum at the lectures/courses that you are teaching multidisciplinary and does it include lectures that are integrated (to include science, technology, engineering, and mathematics)?

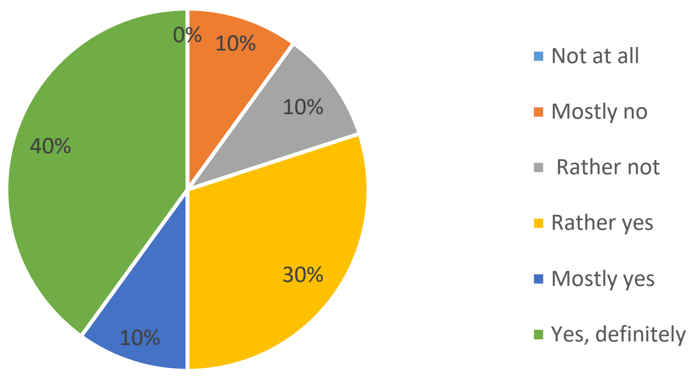


Figure 4.8. Respondents' answers to the question 1.4.

The survey indicates a varied level of integration of STEM education within the faculty. While some respondents acknowledge a strong presence of STEM principles in teaching, others express uncertainty or minimal integration. This suggests a need for greater consistency in incorporating STEM elements across the curriculum. While lectures with STEM components exist, there's room for improvement in ensuring a cohesive and multidisciplinary approach to the STEM curriculum. Professional development and experience in STEM.

4.1.2. Professional Development and Experience in STEM

1.5. Which pedagogical approaches do you use in your STEM teaching?

A. Traditional teaching where the teacher gives information, and students learn from it. Traditional direct instruction (lessons are focused on the delivery of content by the teacher and the acquisition of content knowledge by the students).
B. Teaching with experiments (experiments are used in the classroom to explain the subject matter).
C. Project-/Problem-based approach (students are engaged in learning through the investigation of real-world challenges and problems).
D. Inquiry-Based Science Education (students design and conduct their own scientific investigations).
E. Collaborative learning (students are involved in joint intellectual efforts with their peers or with their teachers and peers).

F. Formative assessment, including self-assessment (student learning is constantly monitored and ongoing feedback is provided; students are provided with opportunities to reflect on their own learning).
G. Others……………….*(This is open question)*.

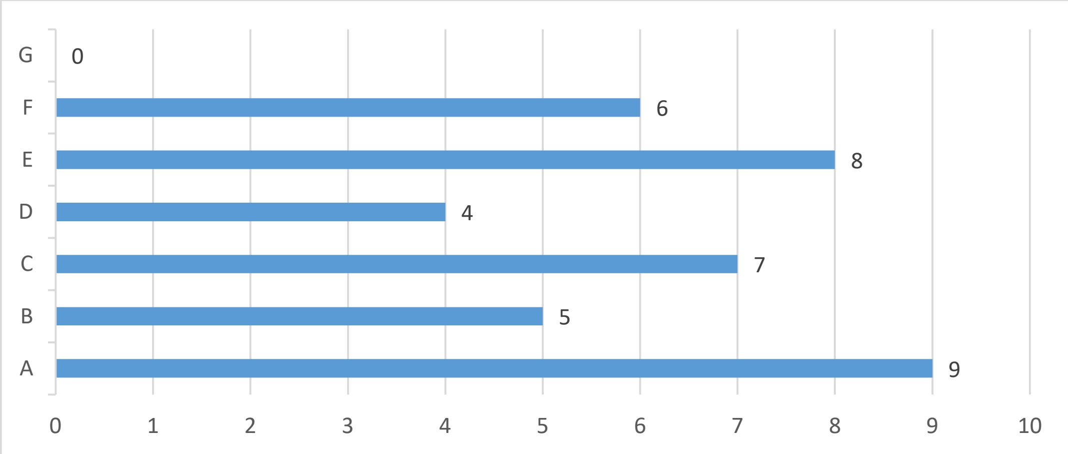


Figure 4.9. Respondents' answers to the question 1.5.

1.6. Please evaluate the STEM implementation in your teaching.

A. I use the STEM approach in teaching.
B. I frequently integrate science, technology, engineering, and mathematics within one curriculum.
C. My STEM approach motivates student for more active learning.
D. STEM approach is for me crucial for preparing students for real challenges in their future careers.
E. I regularly adapt the STEM education system based on the number of students and their knowledge.
F. Preparing for education using STEM methodology is time-consuming for me.
G. I regularly educate myself and explore new possibilities in STEM education methodology.

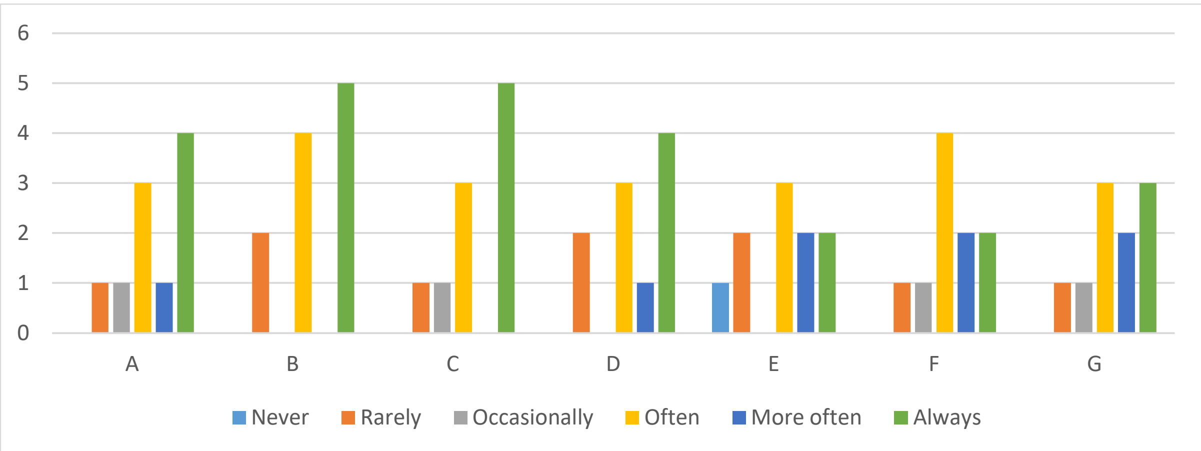


Figure 4.10. Respondents' answers to the question 1.6.

1.7. How would you rate your ability to follow and implement current trends in the STEM (e.g. ICT, team works, project based learning, e.t.c.)?

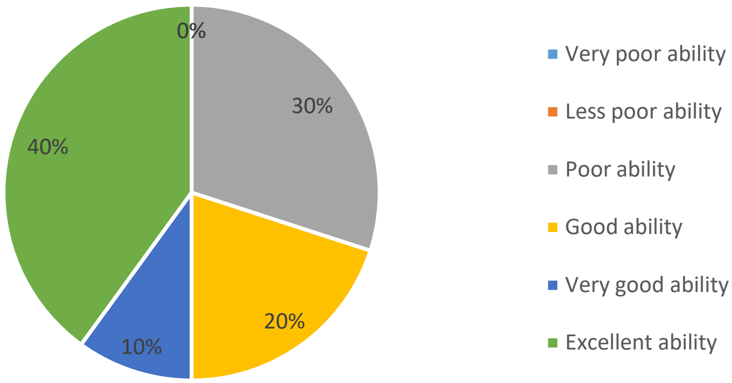


Figure 4.11. Respondents' answers to the question 1.7.

1.8. Would you consider additional training or professional development to better incorporate current STEM trends into your teaching?

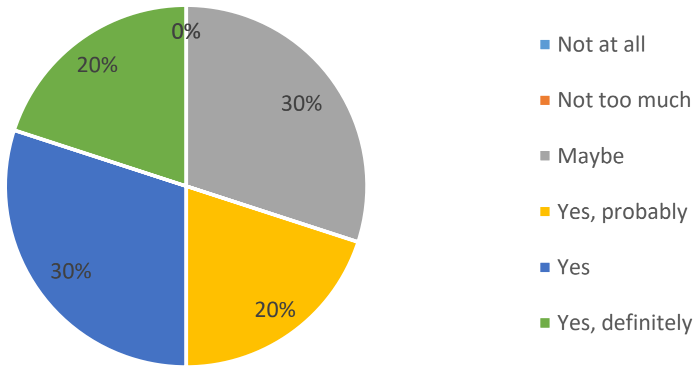


Figure 4.12. Respondents' answers to the question 1.8.

The survey reveals a range of pedagogical methods in STEM teaching, from traditional to innovative approaches like experiments, projects, and collaborative learning. Respondents emphasize the importance of integrating science, technology, engineering, and mathematics, recognizing its role in fostering active learning and preparing students for real-world challenges. While some find STEM methodology time-consuming, many express a readiness to adapt and explore new strategies through additional training or professional development.

4.1.3. Institutional Support (University, Business and Industry Sector - Partners)

1.9. Are business and industry also included in STEM education at your university related to your courses/subjects?

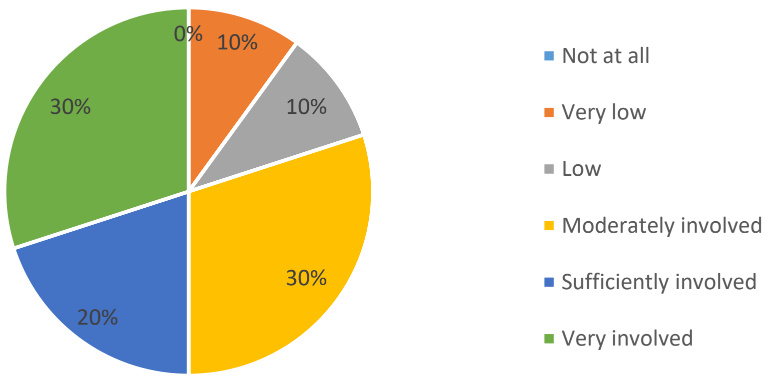


Figure 4.13. Respondents' answers to the question 1.9.

1.10. Please rate university – industry cooperation in STEM education in your teaching.

A. Facilitating company visits.
B. Having STEM professionals at universities (consultations, lectures…).
C. Student Training.
D. Assigning tasks by business/industry sector.
E. Solving tasks for business/industry sector.
F. Financial support.
G. Other…..(*This is open question*).

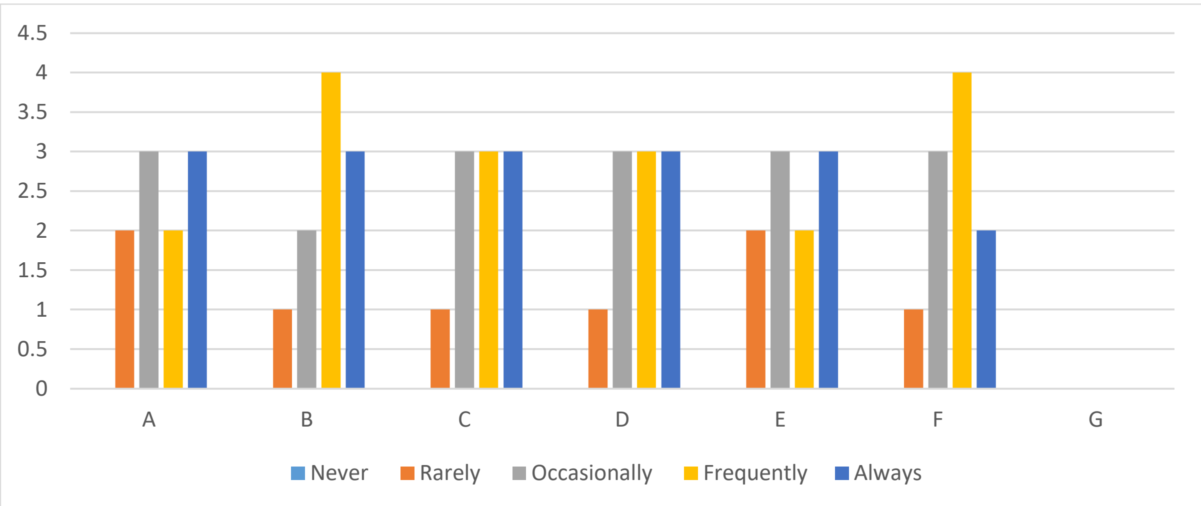


Figure 4.14. Respondents' answers to the question 1.10.

1.10.1. Do you have other types of university-industrial cooperation? *(This is open question)*

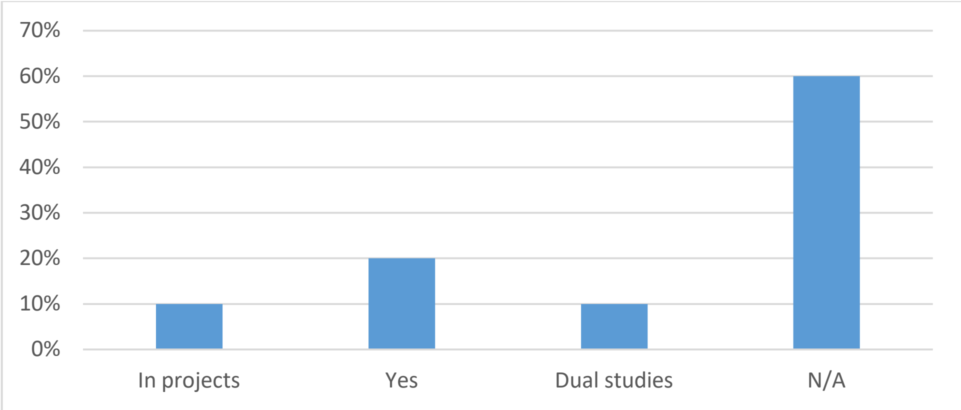


Figure 4.15. Respondents' answers to the question 1.10.1.

1.11. Would you support initiatives that facilitate between industry and universities?

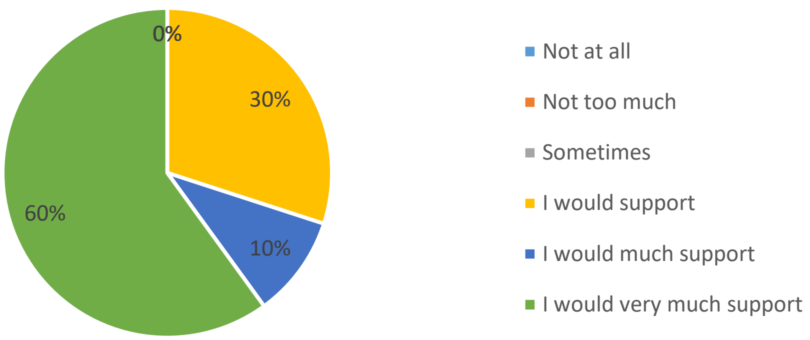


Figure 4.16. Respondents' answers to the question 1.11.

1.12. Do you think that the current support for STEM education from the university is sufficient?

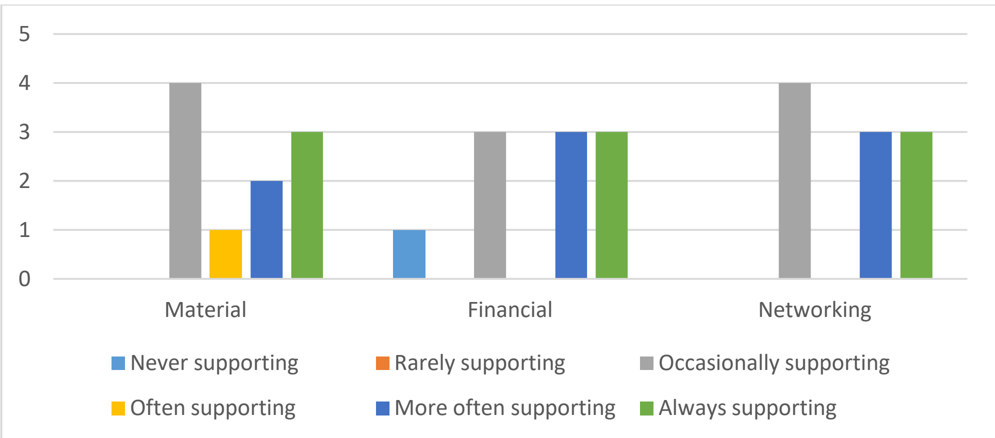


Figure 4.17. Respondents' answers to the question 1.12.

The survey gauges the extent of business and industry involvement in STEM education, with responses ranging from low to very involved. Respondents assess university-industry cooperation across various aspects such as company visits, STEM professional presence, student training, task assignments, problem-solving for industry, and financial support. While alternative forms of cooperation, like projects and dual studies, are reported, a majority of respondents express strong support for initiatives facilitating collaboration between industry and universities. However, some perceive current support for STEM education from the university as insufficient, particularly in terms of material, financial, and networking support.

4.1.4. Material Support (Financial and Non-Financial)

1.13. How would you rate the current availability of literature and materials to support teaching STEM in your subject.

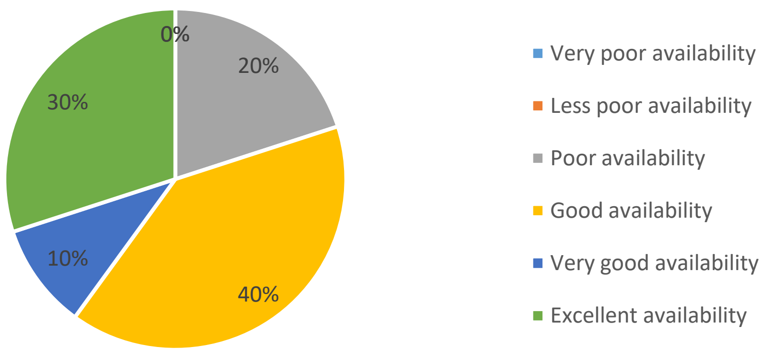


Figure 4.18. Respondents' answers to the question 1.13.

1.14. Do you think the current availability of literature limits the quality of your STEM teaching?

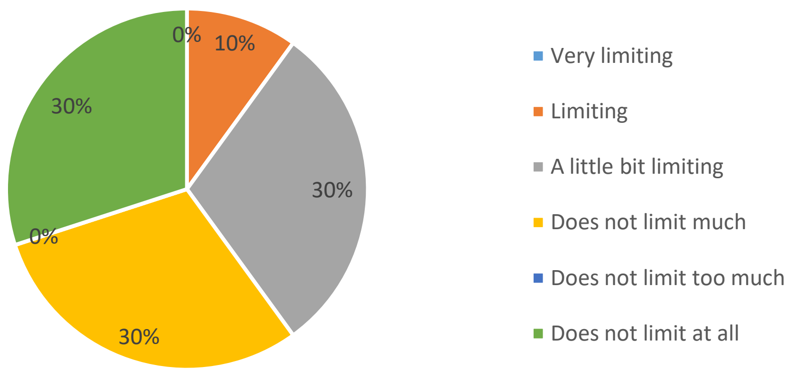


Figure 4.19. Respondents' answers to the question 1.14.

1.15. Are the STEM laboratories at your faculty available for your teaching purposes?

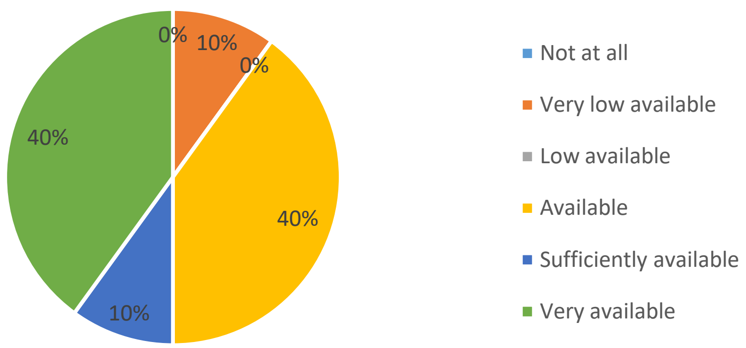


Figure 4.20. Respondents' answers to the question 1.15.

1.16. Do you have sufficient technological support, when implementing STEM education to your subjects?

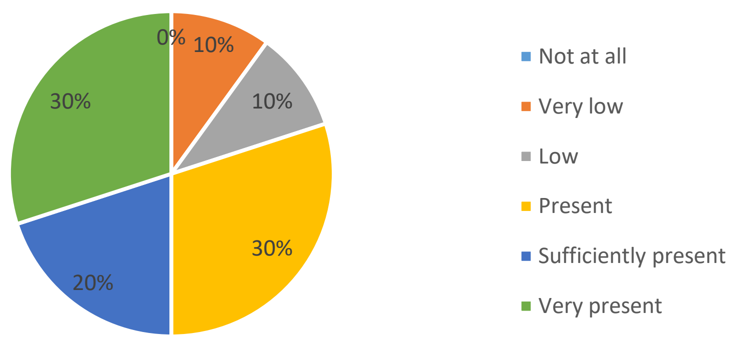


Figure 4.21. Respondents' answers to the question 1.16.

1.17. Do you think the current availability of technological equipment limits the quality of your STEM teaching?

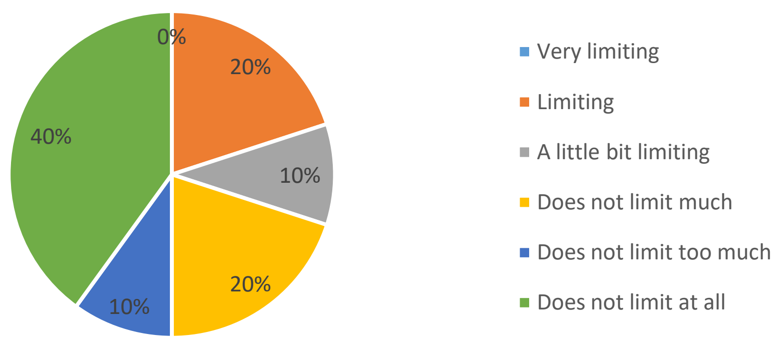


Figure 4.22. Respondents' answers to the question 1.17.

1.18. Is there any non-financial equipment you are missing, that would be helpful for your STEM education?

- No: 7
- More access to recent literature: 1
- Professional applications, tools, technological tools: 1

1.19. What teaching resources do you use when implementing STEM education?

A. Presentations.
B. Office tools (word, excel, notepad…).
C. Software.
D. Programming tools (not only PC programming, machine programming…).
E. Applications.
F. STEM-specific software.
G. Audio/video materials.
H. Robots.
I. General digital devices (e.g. laptops, smartphones, tablets, cameras, video game consoles).
J. Online resources (websites, dictionaries, encyclopedias, etc.).
K. Manipulation in an experimental lab.
L. Online collaborative tools (Padlet, Centimetre, Tricorder, Kahoot…).
M. Resources published by private companies operating in STEM fields.
N. Others……. *(This is open question)*.

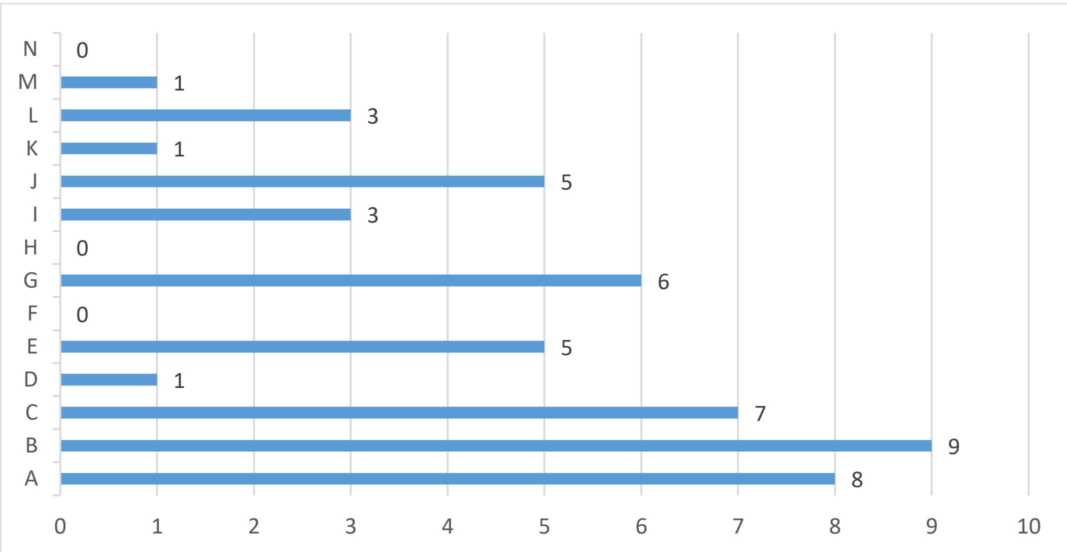


Figure 4.23. Respondents' answers to the question 1.19.

Respondents evaluate the availability of literature and materials to support STEM teaching, with a majority rating it as good to excellent. However, concerns arise regarding the potential limitation of teaching quality due to the current availability of literature, with a notable proportion perceiving some level of limitation. In terms of STEM laboratories, availability varies, with a significant portion indicating sufficient to very available resources. Regarding technological support, respondents report a range of availability, with some perceiving limitations that could affect teaching quality. While some express the need for additional non-financial equipment, most utilize a diverse array of teaching resources, including presentations, office tools, software, and online resources, highlighting a multifaceted approach to STEM education implementation.

4.1.5. Student Achievement

1.20. How well do students achieve good results in combined STEM subjects?

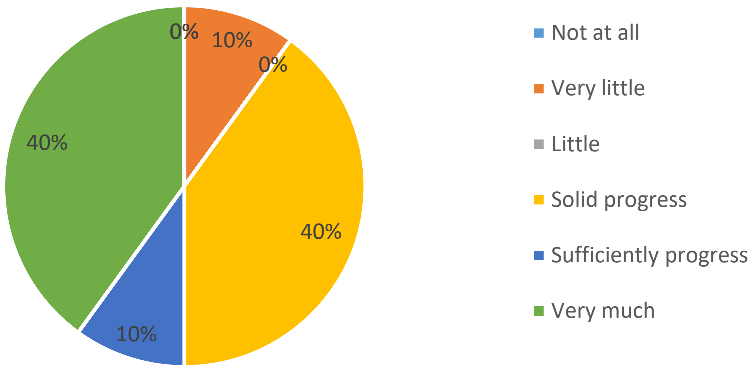


Figure 4.24. Respondents' answers to the question 1.20.

1.21. Is the teaching more difficult for students when using STEM? (Based on student feedback)

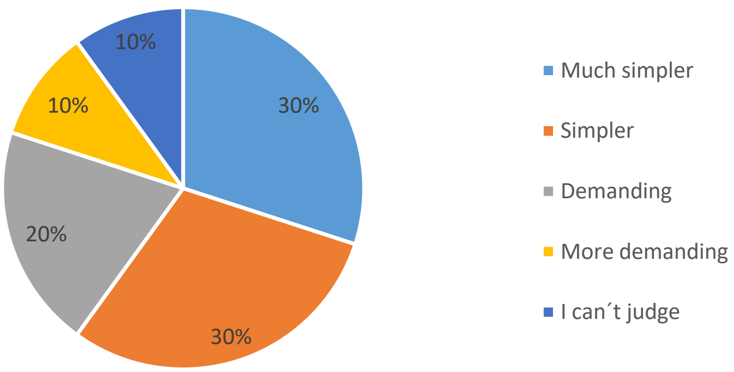


Figure 4.25. Respondents' answers to the question 1.21.

1.22. If you have any other comments, please free to write any comment…… *(This is open question)*

No comments.

Respondents assess student achievement in combined STEM subjects, with a significant portion indicating solid progress or very much achievement. However, a minority perceive little to no achievement. Regarding the difficulty of teaching STEM, opinions vary, with some finding it simpler or much simpler, while others perceive it as demanding or more demanding. A small proportion are unable to judge. These responses highlight the complexity of gauging student performance in STEM subjects and the varied experiences of educators in teaching these disciplines.

4.2. Survey for Students

Field of studies:

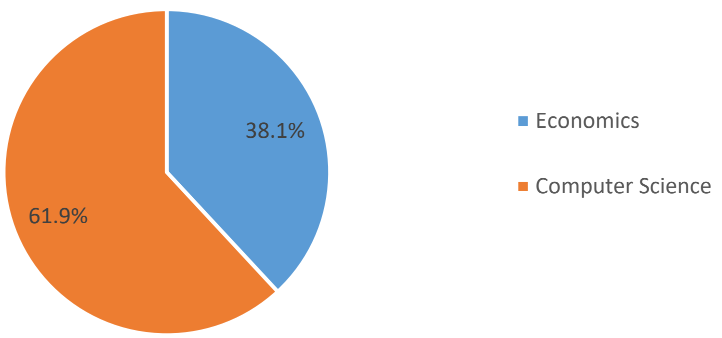


Figure 4.26. Respondents' answers to the question Field of studies.

Type of studies:

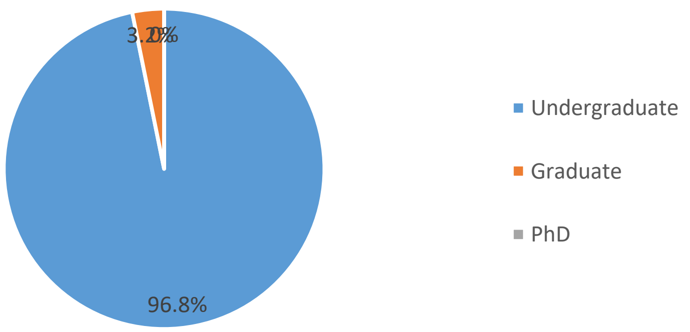


Figure 4.27. Respondents' answers to the question Type of studies.

Finished number of semesters:

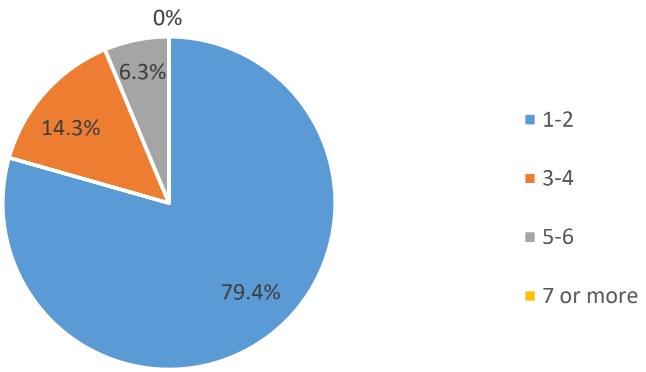


Figure 4.28. Respondents' answers to the question Finished number of semesters.

Sex:

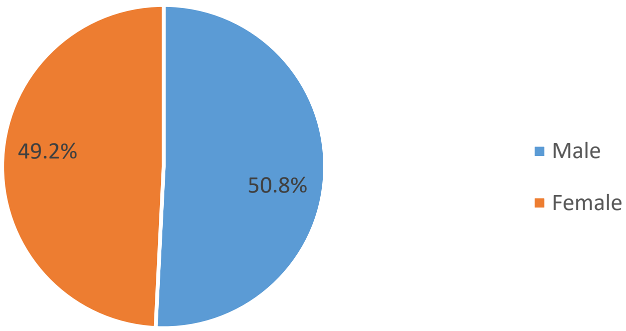


Figure 4.29. Respondents' answers to the question Sex.

Age:

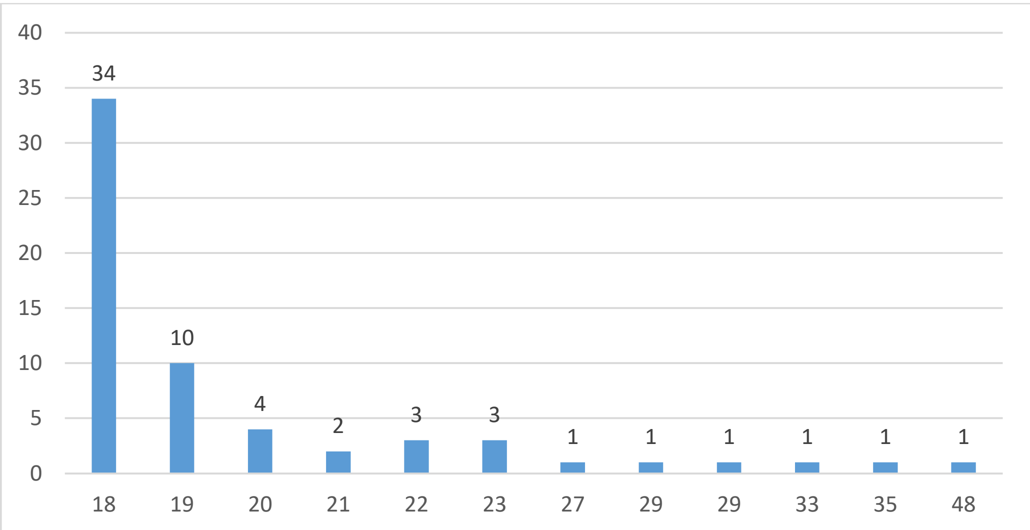


Figure 4.30. Respondents' answers to the question Age.

From this questionnaire we can see that there were 63 respondents from the department of Economics and Computer Science. They are mainly undergraduate and young in age. Most of them are males and most of them have finished 1 to 2 semesters.

4.2.1. Familiarity with the Term STEM

2.1. Are you familiar with the term “STEM“ education?

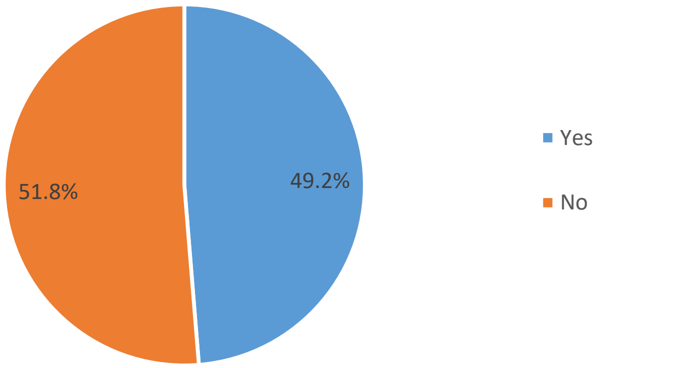


Figure 4.31. Respondents' answers to the question 2.1.

2.2. How many subjects focused on a combination of math, problem solving, technology and science did you have in your studies so far?

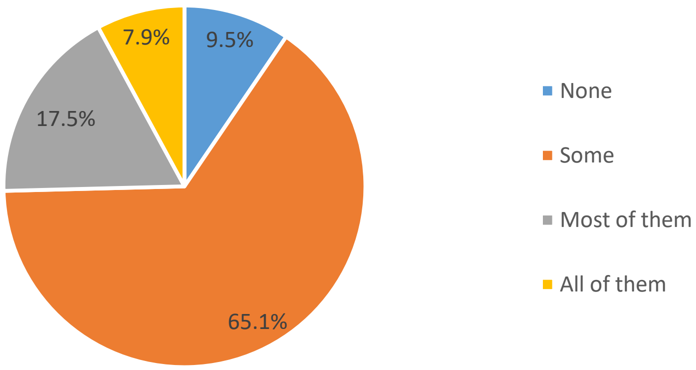


Figure 4.32. Respondents' answers to the question 2.2.

