

***DIGITIZING PRODUCTS:  
CREATING DEMONSTRATORS  
FOR FUTURE EDUCATION***



# **Demonstrators impact assessment**

Student's perspective

Reșița, July 2023



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## Dissemination level

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### About the DigiDemo project

Environmental challenges and digital transformation are two of the main drivers changing the world and the way business will be done in the future. Therefore, it is essential to enable future employees to address these drivers. The skills and competences needed to develop digitalized products and awareness of the environmental challenges are therefore crucial for the European workforce and industry to continue being competitive in a future green economy and to maintain jobs across Europe.

The DigiDemo project addresses these challenges by developing demonstrators especially for higher education allowing to improve mainly mechanical engineering studies by integrating skills and competences allowing them to understand, develop and commercialise connected products. The results will be publicly available and can be used by every institution interested in integrating this type of training in their cursus.



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## Abbreviations

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ESTA	ESTA Belfort (France)
FHV	Fachhochschule Vorarlberg (Austria)
FIV	Fagskolen I Viken (Norway)
UCN	University College Nordjylland (Denmark)
UBB	Babes-Bolyai University (Romania)

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## 1 Introduction

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The evaluation process of the demonstrators is carried out within the evaluation framework, as it was defined inside the project: a peer-review through the project team, members of the different partners and another one provided by the students, as a result of the use of demonstrators in teaching.

The impact assessments of the demonstrators are done by the students based on an online, anonymized, questionnaire, also developed as a part of the evaluation framework. It helps attempting to identify the main characteristics of the demonstrators from the practical use:

- (1) potential to improve interdisciplinary skills
- (2) potential to improve practical skills,
- (2) potential to improve collaboration in interdisciplinary teams,
- (4) potential to improve sustainability awareness, and
- (5) potential to improve digitalization skills,

The students that used the demonstrator(s) in their classes have been invited, individually, to rate, based on their experience, each demonstrator. The feedback to the above indicated criteria was reflected by the obtained answers, which were structured with criteria's between very good/excellent (1) and very unlikely/unsatisfactory (5), or, depending on the question, choosing between indicated options and also open answers / comments, all of them intended to improve their use in future teaching activity.

## 2 Questionnaire

---

The on-line questionnaire to which the students were invited to answer, individually and anonymously, was structured as follows:

1. Has the demonstrator **improved your understanding of the interdisciplinary approach** (mechanical / electronic / control)?  
1 to 5
  
2. Is the possibility to operate changes to the demonstrator's hardware and / or software meant to **improve practical skills**?  
1 to 5
  
- 3.
  
4. Did the demonstrator highlight the need of **collaboration in interdisciplinary teams**? Yes or No
  
5. Indicate what **sustainability issues have been improved** through the demonstrator:
  - ❖ reducing energy consumption
  - ❖ reducing material consumption
  - ❖ using materials with better environmental characteristics
  - ❖ using manufacturing processes with better environmental characteristics
  - ❖ considering recycling (end-of-life) of the product
  - ❖ none
  
6. Focused on **digitalization**, which learning skills have been improved?
  - ❖ programming
  - ❖ web development
  - ❖ data analysis / visualization
  - ❖ none
  
7. How can the demonstrator further **improve the learning process**?
  - ❖ using a digital twin
  - ❖ offering a video tutorial
  - ❖ field visits in the industry
  - ❖ none

### 3 Summary

Overall, in the teaching activity, the student's feedback is one of the main important feedback items we have to build and construct one. If differences between expected goals and results obtained from the applied measuring tools, are meant to improve the teaching activity! The results obtained from the evaluation questionnaires highlighted positive results across the main characteristics of the demonstrators to improve interdisciplinary skills, practical skills, digitalization skills, collaboration in interdisciplinary teams, and sustainability awareness.

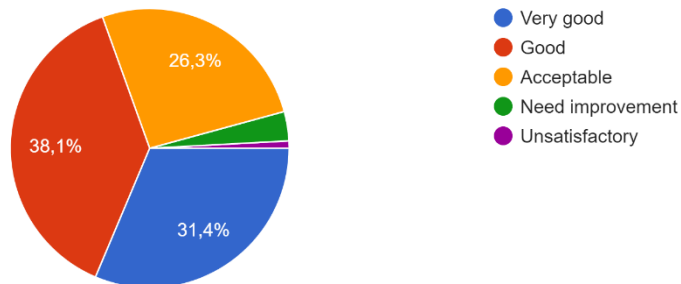
The outcome aligns with expectations since they went through a peer-review process meant to ensure that the demonstrators match the framework used for their development, targeting their overall quality.

Additionally, the evaluation results indicated improvement in two targeted directions, namely interdisciplinary approach, and digitalization - focused on programming skills. Also, the need to work in interdisciplinary teams was strongly highlighted. Based on this, using the demonstrators the students will be able to acquire a better understanding and knowledge, independent of the study program they belong to.

An overall overview obtained from the correspondents that accessed the *online forms*, is reflected in the following graphic summary offered by the platform:

I. Has the demonstrator improved your understanding of the interdisciplinary approach (mechanical / electronic / control)?