2.3. How many classes (subjects/courses) have you taken in each of these categories so far? (Fill in the ratio of courses for each category).

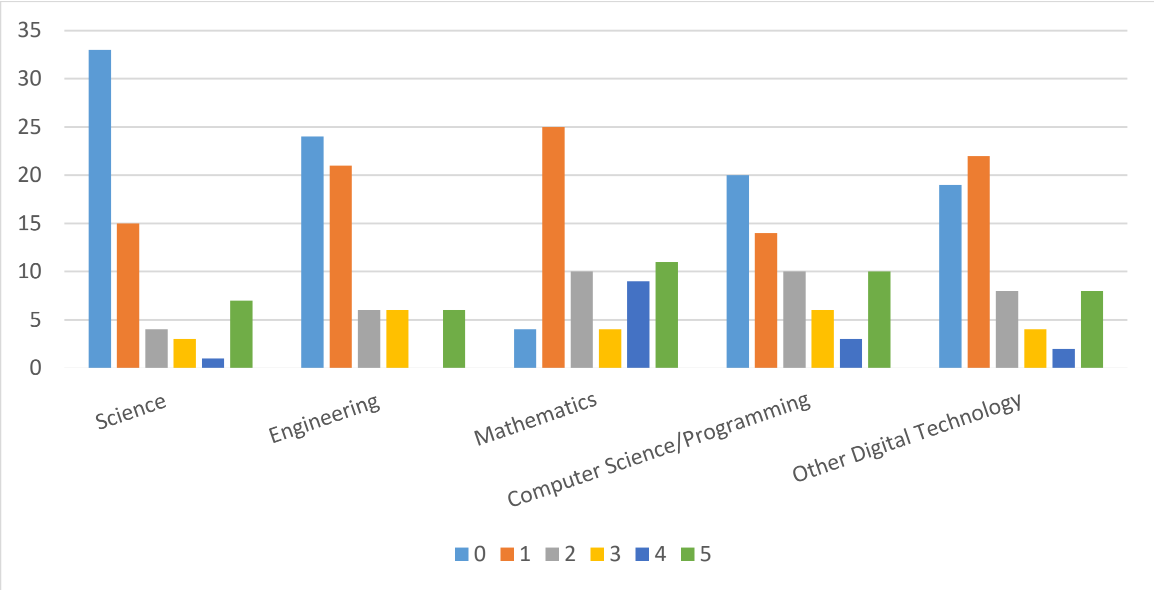


Figure 4.33. Respondents' answers to the question 2.3.

2.4. Does your school offer engineering courses or projects? Engineering (any with problem solving)

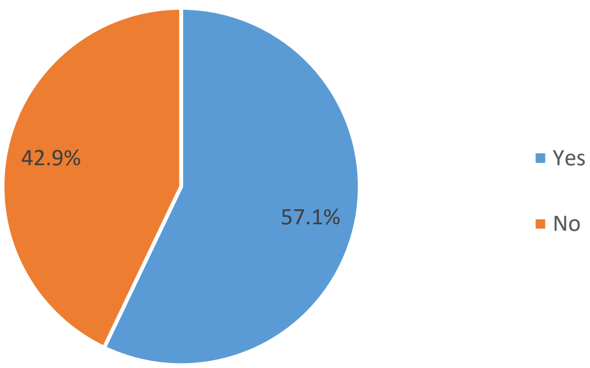


Figure 4.34. Respondents' answers to the question 2.4.

The majority of the respondents are not familiar with the term STEM education, however most of them say that some of the subjects they follow include STEM. All of them say that they have taken classes in STEM categories and most of them believe that the university offers engineering courses or projects.

4.2.2. Business and Industry Partners Involvement in STEM Education

2.5. Are business and industry also included in your STEM education?

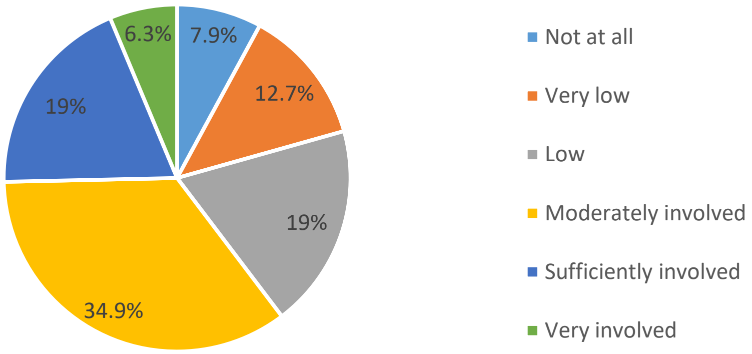


Figure 4.35. Respondents' answers to the question 2.5.

2.6. Do you implement projects assigned by industry partners in your school tasks?

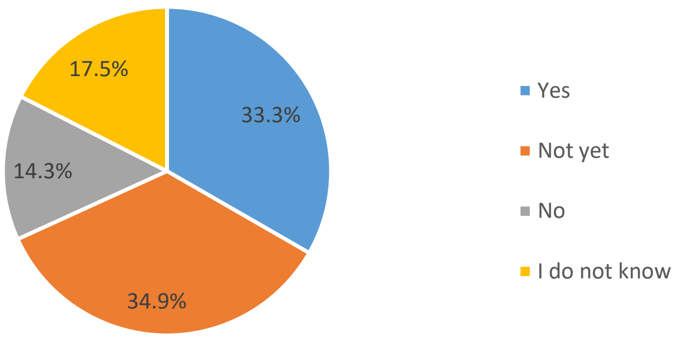


Figure 4.36. Respondents' answers to the question 2.6.

2.7. In your education, do you often deal complex problems that are similar to problems in practice?

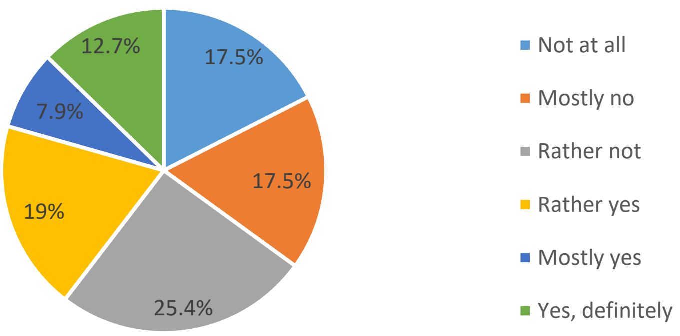


Figure 4.37. Respondents' answers to the question 2.7.

34.90% of respondents believe that businesses and industry are moderately involved in their STEM education. However, most of them do not think that they implement projects assigned by industry partners yet. And most of them say that they don't deal with problems that are similar to problems in practice.

4.2.3. Technology Used Throughout STEM Education

2.8. Do you have classes in the computer classroom?

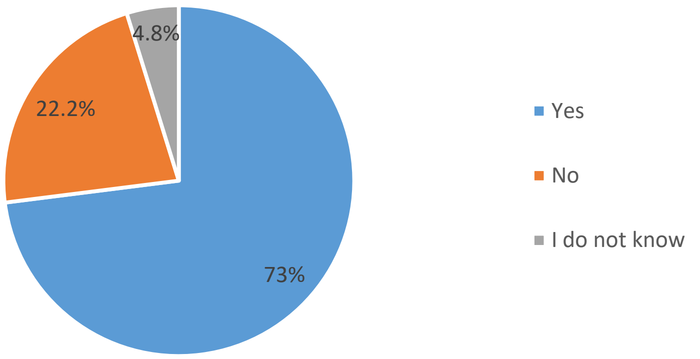


Figure 4.38. Respondents' answers to the question 2.8.

2.9. Do you have classes in specialised laboratories (no computer classroom)?

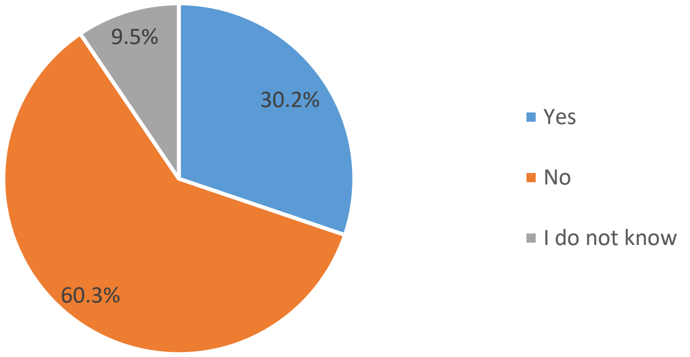


Figure 4.39. Respondents' answers to the question 2.9.

2.10. What percentage of courses/subjects do you use digital technologies (PC, tablet, mobile phone)

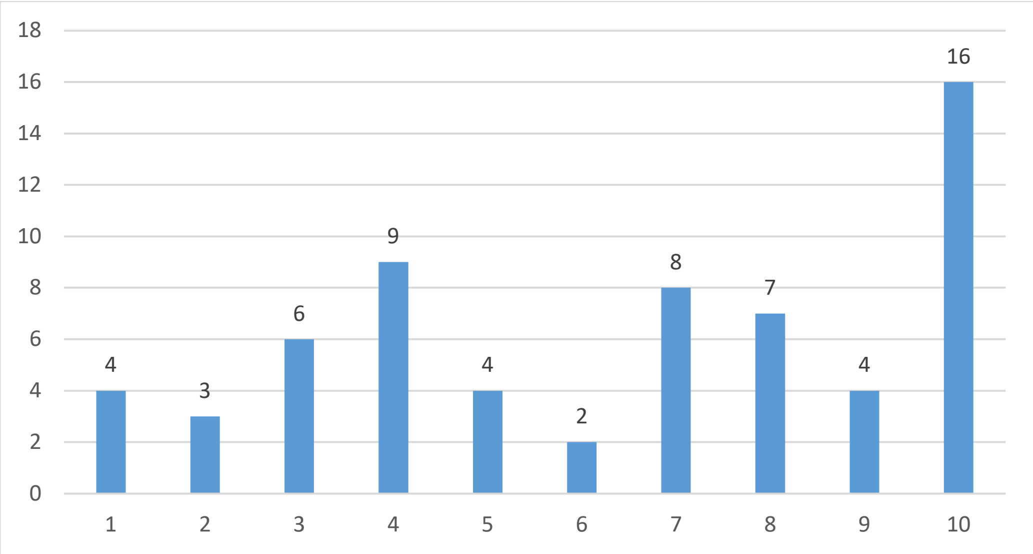


Figure 4.40. Respondents' answers to the question 2.10.

The majority of students say that they have classes in computer classroom, but they say that they don't have classes in specialized laboratories. Regarding the courses in which they use digital technology is somewhere in the middle, some use and some don't..

4.2.4. Future Vision

2.11. In a future, I plan to continue in STEM education. Science (any where science is applied – physics, chemistry, meteorology, economy...), Engineering (any with problem solving), Mathematics, Computer Science/Programming, Other Technology.

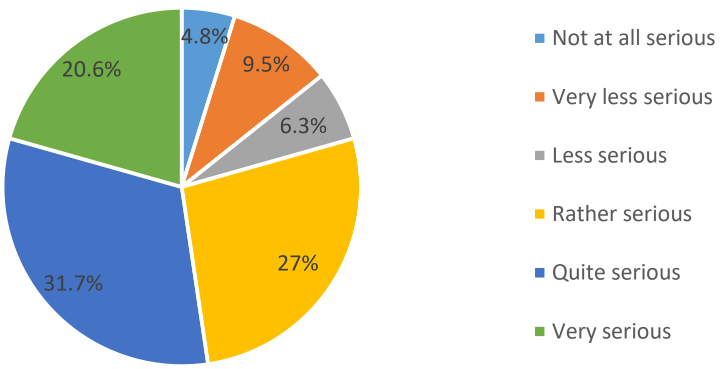


Figure 4.41. Respondents' answers to the question 2.11.

2.12. I see myself in STEM a career (in the future)

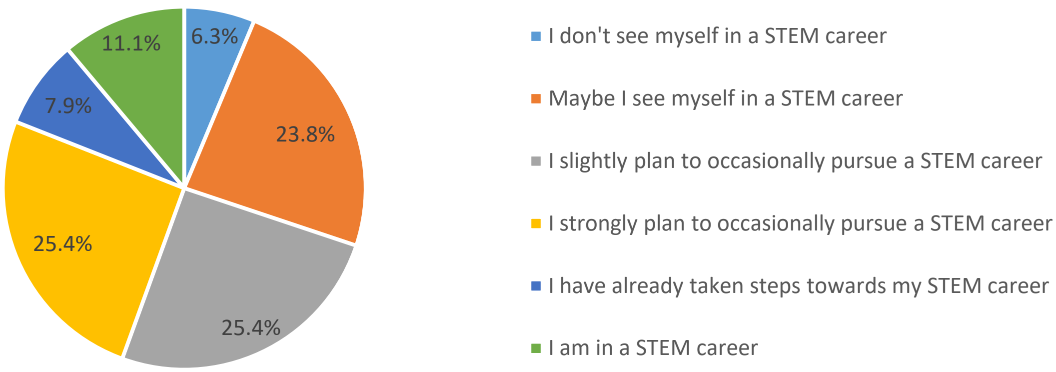


Figure 4.42. Respondents' answers to the question 2.12.

Regarding the future vision we can say that most of the respondents see themselves in a STEM career and are serious about pursuing that path.

4.2.5. Increasing STEM Skills

2.13. I would appreciate more chances to learn STEM.

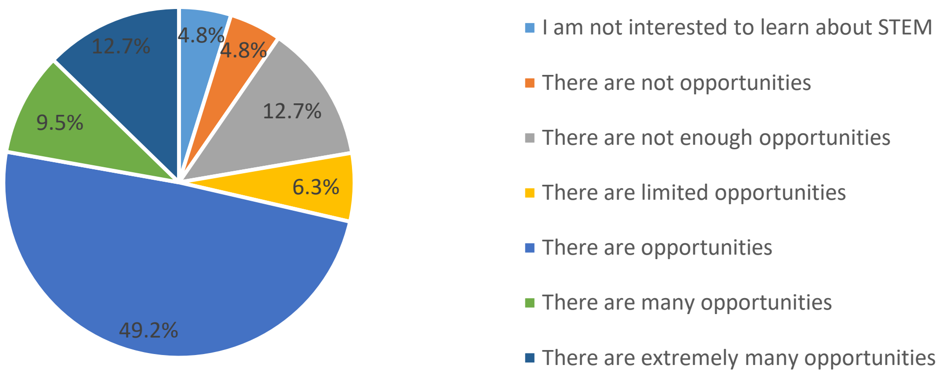


Figure 4.43. Respondents' answers to the question 2.13.

2.14. Rate (evaluate) your skills obtained during your study so far.

A. I can solve some equation and work with variables (in my field of study).
B. I am able to think logically.
C. I can analyze complex problems.
D. I can solve a problem.
E. I can come up with creative idea.
F. I can do the critical analysis.
G. I am open to learn new technologies.

H. I can use digital devices such as computer, tablet, smartphone.
I. I understand basic software applications.
J. I can use and evaluate information from digital sources.
K. I understand the basics of cybersecurity.

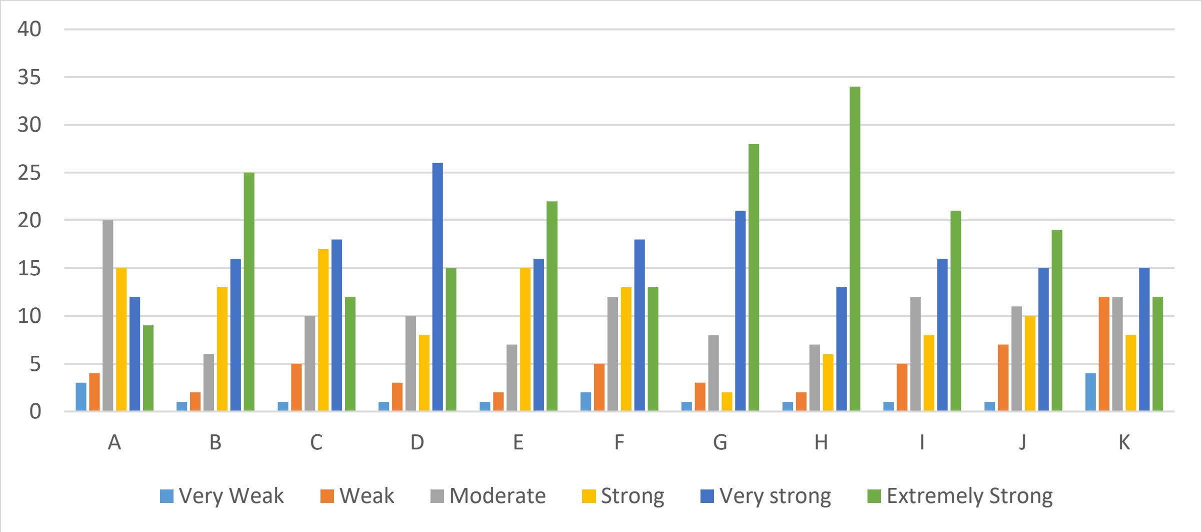


Figure 4.44. Respondents' answers to the question 2.14.

2.15. If you have any other comments, please free to write any comment…… *(This is open question)*

No comments.

Most of the respondents are open to learn more about STEM and are skilled in logical thinking using digital devices, solving problems etc.

5. MULTIMEDIA MULTIFUNCTIONAL ROOMS AT THE FACULTY OF TECHNICAL SCIENCES

5.1. Introduction

In modern education, the concept of smart classrooms represents a revolution that has transformed the way students learn and teachers teach, and it has shown a particular advantage in the time of Covid-19. Smart classrooms use advanced technology to create an interactive, efficient and accessible educational environment. These classrooms are equipped with a variety of technological equipment, including interactive whiteboards, smart audio/video devices, audio-visual systems and e-learning software.

E-learning, as part of the broader concept of smart classrooms, allows students to access educational materials via the Internet, thus facilitating distance learning and more flexible schedules. This approach not only increases the accessibility of education but also improves the quality of the educational experience through the use of multimedia content and interactive teaching methods.

In order to enable multimedia learning, i.e. audio-visual systems, some software solutions and terms for that should be considered:

- LMS (Learning Management Systems): These platforms enable the management and distribution of educational content, monitoring of student progress and communication between students and teachers, assessment, application of exams, quizzes, etc. Examples of popular LMS platforms are Moodle, Blackboard, Canvas, etc.
- Collaboration applications: Software such as Microsoft Teams, Zoom, and Google Classroom enable virtual meetings, screen sharing, and interactive sessions. These applications are particularly useful for distance learning and collaborative learning. It is very important to integrate these applications into the LMS where Video and Audio Conferencing can be used to enable high-quality video and audio calls with a large number of participants, screen sharing where teachers can share their screen to show presentations, documents and other materials. It is also very important to record sessions, where for example Zoom allows you to record sessions that students can review later.

- Presentation software: Tools like PowerPoint, Prezi and Canva are used to create visually appealing and educational presentations that help in better knowledge transfer.

Integrating various software tools in smart classrooms can significantly improve the learning experience. For example, Moodle can be integrated with Zoom to enable virtual classrooms within the LMS platform. Students can access Zoom sessions directly from the Moodle course, facilitating organization and access to learning.

OBS (Open Broadcaster Software) can be used to record and stream Zoom lectures, providing a high-quality recording that students can review later. The combination of these tools provides a comprehensive solution for educational content management, communication and collaboration.

In addition to software, great attention is also paid to hardware, i.e. the technological infrastructure of smart classrooms, which includes a wide range of devices and systems:

- Interactive whiteboards and displays: Enable teachers and students to interactively interact with content, draw, write and manipulate information on the screen in real time. Monitoring is important because it is necessary to ensure that the teacher always has a view of the presentation or multimedia content, but also that the students can have a view of what the teacher is teaching.
- Cameras and microphones: Key to recording and broadcasting live classes, these components enable high-quality audio and video monitoring of lectures. High-resolution cameras and noise-reduction microphones significantly enhance the learning experience. Camera automation plays a key role where it is possible to follow a student while asking a question, a teacher while moving around the classroom, while writing on the board, etc., while microphones using beamfoabing technology help the camera know where to frame itself. Also, the microphones ensure that the online side always has a good sound in order to monitor the teaching and to record the material itself. Different types of microphones, such as condenser, dynamic, gooseneck, boundary and ceiling microphones, are used for different purposes depending on the size and acoustics of the room. For example, gooseneck microphones are suitable for larger rooms and meetings with more participants, while boundary microphones are ideal for smaller rooms where greater sound sensitivity is required.
- The speakers are selected in accordance with the needs of the space and the requirements for sound quality. Directional speakers help minimize sound reaching the microphone, reducing the possibility of feedback and echo.
- Sensors and smart devices: Used to automate and control the classroom environment, such as lighting, air conditioning and security systems. Smart sensors

can detect the presence of people and automatically adjust room conditions, such as lighting, air conditioning, alarms, etc.

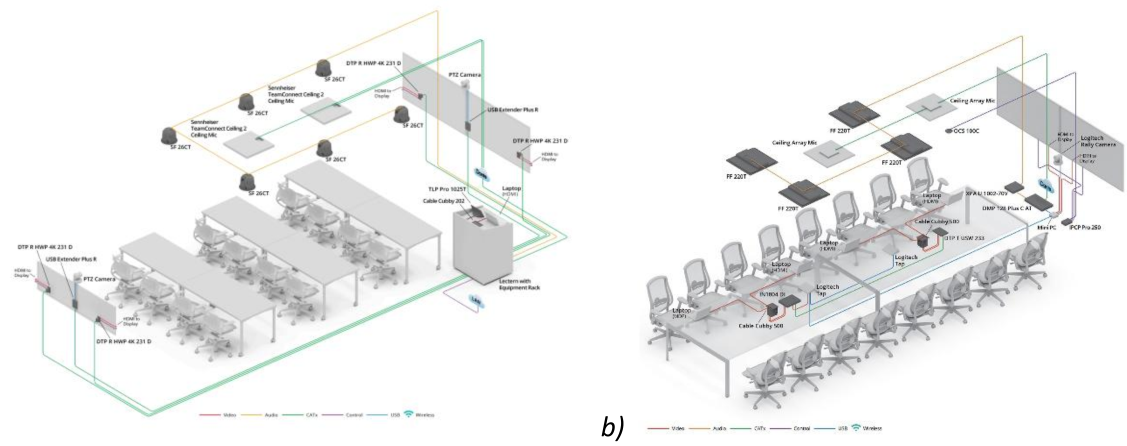
Multimedia smart rooms represent a breakthrough in the evolution of educational and conference spaces. These rooms combine the latest technologies for the transmission of audio and video signals, which enables high quality communication and interactivity.

Audio signal transmission technology is essential for the quality of communication in smart classrooms. Digital signal processors (DSPs) play a crucial role in sound processing, including amplification, equalization, echo cancellation, and noise reduction. DSP processors allow you to tailor the sound to the specific needs of the space, ensuring clear, clear sound without distortion.

Video signal transmission technology is just as important as audio signal transmission technology. HDMI (High-Definition Multimedia Interface) allows the transmission of high-resolution audio and video signals, but is limited by a maximum cable length of 10 meters. For longer distances, it is recommended to use fiber optic cables.

SDI (Serial Digital Interface) is a highly reliable technology that enables transmission over longer distances, over 100 meters, with low latency, which is ideal for professional applications. The SDI can carry up to 16 audio channels, making it suitable for complex audio-visual installations.

NDI (Network Device Interface) is a flexible and easy-to-install technology that enables the transmission of video signals over the network with minimal latency. NDI enables the distribution of video content over a standard Ethernet network, which reduces installation costs and increases system flexibility.



a) b)

Figure 5.1. Example of using SDI, HDMI and NDI for automated multimedia classrooms.

Figure 5.1 shows examples using SDI, HDMI or NDI technology for automated multimedia classrooms and conference rooms. Such examples were the motivation to configure and design a system at the Faculty of Technical Sciences. The challenge during the design was that it was necessary to make 3 separate systems, but when the walls were opened, one system was obtained. Also, it was necessary to combine technologies and program the system in the way that was required before designing.

5.2. Smart Classrooms: Application, Advantages and Disadvantages

Smart classrooms represent an innovative approach to education, integrating advanced technologies to create a richer, more interactive, and more effective learning environment. The introduction of smart classrooms has significantly changed the way teachers teach and students learn, providing them with the tools to educate better and more effectively, especially for generations such as Generation Z.

Smart classrooms are used in a variety of educational settings, including primary and secondary schools, colleges and universities, as well as in corporate education. Their application can be very wide, including the following:

- Interactive Teaching: Smart classrooms enable interactive teaching through the use of interactive whiteboards, projectors, and multimedia content. Teachers can use digital tools to create presentations, animations and videos that enrich the teaching process.
- Recording lectures: Lectures can be recorded in high resolution, allowing students to review the material later, review the material, and better understand complex concepts.
- Live Streaming: Classes can be live-streamed, allowing students who are not physically present to follow the lectures in real-time. This is especially useful for distance students or those who are unable to attend classes due to other commitments.
- Collaborative learning: Smart classrooms support collaborative learning through the use of software tools that enable group work, discussions, and resource sharing.

5.2.1. Benefits of Smart Classrooms

Smart classrooms bring many benefits that significantly improve the educational process:

- Increased student engagement: The use of multimedia content and interactive tools increases student engagement and motivation to learn.

- Flexibility in learning: E-learning allows students to access educational materials at any time and from any location, increasing learning flexibility.
- Better access to information: Digital resources can be easily accessible to all students, regardless of their physical or geographical limitations.
- Effective management of the educational process: Learning management software tools allow teachers to effectively manage the educational process, monitor student progress, and provide feedback.

5.2.2. Disadvantages of Smart Classrooms

While smart classrooms bring many benefits, there are also certain challenges and drawbacks to consider:

- High implementation costs: The introduction of smart classrooms requires significant financial investment in technological equipment, software, and staff training.
- Technical Support and Maintenance: Smart classrooms require ongoing technical support and maintenance to keep systems running properly and without interruption.
- Digital Literacy: Teachers and students must have an appropriate level of digital literacy in order to be able to use technology effectively.
- Privacy and security: The use of digital tools and online systems carries risks to data privacy and security, which requires adequate safeguards.

5.3. Design Challenges

Designing a smart classroom requires careful consideration of several factors. The location and condition of the room play a key role in determining the acoustic properties and quality of the sound. Room acoustics, reverberation time (RT60) and background noise are key parameters that need to be measured and controlled.

Acoustics is one of the most important aspects that affects the sound quality in smart classrooms. Pulse response and RT60 reverb time are important parameters that must be measured and controlled to ensure an optimal sound ambience. Longer RT60 times can lead to mixing and loss of speech clarity, which is especially important in rooms where speech intelligibility is crucial, such as conference rooms or classrooms.

Background noise, also known as ambient sound, is sound that occurs naturally in the environment and can be due to various factors such as external sounds, air conditioning, human activity, or other sound sources. Critical distance, the distance from the sound source to the microphone where the direct sound is at the same level as the ambient sound, also plays an important role in sound quality.

Background noise measurement includes calibration, positioning, measuring, reading results, and analyzing the results. Noise Criteria (NC) is a standardized system for classifying and measuring indoor noise levels. Lower NC numbers indicate a lower noise level, while higher NC numbers indicate a higher noise level. Preferred values for conference rooms are between 20 and 25 NC, while values over 50 are a problem.

Improving the acoustics of a room can be achieved through appropriate sound insulation, reduction of ambient noise and careful selection of the interior of the room. Sound insulation may include the use of insulating materials between walls, ceilings and floors, as well as the installation of plasterboard with holes. Also, avoiding glass and flat surfaces can significantly reduce sound reflection.

If it is not possible to achieve good space quality, DSP is key to achieving high-quality sound in smart classrooms. DSP processors provide amplification, equalization, echo cancellation, and noise reduction.

Gain is the process of increasing the strength of an audio signal. Maintaining a proper amplification structure is essential to creating a good sound system. Insufficient input gain can lead to poor equalization performance, noise reduction, and echo cancellation, while too much gain can cause sound distortion.

The equalizer (EQ) is used to adjust the frequency response of an audio signal. Equalization can be additive or subtractive, with subtractive equalization often used to reduce unwanted frequencies and noise. Equalization can significantly improve sound quality and speech intelligibility.

Acoustic Echo Cancellation (AEC) is a process in the DSP that identifies and eliminates feedback signals within audio communications. AEC is very important in conferencing systems because it removes the echo that occurs when the sound coming out of the speaker is transmitted back to the microphone.

Noise reduction is a process that eliminates unwanted frequencies from audio signals, which is useful for reducing background noise, such as air conditioning noise. Too much noise reduction can cause the speech signal to sound thin and hollow, so it's important to balance this process properly.

Automix is a process that automatically selects the most suitable microphone for use based on the gain and arrival time of the high frequencies. Automix helps reduce noise by shutting down unused microphones, thereby reducing unwanted sound.

Selection of audio and video equipment: Choosing the right audio and video equipment is crucial for the successful implementation of smart classrooms. When choosing equipment, it is necessary to consider the signal quality, the connection method (wired or wireless), the type of microphone (capacitor or dynamic), and the specific needs of the space. These considerations ensure that every part of the system functions optimally and contributes to the overall learning experience.

Audio monitoring is essential to ensure high quality sound during lectures and presentations. Audio monitoring equipment includes:

- Headphones and monitors: Headphones are useful for individual monitoring, while monitors allow you to monitor the sound in a space. High-quality headphones allow teachers and technical staff to hear all the details of sound accurately, while wide-frequency range monitors provide clear, distortion-free sound.
- Audio Interfaces: These devices allow you to connect microphones, headphones, and other audio devices to a computer or other central system. Audio interfaces with low latency and high quality audio conversion ensure accurate monitoring and recording.
- Microphones: The choice of microphone depends on the specific needs of the space. Condenser microphones are highly sensitive and provide high-quality sound, while dynamic microphones are more resistant to background noise. Also, gooseneck and boundary microphones are used for different space configurations and types of lectures.

5.3.1. Cameras & Projectors

Cameras and projectors are essential for recording and displaying high-quality video content. High-resolution cameras allow for detailed recording of lectures, while projectors allow the material to be displayed on large screens.

- Cameras: The choice of cameras depends on the size and configuration of the classroom. PTZ (Pan-Tilt-Zoom) cameras are ideal for large classrooms because they allow you to remotely control, zoom and adjust shooting angles. Cameras with a high pixel count provide a sharp and clear image, which is crucial for quality recording and streaming.
- Projectors: High-quality projectors allow you to display images and video materials in large formats. Projectors with high resolution and light output ensure clear visibility even in lighted rooms. Video Monitoring

Video monitoring enables real-time monitoring and control of video signals, ensuring high quality recordings and transmissions. The video surveillance equipment includes:

- Monitors: High-quality, high-resolution monitors allow you to view video content in real-time. Monitors with color and contrast adjustment features help with precise image control.

- Video Matrices: These devices allow you to switch between different video sources and manage them. Video matrices with support for different formats and resolutions ensure compatibility with all video devices in the classroom.

5.3.2. Control Systems

Control systems enable centralized management of all devices in the smart classroom, making it easier for teachers and technical staff. Today, automated control systems are often used to allow for simple and intuitive management.

- Centralized Control Panels: These panels allow you to control all your audio and video devices from a single point. The user interfaces are often easy to use and allow you to quickly switch between different modes of operation.
- Automation: Automated systems can program the operation of devices according to predefined scenarios, making work easier and reducing the need for manual adjustments. For example, the system can automatically adjust the lighting and sound when a lecture begins.

5.3.3. Connecting to an Audio-Video System

Connection to an audio-visual system is often necessary, primarily for stable communication between new A/V devices, but also for security reasons. Different connection methods are used to ensure flexibility and compatibility with different devices.

- Dongles and Adapters: Using a dongle allows you to easily connect laptops and other devices to a central system. This is especially useful for students who come with their computers or phones. Dongles allow you to connect and transfer data wirelessly without the need for cables.
- Network Connectivity: Networking allows you to transmit high-quality video and audio signals with minimal latency. Ethernet cables and Wi-Fi networks are used for stable and reliable connections.

5.3.4. Choosing Smart Classroom Software

Choosing the right smart classroom software is crucial for providing functionalities such as recording, streaming, collaboration, and learning management. The software must be compatible with the equipment and allow for ease of use. The most commonly used are the mentioned software and their common connection such as: Moodle, Microsoft Teams, Google Classroom, Zoom, OBS. It also develops its own software that allows the integration of these software.

5.4. Practical Room Project Design

A multimedia smart classroom has been implemented at the Faculty of Technical Sciences, which includes the latest technology for recording, streaming and live broadcasting of classes. The room is equipped with advanced audio and video equipment, interactive whiteboards and software for managing educational content.

This project serves as an example of modernizing the educational space and enhancing the learning experience for students. The Smart Classroom allows for recording lectures for students to review later, live streaming for those who are not physically present, and interactive sessions that enhance engagement and interaction between teachers and students.

The implementation of the Smart Classroom at the Faculty of Technical Sciences represents a step forward in the use of technology in education, providing students and teachers with the tools needed for modern and effective learning and teaching. This classroom is an example of how technology can improve the educational process and enable better educational outcomes for all participants.

The solution is designed to be multifunctional for the purpose of organizing smaller or larger conferences, as well as for conducting interactive teaching. In the premises there is audio and video equipment that is programmed to communicate with each other via IP connection and in this way that complete automation of the system is programmed. In addition to full automation, it is configured so that it can be configured manually where the system is fully user-friendly. The multifunctional solution means that the system is easily adaptable to new improvements and can meet the requirements of any situation in the field. For greater functionality, there is a shrinking wall between the spaces, so if necessary, the area of all three classrooms can be used, where all three separate audio/video systems then become one audio/video system.

Room 1 is equipped with two cameras that have the ability to automatically monitor, frame, as well as presentation mode, and these capabilities are based on the application of artificial intelligence. Also, each camera has the ability to adjust the preset and thus allows the cameras to be configured and programmed for different situations (conference, classes, presentations, etc.). In the corners of the room, there are active speakers that communicate with each other, thus configuring the audio signal so that there is no echo or reverberation. The output signal to the active speakers is through the main audio mixer where level correction and additional signal filtering are performed.

In this way, the audio control and audio microphone cover every possible scenario. Since the central part of the table is covered with conference microphones, the rest of the room is sounded by ceiling microphones. There are also 2 TVs and one interactive smart projector in the room, which are used for video control of the attendees, while the projector is also used for presentation and interactivity during the presentation. Since the projector and TVs are facing the attendees at the table, the presenter at the lectern also has a laptop that serves as a video control and a device for interactivity with the projector and presentation device. To control the camera, an IP controller is used, with which it is possible to control the cameras (if necessary: pan, tilt, zoom, presets, focus, whitebalance, ISO, etc.). The selection of cameras is achieved using a mini video mixer that accepts HDMI inputs and connects via a USB connection to a computer. It is possible to start a conference (Zoom, Skype, Teams, etc.) from the computer and thus get signals from the audio and video mixer. Also, it is possible to record and broadcast the event live on platforms such as YouTube, Twitch, Facebook, Instagram, etc., but also send a signal via RTMP connection to a TV studio or record on OBS. Figure 5.2 shows the layout of the furniture and the concept of the room.

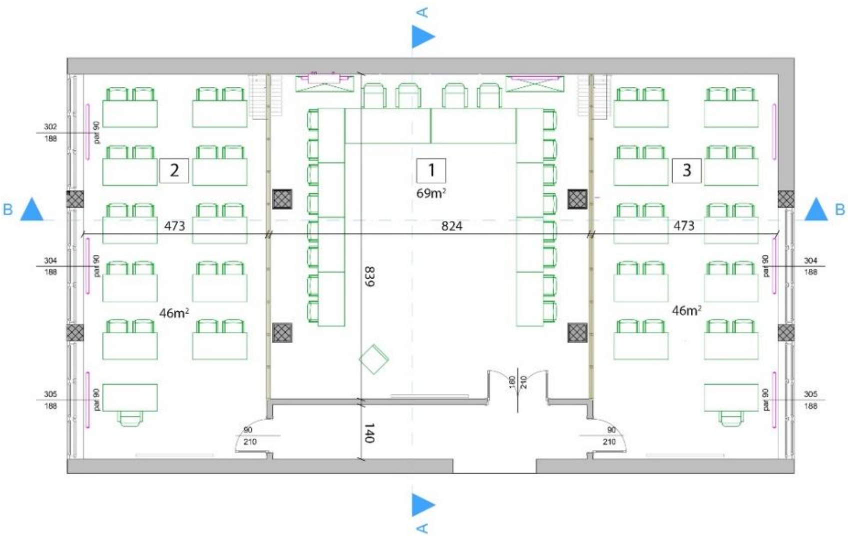


Figure 5.2. Dimensions and arrangement of furniture in rooms.

There is also a StreamDeck device in the room that is configured so that the chair creates HotKeys so that he can fully control the meeting (mutating, accepting new members, recording the meeting, changing the camera). Figure 5.3 shows an example of control via a) PC and b) StreamDeck.

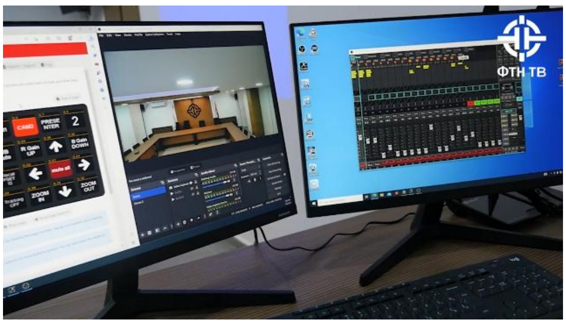
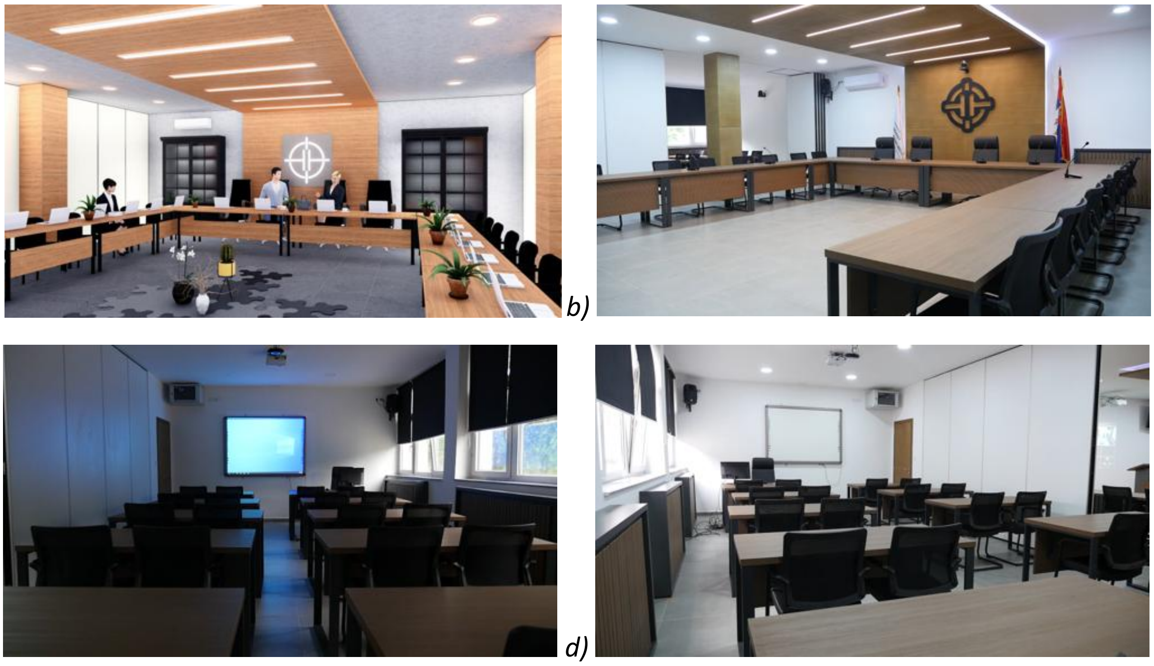
a)  *b)* 

Figure 5.3. Example of manual control a) PC, b) StreamDeck.

Rooms 2 and 3 are identical in size, and for this reason, the same arrangement of devices and equipment will be used. Figure 5.4 shows the layout of a) the render before design, b) the central room after design, c) and d) the two classrooms after design.



a) b) c) d)

Figure 5.4. a) Render before design, b), c) and d) of the room after the completion of the work.

It should be noted that full automation has been achieved in the premises, when the professor wants to record or broadcast classes, it is enough to just start the system where the cameras will automatically follow the professor, as well as sound. In conference rooms, there is also audio-based speaker tracking, which gives the cameras directions on where to record. The iteractivity of those present is put to a higher level by simply inserting a dongle and the user is automatically in the system with his audio/video needs, from the phone to other multimedia devices.

5.5. Conclusion

The implementation of multimedia smart classrooms at the Faculty of Technical Sciences represents a significant step forward in the modernization of the educational process. Equipped with the latest audio and video technology, interactive devices, and advanced software solutions, these classrooms provide a high level of interactivity, flexibility, and efficiency in learning and teaching.

Smart classrooms bring many benefits that significantly improve the educational process. Increased student engagement through the use of multimedia content and interactive tools motivates students and improves their understanding and retention of information. The flexibility in learning, made possible by e-learning, allows students to access educational materials at any time and from any location, thus increasing the accessibility of education. Digital resources enable effective management of the educational process, monitoring student progress and providing feedback.

Choosing the right audio and video equipment is crucial for the successful implementation of smart classrooms. When choosing equipment, it is necessary to consider the quality of the signal, the method of connection (wired or wireless), the type of microphone (capacitor or dynamic), and the specific needs of the space. Audio monitoring is essential to ensure high quality sound during lectures and presentations. High-resolution cameras allow for detailed recording of lectures, while projectors allow the material to be displayed on large screens. Interactive whiteboards and displays allow for interactive communication with content, which improves student engagement and teaching efficiency. Video monitoring enables real-time monitoring and control of video signals, ensuring high quality recordings and transmissions. Choosing the right smart classroom software is crucial for providing functionalities such as recording, streaming, collaboration, and learning management. Software such as Moodle, Zoom, and OBS allow for the integration of various functionalities, thus enhancing the learning and teaching experience.

These were the elements that were described in the paper for better design and use of such a system.

The realization of the multimedia smart classroom at the Faculty of Technical Sciences is an example of how technology can improve the educational process and enable better educational outcomes for all participants. This project provides students and teachers with the tools they need to learn and teach in a modern and effective way, creating a richer and more interactive learning environment.

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6. DESIGN AND IMPLEMENTATION OF DIGITAL MULTIMEDIA TELEVISION SYSTEM

6.1. Introduction

The television (TV) system represents a group of interconnected and dependent TV devices. The television system makes a television studio with a set of departments that together enable the preparation, recording and broadcasting of TV programs. Large television stations, by a rule, have more studios. TV studios are specialized for informative, feature program, tv shows that are recorded or directly broadcasted in the presence of the audience. Depending on the purpose of the TV studio, the equipment is also configured accordingly. One of the roles of the implemented TV studio is that to use it as a laboratory for educational purposes but also as a television studio for content production.

Television systems are designed in that way that can be upgraded and adapted to different standards and resolutions.

This paper presents a functional solution for TV system implemented at the Faculty of Technical Sciences (FTS) in Kosovska Mitrovica within the Erasmus+CBHE Project: Implementation of the study program Digital Broadcasting and Broadband Technologies (DBBT). With the installed TV system can be realized TV programs including recording, production, post-production, direct inclusion of viewers and broadcasting TV programs.

The structure of the implemented TV system on the FTS is shown in Figure 6.1. The structure of the television system is designed to be multifunctional and to satisfy all television standards and criteria. The complete television system has been adapted to the rooms of faculty of Technical sciences and is designed to serve educational purposes, but also to fulfill all production and technical requirements. The implemented studio consists of the following rooms: Reception room, Studio, Director room, Machine room, Editing room, Graphics and Desk.

The TV studio is also known as a television production studio that needs to satisfy, educational, productional and post productional requirements. It is designed so that there are three scenes. The first scene is designed to be neutral, while the second scene is intended for news and addressing viewers. The green screen is for a virtual studio that provides a real-time combination of people and computer-generated environments and objects, and this is the third scene. In the studio there are three video cameras that are recording in Full HD (High Definition) resolution, with signaling (Tally system) and communication (Intercom system) with director rooms. Lighting in the TV studio uses LED (Light Emitting Diode) panels which is adjustable and can be customized for all scenes. Studio is audibly isolated and complete audio and video content are sent to director room.

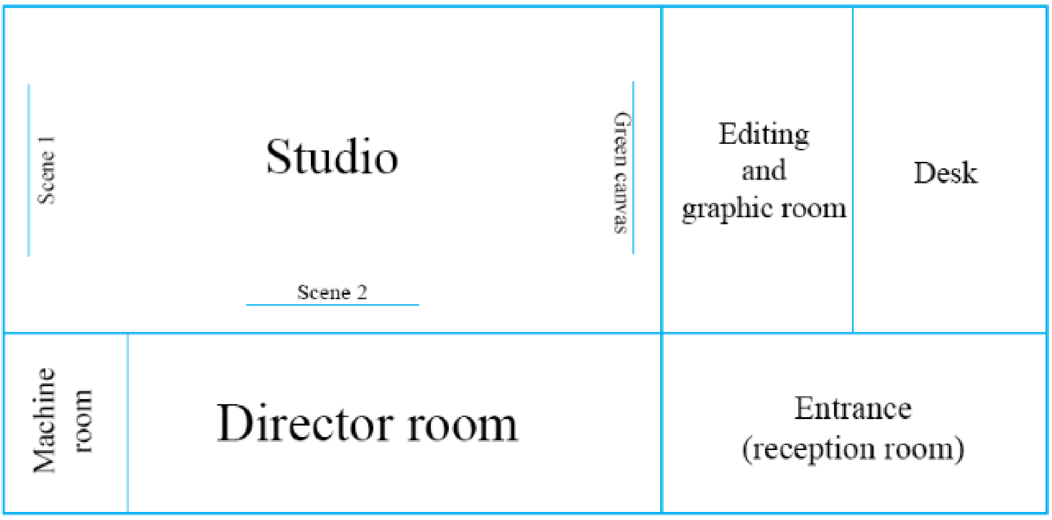

Figure 6.1. Room layout in TV.

Figure 6.2a shows the appearance of the static scene in the TV studio. Depending of the television center concept, director room is mostly including: video mixer, audio mixer, video matrix, audio matrix, a video switch, monitor wall for visual image control from various sources, electronic graphics, intercom system for audio communication with staff, sound director room and all other technical studio departments. The layout of the device in director room is such that it allows each team member to see the pictures and signals, to hear the commands and get instructions to be addressed.

Figure 6.2b shows an example of an implemented video wall in TV director room at FTS. With the video wall, on the monitors, the director room is followed by everything that happens on the scene. Video monitors are professional and high-resolution with true color reproduction and lighting that enable visual image tracking. Computers in director room are equipped with appropriate hardware and all the necessary software for playout, graphics, virtual set and audio/video control directors also receive signals from other sources (satellite, terrestrial, cable television, live inclusion and exchanges with other televisions). In the machine room, in the rack, there are devices that emit high heat and noise, so it is equipped with cooling devices and soundproofed. In the rack there are a video switch, 20x20 matrix, patch box, server, various converters, audio/video distributions and computers.

Figure 6.2c shows a part of the equipment in the machine room. In the room that is designed for editing and graphics, there are computers with all the necessary editing and graphics software: Adobe Premiere, After Effects, Photoshop, Illustrator, etc.

Computers are networked with video director room and desk, so that it is possible to communicate and share content. The indispensable part of designing the television system are desk and editorial staff. Desk boards in the implemented system are editorial and journalistic sections that are responsible for gathering information, planning, organizing, and scheduling realized program.

A virtual studio is a physical space with a green or blue canvas on the wall and floor, where the edges are oblique. Chroma key is a technique used to composite two images or video streams together based on color hues. It is often used in film industry to replace a scene's background by using a blue or green screen as the initial background and placing the actor in the foreground.

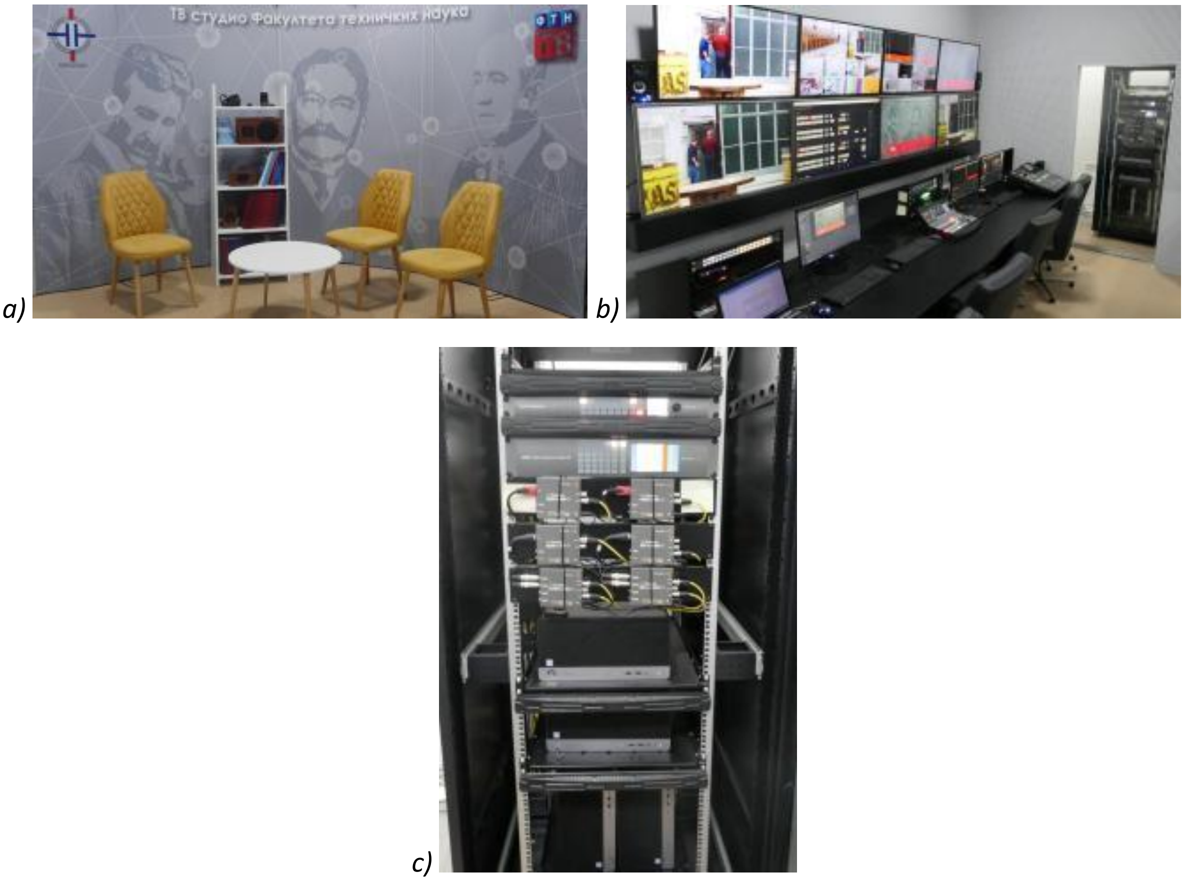

Figure 6.2. a) Scene in a TV studio, b) Video Director. Room, c) Part of the equipment in the machine room.

The information generated by the tracking sensor technology ensures that the inserted objects remain "bound" to the position in the virtual studio regardless of the camera movements. Precise tracking of camera ensures the perfect assembly of the real and virtual world.

Figure 6.3 shows the principle of implemented chroma key model in TV.

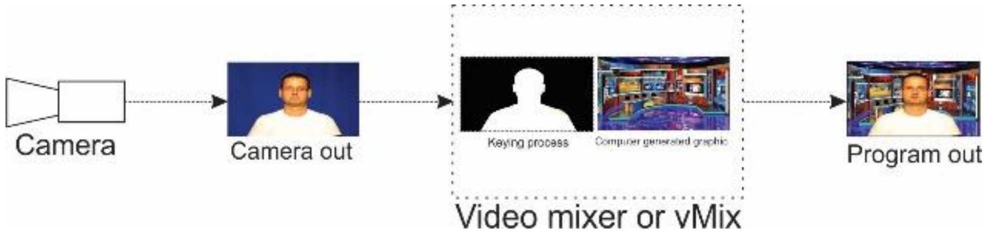

Figure 6.3. Chroma key in TV.

In the proposed solution, the software implementation of the virtual set was achieved using the vMix program. A computer that owns vMix has the appropriate hardware and DeckLink 4K card. It works with three cameras, and each camera also has its own "virtual" plan, so changing the frame also changes behavior of that virtual scene, which actually tracks (tracking technology) changes on the network, and in this way knows what is happening and simulates the change. The hardware implementation of the virtual set is achieved with a video mixer. This eliminates the need for any post-production work and does not require any physical scenes to be made.

6.2. Video System

The laboratory is designed so that the equipment in it can be used for different purposes: education, learning, researching, production, postproduction, streaming, etc. Figure 6.4 shows a detailed video scheme of networked devices in the TV system. The complete video system is set to 1920x1080i resolution. Video cameras, photo cameras, computers, and other accessories are also set to the same resolution, but there is the possibility that the entire system will be set up for 4K resolution. With HD SDI (High Definition Suction Diesel Injection) outputs from the camera, a signal is outputted to the HD SDI input of connection box, while devices with HDMI (High-Definition Multimedia Interface) interface outputted signal to the HDMI input of connection box (Figure 6.4). All devices (video and audio) from the studio through the connection box are connected to appropriate devices into rack in mechanical room. From the HD SDI connection box, the inputs (1), (2), and (3) of the Patch field, which are used in this case as protection and expansion for the matrix, HDMI video signals from the connection box are further connected to the converters HDMI to HD SDI. The signals are sent from the converter to the input (4) and (5) of Patch field, and from the Patch field all signals are connected to the input of the matrix, respectively. Input of the matrix (13), (6), (7) and (8) also produces video signals from other sources, in this case output Playout 1 and Playout 2, Graphics and signal from the Ingest output system. Implemented system also receiving signals from IPTV (Internet Protocol television), cable, terrestrial and satellite TV, through IPTV, DVB-C (Digital Video Broadcasting - Cable), DVB-T2 (Digital Video Broadcasting - Terrestrial) and DVB-S2 (Digital Video

Broadcasting - Satellite) receivers. Video signals obtained from these DVB standards are connected to the Field Meter where the measurement and analysis of the receiving signals, spectrum analysis, level, modulation scheme, etc. can be performed. One of the five video signals from HDMI 5x1, can be selected on the HDMI switch, which needs to be converted to HD SDI using a converter whose HD SDI output is connected to the matrix input (9). A signal from a computer that has a 4K DecLink card with accompanying software for implementing a virtual set is inputted to the (10) the matrix input. The output of the matrix (14) is connected to the ultrascope, and it is possible to analyze and measure the luminance, chrominance, luminance assembled with a chrominance video signals, the histogram of the video signals, and the analysis and measurement of the audio signals. Program output from the connected are also connected to the embedder, and it is connected to the input (11) of the matrix, so it can be manipulated and routed to all the signals via the matrix.

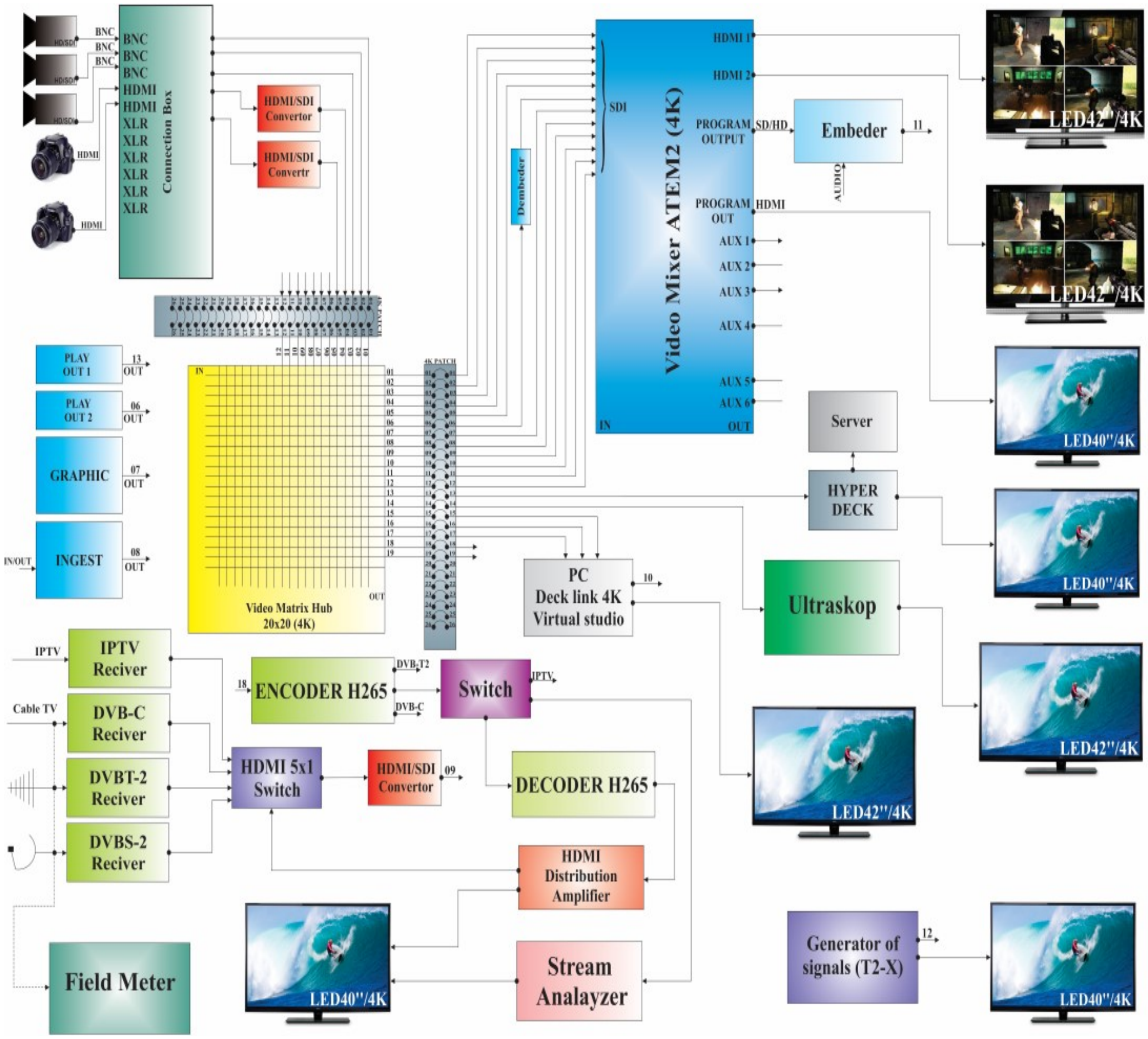

Figure 6.4. A block diagram of the video system.

An input from the signal generator is provided at the input (12) of the matrix, by which it is possible to generate signals with software and perform various signal analyzes and measurements. From the matrix output via the Patch field (06), the embedded HD SDI signal is de-embedded and the de-embedded HD SDI signal is connected to the video mixer input. At the output (18) from the matrix via the Patch field, the program output is connected to Encoder H265 which broadcast program to other television systems (IPTV, DVB-T2, DVB-C) and to the switch. By sending a program output to the switch, it is converted to the transport stream (packets) and distributed to IPTV, the Stream Analyzer and the Decoder H265.

To capture the program output or preview, entire system is connected through a matrix (with (13) HD SDI output) to the HyperDeck with two SSD (Solid State Disk). All incoming signals through the matrix (14) HD SDI output, are analyzed with Ultrascope. Two HDMI outputs from video mixers are connected to two TV monitors as Multiview, since this video mixer has 2ME (2 Mix Effects). Program HDMI output is connected to one of the TV monitors, while a six-AUX (Auxiliary) remain for further routing.

6.3. Audio System

The video and audio signals in the television system processed separately. The image is processed in a video mixer, while the audio is processed in an audio mixer. Figure 6.5 shows a detailed audio scheme of connected devices in the TV system. The audio mixer performs mixing of several input audio signals and there is mixed audio signal on output. In the implemented studio, the audio mixer has 40 audio inputs.

Connection box located in the studio, three wired microphones and three wireless microphones with base (called “bugs”) are connected.

Microphones can be designed as "wire" where microphone signal is transmitted to the audio mixer by copper wire, and "wireless" where microphone signal to audio mixer is transmitted wirelessly, via transmitter and receiver. The transmitter power, which is usually located on the microphone, ranges from 10 mW to 50 mW. The frequency range of wireless microphones is in VHF (Very High Frequency) area (49-108 MHz and 169-216 MHz) and the UHF (Ultra High Frequency) area (450-806 MHz and 900-952 MHz). Signals are transmitted by radio waves, modulated AM (Amplitude Modulation), FM (Frequency Modulation) or some kind of digital modulation.

Audio signals from the connection box are connected to audio mixer on its (1) - (6) microphone inputs. There are also two AUX outputs from the connection box, one of them is audio program output and audio program preview, but if necessary, it can be routed and changed depending on the situation. The (7), (8) line inputs in the audio mixer are connected to the Playout, splited on the left and right channels. There are two Playout systems in the implemented laboratory, audio signals are splited on the left and right output and networked in the (9), (10) line input in the audio mixer. Signals from (3), (4) AUX outputs are connected the embedder which combine the audio program output with video program output as shown in the scheme of the video system (Figure 6.4).

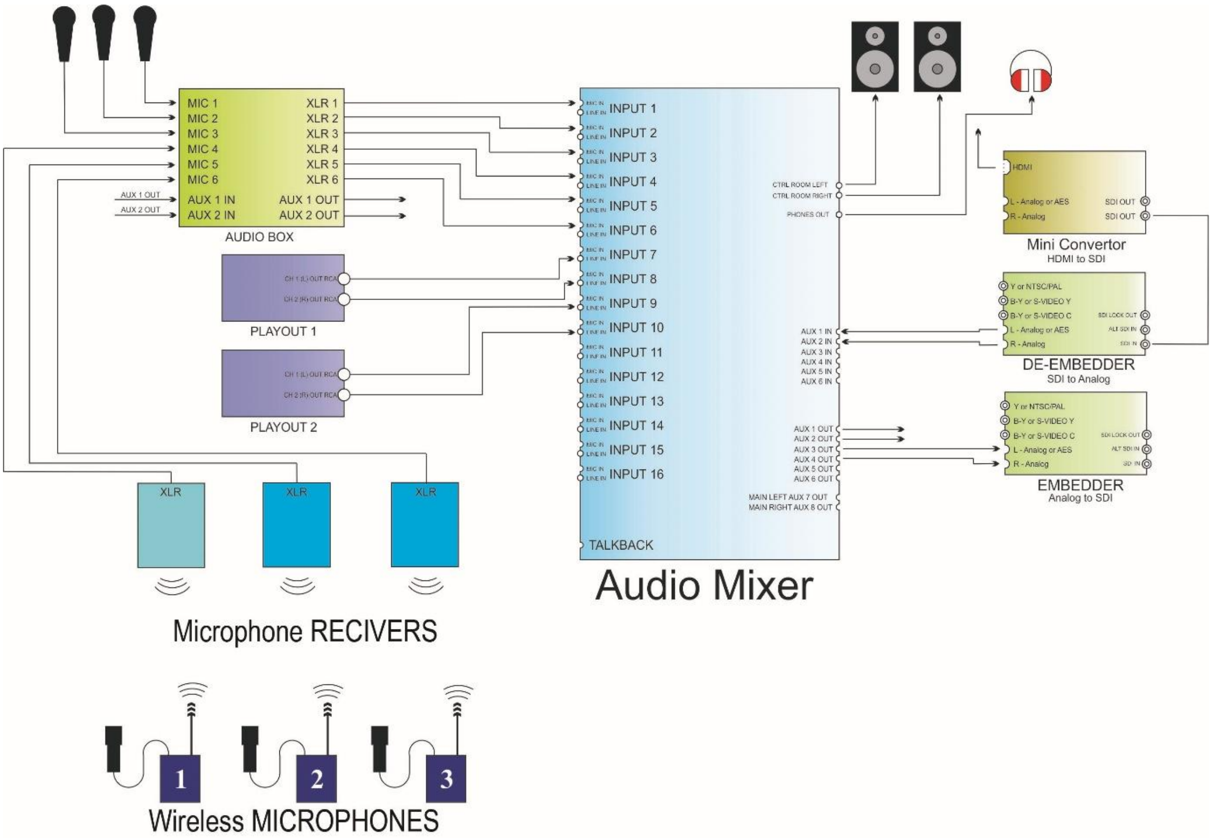

Figure 6.5. A block diagram of the audio system.

6.4. Interactive Connections with Other TV Systems

Laboratory distributing signals from an encoder to a cable (DVB-C) and a terrestrial network (DVB-T2), and it is possible to distribute the signal using Internet Protocol (IP), thus forming a television system based on internet protocol (IPTV). Although, the IP protocol is used to transmit video signals over all types of networks, the implemented studio provides the opportunity to connect with other television systems in the form of signal exchanges. This exchange is enabled by the Set Top Box (STB) on the receiving side which decodes incoming stimulated signal packets.

Two basic ways of delivering video signals over an IP network are downloading content and streaming content. Downloading content is a process that takes over the whole content from the server, which content is stored on the local server. Signal transmission using IP protocol allows interactivity, so it is possible to provide the following options: VOD (Video on demand), Search for content, Program schema, Content scheduling, Chat, etc.

Figure 6.6 shows the method of implementing a TV system connection with other TV systems or devices.

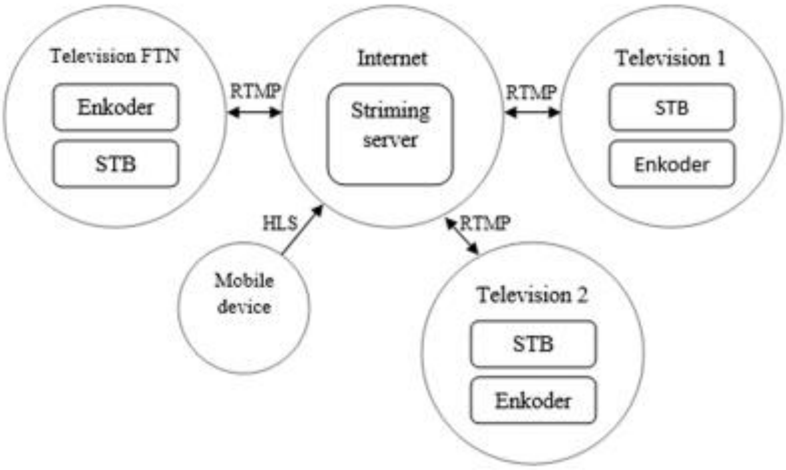

Figure 6.6. The method for connection with other TV systems.

With the streaming content, it is not necessary to download the entire content, but it is sent in real time and then immediately deleted. The protocols most commonly used for streaming are HLS (HTTP Live Streaming), RTP (Real-Time Transport Protocol), RTSP (Real Time Streaming Protocol), RTMP (Real-Time Messaging Protocol) and RTMPE (Real -Time Messaging Protocol Encrypted). Connecting to other television systems or laboratories is achieved through the streaming server where Wowza Streaming Engine is installed. Wowza media system is a software solution for streaming live content and VOD content. With the Flash Media Live Encoder that supports Wowza, content is encoded (H.264 - video and AAC - audio) using the RTMP protocol. On the receiving side, the streamed content can be downloaded via the STB that supports the specified protocols or via the PC containing the editing card. Communication and exchange with other television systems, communication with devices (Mobile phones, tablets, cameras with encoder) that can be anywhere on the ground has been enabled. The solution for this is the Wowza media server and their software solution in the form of an application using the HLS/RTMP protocol.

6.5. Testing the TV Studio Connection with Another TV System

The structure of the television system is designed to be multifunctional and satisfy all television standards and criteria. The complete television system has been adapted to the premises of the Faculty of Technical Sciences and is designed to serve educational purposes, but also to fulfill all production and technical requirements.

On the server, that is located in the engine room, was installed Wowza Streaming Engine where is configured the applications that will allow the connection with other television studios and a mobile phone from the field. For each stream is made a new application, there is application for the stream from this studio in Kosovska Mitrovica to studio in School of Electrical and Computer Engineering of Applied Studies in Belgrade, the application for mobile live broadcast from the field and application from for studio in Belgrade to studio in Kosovska Mitrovica. There must be opened two ports in the network: 1935 and 8088. Using the Wirecast software, which is installed on the computer in the studio and serves as an encoder, the server parameters are configured: public IP address, port and the name of the previously created application in Wowza, resolution, bitrate, etc. Thus, formed stream can be received using STB devices or VLC player.

Figure 6.7a shows a stream sent from a studio in Kosovska Mitrovica, and Figure 6.7b shows the stream sent (received) from studio in Belgrade. Live broadcasting from field using the mobile phone was realized using the GoCoder application. The application is configured with same parameters as server with the only difference in name. Figure 6.7c shows live broadcasting from the field using a mobile phone and 4G network. In this way is realized connection with another TV studio and live broadcast from the field RTMP and HLS protocols.

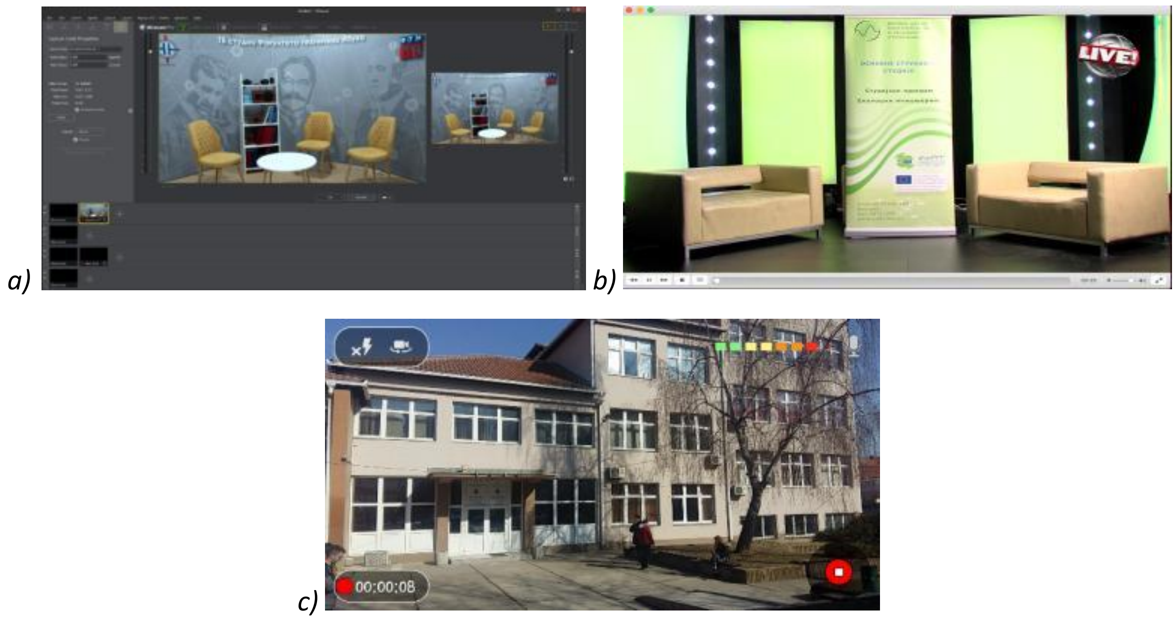

Figure 6.7. a) Streaming signal from studio in Kosovska Mitrovica, b) studio in Belgrade, c) streaming from mobile phone.

Received signal from mobile phone in studio is configured on STB device by entering parameters of the stream (public IP address, port and application name, and it looks like: rtmp://147.91.144.107:1935/ftn/mLive or if stream uses HLS protocol: http://147.91.144.107:1935/ftn/mLive/playlist.m3u8).

Figure 6.8 shows an overview of active connections and used protocols.

From Figure 6.8 it can be seen that the total number of established connections is four, where the connections using the RTMP protocol are the between the studios, while HLS represents the connection with the team on the field. Depending on the situation, other protocols can be used.

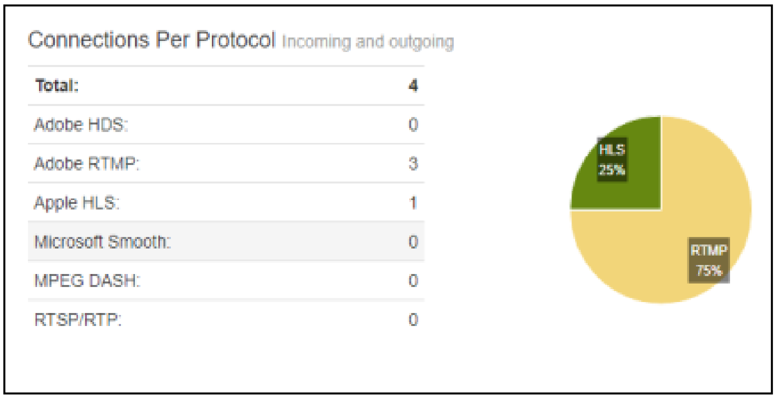

Figure 6.8. Monitoring of active connections and protocols.

Since connection with the team on the field and the exchange of signals with other television studios are through internet connection, stability and quality, both objective and participative, depend on the speed of internet connection. In order to adapt the video to all users, on the server where Wowza Streaming Engine was installed, stream transcoding was made using different resolutions and different bitrate that significantly affect the quality. Three categories of video resolution were analyzed for stream. Table 1 gives the encoder parameters for the applied SD (Standard Definition) resolution, HD (High Definition) resolution and FullHD (Full High Definition) resolution.

Table 6.1. Encoder parameters for streaming.

	SD	**HD**	**Full HD**
Resolution	720x576	1280x720	1920x1080
Number of Frame Per Second (FPS)	25	25	25
Average bitrate [kb/s]	1025	2252	4500
Audio bitrate [kb/s]	128	128	128
Sample rate frequency [Hz]	44100	44100	44100

Figure 6.9 shows the number of received packets in one second for observed interval of 60 seconds, as well as the number of lost packets when streaming SD, HD and FullHD resolution, respectively. Graphs were obtained using the Wireshark software package used to analyze the IP packets. The above graph (line) refers to the number of received packages by the server to the user, while the lower graph (line) represents the number of lost packets.

From given figures can be see that the number of received packets increases with the higher resolution, or the increase in bitrate, because it is necessary to transfer a larger amount of information. Also, the number of lost packets increases, but if the receiver (user) has the required bitrate (which is greater or equal to the bitrate that stream being sent), this number of lost packets will not impair the quality of signal reception.

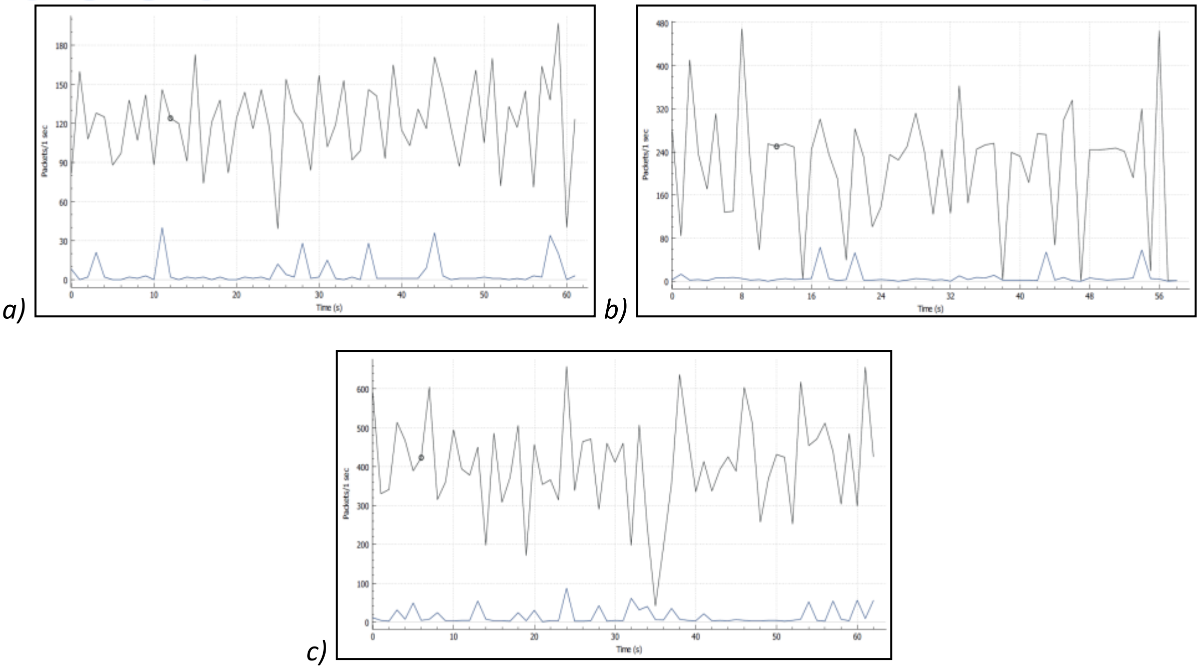

Figure 6.9. Number of received and lost packets for the observed interval of 60s for: a) SD resolution, b) HD resolution, c) FullHD resolution.

6.6. Conclusions

The paper described the implementation of a real multifunctional multimedia TV system from a technical and practical aspect. The development of digital technologies enabled realization of TV systems with a wide range of possibilities for different purposes. Designing and configuring the TV system determines its purpose. In this particular case, using the optimal devices and the way of their networking, a multifunctional multimedia TV system can be used as an educational laboratory and television system. Proposed laboratory enables production and realization of television programs, also enables education, learning, researching and measuring in the field of television technology and multimedia system, production and postproduction (recording of TV content, graphic processing, editing, visual effects, live broadcasting and more), telecommunication, image processing. With this system, students can get acquainted with the principles of implementation of TV programs, as well as with the work of multimedia systems from the engineering aspect. Also, can get acquainted with designing TV systems, broadcasting signals, used protocols for streaming. In this way, they acquire practical and immediately applicable knowledge. The implemented system has the possibility of interactive communication over IP with other TV systems or individuals via mobile devices. The mentioned laboratory can also be used as a system for the distribution of TV program in real time.

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7. CHALLENGES AND OPPORTUNITIES OF ONLINE LEARNING AND TEACHING

7.1. Introduction

By the 21st century, the means of learning and teaching methods have changed. In the Middle Ages, chalk, blackboard and people were the actors, and nowadays all this is combined with camera recording.

Online education is the method of education in which students and teachers or instructors use digital technologies and the Internet to communicate and interact with each other without physically being in the same space. This enables learning and instructional flexibility and enables students to access educational content from many different places and times.

7.2. Online Learning Forms

Online learning is when students learn the curriculum they are required to follow or the curriculum of their choice via the internet. This learning method is called e-Learning. Experience in education shows that, in addition to traditional teaching tools, educational videos, e-books and knowledge assessment tests linked to the curriculum make learning easier and more effective. When using online learning, students usually report their knowledge online.

Many types and methods of online learning have emerged as an evolution of traditional education, but they can be grouped into three broad categories based on their types. One type is "Synchronous learning", where students and instructors communicate via video conferencing. Another distinct method is "Asynchronous learning", where students are provided with pre-recorded lectures alongside the literature. The third main sector is "Blended learning", which combines online and face-to-face learning elements.

7.2.1. Synchronous Learning

Online synchronous learning is when students and teachers engage in real-time learning on virtual platforms. Students join classes in real time through a video conferencing platform at pre-defined times, via a link shared by their instructor. The platform offers features such as chat, screen sharing, polling, and virtual classrooms, so that a collaborative communication platform for learning in a virtual classroom is created.

Students can ask questions orally or in chat, answer questions on tests created by the instructor, or "raise their hand" if they have a question or comment on the course material, so they can interact with the instructor in real time. Virtual rooms allow for small group discussions, sharing documents or using shared virtual whiteboards with the instructor, which in turn can be used to create group work. Instructors can share multimedia resources such as presentations and videos during the class.

Students get instant feedback through online quizzes or Q&A exercises to assess their knowledge. Instructors can monitor student participation and activity during class. It is possible to record lessons so that students can watch them later.

Synchronous learning combines online learning with real-time communication, trying to create the traditional classroom-like participation and its features. The platforms most used for online synchronous learning are Zoom [1], Microsoft Teams [2], Goodle Meet [3], Adobe Connect [4], GoToMeeting [5], Cisco Webex [6].

Synchronous Learning at Óbuda University

Óbuda University uses a variety of synchronous learning methods in its undergraduate and postgraduate courses. Classes are held in real time, so students can interact directly with lecturers and their peers. This live interaction includes virtual lectures, laboratory work, discussions, and collaborative projects through online platforms.

Currently, education in mechanical engineering, mechatronics and safety engineering mostly requires face-to-face participation due to classroom teaching in labs or practical classes, or group work on assignments. These are held with attendance at a predetermined time. Some courses can also be taken online, thus ensuring immediate feedback, and facilitating a collaborative environment for research and development. Synchronous teaching at the Óbuda Univerity is mostly done using BigBlueButton (BBB) [7] and Microsoft Teams [2].

7.2.2. Asynchronous Learning

A common form of online learning is the asynchronous learning method. Another feature of this learning method is that it allows students to learn at their own pace without having to attend classes at a fixed time. This online method is commonly referred to as a Learning Management System (LMS). Students can access the educational content of their choice through an online interface.

The learning content consists of pre-recorded lectures, recorded audio material, quizzes and exercises created by the instructor. The learning material is organised in modules or lessons. Students can learn the material according to their own timetable, but they must follow the deadlines set by the instructor. Tutors also provide discussion forums for students, where students can interact with their peers, take part in discussions about the course material, share ideas and ask questions. They can engage in collaborative learning without the need for real-time presence. Assignments and quizzes are submitted through the LMS interface, which allows instructors to grade students' knowledge and send feedback to students on their progress.

Tutors themselves can decide when to answer students' questions by e-mail or other electronic systems, so that tutors can do their work at a more leisurely pace. Learning is supported by additional resources such as e-books, videos, and other written material. The flexibility of this approach allows students to adapt their studies to their extra-curricular work or other commitments, while continuing to receive guidance and assessment from their tutors throughout their studies.

The platforms used for online asynchronous learning are mostly Blackboard Learn [8], Google Classroom [9], Coursera [10], edX [11], Udemy [12], FutureLearn [13].

Asynchronous Learning at Óbuda University

Óbuda University is primarily integrating asynchronous learning through the e-learning platform, so students can access course materials and lectures at the most convenient time for them. The university provides online resources for English-language engineering and computer science programmes. Students can access a wide range of multimedia content, such as recorded lectures and assignments.

An example is the Electrical Engineering course, which includes comprehensive course materials focusing on communication design, instrumentation, and automation. Similarly, the Computer Engineering course uses asynchronous learning to teach cloud computing technologies, IT security, software design and programming.

These programmes are designed to provide flexibility for full-time or part-time students, allowing them to work independently and integrate their practical skills through asynchronous research and laboratory projects. At the Óbuda University, the Moodle [14] online platform is used for asynchronous teaching.

7.2.3. Blended or Hybrid Learning

Another large group of online education would be blended or hybrid learning. This combines online and face-to-face learning to provide a comprehensive educational experience. Courses are designed to combine the strengths of online and face-to-face learning. Students take part in interactive, hands-on activities in face-to-face classes, such as lab work, group discussions or projects where direct participation is preferred. In addition, the online learning material, accessible at any time, includes lectures, exercises, quizzes and access to supplementary material through a single platform.

The online part often includes pre-recorded lectures or interactive lessons that students can work through at their own pace. In the self-paced mode, students must complete set tasks and quizzes in a predetermined time. This also facilitates asynchronous discussions through forums or group projects created on the online interface, allowing students to participate in learning sessions regardless of their location, interact directly with the instructor and collaborate with their fellow students.

Tutors provide real-time feedback and assessment to students and hold regular face-to-face classes or virtual consultation sessions. Tutors provide support to students through face-to-face consultations. With the flexibility of online teaching and the direct communication of face-to-face consultations, hybrid learning aims to fully satisfy student satisfaction and meet diverse learning needs, while facilitating group learning and collaboration among students.

The platforms most commonly used for online blended, or hybrid learning are Canvas [15], Blackboard Learn [8], Moodle [14], Google Classroom [9], Microsoft Teams [2], D2L Brightspace [16], Schoology [17].

7.2.4. Self-Paced Learning

The "Self-Paced" teaching method can be distinguished from other online methods by its structure. The essence of this method is that students complete the courses online at a pace of their own choosing. An important feature of this type of learning is that there are no predetermined class times.

The students learn through an online platform or learning management system (LMS). The platform includes pre-made educational videos, written course materials, quizzes and projects to be completed. Courses are usually grouped into modules or stand-alone units. When opening the modules, students work through the course material at their own pace, writing the assignments and tests which were in advance.

Reporting on what they have learned and presenting the completed assignments is done online. The results of the tests are reported immediately after the test is written, while the written essays are assessed by the instructor himself and the student is informed of the result after the assessment.

The communication between the student and the tutor is not in real time, but the tutor gives feedback to the student on his/her studies via e-mail or other virtual forums. In this teaching method, there is usually an online platform where students can start discussion forums between themselves, share their comments and experiences.

Upon successful completion of all modules, students can receive a certificate or teaching credits. Coursera [10], Udemy [12], edX[11], Khan Academy [18], LinkedIn Learning [19], FutureLearn [13], Skillshare [20] are the platforms mostly used for online Self-Placed learning.

7.2.5. Massive Open Online Courses (MOOCs)

MOOCs are learning methods that are online courses open to anyone, so one of their main characteristics is that they have many participants in online education. They offer a wide range of courses and are often provided by prestigious universities and institutions. These courses are essentially virtual free universities, which can be free or paid.

MOOCs were originally created to provide education to those who did not have access to traditional education, for example individuals living in rural areas or working full-time. Today, they are at a level that allows them to be used for personal and professional learning and can be accessed from any device with an internet connection.

MOOCs offer educational materials at an affordable price and provide a flexible way to learn new skills and a wide range of quality educational experiences. Once a course has started, students can learn the weekly material at a time that suits them, without having to be online at the same time as other learners.

A wide range of online teaching techniques are provided to students, including pre-made videos, discussion forums, assignments, social networks and other materials. MOOCs cannot fully replace the traditional information and knowledge transfer mode for several reasons. The traditional teaching mode provides opportunities for direct interaction between teacher and student and for training independent learning skills, which are missing in MOOCs.

The online Massive Open Online Courses (MOOCs) are mostly taught using Swayam [21], OpenLearn [22], Coursera [10], edX [11], Udacity [23], FutureLearn [13], Khan Academy [18] platforms.

Massive Open Online Courses (MOOCs) at Óbuda University

Óbuda University offers Massive Open Online Courses (MOOCs) as part of its education, providing flexible learning opportunities. The university is present in various technical fields such as engineering, information, technology, and business management by offering MOOCs. These courses are designed to be easily accessible, allowing more students to participate in online education without the constraints of traditional classroom methods.

Óbuda University offers MOOCs that cover a wide range of subjects. They cover areas such as cybersecurity, robotics and automation, aligned with the university's teaching areas. The MOOCs are designed to be aligned with the university's face-to-face teaching, allowing this type of online education to be used as a face-to-face classroom for students who wish to learn.

The Carpathian-Mediterranean Online Education Centre (K-MOOC) of Óbuda University [24] offers online courses in several areas. Students can take for example the following courses:

- "Fundamentals of Statistics" introduces students to the basic methodology and applications of statistics. The course aims to provide students with the opportunity to learn statistical skills, from performing simple analyses to interpreting results in different professional contexts.
- "Autonomous Inference and Control Systems" course covers basic computational skills such as fuzzy logic, neuro-fuzzy systems, neural networks. This will enable students to learn about the technology of autonomic control systems.
- "Institutions and Organizations" course provides a theoretical background for understanding domestic and international organizations, power structures and the relationships between economic, political and security institutions.
- "MATLAB Programming" provides an introduction to MATLAB programming, allowing students to solve engineering problems using the platform.
- "Ergonomics" course, where students will learn about ergonomic principles and their practical applications, gaining a deeper insight into the human-centred aspects of the field.

7.3. Conclusions

Online learning has come popular worldwide, offering a variety of formats to meet different educational needs. Synchronous learning, which involves real-time interaction between instructors and students via video conferencing, has become a popular choice. This method can be found at Óbuda University, where live sessions facilitate direct engagement and immediate feedback.

In contrast, asynchronous learning provides flexibility by allowing students to access learning materials in the way that is most convenient for them. This method has become accepted worldwide, empowering learners who have other commitments. At Óbuda University, asynchronous learning is also used, allowing students to learn at their own pace while having access to recorded lectures and courses.

Blended or hybrid learning, a combination of online and face-to-face learning, is a globally recognised compromise. The two methods combine the flexibility of digital learning with the social engagement of traditional classrooms.

Self-paced learning, the other type of online education, gives students the autonomy to progress through their courses on their own schedule. This method is widely used, giving students more control over their educational progress.

The K-MOOC (Carpathian-Mediterranean Online Education Centre of Óbuda University) implements these concept, aiming to expand educational opportunities by combining technology and the open access model. This form of learning allows Óbuda University to meet individual student needs while adapting to global educational trends.

7.4. References

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[11] https://www.edx.org/
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[13] https://www.futurelearn.com/
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[16] https://www.d2l.com/brightspace/
[17] https://www.powerschool.com/classroom/schoology-learning/
[18] https://www.khanacademy.org/

[19] https://learning.linkedin.com/
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8. USING THE MOODLE QUIZ FOR ASSESSMENT

8.1. Introduction

Using Moodle Quiz for assessment is an effective way to evaluate learners' understanding and knowledge. Moodle [1], being a popular learning management system (LMS), offers a versatile quiz module that instructors can utilize to create various types of assessments, from simple multiple-choice quizzes to complex exams with diverse question formats.

In this paper different Moodle quiz are shown in details for the assessment of students. The second part of the work describe some statistics through of a certain subject solved Moodle quizzes by the students and explain the differences between the question types from the evaluation point of view.

8.2. Moodle Quiz Types

The Moodle quiz is a blank slate until it is populated with tasks. There are three formats for the questions: open-ended, closed-ended, and mixed. The value of open-ended questions is in the tutor’s creativity and ability to exploit the question format to engage students with aspects of academic writing relevant to their programmes of study and writing needs [2-4]. In this format, there are two question or task types: an Essay and a Short answer question.

In the "Essay question", the students can write at length on a particular subject and must be manually graded. In this question type the student can not guest but the disadvantage that it is easy to ask artificial intelligence for the answer. In the "Short answer" question, the students are expected to respond with a word, a number, or a phrase. The expected answer could be very specific. The answer could be a word or a phrase, but it must match one of your acceptable answers exactly. It's a good idea to keep the required answer as short as possible to avoid missing a correct answer that's phrased differently.

The closed-ended questions are as follows: True/False, Multiple Choice, Drag and drop onto image, Matching type, Simple calculated, Numerical. In the "True/False" a student is given only two choices for an answer, the student can guess the answer by 50% chance. The "Multiple Choice" is better, single answer or multiple answers could be chosen by the instructor. Each answer may carry a positive or negative grade, so that choosing ALL the options will not necessarily result in good grade. "Drag and drop onto image" is a question where there is an image containing different parts or objects, and you would be asked to drag labels or descriptions onto specific areas of the image to correctly identify those parts or objects (Figure 8.1).

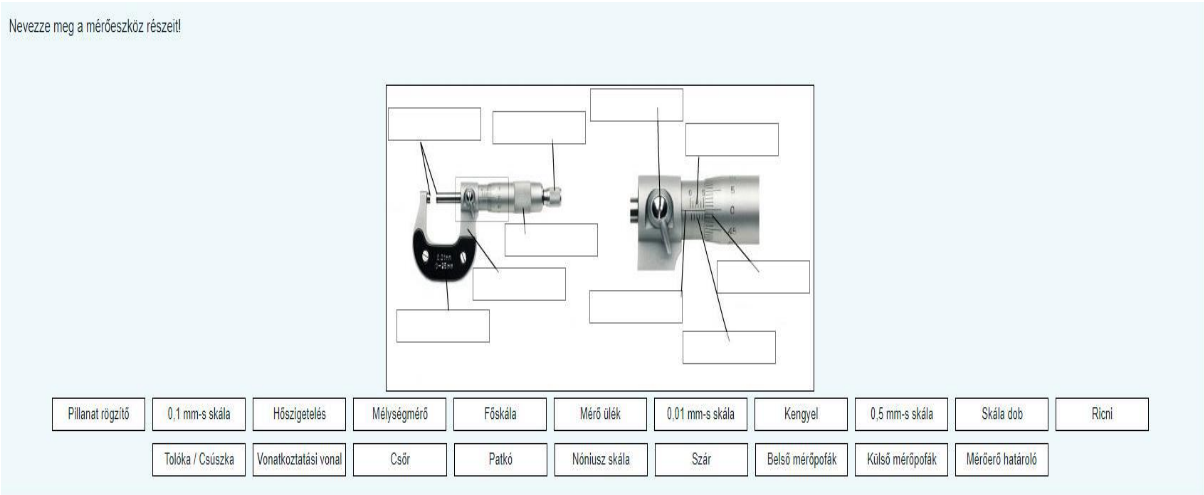

Figure 8.1. Example for "Drag and drop onto image" type question.

"Matching type" questions have a content area and a list of names or statements which must be correctly matched against another list of names or statements (Figure 8.2).

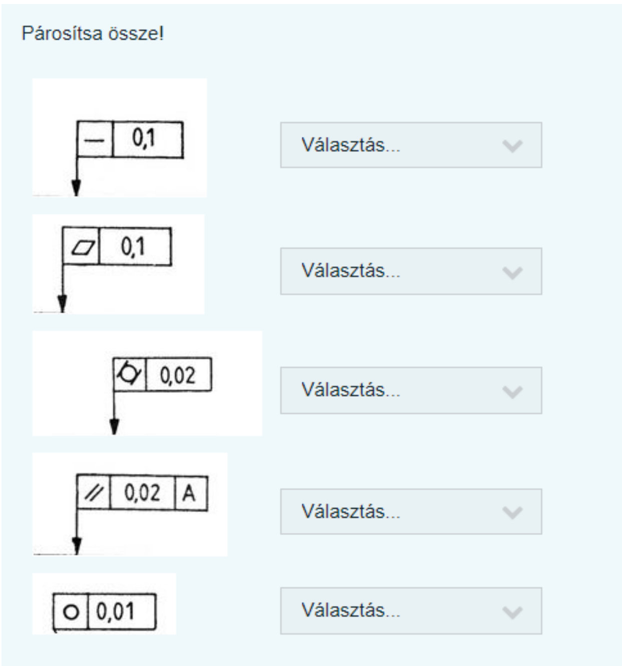

Figure 8.2. Example for "Matching type" question.

"Simple calculated" questions offer a way to create individual numerical questions whose response is the result of a numerical formula which contain variable numerical values by the use of wildcards (i.e. {x} , {y}) that are substituted with random values when the quiz is taken. For example:

The measurement result is: {2:NUMERICAL:=15.13#}mm ±{2:NUMERICAL:=0.25#}mm

From the student perspective, a "numerical" question looks just like a short-answer question. The difference is that numerical answers are allowed to have an accepted error. This allows a fixed range of answers to be evaluated as one answer. For example, if the answer is 30 with an accepted error of 5, then any number between 25 and 35 will be accepted as correct.

8.3. Practice at Óbuda University

One subject was chosen to show the behaviour of certain Moodle question types during the evaluation of students' knowledge. The subject name is Measurement technique I, which is a compulsory subject for all students in the field of mechanical engineering. The online tests were examined through a period between 2018 and 2023. It is seen on Figure 8.3 that the ratio of the "Multiple choice" question is the largest in each year, the second is the "Matching type", the third is the numerical. These questions are in a question bank and the students had to solve some parts of the randomly chosen questions during their assessment.

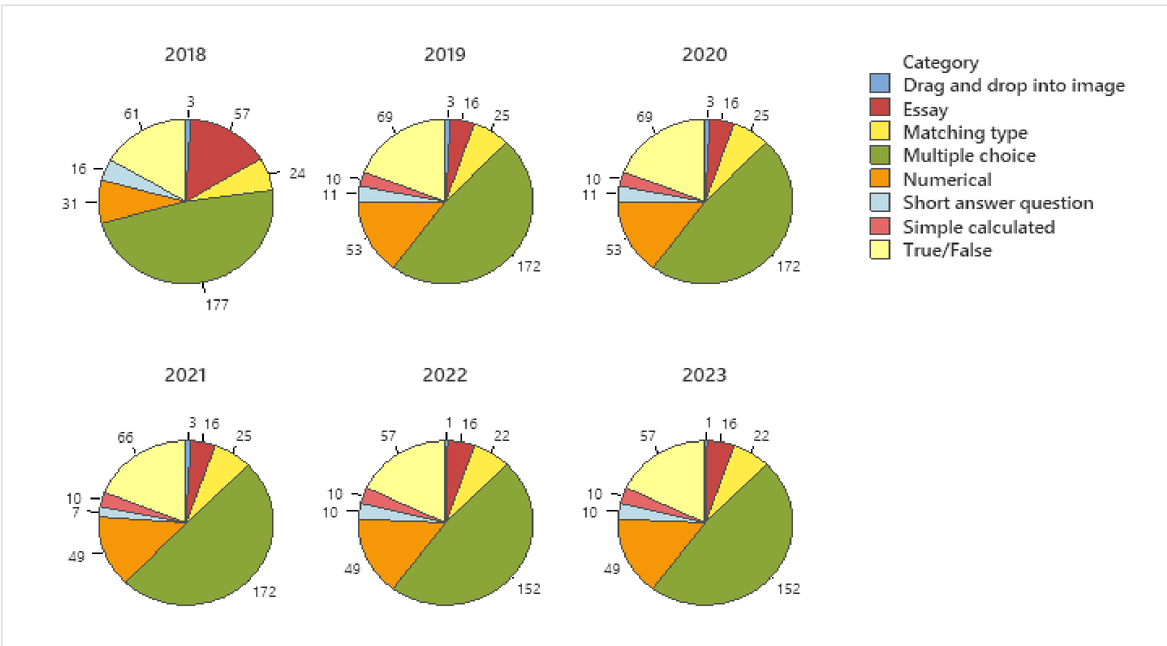

Figure 8.3. The composition of the used test per question types by year.

The next graphs (Figure 8.4-8.6) show the difference between the hardnesses of question types divided by the three parts of the topics: Laboratory work (Figure 8.4), Reading devices (Figure 8.5) and Theory (Figure 8.6). The average grade in % in on the y axis where 100% means that every student knows the right answer. The points are the average values and the interval refers to the 95% confidence interval for the expected value.

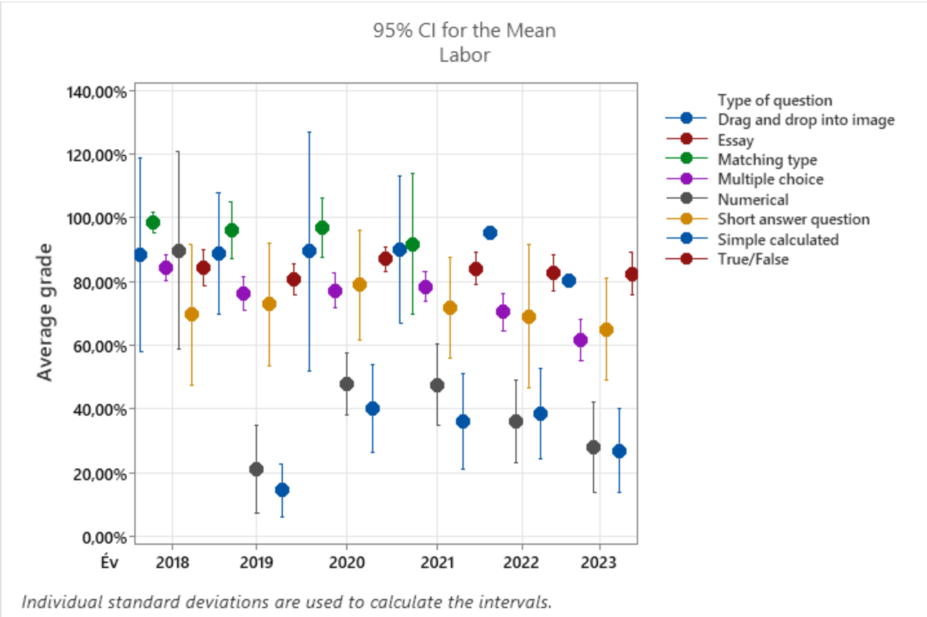

Figure 8.4. The average results of Laboratory topic for the answered question for the different question types by year (Average grade 100% means that every student knows the right answer).

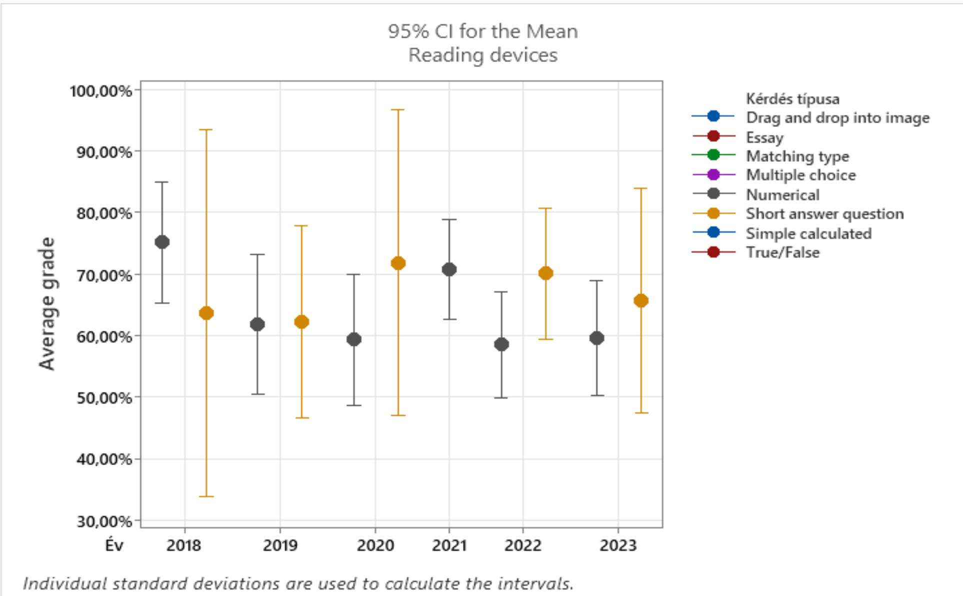

Figure 8.5. The average results of Reading devices topic for the answered question for the different question types by year (Average grade 100% means that every student knows the right answer).

In Figure 8.4 the least light question type is the "Matching type", then the "Drag and drop onto image". The hardest question types for the students are "Numerical" and "Simple calculated". In Figure 8.5. it is shown that how capable to read the devices (i.e. micrometer or caliper from a picture). The results show that they are not good enough to answer the right question in "Numerical" or "Short answer". In Figure 8.6. the least light question is the "True/False" and the worst is the "Essay".

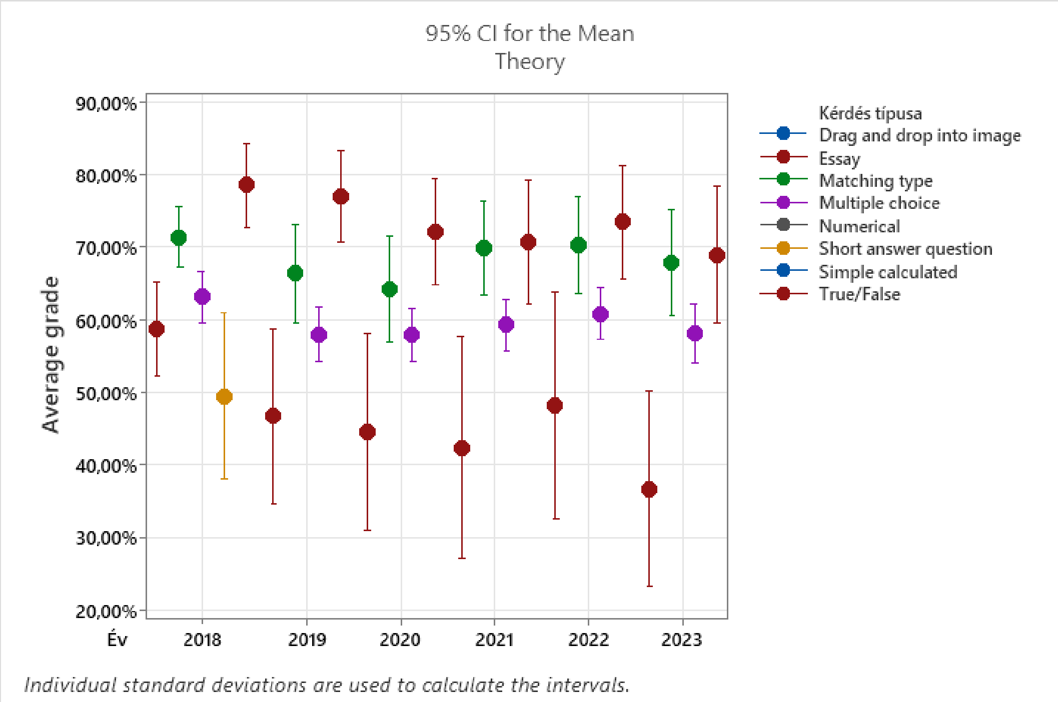

Figure 8.6. The average results of Theory topic for the answered question for the different question types by year (Average grade 100% means that every student knows the right answer).

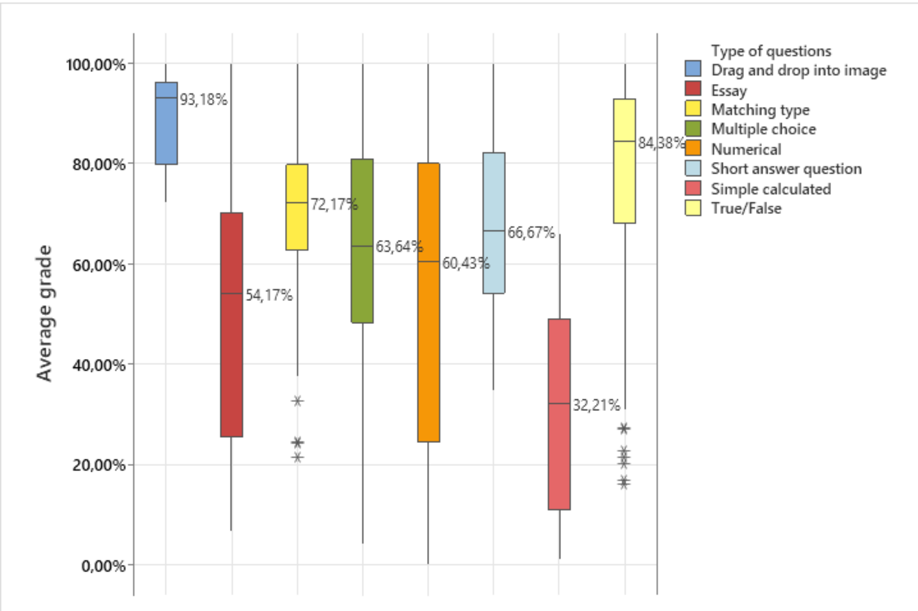

Figure 8.7. The average results of all topics for the answered question for the different question types (Average grade 100% means that every student knows the right answer).

Summarizing the above showed results in one graph (Figure 8.7) it is seen that the absolute easiest question is the "Drag and drop into image", the nest is the "True/False". In

Figure 8.7 the boxplots of all data are where the horizontal lines show the median values of each group (for the 6 examined year in total), the box in the plot represents the interquartile range of the data. The whiskers extend from the box to indicate the range of the dataset, excluding outliers, which are plotted separately as individual points.

8.4. Conclusions

Multiple Choice Questions are popular due to their ease of grading and efficiency in assessing basic knowledge. However, they may not effectively measure higher order thinking skills or provide insight into deeper understanding.

True/false questions are straightforward but can be limited in assessing complex understanding or critical thinking abilities. Short answer questions allow for more flexibility than MCQs, enabling students to demonstrate understanding in their own words.

Essay questions are versatile and allow for in-depth exploration of topics. They are effective for assessing critical thinking, analysis, and synthesis skills. However, grading essays can be time-consuming and subjective. Recently the artificial intelligence (AI) could easily answer the questions and it is hard to control.

Matching questions are useful for assessing knowledge of relationships between concepts or terms. They can be effective for evaluating understanding but may be limited in assessing deeper comprehension.

The effectiveness of online question types depends on factors such as the learning objectives, the level of the learners, and the subject matter. A well-designed assessment should include a variety of question types to accurately measure different levels of understanding and skills.

8.5. References

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9. ENHANCING STEM EDUCATION THROUGH DIGITAL TRANSFORMATION: THE ROLE OF HMI-LAB AT THE UNIVERSITY OF ŽILINA

9.1. Introduction

The digital age has revolutionized the way we approach education, particularly in the fields of Science, Technology, Engineering, and Mathematics (STEM). At the forefront of this transformation is the Human-Machine Interaction Laboratory (HMI-LAB) at the University Science Park, University of Žilina. This unique laboratory is dedicated to exploring human-machine interaction (HMI), with a focus on enhancing both educational and practical applications through cutting-edge research and technology. The laboratory's mission is to not only advance scientific knowledge but also to integrate these findings into practical applications that can enhance the educational process and overall user experience in various technological domains.

The DIGSTEM project aims to improve STEM teaching processes through digital transformation. This initiative underscores the commitment to integrating advanced digital tools and methodologies in STEM education to foster better learning outcomes and prepare students for future technological advancements. The DIGSTEM project is a collaborative effort that brings together experts from various fields to address the challenges and opportunities posed by digital transformation in education. By leveraging digital technologies, the project aims to create a more engaging, efficient, and effective learning environment for students.

9.2. Overview of HMI-LAB

HMI-LAB is a distinguished facility within the University Science Park at the University of Žilina. It provides a controlled environment for comprehensive testing of human-machine interactions under diverse conditions. By meticulously analysing collected data, the lab identifies and recommends enhancements to improve the efficiency and safety of these interactions, establishing itself as an invaluable resource for both research and practical applications. Equipped with state-of-the-art facilities and leveraging a multidisciplinary approach, HMI-LAB enables researchers to conduct extensive studies that explore the intricate dynamics of human-machine interaction. This holistic methodology is crucial for the development of technologies that are not only highly functional but also intuitive, user-friendly, and safe.

9.2.1. Human-Machine Interaction

Human-machine interaction (HMI) refers to the dynamic communication and interaction between humans and machines. It is essentially "the place where technology meets with humans." This interaction is critical in numerous fields, ranging from automotive design to consumer electronics, where understanding user behaviour and optimizing interfaces can significantly impact safety, usability, and user satisfaction.

The study of HMI is inherently multidisciplinary, involving cognitive psychology, engineering, computer science, and ergonomics. Cognitive psychology contributes insights into human perception, memory, and decision-making processes, which are vital for designing interfaces that align with natural human thought processes. Engineering provides the technical foundation for creating and implementing these interfaces, ensuring they are robust and reliable. Computer science offers the tools and algorithms necessary for developing responsive and adaptive systems, while ergonomics focuses on the physical interaction between users and devices, ensuring comfort and efficiency.

One theoretical framework within HMI is the Model Human Processor (MHP), which conceptualizes the human mind as a system composed of perceptual, cognitive, and motor processors. This model helps in predicting how users will interact with a system and where potential bottlenecks or errors might occur. Another important concept is Fitts's Law, which predicts the time required to move to a target area, such as a button on a screen, based on the distance to and size of the target. This law is instrumental in designing user interfaces that are both efficient and user-friendly.

By comprehensively understanding how humans interact with machines, researchers can design interfaces that are intuitive, minimize errors, and enhance the overall user experience. This includes creating adaptive systems that respond to user behaviour in real-time, providing feedback that helps users learn and adapt more quickly, and ensuring that interactions are as seamless and natural as possible. The ultimate goal of HMI research is to create technologies that not only meet functional requirements but also align with human needs and capabilities, leading to more effective and satisfying user experiences.

9.2.2. Integrating Neuroscience in HMI

HMI-LAB leverages neuroscience to delve into consumer responses and decision-making processes. The core principles involve:

- Brain Imaging: Utilizing techniques such as functional Magnetic Resonance Imaging (fMRI) to visualize which areas of the brain are activated during specific tasks. This provides insights into cognitive load and emotional responses, allowing researchers to understand how different stimuli affect brain activity and decision-making.
- Eye Tracking: Using devices like Tobii Pro Glasses 3 and Eye Tracking Glasses 2 to track where and how long a person looks at various stimuli. This technology helps understand focus, attention, and visual engagement. Eye tracking can reveal which elements of an interface attract attention, which are ignored, and how users navigate through visual information.
- Facial Expression Analysis: Employing software like iMotions to analyse facial expressions. This enables the measurement of emotional reactions to different stimuli, providing a deeper understanding of user satisfaction and emotional engagement. Facial expression analysis can help in designing products and interfaces that elicit positive emotional responses.
- Physiological Measurements: Monitoring physical responses such as heart rate, skin conductivity, and body temperature using biosensors. This data can indicate stress levels, arousal, and overall engagement. Physiological measurements are crucial for assessing the physical impact of interactions and ensuring that technologies do not induce undue stress or discomfort.

By adapting these principles to education, the lab aims to enhance student engagement and optimize learning content through continuous feedback and assessment. Neuroscience provides valuable insights into how students learn, what engages them, and how to design educational materials that are both effective and enjoyable.

9.2.3. State-of-the-Art Equipment

HMI-LAB is equipped with both advanced software and hardware to conduct its comprehensive research.

Software Tools:

- SMI Scientific Center Premium Edition: A suite for scientific analysis and visualization of eye tracking data. This software allows detailed examinations of gaze patterns, providing insights into how users interact with visual information.
- EMOTIV Enterprise Plus Edition: An advanced platform for brain-computer interface research. It provides tools for real-time brain activity monitoring, enabling the study of cognitive and emotional states during interactions with technology.

- iMotions: An integrated analysis platform that combines multiple biometric sensors, including eye tracking, facial expression analysis, and EEG. This offers a holistic view of human responses, allowing researchers to correlate different types of data and gain a comprehensive understanding of user behaviour.
- Tobii Pro Studio: Software for designing, conducting, and analysing eye tracking studies. It is widely used in usability research and consumer behaviour studies, helping researchers to optimize visual interfaces for better user experiences.

Hardware Tools:

- Eye Tracking Devices:
  - Tobii Pro Glasses 3: Wearable eye tracking glasses that capture natural viewing behaviour in real-world environments. These glasses are essential for studying how users interact with their surroundings in a naturalistic setting.
  - Pupil Core Eye tracking Glasses: High-precision binocular eye tracking glasses suitable for a wide range of research applications. They provide detailed data on gaze direction, pupil size, and visual attention.
  - RED500 Laptop System: A stationary eye tracker integrated into a laptop. This system allows for detailed analysis of visual engagement in controlled environments, making it ideal for laboratory studies.
  - SMI Eye Tracking Glasses: These advanced glasses provide detailed insights into visual attention and focus, capturing high-precision eye movement data. They are particularly useful for studying user interaction in dynamic and real-world environments.
  - Tobii Pro Fusion: A powerful eye tracker designed for both screen-based and real-world research. It offers high accuracy and precision, making it ideal for detailed visual behaviour studies and complex research scenarios.
- Brain Activity Monitoring:
  - Emotiv EEG Neuroheadset: Wireless EEG headsets that measure electrical activity in the brain. These devices are used for cognitive research and neurofeedback, providing real-time data on brain function.
  - Muse 2 Neuroheadset: A compact and user-friendly EEG device that tracks brain signals, heart rate, and body movements. It is widely used for mindfulness and cognitive studies.
  - Advanced Brain Monitoring Headset X24: A sophisticated device for capturing high-resolution EEG data. It provides deep insights into brain function, enabling detailed studies of cognitive and emotional states.
- Biosensors:
  - BIOHARNESS Telemetric System: A wearable system that tracks physiological metrics such as heart rate, respiration, and skin temperature in real-time.

This system is essential for studying the physical impact of interactions and ensuring user comfort.
  - BIOPAC Sensors: A comprehensive set of sensors for measuring blood pressure, pulse, temperature, and skin resistance. These sensors are crucial for physiological research, providing detailed data on bodily responses to different stimuli.
  - Mindfield eSense Skin Response (GSR): A device that measures galvanic skin response, indicating levels of physiological arousal and stress. GSR data can reveal how users react to different stimuli, helping to design interfaces that are calming and stress-free.
  - Shimmer3 GSR and EXG Sensors: High-precision sensors for capturing skin conductance and electromyography (EMG). These sensors are used to monitor muscle activity and emotional states, providing a detailed understanding of user responses.

9.3. Research Areas

The research conducted at HMI-LAB spans a variety of areas, each contributing valuable insights into human behaviour and interaction with technology:

- Impact Analysis: Studying how external conditions such as noise, lighting, and environmental stressors affect human interaction with machines. This includes examining reaction times and behaviour in crisis situations. Understanding these impacts can lead to the design of more resilient and user-friendly systems.
- Mental Condition Analysis: Investigating how mental states, such as stress, fatigue, and cognitive load, influence a person's ability to operate machinery and devices effectively. This research is crucial for developing systems that support user well-being and productivity.
- Transport Infrastructure Analysis: Evaluating how users interact with transport systems, focusing on safety, usability, and efficiency. This research includes auditing road signs and assessing the impact of visual distractions like billboards. The goal is to improve transport systems for better user experience and safety.
- Ergonomic Design: Improving the design of vehicles, machinery, and workplaces to enhance usability, safety, and comfort. This involves studying user ergonomics in both simulated and real environments. Ergonomic design is essential for preventing injuries and enhancing productivity.
- Visual Smog Analysis: Assessing how visual clutter from advertisements and signs affects driver behaviour and road safety. The goal is to develop guidelines for minimizing visual distractions, thereby improving road safety and reducing accidents.

9.3.1. Realized Research and Student Theses

HMI-LAB has facilitated numerous research projects and student theses, contributing significantly to both academic knowledge and practical applications. Examples include:

- UX Testing of E-shops and Websites: Analysing user experience to optimize online shopping interfaces and improve customer satisfaction. This research helps businesses design more effective e-commerce platforms.
- Email Newsletter Testing: Assessing the effectiveness of different email newsletter formats and designs to enhance engagement. The findings can improve communication strategies for better user retention.
- A/B Advertising Testing: Comparing different versions of advertisements to determine which performs better in terms of attracting and retaining customers. This method provides data-driven insights for optimizing marketing campaigns.
- Customer Flow Testing in E-shops: Studying how customers navigate online stores to identify bottlenecks and optimize the shopping experience. This research aims to increase conversion rates and improve overall customer satisfaction.
- Influence of Visual Smog on Drivers: Examining how billboards and other visual distractions impact driver attention and road safety. The results can inform regulations to minimize distractions and enhance driver safety.
- Visibility of Traffic Signs: Testing the visibility and readability of traffic signs under various lighting conditions to improve road safety. This research ensures that traffic signs are effective in guiding drivers, reducing the risk of accidents.

9.3.2. Promoting Science and Technology Education

In addition to research, HMI-LAB actively promotes science and technology education through various public engagement activities, such as:

- Christmas at the University: Hosting presentation stands to showcase technological innovations and research findings. These events provide an opportunity for the public to engage with cutting-edge research and its applications.
- University Open Days: Presenting the laboratory's work to the public to inspire interest in STEM fields. Open days allow prospective students and the community to see the practical applications of research and its impact on society.
- Researchers' Night: Participating in events like ITExpo and the European Researchers' Night to engage with the community and highlight the importance of research. These events foster a greater appreciation for scientific inquiry and its benefits.

- Collaboration with Schools: Partnering with educational institutions to provide lectures, workshops, and hands-on experiences for students. These collaborations aim to inspire the next generation of scientists and engineers.
- Public Lectures and Workshops: Offering educational sessions to share knowledge and stimulate interest in science and technology. Public lectures and workshops provide valuable learning opportunities for the community.

9.4. Conclusions

The HMI-LAB at the University of Žilina exemplifies the transformative power of integrating advanced technologies and research methodologies into STEM education. By fostering a deeper understanding of human-machine interactions, the lab not only enhances educational outcomes but also contributes to the development of safer, more efficient technological solutions. Through its comprehensive research, state-of-the-art equipment, and commitment to public engagement, HMI-LAB is paving the way for future innovations in STEM education and beyond.

STEM education at HMI-LAB is particularly enriched by the lab’s interdisciplinary approach. The integration of cognitive psychology, engineering, computer science, and ergonomics provides students with a holistic view of technology design and implementation. This multidisciplinary framework is essential for training the next generation of engineers and scientists, equipping them with the skills needed to tackle complex problems and innovate in various technological fields.

HMI-LAB’s focus on real-world applications ensures that students gain practical experience alongside theoretical knowledge. By engaging in projects that analyse user interactions with technology in diverse settings, students learn to apply their skills in meaningful ways. This hands-on experience is invaluable, fostering a deep understanding of how theoretical concepts translate into practical solutions that enhance user experience and safety.

Furthermore, the lab’s commitment to leveraging neuroscience in education introduces students to advanced techniques for measuring and analysing human responses. This exposure to cutting-edge tools and methods not only broadens their technical expertise but also enhances their ability to design user-centric technologies. By understanding how users think and feel, students can create interfaces and systems that are not only functional but also intuitive and engaging.

Public engagement activities and collaborations with schools amplify the impact of HMI-LAB on STEM education. These initiatives inspire younger students to pursue careers in science and technology, fostering a new generation of innovators. By showcasing the exciting possibilities within STEM fields and providing accessible learning opportunities, HMI-LAB helps bridge the gap between education and industry, ensuring that students are well-prepared to meet the demands of the future workforce.

In conclusion, HMI-LAB at the University of Žilina is a beacon of innovation in STEM education. Its comprehensive approach, combining interdisciplinary research, practical applications, and public engagement, provides a robust framework for educating future scientists and engineers. By continuing to push the boundaries of human-machine interaction research, HMI-LAB not only advances technological development but also enriches the educational landscape, preparing students to become leaders in their fields.

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10. ADVANCED STEM EDUCATION: USING UHF RFID MIDDLEWARE FOR DATA CAPTURE AND STORAGE IN IT APPLICATIONS

10.1. Introduction

STEM education is critical in today's society because STEM subjects help students develop the critical thinking, analytical and problem-solving skills that are essential for success in the 21st century. Practical STEM education is equally important because it allows students to engage with and understand key concepts and processes, even if they do not directly address real-world problems. Thus, by attempting to develop solutions to the problem at hand, students gain valuable insights into the meaning of various concepts, key processes, information flows, and develop a holistic view of the issue. The aim of this paper is to describe in simple terms the teaching subject on the stem problem and this subject is "information technology applications".

10.2. RFID Technology

In the modern world, RFID (Radio Frequency Identification) technology plays a key role in various industries. RFID technology enables wireless communication between a reading device and a special tag (RFID identifier) placed on the object to be identified. The communication is realized through electromagnetic waves, therefore, unlike barcode technology, no direct visibility between the reading device and the RFID tag is required. RFID technology belongs to the so-called AIDC (Automatic Identification and Data Collection) family of identification technologies. Other technologies include, for example, the already mentioned barcode technology, voice technology, OCR technology and others. It can be said that the aim of these technologies is to automate the process of object identification and data collection without human intervention or with a significant simplification of the identification process of data collection for the users of this technology. Among the effects resulting from the use of technologies are mainly the increase in efficiency and process precedence. Thus, the elimination of possible error and the acceleration of the identification process ensures the efficiency. Among the long-term effects, one can also mention, for example, the increase in decision-making because of the long-term collection of information. Of course, each process in a different environment and in terms of the requirement of a particular enterprise, technology can be used for different purpose. [1]

There are different types of RFID systems that can vary according to various factors, but basically, they can be divided according to the frequency band within which they operate on:

- Low Frequency (LF) 125-134 kHz, which is used for animal identification, access control systems or shoplifting prevention systems.
- High Frequency (HF) 13,56 MHz, which is used in access control systems, contactless payment systems, i.e. NFC, and shoplifting prevention systems.
- Ultra-High Frequency (UHF) 860-960 MHz, which is mainly used for logistics, i.e. tracking logistics and business units, as well as becoming increasingly used for automated sales of goods in self-service shops.
- Microwave systems 2.45 GHz is used for applications where emphasis is placed on long reading distance or reading an object moving at a higher speed. These can be systems such as electronic toll systems or tracking runners in races.

RFID technology consists of 3 main parts, namely:

- RFID identifiers or also sometimes referred to as RFID tags - are small electronic devices that are attached to objects (or can be embedded inside the object) that are subject to tracking or identification. Each RFID tag consists of an RFID antenna and a chip (i.e., an integrated circuit). They may also be equipped with other elements, such as a memory for storing data (in most cases) and may also contain various sensors that monitor the environment in which the RFID identifier is located. These may be sensors for temperature, humidity, light, GPS, etc. There are many classifications of RFID tags according to various factors, but perhaps the most important is identification by power source. Basically, they can be active and passive, where active ones have their own power source compared to passive ones. For the active ones, according to the way the actual power source is used, they are further classified into semi-active and semi-passive. The former uses its own power supply to extend the range of the transmitted signal and the latter uses it to power only parts of the circuitry, such as memory or sensors. In Figure 10.1, the different types of RFID identifiers can be seen. In the first place, there is an example of a UHF RFID identifier alien without a tag, followed by an industrial RFID identifier destined to logistic handling units and the last one is a semi-passive RFID tag with a battery allowing to record temperature according to the setting of the reading latency. [1]

Figure 10.1. RFID tags.

- RFID readers - are devices that communicate wirelessly with RFID tags, in order to identify an object with the aforementioned objects. RFID readers can be either stationary or mobile. For stationary RFID readers, it is necessary to mention that these allow the connection of multiple reader antennas. In Figure 10.2, the stationary antenna can be seen as Motorola FX 7400, Alien ALR-9800 and the mobile reader Motorola TC200J. [1]

Figure 10.2. Stationary and mobile RFID readers.

- RFID middleware - is a special type of software that allows to connect RFID hardware, i.e. RFID readers with enterprise systems. It represents software for management, filtering or basic analysis of data obtained from read RFID tags. The basic functions include filtering, aggregation and integration of data into enterprise systems. This process can be better seen in Figure 10.3. [1]

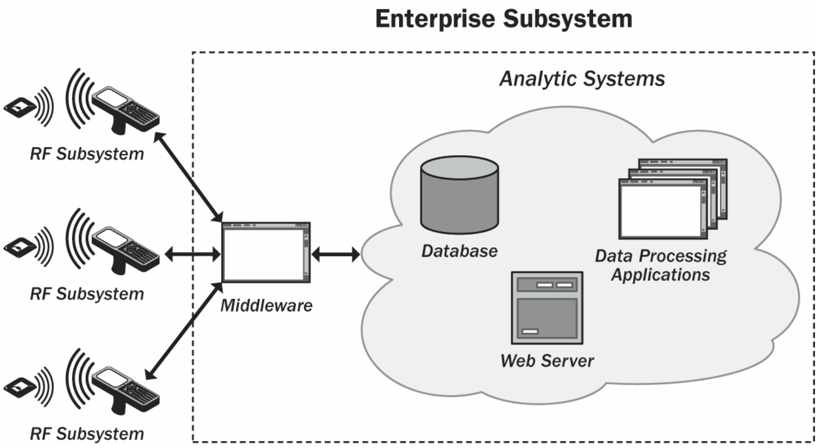

Figure 10.3. RFID subsystem with enterprise subsystem.

The most common type of RFID readers are those that use passive RFID technology. That is, they communicate with RFID tags without their own power supply. The principle of operation of such a system consists in short-term acquisition of the RFID identifier by electromagnetic waves. Each passive RFID reader has one or more antennas. These antennas can operate according to the reader support in 3 different modes viz:

- Electromagnetic wave transmission mode,
- Reading mode,
- Alternating transmit and read mode.

The principle of retrieval lies in the fact that the antennas emit an electromagnetic field, with the direction and length of the transmitted waves depending on the setting and technical design of the RFID antennas. Thus, if the RFID enters this electromagnetic field, it absorbs this field through its antennas and converts it to power its circuits. The circuit thus energized then reads the information (unique identifier) stored in the RFID tag's memory and the tag again sends this information into space via the RFID tag's antenna. This information is then read by the RFID reader and converted into the required form. The principle of operation is shown in Figure 10.4.

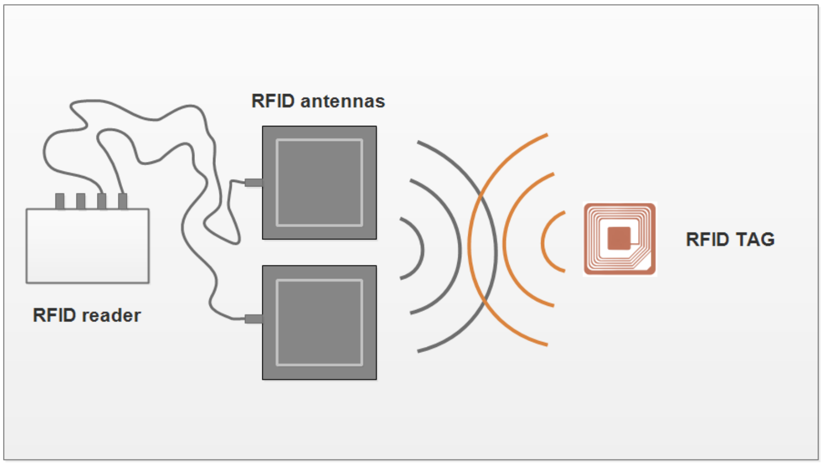

Figure 10.4. Functional principles of RFID technology.

10.3. Introduction to the Education Subject

Within the Department of Communications, emphasis is placed on the training of future professionals in the field of logistics and distribution, which is reflected in the composition of courses taught in the Department of Communications. This particular course, "Applications of Information Technology, focuses on key aspects of the technological processes of the logistics and distribution chain and warehousing. Students in this course will gain knowledge regarding the creation of labels for shipping and trading units, also the basics of warehouse management and automation of identification of logistics units.

During the practical part of the course, students will develop skills in designing and creating barcode and RFID identifier labels. Likewise, he/she will master working with real RFID middleware and RFID readers, which are available in the Automatic Identification Laboratory, which falls after the catheter connections, as part of the education. Through this course, students will prepare for real-world challenges in logistics and distribution with the ability to manage and optimize logistics processes using modern technologies and standards.

10.4. AMP Aton OnID

Aton onId is a tool from an Italian company dedicated to creating complex solutions based on RFID technology. Their tool i.e. Middleware is designed to be user friendly and does not require deep programming skills. However, basic theoretical programming knowledge such as conditions and loops are useful to fully understand its functionalities.

Working in the Aton onID middleware involves creating so-called unit processors and interconnecting them. These interconnections can be fixed or conditional, which provides flexibility when creating applications. The application development process is intuitive and follows a standard "Drag and Drop" style, meaning that users can simply drag and drop components into the workspace and connect them as needed.

An application in Aton onID is made up of a set of interconnected processors. The behaviour of individual processors can be further customised through their internal settings to provide the desired functionality. Data is sent between processors via XML messages, with identification implemented using the XPath language, also known as the "path language".

Figure 10.5. Selection item menu.

When inserting an element into the workspace area, 3 basic elements are available, namely:

- The database connector processor,
- Functional processors,
- And labels.

In Figure 10.5 you can see the element selection menu.

As already mentioned, all processors and their connections are created within the workspace area. Apart from this part of the middleware, there is also a so-called terminal, which is used for feedback on functionality, bugs and as a verification tool for application functionality. In Figure 10.6, on the left side, the workspace area can be seen and on the right side of the figure the logging terminal.

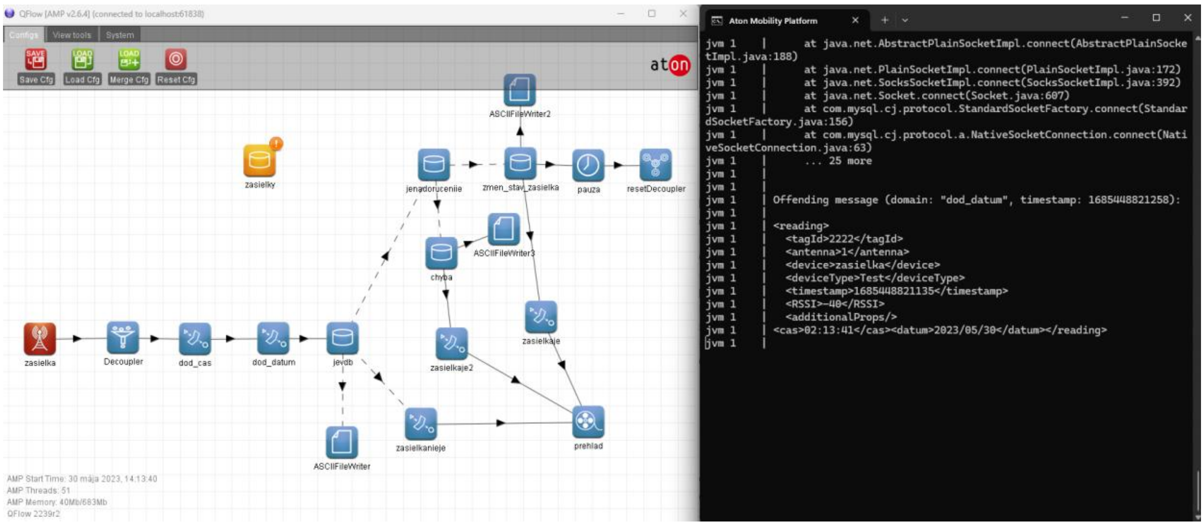

Figure 10.6. Parts of Aton onld graphical environment.

The second group, i.e. functional processors, are organized into so-called processor families, which are groupings of processors with similar functionality or meaning. Here is a basic listing of processor families and their functions:

- The processors for connecting RFID readers.
- Processors for data filtering.
- Processors for data editing.
- Processors for mathematical operations.
- Processors for working with databases, i.e. SQL queries.
- Processors for working with other systems or peripherals.

In Figure 10.7 we can see a list of the individual processor families, the processes that fall under a particular group and the description of the processor itself.

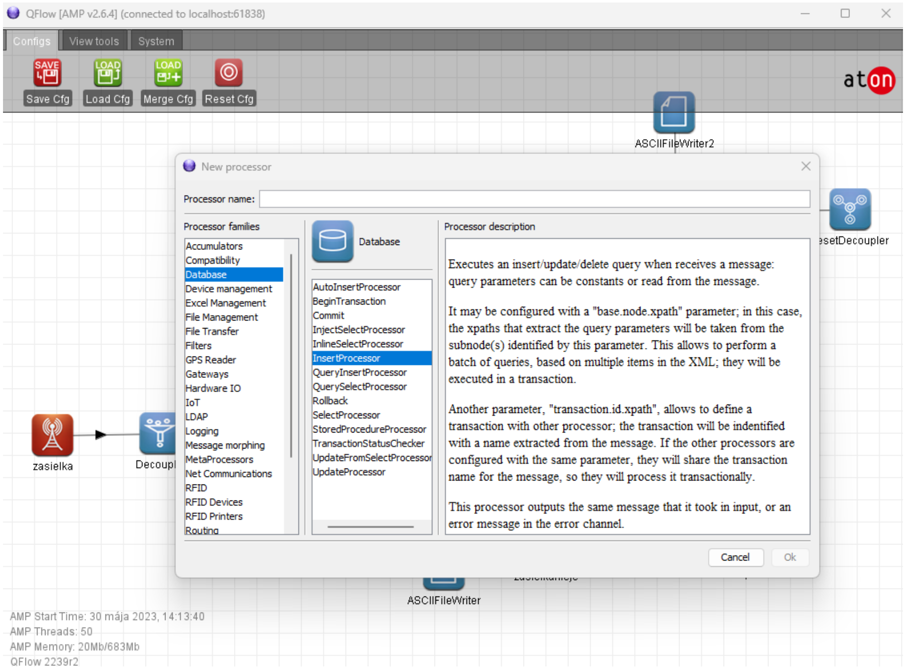

Figure 10.7. Processor families and their selection.

Figure 10.8 also shows the actual setup of a particular processor. Most processors require input and output parameters to be set. Specifically, this processor performs the "select" operation, i.e., retrieving data from the database based on input parameters (xpath: /reading/tagId) floating into this processor from the previous processor. I.e. query states to retrieve the "status" column from the "mailings" table for the row where column "tagId" is equal to the input parameter. Some have multiple input settings, some perform only one task, so they don't need to be set at all.

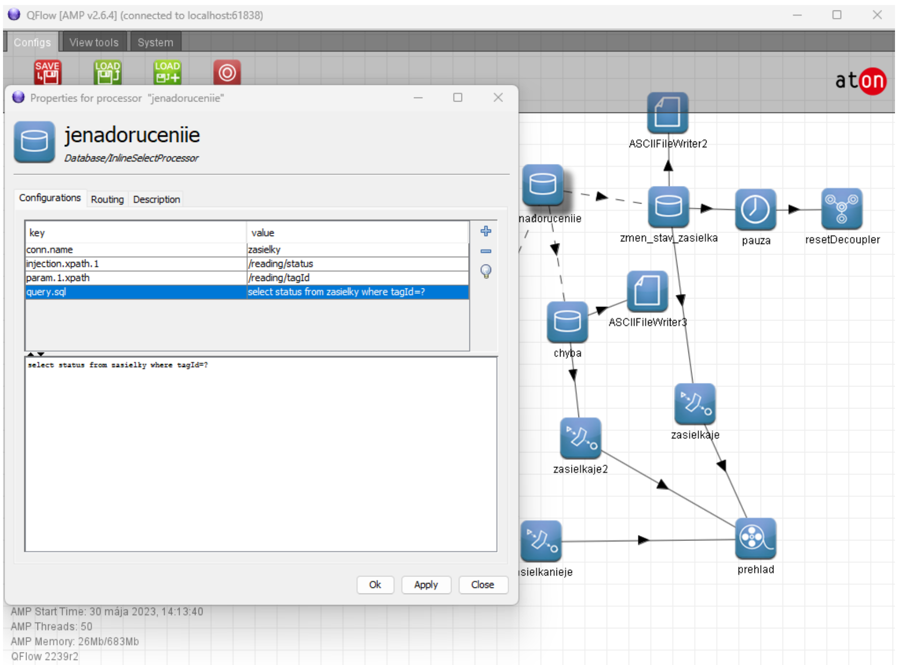

Figure 10.8. Processor settings.

Within the development of the application, there is also available within the processor family for connecting RFID readers, a fictional or rather simulation RFID reader, which after setup displays similar characteristics to the real one. This functionality therefore allows applications to be tested first in a safe and controlled environment before real testing. Of course, in the case of real testing of our students, the testing in the lab must adapt to the mapped processes of the real process. As part of their project, students first work on the background information and processes. Based on the analysis of the data and information and their relationships, they then develop a database application, i.e. a schema. They analyse different possibilities for the form of the unique identifier that is to be used to identify the object in the project. They then develop a middleware application on this schema, first simulating and then verifying the functionality on a real RFID device in the AIDC lab.

10.5. Conclusion

Advanced STEM education, such as provided by our education subject at the University of Žilina, is essential for preparing future professionals in logistics and distribution. The "Applications of Information Technology" education subject focuses on key technological processes, including warehousing and automatic identification using RFID technology. RFID (Radio Frequency Identification) is crucial for efficient and accurate data collection and object identification. Our hands-on approach with Aton onID middleware enables students to develop practical skills in creating and interconnecting unit processors in a user-friendly environment. Through practical exercises and simulations, students learn to design, test, and verify RFID applications, gaining valuable insights into modern logistics technologies. This education prepares them to manage and optimize logistics processes, ensuring they are well-equipped for real-world challenges in their future careers.

10.6. References

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11. ONLINE LEARNING ENVIRONMENT AT UNIVERSITY OF ZILINA

11.1. Introduction

The DIGSTEM project aims to revolutionize the teaching process in STEM (Science, Technology, Engineering, and Mathematics) fields through the integration of digital technologies. This initiative is a response to the growing need for innovative teaching methods that cater to the evolving educational landscape [1].

The primary goal of DIGSTEM is to enhance the learning experience by making it more interactive, efficient, and engaging for both students and educators. This is achieved through the use of advanced digital tools and platforms that facilitate various educational activities. By incorporating these technologies, the project ensures that learning is more accessible and flexible, accommodating the diverse needs of the modern student body.

The online learning environment at the University of Zilina is a cornerstone of the DIGSTEM project. It encompasses a comprehensive suite of digital resources and applications designed to support both teaching and administrative functions. Key features include the Vzdelavanie.uniza.sk platform, which integrates the LMS MOODLE, mobile applications, and a variety of web services such as the Library MS Teams and the Academic Information and Learning System (AILS) (Figure 11.1).

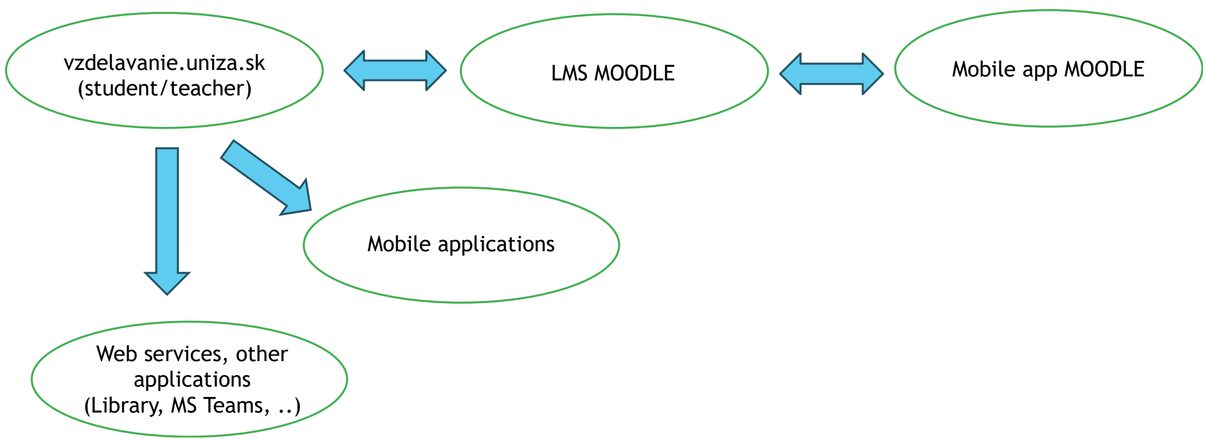

Figure 11.1. AILS (Academic Information and Learning System) structure at UNIZA [2].

This robust infrastructure not only streamlines the educational process but also provides students and educators with the tools they need to succeed in a digital age. From managing study plans and course content to facilitating communication and feedback, the online learning environment is tailored to meet the needs of the academic community at the University of Zilina.

By leveraging digital transformation, the DIGSTEM project aims to set a new standard in STEM education, fostering an environment where learning is continuous, collaborative, and conducive to the development of future-ready skills.

11.2. Main Features of the Online Learning Environment

Academic Information and Learning System (AILS) at University of Zilina is a comprehensive system that integrates various educational tools and resources, providing a centralized platform for managing academic information and learning activities. It includes features for course registration, grade tracking, and academic advising.

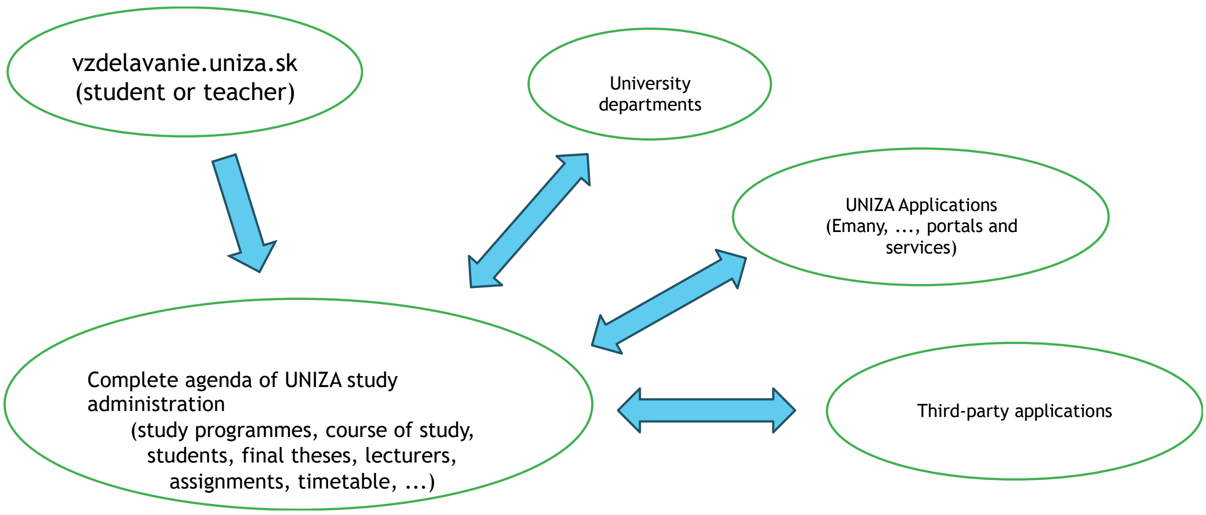

Figure 11.2. Information system - vzdelavanie.uniza.sk [3].

Vzdelavanie.uniza.sk (Figure 11.2) is the primary online learning platform at the University of Zilina. Vzdelavanie.uniza.sk, serves as the central hub for all digital educational ctivities. It offers a comprehensive suite of tools designed to enhance the learning experience for both students and educators. The platform is divided into several key components:

- LMS MOODLE: MOODLE (Modular Object-Oriented Dynamic Learning Environment) is the core Learning Management System used by the university. It supports a wide range of educational activities, including course management, online quizzes, discussion forums, and resource sharing. MOODLE is highly customizable and allows instructors to create interactive and engaging course content tailored to their teaching methods and student needs [4].

- Mobile App MOODLE: To ensure flexibility and accessibility, the University of Zilina provides a mobile application version of MOODLE. This app allows students and teachers to access course materials, submit assignments, participate in discussions, and receive notifications on their mobile devices. The mobile app ensures that the learning process can continue seamlessly, regardless of location.

Mobile applications are a crucial aspect of the online learning environment, enhancing the accessibility and convenience of educational resources. The University of Zilina offers several mobile apps designed to support various educational functions:

- MOODLE Mobile: This app provides a mobile-friendly interface for the MOODLE platform, allowing users to engage with course content and activities from their smartphones or tablets.
- Library Access App: This app enables students and staff to access the university's library resources, including e-books, journals, and research databases, from their mobile devices.
- MS Teams App: The mobile version of Microsoft Teams allows for real-time communication and collaboration, facilitating virtual meetings, class discussions, and group work on the go.

Web Services and Other Applications

The integration of web services and various applications into the online learning environment at the University of Zilina enriches the educational experience by providing diverse tools and resources, for example Library or MS Teams app. MS Teams is a collaborative platform that integrates with the university's library services, allowing students and faculty to conduct virtual meetings, share resources, and collaborate on projects.

11.2.1. Key Functionalities of the AILS System of UNIZA

Main Page of Vzdelavanie.uniza.sk

The main page of Vzdelavanie.uniza.sk serves as a centralized portal for all study-related activities. This page offers a comprehensive view of study programs, course information, student records, and administrative tasks. Key functionalities include:

- Study Programs Overview: Students can access detailed information about various study programs, including course requirements, elective options, and progression pathways.
- Course Information: Detailed course descriptions, schedules, and syllabi are available, helping students make informed decisions about their studies.
- Student Records: Access to academic records, including grades, attendance, and progress reports, ensuring students can monitor their academic performance.
- Administrative Tasks: Streamlined processes for tasks such as course registration, fee payments, and scheduling, making it easier for students and teachers to manage their academic activities.

This portal is designed to streamline the management of academic activities, making it easier for students and teachers to access the information they need. By providing a one-stop platform for all academic needs, the main page helps improve efficiency and reduce administrative burdens [3].

Microsoft Teams

Microsoft Teams is utilized to enhance collaboration and communication within the university. Key functionalities of MS Teams in the academic setting include:

- Class Organization: Teachers can create and manage virtual classrooms, where they can post announcements, share resources, and assign tasks.
- Resource Sharing: Easy sharing of documents, presentations, and other educational materials, ensuring all students have access to the necessary resources.
- Virtual Meetings: Conducting live virtual classes and meetings, allowing for real-time interaction between teachers and students.
- Collaboration Tools: Features such as chat, file sharing, and collaborative document editing, facilitating group work and peer interactions.

The integration of MS Teams with other educational tools ensures a seamless experience for both educators and students, promoting an interactive and engaging learning environment [5].

Electronic Applications for Studies

Electronic applications provide a user-friendly interface for managing various academic activities. These applications are designed to support both students and teachers in their academic endeavors. Key functionalities include:

- Course Enrollment: Simplified course registration processes, allowing students to easily enroll in their desired courses each semester.

- Study Material Access: Centralized access to study materials, including lecture notes, textbooks, and multimedia resources, enabling students to efficiently gather the information they need.
- Assignment Submission: Online platforms for submitting assignments, ensuring a streamlined process for both students and teachers. Teachers can provide feedback and grades directly through the system.
- Academic Progress Tracking: Tools for tracking academic progress, including grade monitoring, attendance tracking, and progress reports. This helps students stay informed about their performance and areas for improvement.
- Communication Tools: Integrated messaging and notification systems, allowing for effective communication between students and teachers regarding course updates, deadlines, and other important information.

These electronic applications are crucial for creating a cohesive and efficient academic environment, where both students and teachers can focus on their educational goals without being hindered by administrative complexities.

11.2.2. Detailed Application Insights at UNIZA

The Academic Information and Learning System (AILS) at the University of Zilina provides a comprehensive and user-friendly platform that supports various academic activities and processes. The system includes several key features that are essential for managing and enhancing the educational experience. Here are detailed insights into its functionalities:

- Study Plans: Study plans are carefully structured to provide students with a clear roadmap of their academic journey. These plans outline the required courses, electives, prerequisites, and the sequence in which courses should be taken. This ensures that students can plan their studies effectively and meet their academic goals.
- Courses by Department: Each department at the University of Zilina provides detailed information about the courses they offer. This includes course descriptions, learning objectives, prerequisites, and scheduling information. Students can use this information to choose courses that align with their academic and career goals.
- Emany Payment Application: The Emany payment application is designed to facilitate financial transactions related to student services. This includes tuition payments, fees for various services, and other financial activities. The application ensures a smooth and transparent process for handling financial transactions (Figure 11.3).

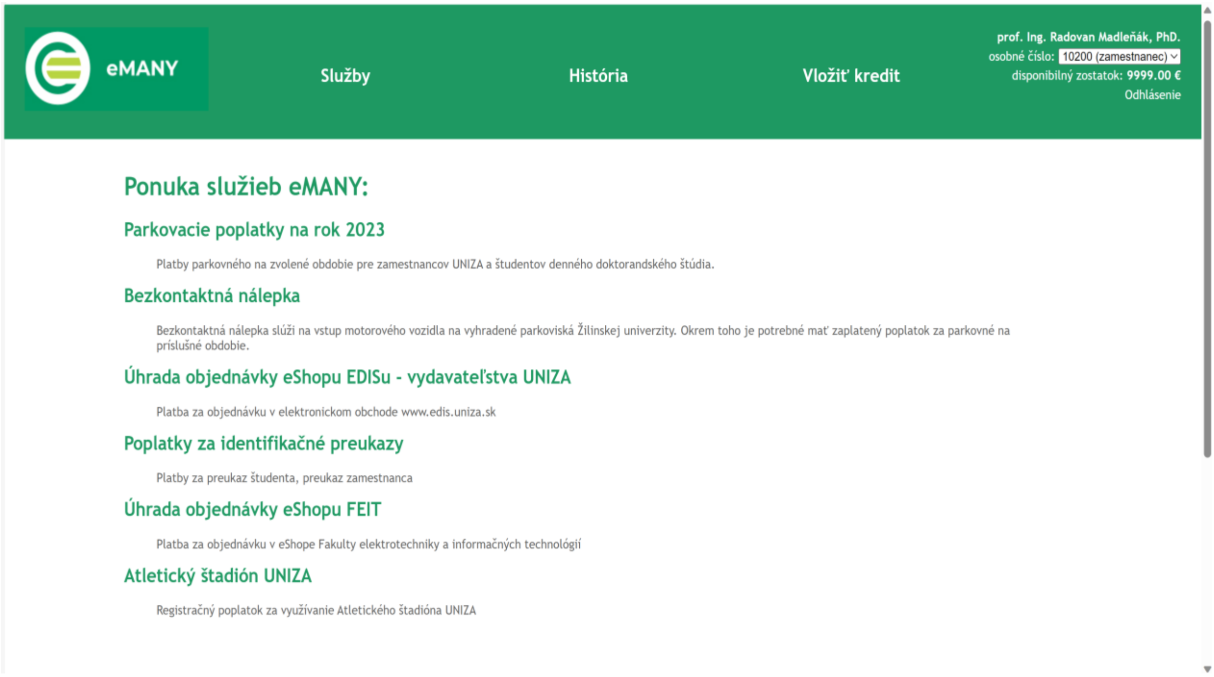

Figure 11.3. Uniza payment application – Emany [6].

Timetable Management System

Efficient timetable management is essential for coordinating lectures, rooms, and teacher assignments. The timetable management system allows for the creation and adjustment of schedules, ensuring that resources are used optimally and scheduling conflicts are minimized. This system helps in maintaining an organized and efficient academic calendar.

Course Syllabus System

The course syllabus system provides students with detailed information about the content, objectives, and requirements of each course. This includes information about textbooks, grading criteria, assignment deadlines, and exam schedules. The syllabus helps students understand what is expected of them and how to prepare for each course.

Exams and Grades System

The exams and grades system manages the scheduling of exams, student registrations, and the grading process. This ensures that exams are conducted fairly and that students' performances are evaluated accurately. The system provides transparency and accountability in the grading process, allowing students to track their academic progress.

Special Features for Students

- Specific Needs Indicator: The specific needs indicator is designed to support students with special requirements. This feature ensures that all students have equal access to educational resources and opportunities, accommodating their unique needs to provide an inclusive learning environment.
- Student Feedback System: The student feedback system allows students to provide their input on various aspects of their courses and the learning environment. This feedback is used to improve the quality of education by identifying areas for improvement and implementing changes based on student suggestions (Figure 11.4).
- Messaging System: The messaging system facilitates communication between teachers and students. This system allows for timely dissemination of information, such as announcements, assignment reminders, and feedback on student work. Effective communication is essential for maintaining an engaging and productive learning environment.

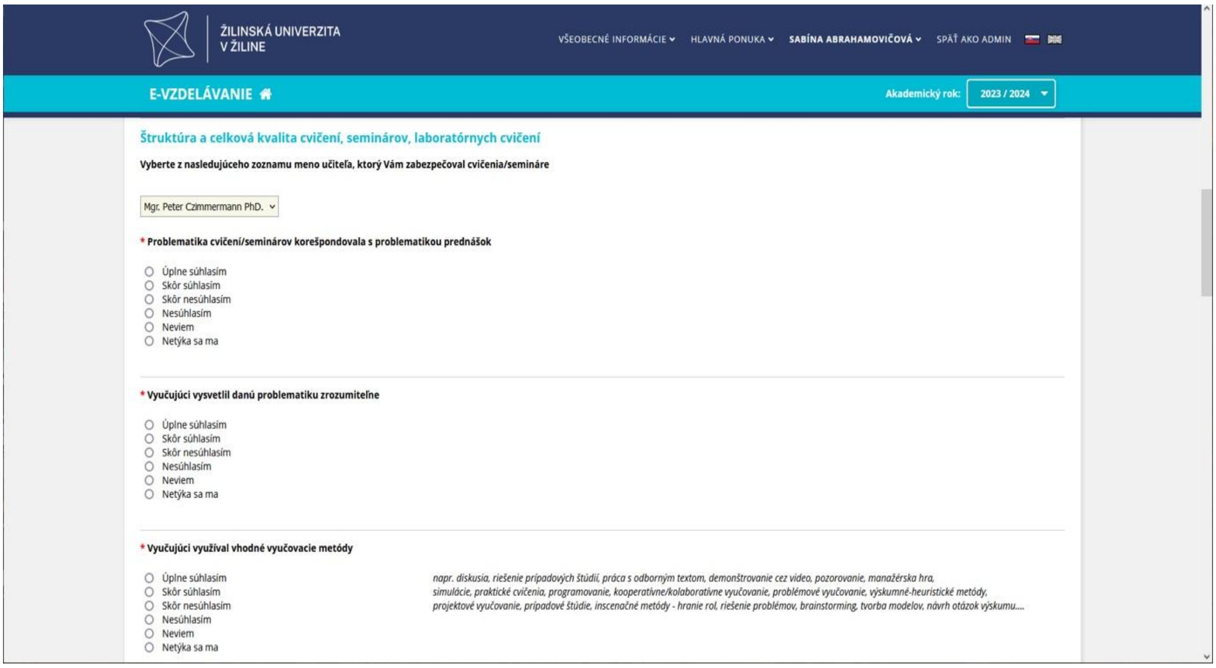

Figure 11.4. Vzdelavanie.uniza.sk – Student Feedback System [7].

Final Thesis Management System

The final thesis management system includes features for submitting thesis applications, tracking progress, and accessing a comprehensive list of available thesis topics. This system streamlines the process of managing final theses, ensuring that students can complete their projects successfully.

11.3. Moodle at UNIZA

The Moodle platform at the University of Zilina is a versatile and robust Learning Management System (LMS) designed to support various aspects of the educational process. It offers a range of features and functionalities that cater to the needs of both students and educators (Figure 11.5).

11.3.1. Moodle Features

The Moodle platform supports seamless course enrollment processes with robust role assignments and security measures. Key aspects include:

- Role Assignments: Students and teachers are assigned specific roles, each with tailored permissions to access course materials and perform necessary actions. This ensures that users only access the content and tools relevant to their roles, maintaining the integrity and security of the platform.
- Enrollment Management: The system allows for automated and manual enrollment processes, enabling administrators to efficiently manage course enrollments and track student participation.

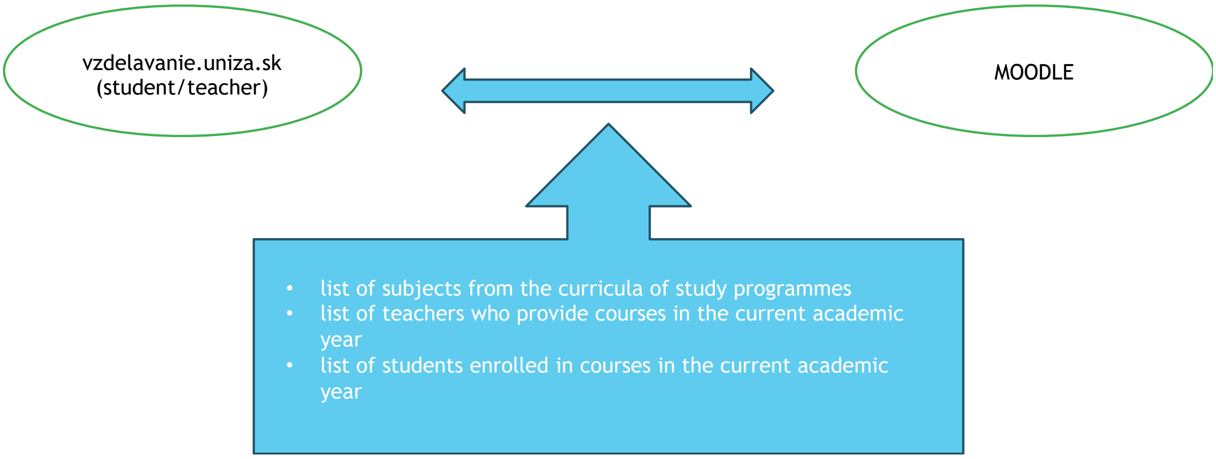

Figure 11.5. UNIZA Moodle IS - user's view [3].

Moodle's user interface is designed to enhance the user experience with detailed views and functionalities:

- Content Creation and Management: Instructors can create and manage course content using various tools. This includes uploading documents, creating multimedia presentations, and organizing course materials into structured modules.
- Assessments and Tracking: Moodle provides tools for creating and administering assessments, such as quizzes, assignments, and exams. Instructors can track student progress through detailed reports and analytics, allowing for timely interventions and support.

- User Interface: The platform offers a user-friendly interface that is intuitive and easy to navigate. Students can easily access course materials, submit assignments, participate in forums, and view their grades [3].

The University of Zilina provides public access to LMS Moodle system for specific purposes:

- Erasmus students can access Moodle to participate in courses and activities offered by the university. This fosters international collaboration and ensures that visiting students can seamlessly integrate into the academic environment.
- Public access is also granted for promotional purposes, allowing prospective students and external parties to explore the university's educational offerings and resources. This helps showcase the university's commitment to high-quality education and innovative teaching methods.

11.3.2. Security of E-Learning Systems

Ensuring the security of the e-learning systems is a top priority for the University of Zilina (Figure 11.6). Key security measures include:

- Data Encryption: All data transmitted and stored within the Moodle platform is encrypted to protect against unauthorized access and data breaches.
- Secure Login Processes: The platform employs secure login processes, including multi-factor authentication, to ensure that only authorized users can access the system.
- Regular Security Audits: The university conducts regular security audits to identify and address potential vulnerabilities. This proactive approach helps maintain the integrity and reliability of the e-learning environment.

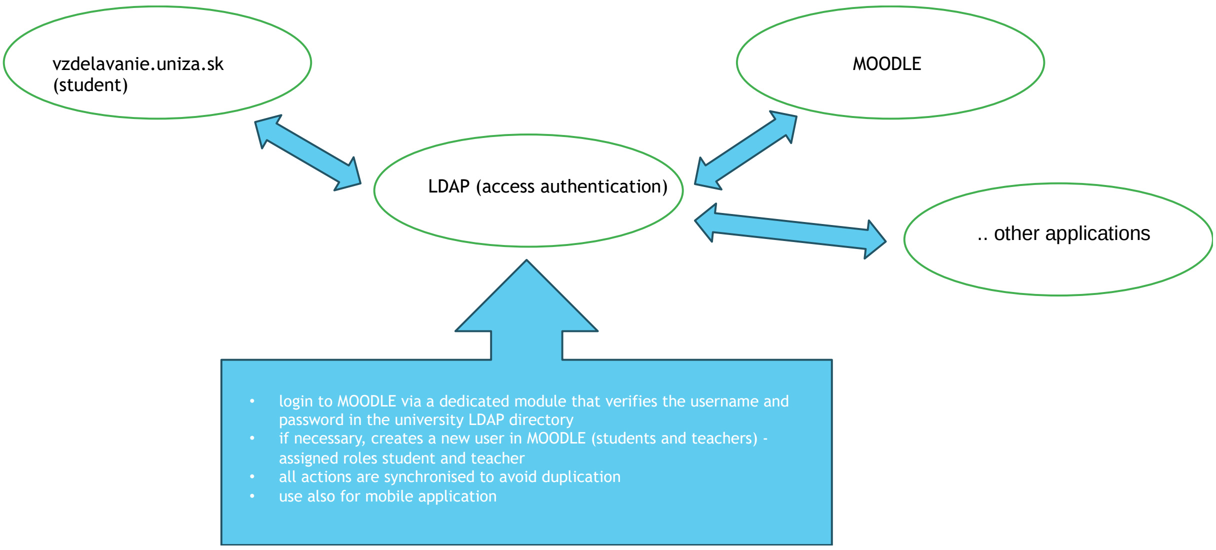

Figure 11.6. Security of UNIZA eLearning systems.

LDAP (Lightweight Directory Access Protocol) authentication is used to synchronize and automate user data across various systems [8]. Key benefits include:

- User Data Synchronization: LDAP ensures that user data is consistently and accurately reflected across all systems, reducing the need for manual updates and minimizing errors.
- Automated Role Assignments: By integrating LDAP with Moodle, role assignments can be automated based on user attributes, such as their department or course enrollment. This simplifies user management and enhances security.
- Enhanced Security: LDAP authentication provides a secure and centralized method for managing user credentials, reducing the risk of unauthorized access and ensuring that all actions are properly authenticated and logged.

11.4. Summary

The online learning environment at the University of Zilina, underpinned by the DIGSTEM project, represents a significant advancement in the integration of digital technologies in STEM education. By adopting innovative teaching methods and leveraging advanced digital tools, the university has created a dynamic and flexible educational ecosystem that enhances the learning experience for both students and educators.

The comprehensive suite of resources of the Academic Information and Learning System available on the Vzdelavanie.uniza.sk platform, including the LMS MOODLE, mobile applications, and various web services such as the University Library and MS Teams provides a robust infrastructure that supports both teaching and administrative functions. This integrated approach not only streamlines academic activities but also facilitates effective communication, feedback, and administrative management, thereby improving overall efficiency.

Key functionalities of the AILS system, offer a centralized platform for managing academic information and activities. These features help students and educators access essential resources, manage coursework, and track academic progress seamlessly. Detailed application insights further highlight the system's capability to support structured study plans, course information, financial transactions, and timetable management.

The Moodle platform at UNIZA stands out as a versatile and robust LMS, supporting a wide range of educational activities. Its features, including course enrollment, content creation, assessments, and user interface, enhance the educational experience by providing a user-friendly and secure environment.

Ensuring the security of e-learning systems is a top priority for the University of Zilina. Measures such as data encryption, secure login processes, and regular security audits protect the integrity of the e-learning environment. Additionally, LDAP authentication enhances security and simplifies user management by automating role assignments and ensuring consistent user data synchronization.

In conclusion, the online learning environment at the University of Zilina exemplifies the effective integration of digital technologies in education. By fostering a continuous, collaborative, and future-ready learning environment, the DIGSTEM project sets a new standard in STEM education, positioning the university as a leader in innovative teaching and learning practices. This commitment to digital transformation ensures that the University of Zilina will continue to meet the evolving needs of students and educators in the digital age.

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[2] University of Žilina. 2023. e-vzdelávanie**.** Retrieved June 12, 2024, from https://uniza.sk/index.php/studenti/prakticke-informacie/e-vzdelavanie

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12. THE USE OF E-LEARNING TOOLS IN THE TEACHING OF TECHNICAL SUBJECTS AT THE UNIVERSITY OF ZILINA

12.1. Introduction

STEM education is essential in today's society because STEM subjects help students develop the critical thinking, analytical and problem-solving skills that are essential for success in the 21st century. However, traditional methods of teaching STEM subjects often fail to meet the specific needs and demands of today's generation of students. Students today are characterized by shorter concentration times, a preference for interactive and engaging content, and a need for meaningful connections between theory and practice. One way to bring STEM fields closer to today's students is through the use of e-learning tools. In fact, e-learning tools play an important role in modernizing STEM education and making it more accessible and attractive to students at all levels. The aim of this paper is to provide information about the use of STEM tools for teaching the subject of database design at the Department of Communications at the University of Žilina. The article will introduce the concept of teaching implemented by a combination of educational tools.

12.2. STEM educational tools

Educational tools used in teaching the subject of database design can be divided into two main groups. The first group of tools can be labelled as internal, i.e. those tools that are directly available for each subject taught at the University of Žilina and the second group, i.e. external, are tools that are available only specifically for this subject. The two groups form a specific mutually interacting and complementary group of tools that help students to acquire not only knowledge but also skills.

The internal tools group includes:

- LMS Moodle,
- MS Teams.

The external tools group includes:

- Oracle Academy i-learning system,
- APEX.

In Figure 12.1, a brief summary of the activities used for each i-learning tool can be seen.

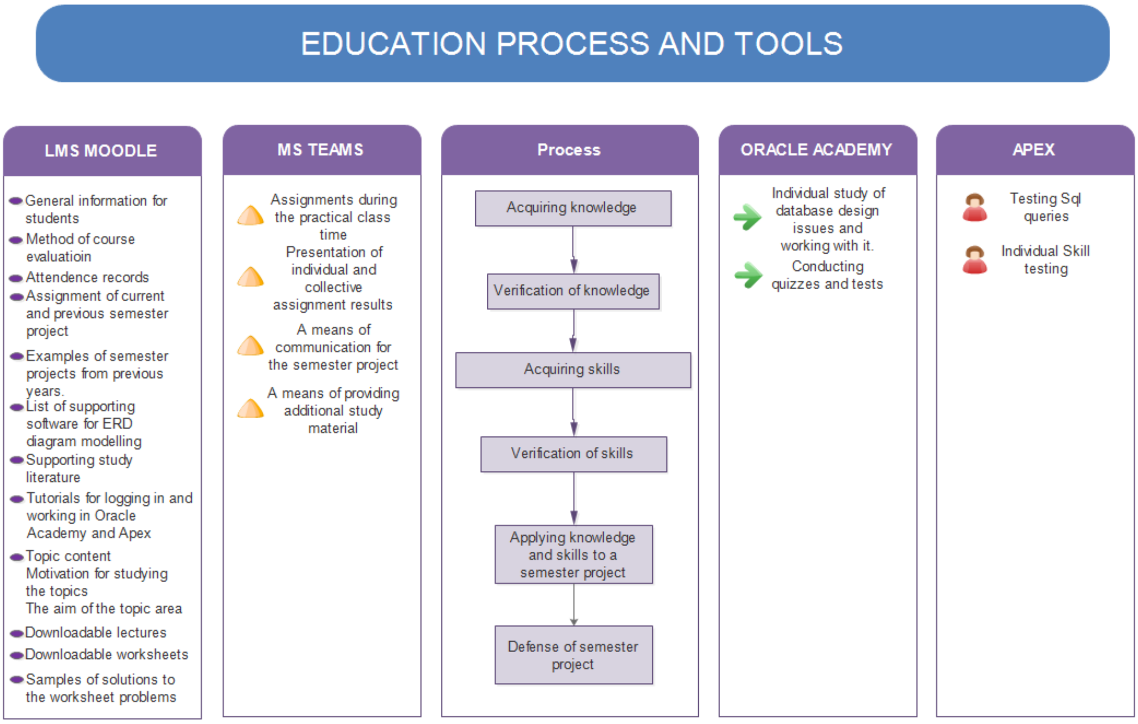

Figure 12.1. Activities of the educational process in individual tools.

12.2.1. LMS Moodle

LMS Moodle is one of the most used open-source platforms in the world. Its structure and add-on import capabilities make it a unique tool for creating courses, sharing information, assigning tasks and evaluating progress.

The main purpose of the LMS Moodle in teaching the subject is to provide a syllabus, instructions and support material that is separately specified for each week of teaching (i.e. sections). In the introductory section, information about the assessment system within is provided as well as a tutorial with an example of how to calculate the final assessment based on the completed assignments, see Figure 12.2.

Cvičenie z predmetu Databázový dizajn

- Oznámenia
- Prosby a námitky
- Dochádzka
- Skúška 27.5. 2024
- Skúška 24.5. 2024

Systém hodnotenia cvičení:

	Hodnotený prvok		body (max)	v %
1.	Testy na tématiku databázového dizajnu (Databázový dizajn)	Pololetní test	50	100%
		Konečný test	50	
2.	Testy na tématiku používání SQL dotazů (SQL dopyty)	Pololetní test	50	100%
		Konečný test	50	
3.	Semestrální projekt (Návrh ERD diagramu)	Práce	50	100%
		Prezentace	50	
4.	Bonusy a aktivita		10	10%

Maximálny počet bodov, ktoré môže študent získať za cvičenie, je 50b.

Výpočet počtu bodov za cvičenie možno vypočítať podľa nasledujúceho vzorca:

$$Výsledok = \left(\left(\frac{\text{Databázový dizajn} + \text{SQL dopyty} + \text{Návrh ERD diagramu}}{3}\right) + \text{bonus a aktivita}\right) * 0{,}5$$

Figure 12.2. Course evaluation system [1].

Príklad: Budeme simulovať, že ste za každú časť získali nasledujúce body.

1.	Testy na tématiku databázového dizajnu (Databázový dizajn)	Pololetní test	32	60%
		Konečný test	38	
2.	Testy na tématiku používání SQL dotazů (SQL dopyty)	Pololetní test	40	90%
		Konečný test	50	
3.	Semestrální projekt (Návrh ERD diagramu)	Práce	40	75%
		Prezentace	35	
4.	Bonusy a aktivita		10	10%

Takže výpočet bude vyzerať takto:

$$Výsledok = \left(\left(\frac{\text{Databázový dizajn} + \text{SQL dopyty} + \text{Návrh ERD diagramu}}{3}\right) + \text{bonus a aktivita}\right) * 0{,}5$$

$$Vysledok = \left(\left(\frac{60+90+75}{3}\right) + \text{bonus a aktivita}\right) * 0{,}5$$

$$Vysledok = \left(\left(\frac{225}{3}\right) + \text{bonus a aktivita}\right) * 0{,}5$$

$$Vysledok = ((75) + (75 * 0{,}1)) * 0{,}5$$

$$Vysledok = ((75) + 7{,}5) * 0{,}5$$

$$Vysledok = (82{,}5) * 0{,}5$$

$$Vysledok = 42{,}25b$$

To znamená, že za cvičenie na skúšku získate 42,25 bodu z možných 50 bodov.

Figure 12.3. Example of evaluation system [1].

Examples of semester projects from previous years are available on the learning platform, as well as project assignments valid for the current and previous years (see Figure 12.4). These projects serve as reference material so that students can see what results are expected of them in their future projects. Students can use different ERD tools to create their projects, with the choice of a particular tool depending on their preferences. A list of the recommended tools mentioned is given after the project examples section.

Semestralný projekt

Predchádzajúce a súčasné projektové úlohy (zadania), t. j. scenáre:

- Semestralný projekt - Zdravie, scénár rok 2022
- Semestralný projekt - Recykluj, scenár rok 2023
- Semestrální projekt - Knihovna Opočno rok 2024

Podpůrný software pro modelování ERD diagramů - odlišné notace

- **SQL Developer Data modeller (free)**
  Odkaz ke stažení: **https://www.oracle.com/database/sqldeveloper/technologies/sql-data-modeler/download/**
- **Mysql Workbench**
  Odkaz ke stažení: **https://dev.mysql.com/downloads/workbench/**
- **MS Vision (free pro studenty uniza)**
- **EDraw Max (Komerční)**
- **DrawIO (free a online)**

Figure 12.4. Semester Project and practical tools [1].

The basic list of information within the course is concluded with a list of supporting literature related to the subject area, see Figure 12.5.

Podpůrná naučná literatura:

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Figure 12.5. Supporting literature [1].

As part of the resources related to the introductory lecture, the Moodle course also includes video tutorials for logging into the Oracle Academy i-learning platform, see Figure 12.6.

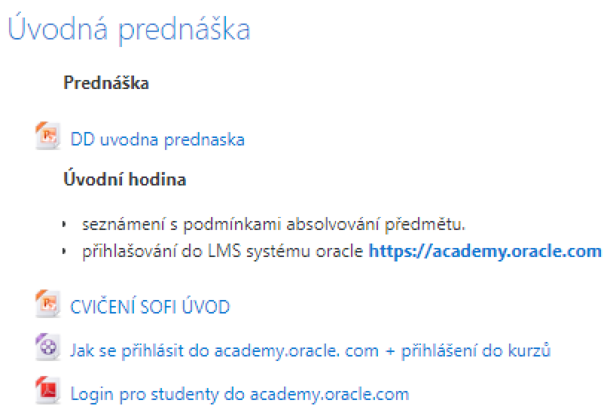

Figure 12.6. Introductory lesson [1].

Each lesson has its own section in the Moodle channel, which is made up of basic information. That is, the content of the topic area is specified in the form of a list, followed by the motivation, i.e. what the student should know after appropriate study and review of the topic area, followed by the objective, which specifies the purpose in terms of the overall purpose of database design. Within each section, the lecture in ppt file and also the worksheets in work and pdf versions are available for download. The worksheet is used for the practical part of the course. The basic concepts for the subject are always presented, including exercises for practice. A sample section can be seen in Figure 12.7.

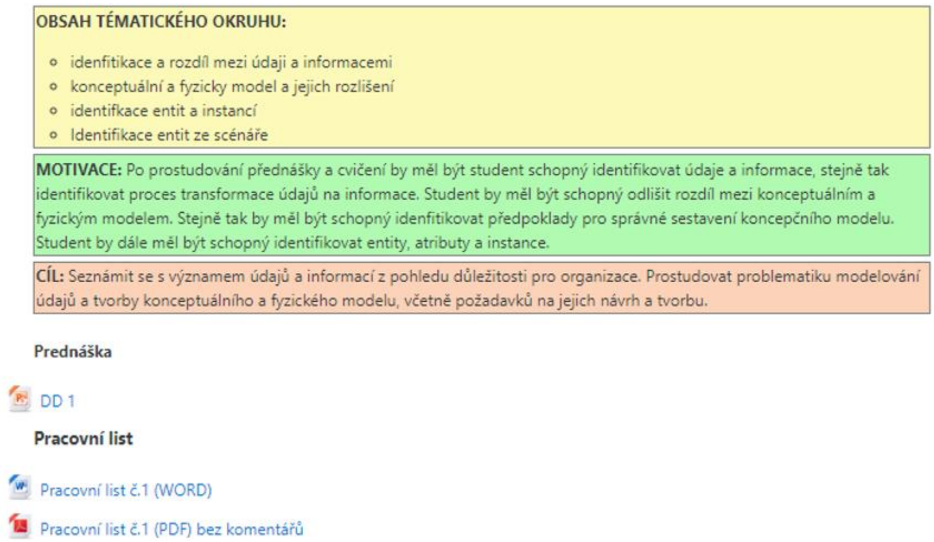

Figure 12.7. Educational sessions of the topic area [1].

For example, one of the first challenges students encounter when designing databases is the ability to identify the difference between data and information and how to extract information from the data. An example of the worksheet task is shown in Figure 12.8.

Úloha 2:
Vyjmenujte co nejvíce různých informací, které vyplývají z této zprávy, tj. zprávy jídelny.

Datum	Objem prodeje studentům	Objem prodeje zaměstnancům	Hamburger / Taco Bar	Pizza Bar	Polévka / Salát Bar
02/Dec/2020	497	23	335	122	63
03/Dec/2020	440	19	285	126	48
04/Dec/2020	447	30	301	126	50
05/Dec/2020	442	27	325	107	37
06/Dec/2020	330	12	229	83	30

a. Co tato zpráva znamená?
……………………………………………………………………………………………
b. Jaké údaje byly shromážděny?
……………………………………………………………………………………………
c. Jaké informace poskytuje uvedená tabulka?
……………………………………………………………………………………………
d. Co myslíte, k čemu budou sloužit tyto informace?
……………………………………………………………………………………………
e. Uveďte alespoň dva závěry vyplývající z poskytnutých údajů.
……………………………………………………………………………………………
f. Uveďte alespoň dvě otázky, které byste se zeptali k poskytnutým údajům
……………………………………………………………………………………………

Figure 12.8. Sample task from the worksheet [1][2].

Within the Moodle, there are also forms for assigning and submitting partial assignments to test your knowledge of more challenging subjects.

12.2.2. MS Teams

Another tool is MS Teams, which is not only used for communication, but also as a tool for quick response and presentation of complex topics, SQL code, or important information and educational materials. In addition, it allows the presentation of parts of a semester project before it is submitted, thus serving as a means of verification and validation. In the semester project, students are given an assignment that includes a scenario with specific requirements made up of business rules.

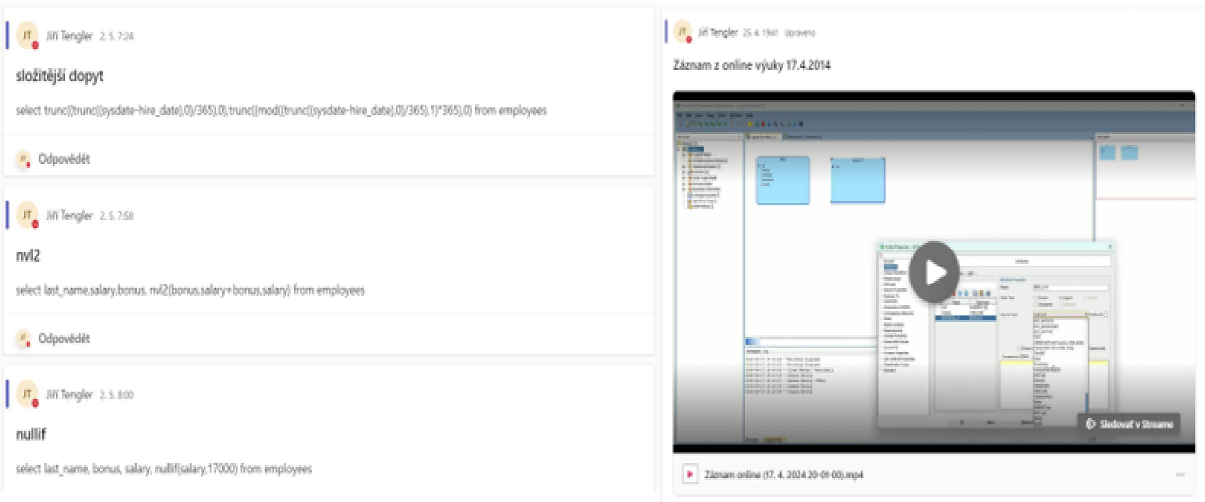

Figure 12.9. Example of activity in MS teams.

A sub-channel for semester projects is created on the MS Teams - Database Design channel, which serves as a means of communication with the fictitious database design client. Students can ask questions about their database design here during the semester and the instructor responds flexibly. In addition, MS Teams is used as a tool for voluntarily implemented on-line lessons when it is necessary to explain the activities and work with the aforementioned tools for creating ERD diagrams (Figure 12.9). That is, such lessons that are beyond the scope of the teaching of this subject.

12.2.3. Oracle academy i-learning

Within the Oracle Academy i-learning system, students are individually educated in database design and database work using the SQL language. Together with physical lectures, this system forms the theoretical framework of the course, which includes the acquisition of knowledge and its subsequent verification. In Oracle Academy i-learning, there is a duplication of the material covered in the physical lectures and the material taught in the Oracle Academy system. The repetition of the material is implemented in the form of reading lectures within individual sections, which form a coherent thematic area (see Figure 12.10).

Figure 12.10. Example of presentation in Oracle Academy [2].

At the end of each section, there is a revision quiz with a predetermined required grade that the student must obtain in order for the quiz to be considered successfully completed. There is also feedback within the quiz, see Figure 12.11.

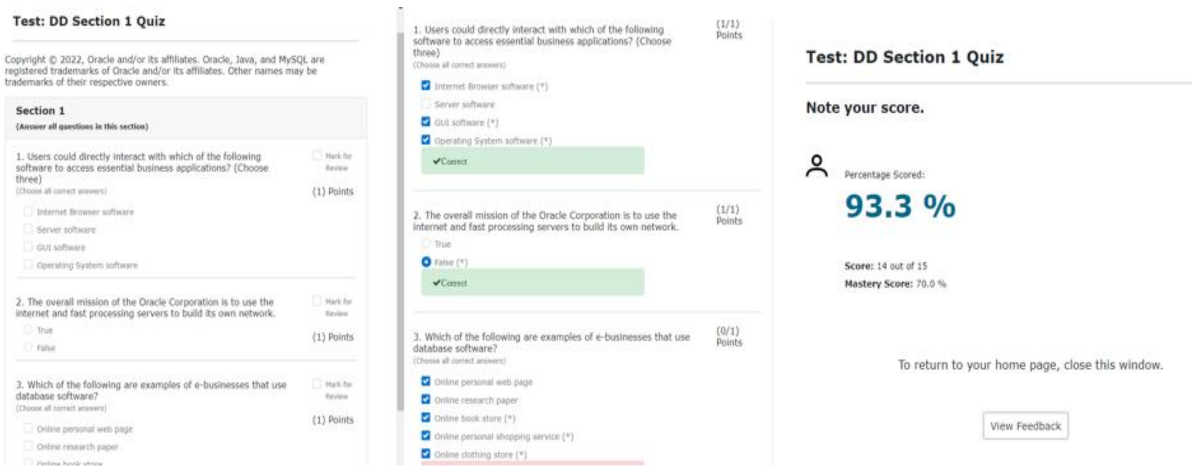

Figure 12.11. Quizzes [2].

The results of the quizzes, however, do not enter the course grade, they only serve as feedback to the students. In addition to the section quizzes, there are two main tests in Oracle Academy: a mid test and a final test. The grades from these tests already affect the student's overall grade, along with the project grade. The mid and final tests are similar in nature to the quizzes but contain more questions from more sections and are therefore more comprehensive review tests. Successful completion of both tests is a prerequisite for Oracle Academy certification. In Figure 12.12 you can see on the left side the assessment output of a particular student as well as a sample of the certificate obtained.

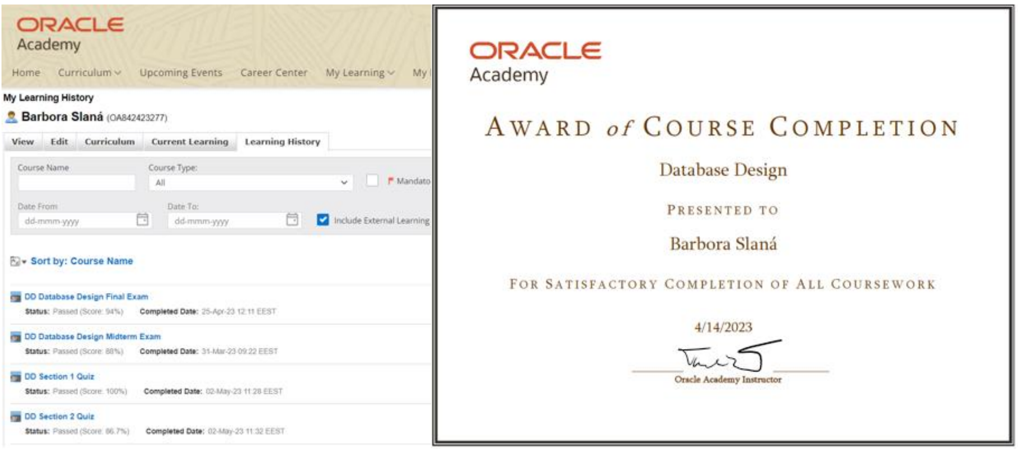

Figure 12.12. Student assessment output [2].

12.2.4. APEX

The last tool we will look at is APEX. This platform is specifically designed for development on Oracle databases. It enables the creation of enterprise applications while providing the ability to execute SQL queries at the database level. Students have the option to either create their own database schema or use one that the teacher has loaded into the system. The typical schema used in Oracle Academy courses is directly linked to the course materials, allowing students to virtually test SQL queries directly within the database schema. In Figure 12.13 you can see the environment of the platform and its workspace.

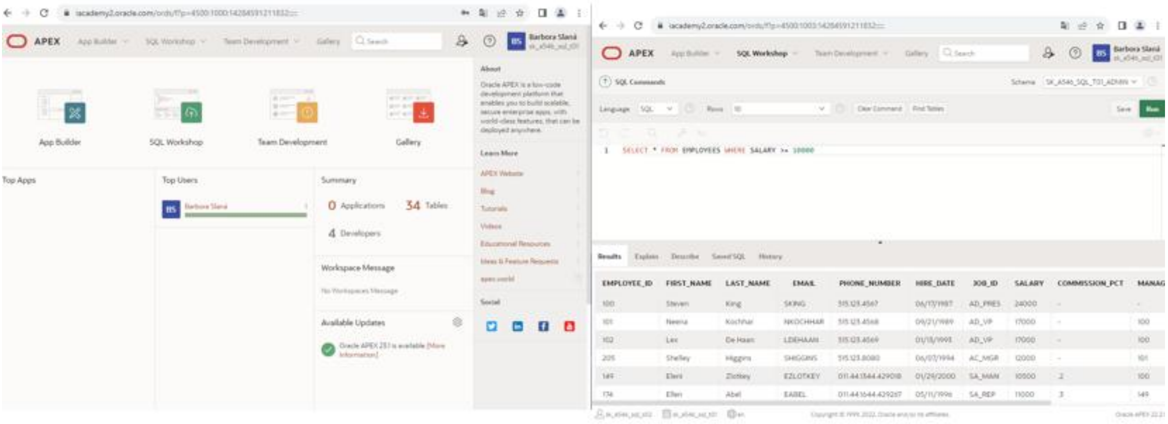

Figure 12.13. APEX tool and its workplace [3].

12.3. Conclusion

STEM education is essential to prepare students for the challenges of modern society. Traditional teaching methods often fail to meet the specific needs of today's students who prefer an interactive and hands-on approach. The use of e-learning tools is a key innovation that can not only modernise the teaching of STEM subjects but also make it more accessible and attractive.

At the Department of Communications at the University of Žilina, several e-learning tools have been used in the teaching of database design, namely LMS Moodle, MS Teams, Oracle Academy platform and APEX. Although we integrated multiple tools, the main teaching tools were LMS Moodle and Oracle Academy. Of course, usually one LMS system is mainly used for teaching, however, because this course relies on Oracle Academy course and obtaining certificates is contingent on taking tests in this LMS, therefore both systems are used in the teaching. Thus, it is not necessary to use many platforms, but if combining them better fulfils the purpose of the course, there is no reason not to use more tools. The key is to ensure that the tools support interactivity, provide a robust theoretical foundation and enable practical application of knowledge.

For a subject such as database design, it is particularly important to combine theoretical learning with practical exercises. E-learning tools can provide a playful and engaging way for students to learn about theoretical concepts, which they can then test and apply during practical assignments and exercises. This approach not only increases understanding of the material, but also develops key skills such as critical thinking, analysis and problem solving.

The experience of this demonstration confirms that the use of e-learning tools is essential for successful STEM education. These tools enable the creation of an effective and engaging learning environment that meets the needs of today's students and prepares them for future careers in technically challenging fields. Further research could explore the long-term impacts of using different e-learning tools on student learning outcomes and career success, as well as their application in a wider range of STEM subjects.

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13. VIRTUAL REALITY (VR) AND AUGMENTED REALITY (AR) IN STEM EDUCATION

13.1. Introduction

Before the advent of advanced technologies like Artificial Intelligence (AI), Virtual Reality (VR), and Augmented Reality (AR), STEM (Science, Technology, Engineering, and Mathematics) education relied heavily on traditional teaching methods. These included textbooks, lectures, hands-on experiments, and physical models to convey complex scientific concepts. Learning was often limited to the theoretical understanding imparted through classroom instruction and the practical experience gained in laboratory settings. While these methods provided foundational knowledge, they often lacked the immersive and interactive elements that could engage students fully and enhance their understanding of abstract and dynamic phenomena. As a result, students faced challenges in visualizing and comprehending intricate scientific principles, which sometimes hindered their enthusiasm and motivation for STEM subjects.

13.2. What are AR and VR

Augmented reality (AR) augments your surroundings by adding digital elements to a live view, often by using the camera on a smartphone.

Virtual reality (VR) is a completely immersive experience that replaces a real-life environment with a simulated one.

13.2.1. Augmented Reality (AR)

AR overlays digital information, such as images, videos, or sounds, onto the real-world environment. This enhancement is typically achieved through devices like smartphones, tablets, or AR glasses. AR integrates digital content with the user's surroundings in real-time, allowing users to interact with both virtual and real-world elements simultaneously. Examples include mobile apps that superimpose navigation directions onto live camera feeds or AR games that blend digital characters with the physical environment.

AR is widely used in various fields, including education, gaming, retail, and healthcare. In education, AR can bring textbooks to life by displaying interactive 3D models and animations over printed pages, thereby enhancing the learning experience. In AR, a virtual environment is designed to coexist with the real environment, with the goal of being informative and providing additional data about the real world, which a user can access without having to do a search. For example, industrial AR apps could offer instant troubleshooting information when a handset is aimed at a piece of failing equipment.

13.2.2. Virtual Reality (VR)

VR creates a fully immersive, computer-generated environment that users can interact with using specialized equipment like VR headsets, gloves, or controllers. Unlike AR, VR completely replaces the user's real-world environment with a virtual one. VR immerses users in a virtual world where they can move around and interact with digital objects as if they were real. This is achieved through head-tracking, motion sensors, and stereoscopic displays that provide a 360-degree view of the virtual environment.

Virtual Reality is commonly used in fields such as gaming, training, simulation, and education. In STEM education, VR allows students to explore complex scientific phenomena, conduct virtual experiments, and visualize abstract concepts in a highly interactive and engaging manner.

13.3. Technology between AR

The key components of an augmented reality system are a camera, a headset, a processor, a sensor, a controller, and a display. The camera takes pictures of the actual environment. The processor finds and figures out the orientation and location of everything in the pictures. The processor also does the rendering for the virtual items.

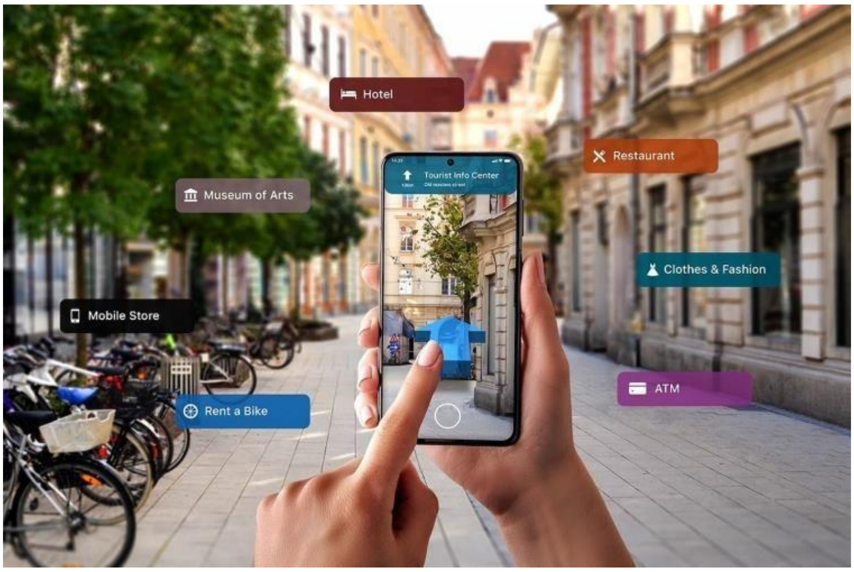

Figure 13.1. Augmented reality in our daily life.

13.3.1. Hardware

- Cameras and Sensors: Devices like smartphones, tablets, and AR glasses are equipped with cameras and sensors to capture and interpret the real-world environment. These sensors can include accelerometers, gyroscopes, and GPS, which help determine the device's position and orientation.
- Displays: The display technology used in AR devices can range from simple smartphone screens to sophisticated AR headsets and smart glasses (Google Glass). These displays project digital images onto the real-world view.
- Processors: AR requires powerful processors to handle the real-time analysis and rendering of augmented content. Modern AR devices use advanced CPUs and GPUs to ensure smooth performance and realistic graphics.

13.3.2. Software

- Computer Vision: This technology enables AR devices to understand and interpret the physical world by processing the data from cameras and sensors. Computer vision algorithms identify and track objects, surfaces, and movements within the environment.
- Simultaneous Localization and Mapping (SLAM): SLAM technology is essential for AR as it helps create a real-time map of the environment while simultaneously tracking the device's location within it.

- Depth Tracking: Depth sensors, such as LiDAR (Light Detection and Ranging), measure the distance between the device and objects in the environment. This information is crucial for placing virtual objects at the correct scale and perspective.
- AR Development Platforms: Software development kits (SDKs) and frameworks like ARKit (Apple), ARCore (Google), and Vuforia provide the tools and libraries necessary for creating AR applications. These platforms offer pre-built functionalities for object recognition, motion tracking, and environmental understanding.

13.4. Technology between VR

Virtual reality is the use of computer technology to create a 3-dimensional artificial environment and place the user in it. There are three basic types of virtual reality.

Non-immersive VR systems: Users are aware of their surroundings and use a monitor to enter the 3-D world, for example, video games.

Semi-immersive VR systems: Users usually have a large screen in front of them and input devices that they can use. Semi-immersive VR technology is used in flight simulation.

Fully-immersive VR systems: These are VR systems that provide very realistic simulation. Users wear a headset and enter an alternate reality.

Figure 13.2. Virtual reality.

13.4.1. Hardware

- Head-Mounted Displays (HMDs):
  - These are the primary devices used to experience VR. Examples include the Oculus Rift, HTC Vive, and the Valve Index. HMDs provide stereoscopic 3D visuals, often with a wide field of view, to create an immersive experience.
  - Features: Most HMDs include high-resolution screens for each eye, refresh rates above 90 Hz to reduce motion sickness, and lenses that provide a wide field of view.
- Tracking Sensors:
  - Inside-Out Tracking: Modern VR systems often use inside-out tracking, where cameras and sensors on the HMD track the user's position and movements within the physical space.
  - Outside-In Tracking: Older systems may use external sensors placed around the room to track the HMD and controllers.
  - Motion Sensors: Accelerometers, gyroscopes, and magnetometers track the user's head movements and adjust the virtual environment accordingly.
- Computing Power:
  - High-performance computers or gaming consoles process the complex graphics and physics calculations required for VR. These systems need powerful CPUs and GPUs to render high-quality, immersive environments in real-time.
  - Standalone VR Headsets: Devices like the Oculus Quest offer a self- contained VR experience without the need for a connected PC or console, integrating all necessary hardware components.

13.4.2. Software

- VR Engines and Development Platforms:
  - Unity and Unreal Engine: These are popular game development engines that provide tools for creating VR content. They offer extensive libraries, physics engines, and support for various VR devices.
  - SDKs and APIs: Software development kits (SDKs) and application programming interfaces (APIs) like OpenVR and Oculus SDK provide the necessary frameworks to develop VR applications, ensuring compatibility with different hardware.

Figure 13.3. Student using VR headset in class.

With VR headsets, students can learn about the structural properties of bridge building, explore the inner workings of the human heart, study the growth habits of giant redwoods—all from the comfort of the classroom.

For students in higher education, virtual reality is a valuable tool for helping develop the core skills associated with their chosen post-graduate fields. While STEM industries adapt to the ever- changing technological landscape, educators are able to prepare future workforces through VR- based learning.

13.5. Key Differences between AR and VR

Augmented reality (AR) and virtual reality (VR) are two technologies that are related but at the same time very different. Both are used to create immersive experiences, but have significant differences in the way they work and the types of experiences they can provide.

AR makes it possible for you to suddenly see virtual stuff dancing around your living room while chilling on the sofa with just a smart device in your hand.

VR or virtual reality, on the other hand, is where things take a sci-fi twist. VR is like teleporting you into a whole new world that's purely digital magic. By using a VR headset, you can enter a 3D universe that's totally separate from your sofa and snacks.

Figure 13.4. AR vs VR.

In AR, you interact with both the real world and digital elements simultaneously. AR usually requires devices like smartphones, tablets, or AR glasses (Google Glass), with less demanding hardware.AR allows users to interact with both virtual and real objects in real-time, enhancing the user's perception of the physical environment.

In VR, you are entirely immersed in a digital environment, isolating you from the real world. VR necessitates specialized headsets and powerful computers to create and sustain the immersive experience. VR environments are entirely computer-generated, allowing for complete control over the visual and auditory experience

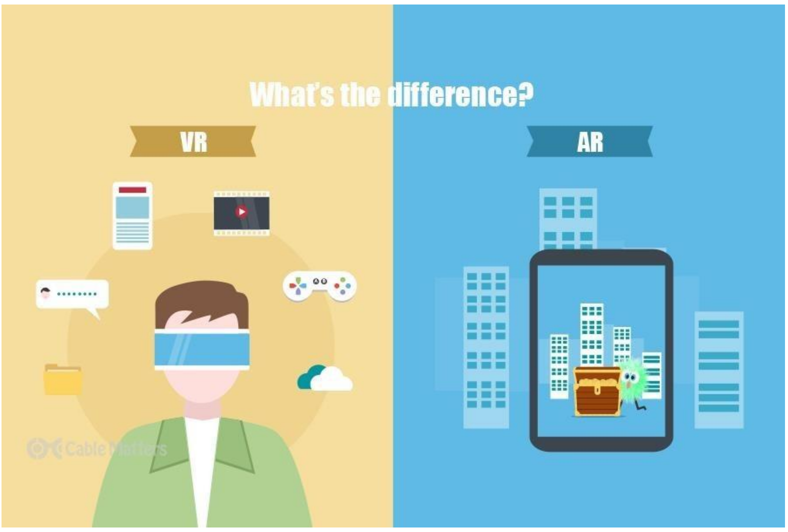

Figure 13.5. Differences between VR and AR.

13.6. Examples of VR and AR in Teaching Various STEM Subjects

AR technology and application gives a fresh perspective on experimental activities performed in the lab, which play a significant role in science education. Usually, students can learn about the structures and features of a chemical element using visual gadgets such as videos, pictures, animation but the capacity to examine these visual tools are limited.

With AR, it is possible to compare each element's physical structure to others, view it in 3-D, and follow the information displayed on the mobile screen. Through a deep connection between technology and learning, augmented reality (AR) offers a unique path of knowledge.

13.6.1. Biology

VR applications allow students to explore the human body in detail, from skeletal structure to organs and tissues.

- Human Anatomy: Applications like The Body VR and Anatomy VR allow students to explore the human body in detail. They can virtually dissect organs, view detailed 3D models, and understand physiological processes.
- Cell Biology: Programs such as Cell Explorer enable students to navigate inside a cell, observing the structure and functions of organelles in an immersive environment.
- Ecology and Environment: Apps like iNaturalist AR enable students to explore local flora and fauna with augmented overlays that provide detailed information about species, ecosystems, and biodiversity.

13.6.2. Physics

VR environments can simulate electromagnetic phenomena such as electric fields, magnetic fields, and electromagnetic waves.

- Mechanics and Motion: VR simulations like Newton's Playground allow students to experiment with physical laws by building structures, testing forces, and understanding concepts like gravity, friction, and momentum in a virtual space.
- Quantum Physics: Quantum VR can help students visualize complex quantum phenomena, such as wave-particle duality and quantum entanglement, which are difficult to grasp through traditional teaching methods.
- Kinematics: Apps like Newton's Laws AR help students understand motion and forces by visualizing vectors, trajectories, and interactions in real-world settings.

13.6.3. Chemistry

VR simulations can allow students to explore the three-dimensional structures of molecules and visualize chemical bonding.

- Molecular Structures: MEL Chemistry VR lets students interact with 3D models of molecules, manipulate chemical bonds, and observe reactions on a molecular level.
- Lab Simulations: Programs like Labster provide virtual chemistry labs where students can conduct experiments safely, learning about chemical reactions, titrations, and laboratory techniques without the risk of handling dangerous chemicals.
- Periodic Table: AR apps such as Elements 4D bring the periodic table to life, allowing students to interact with 3D representations of elements and learn about their properties and reactions.

13.6.4. Engineering

VR environments can offer immersive CAD modeling experiences where students can design and visualize engineering projects in three dimensions.

- Design and Prototyping: VR tools like Gravity Sketch and MakeVR allow engineering students to create and manipulate 3D models, helping them visualize and refine their designs before creating physical prototypes.
- Mechanical Systems: Applications like Siemens NX VR provide immersive environments for understanding and designing complex mechanical systems, enhancing students' comprehension of machine components and operations.

13.6.5. Mathematics

VR applications can create 3D geometric shapes and figures that students can manipulate and explore in virtual space. VR simulations can visualize calculus concepts such as limits, derivatives, and integrals.

- Geometry and Algebra: AR apps like GeoGebra AR and Math Alive allow students to visualize geometric shapes, functions, and graphs in 3D, enhancing their understanding of spatial relationships and abstract concepts.
- Interactive Problem Solving: Photomath AR can help students solve equations and understand step-by-step solutions by overlaying the solution process onto the real world.

13.7. Application of VR in Mathematics

Mathematics is often considered a challenging subject to teach and learn. But when paired with VR, math education becomes more engaging, interactive, and accessible.

Traditional math instruction can be abstract and detached from real-world contexts, making it difficult for some students to grasp concepts. VR math applications bridge this gap by providing students with visual representations and interactive simulations that make math more tangible and relatable.

With VR, the exploration of math goes beyond the static confines of a textbook or the flat view of a chalkboard. VR provides a three-dimensional stage where mathematical concepts become tangible entities, and students can interact with numbers, shapes, and functions in an immersive, intuitively comprehensible manner.

Figure 13.6. Virtual reality offers new avenues for remote collaborative learning and teaching - School of Education.

Virtual Reality (VR) and Augmented Reality (AR) enables visual learners to see how abstract Math concepts work in a three-dimensional (3D) environment which makes them easier to understand and retain. These modern technologies transform complex mathematical concepts into interactive and tangible visual experiences. Students can now explore geometric shapes, solve challenging problems, and complete practical exercises in ways that deepen their understanding and connection with the world of mathematics.

They can also rotate shapes, zoom in and out, and change their properties easily. This interaction allows them to better understand shapes and deal with them creatively.

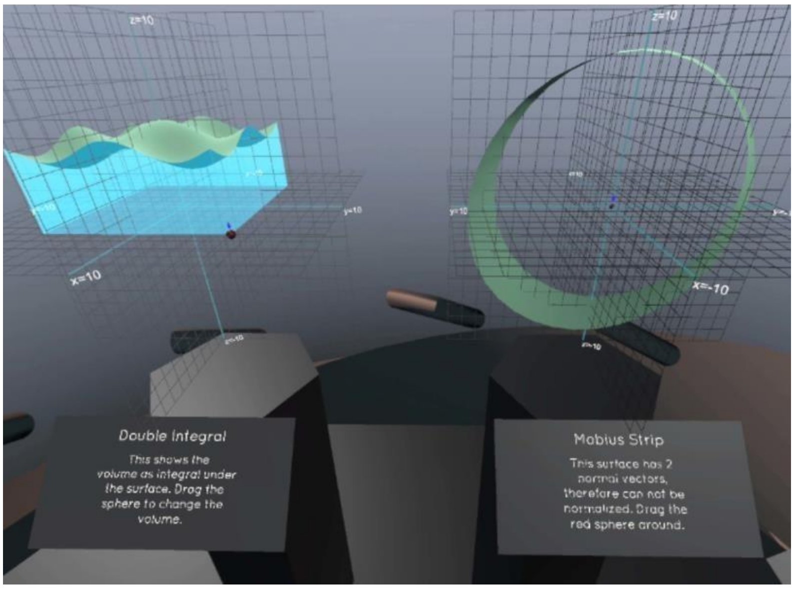

Figure 13.7. Concept of Double integral and Mobius Strip with Virtual reality.

13.7.1. Mobius Strip

Möbius strip, a one-sided surface that can be constructed by affixing the ends of a rectangular strip after first having given one of the ends a one-half twist. This space exhibits interesting properties, such as having only one side and remaining in one piece when split down the middle. The properties of the strip were discovered independently and almost simultaneously by two German mathematicians, August Mobius and Johann Listing, in 1858.

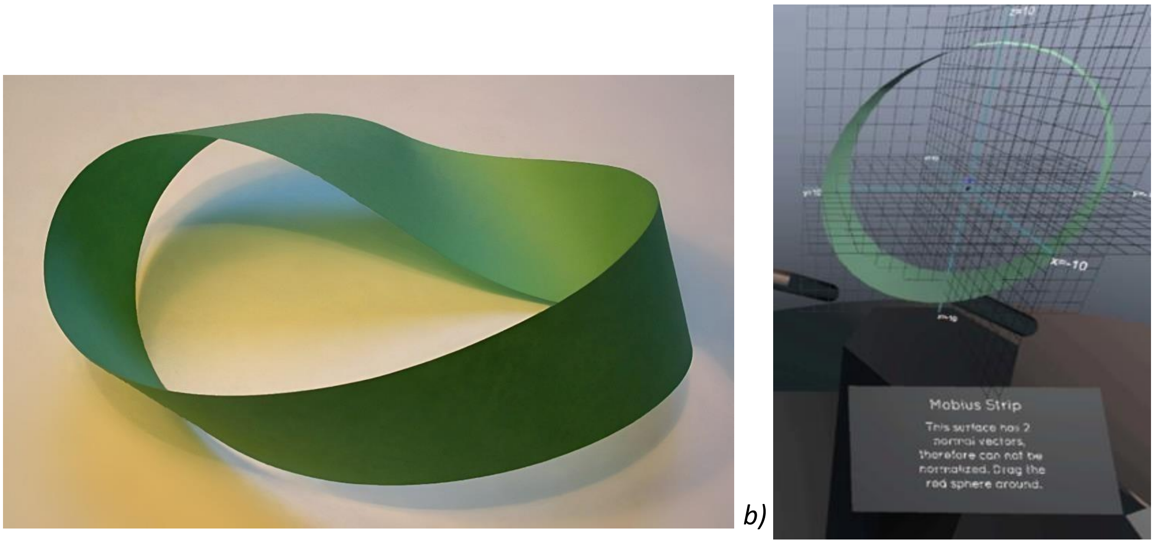

Figure 13.8. a) Mobius strip in real life, b) Mobius strip with VR.

Figure 13.9. Studying Mobius strip with VR using Calcflow App.

13.8. Comparison of the Advantages and Disadvantages of Virtual Reality

Immersive Learning: VR provides an immersive and realistic learning experience, allowing users to interact with virtual environments and objects as if they were real.

Repeatable Scenarios: Trainees can repeat VR scenarios as often as needed to refine skills and build muscle memory, ensuring consistent and thorough training outcomes.

Data Collection and Assessment: VR systems can collect detailed performance data, enabling trainers to assess trainee progress, identify strengths and weaknesses, and adapt training accordingly.

Motion Sickness: Some users may experience motion sickness or discomfort due to the sensory disconnect between virtual and physical movements, leading to nausea and dizziness.

Cost and Accessibility: VR systems can be expensive to develop and maintain, making them less accessible to organizations with limited budgets. High-quality hardware and software requirements can also pose barriers to adoption.

Isolation and Social Disconnect: Prolonged use of VR can lead to isolation from the real world and reduced face-to-face interaction, potentially impacting social skills and relationship.

13.9. Future Directions for VR And AR in the Educational Landscape

Virtual Reality (VR) and Augmented Reality (AR) have the potential to significantly transform the educational landscape, offering immersive and interactive experiences that can enhance learning outcomes.

Personalized Learning: VR and AR can adapt to individual student needs and learning styles, providing personalized experiences that cater to each student's pace and preferences.

Simulation-based Learning: VR simulations offer a safe and controlled environment for students to practice complex tasks and procedures, such as scientific experiments, medical procedures.

Experiential Learning: Immersive experiences in VR/AR can bring abstract concepts to life and engage students through experiential learning.

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14. ARTIFICIAL INTELLIGENCE IN HIGHER EDUCATION

14.1. Introduction

Artificial Intelligence (AI) is becoming increasingly prevalent in various sectors, and higher education is no exception. The integration of AI into educational settings is poised to revolutionize the way learning and teaching are conducted. Before the advent of AI, higher education relied heavily on traditional teaching methods such as lectures, textbooks, and hands-on experiments. These methods, while effective to some extent, often lacked the ability to fully engage students or provide immersive learning experiences.

AI has the potential to address these limitations by offering personalized learning experiences, streamlining administrative processes, and enhancing research capabilities. AI technologies such as machine learning, natural language processing, and predictive analytics can analyze vast amounts of data to provide insights and automate tasks that were previously time-consuming and labor-intensive. The introduction of AI in higher education also brings about a shift in the educational paradigm, moving from a one-size-fits-all approach to a more customized and student-centric model. This shift not only enhances the learning experience for students but also allows educators to focus more on teaching and less on administrative duties. Moreover, AI can provide real-time feedback and support to students, which is crucial in today's fast-paced educational environment.

Furthermore, the adoption of AI in higher education is not just about improving efficiency and effectiveness; it also opens up new possibilities for innovation in teaching and learning. For instance, AI-powered virtual assistants can provide 24/7 support to students, helping them with their queries and assignments. AI can also be used to create virtual laboratories where students can conduct experiments without the risks associated with physical labs.

In conclusion, the integration of AI in higher education is a transformative development that promises to enhance both teaching and learning experiences. By leveraging the power of AI, educational institutions can provide more personalized, efficient, and innovative educational experiences, ultimately preparing students for the challenges of the 21st century.

14.2. What is AI in Higher Education

14.2.1. Definitions and Key Concepts

Artificial Intelligence (AI) in higher education refers to the use of advanced computational techniques to perform tasks that typically require human intelligence. This includes capabilities such as learning, reasoning, problem-solving, understanding natural language, and perceiving the environment. In the context of higher education, AI encompasses a wide range of applications, from personalized learning systems to administrative automation and predictive analytics. Machine learning, a subset of AI, involves the use of algorithms that can learn from and make predictions based on data. This technology is particularly useful in education for analyzing student performance data and identifying patterns that can inform instructional strategies. For example, machine learning algorithms can predict which students are at risk of falling behind and suggest interventions to help them catch up. Natural language processing (NLP) is another crucial aspect of AI that enables computers to understand, interpret, and generate human language. In higher education, NLP can be used to develop virtual teaching assistants that can answer student queries, provide feedback on assignments, and even conduct tutoring sessions. These AI-driven assistants can operate around the clock, providing support whenever students need it. Predictive analytics, another key component of AI, involves using statistical techniques to analyze current and historical data to make predictions about future outcomes. In an educational setting, predictive analytics can help institutions identify trends and patterns in student performance, enabling them to make data-driven decisions. For instance, predictive models can forecast enrollment trends, helping universities plan their resources more effectively.

Moreover, AI in higher education also includes the development and use of intelligent tutoring systems (ITS). These systems use AI to provide personalized instruction and feedback to students, adapting to their individual learning styles and paces. ITS can enhance the learning experience by offering tailored support and resources, helping students to better understand and retain course material. In summary, AI in higher education encompasses a broad range of technologies and applications that leverage advanced computational techniques to enhance teaching, learning, and administrative processes. By understanding and harnessing these key concepts, educational institutions can create more effective and personalized learning environments.

14.2.2. Applications of AI in Higher Education

The applications of AI in higher education are vast and varied, encompassing areas such as personalized learning, administrative efficiency, student support, and research. One of the most significant applications is in personalized learning, where AI systems analyze individual student performance and learning styles to create customized learning experiences. These systems can adapt content, pace, and assessment methods to meet the unique needs of each student, making education more engaging and effective. AI-powered personalized learning platforms, such as Knewton and Coursera, use algorithms to analyze data from students' interactions with course material. This data is then used to tailor content to the students' strengths and weaknesses, ensuring that each student receives the support they need to succeed. This personalized approach can help bridge the gap between different learning styles and paces, providing a more inclusive educational experience.

In addition to personalized learning, AI is also being used to enhance administrative efficiency. Tasks such as grading, scheduling, and student support can be automated using AI, freeing up time for educators to focus more on teaching and research. For example, AI-powered grading systems can quickly and accurately assess student assignments, providing immediate feedback and reducing the workload for instructors. This not only saves time but also ensures consistency and fairness in grading. Virtual teaching assistants, powered by AI, are another application that is gaining traction in higher education. These assistants can provide 24/7 support to students, answering their queries, assisting with assignments, and even offering tutoring sessions. This continuous support can significantly enhance the learning experience, as students can get help whenever they need it, without having to wait for office hours or appointment slots. AI is also being used to enhance research capabilities in higher education. AI-driven data analysis tools can process large datasets quickly and accurately, providing insights that would be difficult to obtain manually. These tools can be used to analyze research data, identify trends, and generate hypotheses, accelerating the research process and enabling more in-depth and comprehensive studies.

Moreover, AI can also play a role in career guidance and student advising. By analyzing data on student performance, interests, and career goals, AI systems can provide personalized recommendations for courses, internships, and career paths. This can help students make informed decisions about their education and career, ensuring that they are well-prepared for the job market. In summary, the applications of AI in higher education are diverse and impactful, offering benefits such as personalized learning, administrative efficiency, enhanced student support, and improved research capabilities. By leveraging these applications, educational institutions can provide a more effective, efficient, and engaging educational experience for their students.

14.3. Current Technology in AI

14.3.1. Hardware

The hardware that supports AI in higher education is critical for the implementation and efficiency of AI applications. High-performance computers and servers are essential for processing the vast amounts of data and complex algorithms that AI systems rely on. These computers must be equipped with powerful CPUs and GPUs capable of handling intensive computational tasks, such as machine learning model training and real-time data analysis. Cloud computing plays a significant role in AI infrastructure, providing scalable and accessible resources for AI applications. Cloud platforms such as AWS, Google Cloud, and Microsoft Azure offer powerful computing resources on demand, allowing educational institutions to scale their AI applications as needed. This flexibility is crucial for handling varying workloads and ensuring that AI systems can operate efficiently without the need for significant upfront investment in physical hardware. Specialized devices, such as AI-enabled smartboards and interactive kiosks, are increasingly being used in classrooms to enhance the learning experience. Smartboards equipped with AI can recognize handwriting, provide real-time feedback, and even adapt lessons based on student interactions. Interactive kiosks can offer personalized assistance to students, helping them navigate campus resources, check schedules, and access information quickly and easily. Additionally, wearable technology, such as VR headsets and AR glasses, is being integrated into educational settings to provide immersive learning experiences. These devices allow students to engage with virtual simulations and augmented reality environments, making abstract concepts more tangible and interactive. For example, VR headsets can transport students to historical sites, inside the human body, or even to outer space, providing experiential learning opportunities that traditional methods cannot match.

In summary, the hardware supporting AI in higher education is diverse and sophisticated, ranging from high-performance computers and cloud computing resources to specialized devices and wearable technology. These hardware components are essential for enabling the advanced capabilities of AI systems and ensuring that they can deliver the desired educational outcomes effectively.

14.3.2. Software

The software that powers AI in higher education includes a wide range of tools and platforms that enable the development, deployment, and management of AI applications. Machine learning algorithms are at the heart of many AI systems, providing the ability to analyze data, recognize patterns, and make predictions. These algorithms are implemented using frameworks such as TensorFlow, PyTorch, and Scikit-learn, which provide the necessary tools for building and training machine learning models. Natural language processing (NLP) is a crucial component of AI software, enabling systems to understand, interpret, and generate human language. NLP technologies power virtual assistants, chatbots, and automated grading systems, allowing them to interact with students and educators in a natural and intuitive manner. For example, NLP can be used to analyze student essays, provide feedback on writing style and grammar, and even detect plagiarism. AI development platforms, such as IBM Watson and Microsoft Azure AI, offer comprehensive tools for creating and deploying AI applications. These platforms provide pre-built models, APIs, and development environments that simplify the process of building AI solutions. They also offer services such as data preprocessing, model training, and deployment, making it easier for educational institutions to integrate AI into their existing systems. Additionally, AI-powered analytics tools are essential for monitoring and evaluating the performance of AI applications. These tools can track student interactions, measure learning outcomes, and provide insights into the effectiveness of AI interventions. By analyzing this data, educators can make data-driven decisions to improve teaching strategies and enhance the learning experience. In summary, the software that supports AI in higher education includes machine learning frameworks, natural language processing tools, AI development platforms, and analytics tools. These software components are essential for building, deploying, and managing AI applications, enabling educational institutions to leverage the full potential of AI to enhance teaching and learning.

14.4. Key Trends in AI within Higher Education

One of the key trends in AI within higher education is the increasing use of AI for personalized learning paths. Personalized learning involves tailoring educational content and experiences to meet the individual needs, preferences, and learning styles of each student. AI systems analyze data from students' interactions with course material, assessments, and even their engagement patterns to create customized learning paths. This approach not only improves student engagement but also enhances understanding and retention of course material. AI-powered analytics are also becoming more prevalent in higher education. These analytics tools track student performance, identify at-risk students, and provide insights into the effectiveness of teaching strategies. By leveraging predictive analytics, institutions can intervene early to support struggling students, improving retention rates and overall student success. For example, AI can predict which students are likely to drop out based on their academic performance and engagement levels, allowing educators to provide targeted support and resources. The development of virtual assistants for student support is another significant trend. These AI-powered assistants, often implemented as chatbots or voice-activated systems, provide real-time assistance to students. They can answer questions about course material, help with administrative tasks, and even provide tutoring. Virtual assistants are available 24/7, offering continuous support and reducing the burden on faculty and staff. AI is also being used to streamline administrative tasks, making processes more efficient and reducing the workload for educators. Tasks such as grading, scheduling, and enrollment management can be automated using AI, allowing educators to focus more on teaching and research. For example, AI-powered grading systems can quickly and accurately assess student assignments, providing immediate feedback and ensuring consistency and fairness in grading. The expansion of online learning platforms powered by AI is another important trend. These platforms offer flexible and accessible education options, allowing students to learn at their own pace and from anywhere in the world. AI enhances these platforms by providing personalized content, adaptive assessments, and interactive learning experiences. For instance, AI can recommend additional resources based on a student's progress, helping them to better understand and master the course material.

In summary, the key trends in AI within higher education include personalized learning paths, AI-powered analytics, virtual assistants for student support, streamlined administrative tasks, and the expansion of AI-enhanced online learning platforms. These trends are driving significant changes in the educational landscape, making learning more personalized, efficient, and accessible.

14.5. Benefits of AI in Higher Education

14.5.1. For Students

The benefits of AI for students in higher education are numerous and far-reaching. One of the most significant advantages is the provision of personalized learning experiences. AI systems analyze individual student data, including their learning styles, performance, and engagement patterns, to tailor educational content and assessments. This personalized approach ensures that students receive the support they need to succeed, enhancing their understanding and retention of course material. AI-powered personalized learning platforms, such as Knewton and Coursera, adapt content to match each student's strengths and weaknesses. This customization allows students to learn at their own pace, focusing on areas where they need improvement. By providing targeted resources and interventions, AI helps bridge the gap between different learning styles and paces, making education more inclusive and effective. Another significant benefit for students is the 24/7 access to AI tutors and assistance. AI-powered virtual assistants and chatbots are available around the clock, providing immediate support and answering queries. This continuous availability is particularly beneficial for students who need help outside of regular office hours. AI tutors can assist with homework, explain difficult concepts, and even offer personalized tutoring sessions, enhancing the overall learning experience. AI also enhances study tools, making information retention and understanding easier for students. Tools like Quizlet and Socrative use AI to create customized study sets, flashcards, and real-time assessments. These tools help students to review and reinforce their knowledge, improving their performance in exams and assignments. Additionally, AI-powered writing assistants like Grammarly provide real-time feedback on writing style, grammar, and plagiarism, helping students to improve their writing skills.

Improved career guidance is another benefit of AI for students. By analyzing data on student performance, interests, and career goals, AI systems can provide personalized recommendations for courses, internships, and career paths. This data-driven approach helps students make informed decisions about their education and career, ensuring that they are well-prepared for the job market. AI-driven analytics can also identify skills gaps and suggest relevant training programs, enhancing students' employability.

In summary, the benefits of AI for students in higher education include personalized learning experiences, continuous access to AI tutors, enhanced study tools, and improved career guidance. By leveraging these benefits, students can achieve better educational outcomes and be better prepared for their future careers.

14.5.2. AI Platforms and Tools for Students to Study Better

- Quizlet AI
    - Quizlet is an AI-powered study tool that helps students create custom study sets and interactive learning experiences. By using machine learning algorithms, Quizlet adapts to each student's learning style and pace, providing personalized study resources. Quizlet offers various study modes, including flashcards, quizzes, and games, making learning more engaging and effective. The platform also tracks student progress, highlighting areas that need improvement and offering targeted practice to strengthen those areas. This personalized approach helps students retain information better and perform well in exams.
- Wolfram Alpha
    - Wolfram Alpha is a powerful computational intelligence tool that assists students in solving complex problems. It uses algorithms and a vast database of knowledge to provide answers to queries in various subjects, including mathematics, science, engineering, and more. Students can use Wolfram Alpha to perform calculations, visualize data, and understand intricate concepts. The tool also offers step-by-step solutions to problems, making it an excellent resource for learning and homework help.
- Grammarly

  - Grammarly is an advanced writing assistant that enhances writing skills and checks for plagiarism. It uses AI to analyze text for grammar, punctuation, style, and tone. Grammarly provides real-time feedback and suggestions to improve writing quality. The tool also includes a plagiarism checker that scans text against millions of online sources to ensure originality. Grammarly is widely used by students for writing essays, research papers, and other academic documents, helping them produce clear and error-free content.
- Evernote
  - Evernote is an organizational tool with AI features that assist in note-taking and task management. It allows students to capture, organize, and share notes across devices. Evernote's AI capabilities include text recognition in images, smart search, and automated categorization of notes. The tool also integrates with other apps and services, making it a central hub for managing study materials and tasks. Evernote helps students stay organized, track assignments, and enhance productivity.
- Coggle
  - Coggle is an AI-assisted mind mapping tool that helps students brainstorm and visualize ideas. It enables users to create collaborative mind maps that capture and organize thoughts in a structured way. Coggle's intuitive interface and AI features make it easy to connect ideas, add images and links, and collaborate with others in real-time. This tool is particularly useful for planning projects, studying complex topics, and organizing information visually.
- Dragon Naturally Speaking
  - Dragon Naturally Speaking is a voice recognition software that converts speech into text. It allows students to take notes, write essays, and perform other writing tasks using their voice. The software is highly accurate and adapts to the user's voice over time, improving recognition accuracy. Dragon NaturallySpeaking is beneficial for students with disabilities, those who prefer speaking over typing, and anyone looking to increase productivity by dictating instead of typing.
- GPT-3 Plugins
  - GPT-3 plugins are AI tools that leverage OpenAI's GPT-3 language model to assist with studying and productivity. These plugins can generate summaries, answer questions, provide explanations, and even write essays. By integrating with various applications, GPT-3 plugins offer contextual assistance and enhance learning experiences. They help students understand complex topics, generate ideas, and streamline study workflows.
- My Study Life

- My Study Life is an AI-powered app that helps students organize their study schedules and tasks. The app allows users to manage timetables, track assignments, and set reminders for important deadlines. My Study Life's AI features include smart scheduling, conflict detection, and progress tracking. The app syncs across devices, ensuring that students have access to their schedules and tasks anytime, anywhere. This tool helps students stay organized, manage their time effectively, and reduce stress.

- Socratic by Google
    - Socratic by Google is an AI-powered homework helper that provides instant answers and explanations to student queries. By using natural language processing and machine learning, Socratic can understand and respond to questions across various subjects, including math, science, literature, and more. The app also offers step-by-step solutions and visual explanations, making it easier for students to grasp difficult concepts. Socratic is an excellent resource for quick homework help and study support.
- Chegg Study
    - Chegg Study is a comprehensive study platform that offers guided solutions, expert Q&A, and textbook rentals. Chegg's AI-powered tools provide personalized study assistance, helping students understand and solve problems from their textbooks. The platform also offers practice quizzes, flashcards, and writing help. Chegg Study connects students with subject experts who can provide detailed explanations and answers to their questions, making it a valuable resource for homework help and exam preparation.

14.5.3. For Professors

AI offers several benefits for professors in higher education, helping them to enhance their teaching effectiveness and streamline administrative tasks. One of the most significant advantages is the use of AI tools for grading and assessing student work. AI-powered grading systems can quickly and accurately evaluate assignments, providing immediate feedback to students. This automation not only saves time for professors but also ensures consistency and fairness in grading, reducing the potential for human error and bias.

AI also provides valuable insights into student performance, enabling professors to tailor their teaching methods to better meet the needs of their students. By analyzing data on student engagement, performance, and learning styles, AI systems can identify areas where students are struggling and suggest targeted interventions. These insights help professors to adapt their instructional strategies, providing more personalized and effective teaching.

Automated administrative tasks are another significant benefit of AI for professors. Tasks such as scheduling, enrollment management, and student support can be automated using AI, reducing the administrative burden on faculty. This automation allows professors to focus more on teaching and research, improving their productivity and job satisfaction. For example, AI-powered systems can handle routine tasks such as sending reminders, tracking attendance, and managing course materials, freeing up time for professors to engage with their students. Enhanced research capabilities are another advantage of AI for professors. AI-driven data analysis tools can process large datasets quickly and accurately, providing insights that would be difficult to obtain manually. These tools can be used to analyze research data, identify trends, and generate hypotheses, accelerating the research process and enabling more in-depth and comprehensive studies. AI can also assist with literature reviews, identifying relevant research papers and summarizing key findings. Collaboration tools powered by AI can also enhance the teaching and research experience for professors. AI-driven platforms can facilitate communication and collaboration among faculty, students, and researchers, enabling them to work together more effectively. For instance, AI tools can assist with project management, document sharing, and real-time collaboration, making it easier for teams to coordinate and achieve their goals.

In summary, the benefits of AI for professors in higher education include efficient grading and assessment, insights into student performance, automated administrative tasks, enhanced research capabilities, and improved collaboration tools. By leveraging these benefits, professors can provide more effective and personalized teaching, conduct more comprehensive research, and improve their overall productivity and job satisfaction.

14.5.4. Google Extensions and ChatGPT Plugins for Professors

- Google Scholar Button
  - The Google Scholar Button is a valuable tool for academic research. It allows professors to easily access academic papers, articles, and research materials directly from their browser. This extension simplifies the search process by providing a convenient toolbar button that can be used to perform searches on Google Scholar without leaving the current webpage. Professors can quickly find citations, access full-text documents, and save articles for later reference. This tool enhances the efficiency of research and helps professors stay updated with the latest developments in their field.
- Mote
  - Mote is a versatile tool that enables professors to leave voice feedback and comments on student assignments. This extension integrates seamlessly with

Google Docs, Slides, and Classroom, allowing educators to provide personalized audio feedback. Voice comments can convey tone and emphasis that text comments might miss, making feedback more engaging and easier for students to understand. Mote supports multiple languages, making it accessible to a diverse student population. This tool saves time and adds a personal touch to the feedback process, enhancing the overall learning experience.

- Grammarly for Chrome
    - Grammarly for Chrome is an essential tool for writing and grammar assistance. This extension helps professors and students improve their writing by providing real-time suggestions for grammar, spelling, punctuation, and style. Grammarly also offers advanced features such as tone detection and plagiarism checking. By integrating with various online platforms, including Google Docs, emails, and social media, Grammarly ensures that users can write clearly and effectively in any context. This tool enhances the quality of academic writing and helps maintain academic integrity.
- Kami
    - Kami is a powerful PDF and document annotation tool that enhances collaborative learning. This extension allows professors and students to annotate, highlight, and comment on PDFs and other documents in real-time. Kami supports text, audio, and video annotations, making it a versatile tool for interactive learning. It also integrates with Google Classroom, enabling seamless assignment creation and submission. Kami's features facilitate active engagement with course materials, promote collaborative learning, and support diverse learning styles.
- CheckMark
    - CheckMark is designed to provide faster feedback on Google Docs. This extension allows professors to insert commonly used feedback comments with a single click. By creating a library of reusable comments, CheckMark streamlines the feedback process, saving time and ensuring consistency. This tool is particularly useful for grading assignments and providing formative feedback. By simplifying the feedback process, CheckMark enables professors to focus more on providing detailed and meaningful feedback to students.
- OrbitNote
    - OrbitNote transforms PDFs into interactive teaching materials. This extension allows professors to add text, voice, and video annotations to PDFs, creating a more engaging and interactive learning experience. OrbitNote supports features such as text-to-speech, translation, and dictionary lookups, making content more accessible to all students. By enhancing PDFs with interactive

elements, OrbitNote helps professors create dynamic and personalized learning materials that cater to different learning needs.

- Edpuzzle
    - Edpuzzle is a user-friendly tool for creating interactive video lessons. This extension allows professors to embed questions, notes, and audio commentary into videos, turning passive watching into an active learning experience. Edpuzzle tracks student engagement and performance, providing valuable insights into their understanding of the content. This tool is ideal for flipped classrooms and blended learning environments, as it allows professors to assess student comprehension and adapt instruction based on real-time data.
- Screencastify
    - Screencastify is a simple and powerful tool for recording and sharing lessons and feedback. This extension allows professors to create video recordings of their screen, webcam, or both, making it easy to create instructional videos, tutorials, and feedback sessions. Screencastify integrates with Google Drive and Classroom, facilitating easy sharing and collaboration. By providing a visual and auditory way to communicate, this tool enhances the clarity and effectiveness of instruction and feedback.
- Pear Deck
    - Pear Deck is an interactive presentation tool that engages students and promotes active learning. This extension integrates with Google Slides, allowing professors to add interactive questions, polls, and activities to their presentations. Students can respond in real-time using their devices, making the learning experience more dynamic and participatory. Pear Deck provides instant feedback and assessment data, helping professors gauge student understanding and adapt their teaching strategies accordingly.
- Flipgrid
    - Flipgrid is a social learning video platform that encourages student engagement and collaboration. This extension allows students to create and share short video responses to prompts and discussions. Flipgrid promotes a sense of community and allows students to express their ideas and reflections in a creative and personalized way. Professors can use Flipgrid to facilitate discussions, assess student understanding, and foster a collaborative learning environment. This tool supports diverse learning styles and enhances communication skills.

14.6. Examples of AI Tools and Platforms in STEM Education

AI tools and platforms are increasingly being integrated into STEM education to enhance teaching and learning experiences. These tools leverage advanced technologies to provide personalized learning, real-time assessments, and interactive content. Here are some notable examples:

- Knewton
  - Knewton is a personalized learning platform that uses AI to adapt course content to the needs of individual students. By analyzing student performance data, Knewton identifies areas where students are struggling and provides targeted resources and interventions. This adaptive learning approach ensures that each student receives the support they need to succeed, enhancing their understanding and retention of course material.
- Turnitin
  - Turnitin is an AI-powered plagiarism detection tool widely used in higher education. It scans student submissions against a vast database of academic papers, articles, and online content to identify potential plagiarism. Turnitin also provides detailed feedback on writing style and grammar, helping students to improve their writing skills. By ensuring academic integrity, Turnitin supports a fair and rigorous learning environment.
- Cognii
  - Cognii is a virtual learning assistant that uses natural language processing (NLP) to provide interactive learning experiences. It engages students in conversational assessments, offering personalized feedback and guidance. Cognii's AI-driven approach helps students to understand complex concepts and improve their critical thinking skills. It also provides real-time support, answering student queries and assisting with assignments.
- Quizlet
  - Quizlet is an AI-based study and flashcard tool that helps students to review and reinforce their knowledge. It uses machine learning algorithms to create customized study sets based on student performance and engagement patterns. Quizlet offers various study modes, including flashcards, quizzes, and games, making learning more engaging and interactive. By providing personalized study resources, Quizlet enhances information retention and exam preparation.
- Socrative
  - Socrative is a real-time student assessment tool that uses AI to create and analyze quizzes, polls, and surveys. It provides immediate feedback to students, helping them to identify areas where they need improvement. Socrative also offers detailed analytics on student performance, enabling

educators to adapt their teaching strategies. By facilitating formative assessments, Socrative supports a more responsive and effective learning environment.

- Grammarly
  - Grammarly is an advanced grammar and writing assistant that uses AI to analyze text for grammatical errors, writing style, and plagiarism. It provides real-time feedback and suggestions for improvement, helping students to enhance their writing skills. Grammarly is widely used in higher education for writing assignments, research papers, and academic communication. By improving writing quality, Grammarly supports better academic performance and communication.
- Duolingo
  - Duolingo is an AI-powered language learning platform that offers personalized language courses. It uses machine learning algorithms to adapt lessons based on individual progress and learning styles. Duolingo provides interactive exercises, quizzes, and games, making language learning more engaging and effective. By offering personalized language education, Duolingo supports multilingualism and cultural understanding.
- Edmodo
  - Edmodo is a learning management system with AI features that facilitate communication, collaboration, and content sharing. It offers tools for creating and managing assignments, quizzes, and discussions. Edmodo's AI-driven analytics provide insights into student performance and engagement, helping educators to adapt their teaching strategies. By supporting a collaborative learning environment, Edmodo enhances the overall educational experience.
- Coursera
  - Coursera offers AI-enhanced courses and specializations for professional development. It uses machine learning algorithms to recommend courses based on individual interests and career goals. Coursera also provides interactive learning experiences, including video lectures, quizzes, and peer-reviewed assignments. By offering personalized and flexible learning options, Coursera supports lifelong learning and career advancement.

In summary, AI tools and platforms such as Knewton, Turnitin, Cognii, Quizlet, Socrative, Grammarly, Duolingo, Edmodo, and Coursera are transforming STEM education. These tools provide personalized learning, real-time assessments, and interactive content, enhancing the overall teaching and learning experience. By leveraging these AI-driven solutions, educational institutions can offer more effective, efficient, and engaging educational experiences.

14.7. Challenges and Considerations

The integration of AI in higher education brings numerous benefits, but it also presents several challenges and considerations that must be addressed to ensure successful implementation and adoption.

- Data Privacy and Ethical Concerns
  - One of the primary challenges associated with AI in higher education is ensuring the privacy and security of student data. AI systems rely on large amounts of data to function effectively, including personal information, academic records, and engagement metrics. Ensuring that this data is collected, stored, and used in compliance with privacy regulations is critical. Institutions must implement robust data protection measures and be transparent about how data is used. Additionally, ethical considerations around the use of AI, such as bias in algorithms and the potential for surveillance, must be addressed to maintain trust and integrity.
- Access and Equity
  - Ensuring equitable access to AI resources is another significant challenge. While AI has the potential to enhance educational experiences, not all students have equal access to the necessary technology and infrastructure. Disparities in access to high-speed internet, computing devices, and AI-powered tools can exacerbate existing inequalities in education. Institutions must take steps to provide equitable access to AI resources, such as offering loaner devices, expanding internet access, and designing inclusive AI applications that cater to diverse student needs.
- Balancing AI and Human Interaction
  - While AI can automate and enhance many aspects of education, it is essential to maintain a balance between AI and human interaction. Education is inherently a social process, and human interaction plays a crucial role in teaching, mentoring, and building relationships. Over-reliance on AI can lead to a reduction in face-to-face interactions, which may negatively impact students' social skills and emotional well-being. Institutions must find ways to integrate AI in a manner that complements and enhances human interaction rather than replacing it.
- High Initial Investment Costs
  - Implementing AI in higher education can be expensive, requiring significant investments in technology, infrastructure, and training. Institutions may face financial constraints that limit their ability to adopt AI solutions. To address this challenge, institutions can seek funding from government grants, private

partnerships, and philanthropic organizations. Additionally, starting with pilot projects and scaling up gradually can help manage costs and demonstrate the value of AI investments.

- Continuous Updating and Maintenance
  - AI systems require ongoing updates and maintenance to remain effective and relevant. Algorithms need to be retrained with new data, software must be updated to address vulnerabilities, and hardware may need periodic upgrades. Institutions must allocate resources for the continuous monitoring and maintenance of AI systems. Additionally, staying informed about advancements in AI technology and best practices is essential to ensure that AI applications remain cutting-edge and effective.

In summary, the integration of AI in higher education presents challenges related to data privacy and ethics, access and equity, balancing AI and human interaction, high initial investment costs, and continuous updating and maintenance. Addressing these challenges requires a comprehensive and thoughtful approach that considers the needs and concerns of all stakeholders. By proactively addressing these issues, institutions can harness the full potential of AI to enhance teaching and learning.

14.8. Future Directions for AI in the Educational Landscape

The future of AI in higher education holds immense potential for transforming teaching and learning processes. As AI technology continues to advance, it will drive significant changes in educational approaches, assessment methods, and student engagement.

Changing Educational Approaches: Traditional educational approaches often focus on memorization and rote learning. However, the integration of AI encourages a shift towards teaching students how to effectively use and apply information. AI-powered tools can support critical thinking, problem-solving, and creativity by providing interactive and personalized learning experiences. For example, AI can facilitate project-based learning, where students work on real-world problems and apply their knowledge in practical contexts. This approach not only enhances understanding but also prepares students for the demands of the modern workforce.

- Project-Based and Collaborative Learning
  - AI can support project-based and collaborative learning by providing tools that facilitate teamwork and real-time collaboration. AI-driven platforms can enable students to work together on projects, regardless of their physical location, by offering features such as shared workspaces, virtual whiteboards,

and communication tools. These platforms can also provide real-time feedback and suggestions, helping students to improve their work and learn from each other. Collaborative learning experiences foster essential skills such as communication, teamwork, and leadership, which are crucial for success in today's interconnected world.

- Assessment Reforms
    - Traditional assessment methods, such as standardized tests and exams, may not fully capture a student's understanding and abilities. AI offers the potential to revolutionize assessment by providing more comprehensive and holistic evaluations. AI-powered assessment tools can analyze various aspects of a student's performance, including problem-solving skills, creativity, and collaboration. For example, AI can assess project-based work by evaluating the quality of solutions, the process followed, and the contributions of each team member. By focusing on real-world applications and critical thinking, AI-driven assessments can provide a more accurate measure of a student's capabilities and readiness for the future.
- Simulation-Based Learning
    - AI-driven simulations and virtual environments can provide immersive learning experiences that allow students to explore complex concepts and scenarios. For example, virtual labs can enable students to conduct experiments and explore scientific principles without the constraints of physical resources. AI-powered simulations can also provide realistic scenarios for training in fields such as medicine, engineering, and aviation. These immersive experiences help students to develop practical skills, apply theoretical knowledge, and gain confidence in their abilities.
- Experiential Learning
    - AI can enhance experiential learning by providing interactive and engaging experiences that make abstract concepts more tangible. For example, AI-powered augmented reality (AR) and virtual reality (VR) tools can bring historical events to life, allow students to explore distant places, and visualize complex scientific phenomena. These tools provide a hands-on learning experience that enhances understanding and retention. By integrating AI into experiential learning, educational institutions can create more engaging and effective learning environments.
- Lifelong Learning and Professional Development
    - AI can support lifelong learning and professional development by providing personalized and flexible learning opportunities. AI-powered platforms can recommend courses, certifications, and training programs based on an individual's career goals, interests, and learning preferences. These platforms can also provide continuous feedback and support, helping learners to stay

motivated and achieve their goals. By offering personalized and accessible learning opportunities, AI can help individuals to stay relevant and competitive in a rapidly changing job market.

In conclusion, the future of AI in higher education is promising, with the potential to drive significant changes in educational approaches, assessment methods, and student engagement. By embracing AI technology, educational institutions can create more personalized, interactive, and effective learning experiences, preparing students for the challenges and opportunities of the 21st century.

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