118 răspunsuri

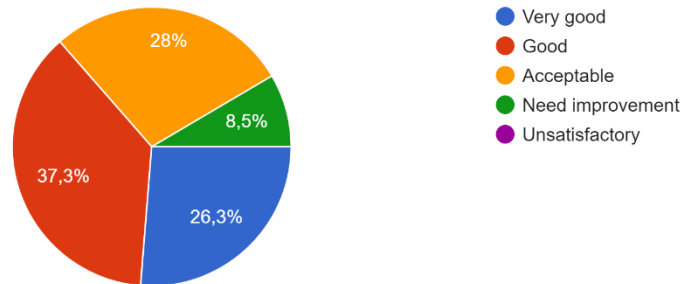


**Figure 3.1 Interdisciplinary approach**

## Demonstrators impact assessment

II. Is the possibility to operate changes to the demonstrator's hardware and / or software meant to improve practical skills?

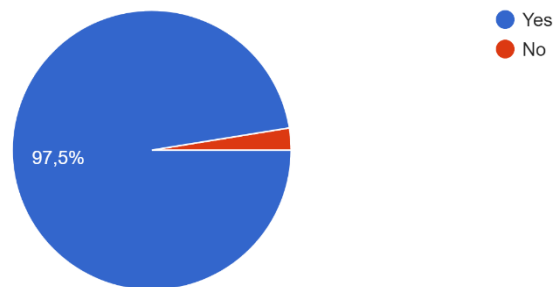
118 răspunsuri



**Figure 3.2 Practical skills**

III. Did the demonstrator highlight the need of collaboration in interdisciplinary teams?

118 răspunsuri



**Figure 3.3 Collaboration (single response)**

IV. Indicate what sustainability issues have been improved through the demonstrator:

118 răspunsuri

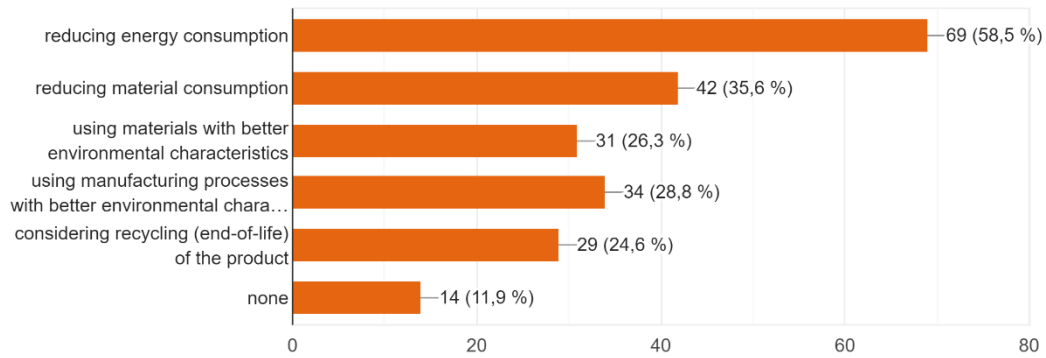


Figure 3.4 Sustainability (multiple response)

V. Focused on digitalization, which learning skills have been improved?

118 răspunsuri

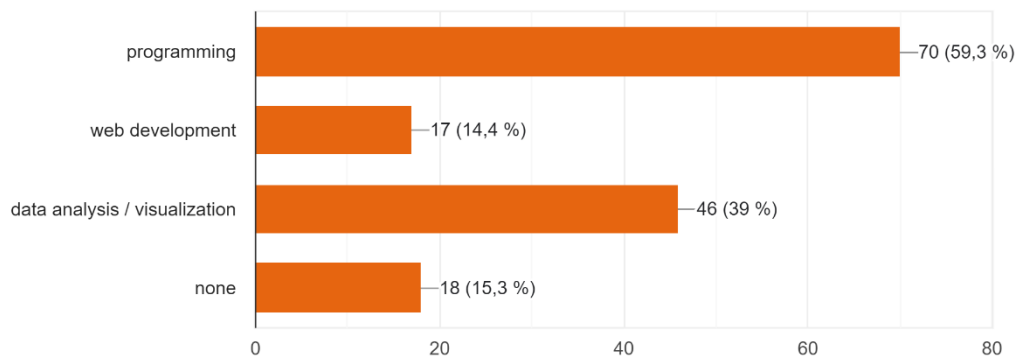
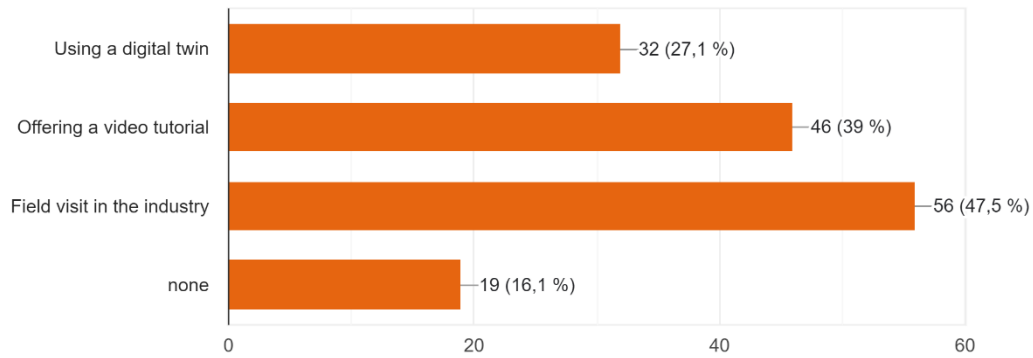


Figure 3.5 Learning skills (multiple response)

VI. How can the demonstrator further improve the learning process?

118 răspunsuri



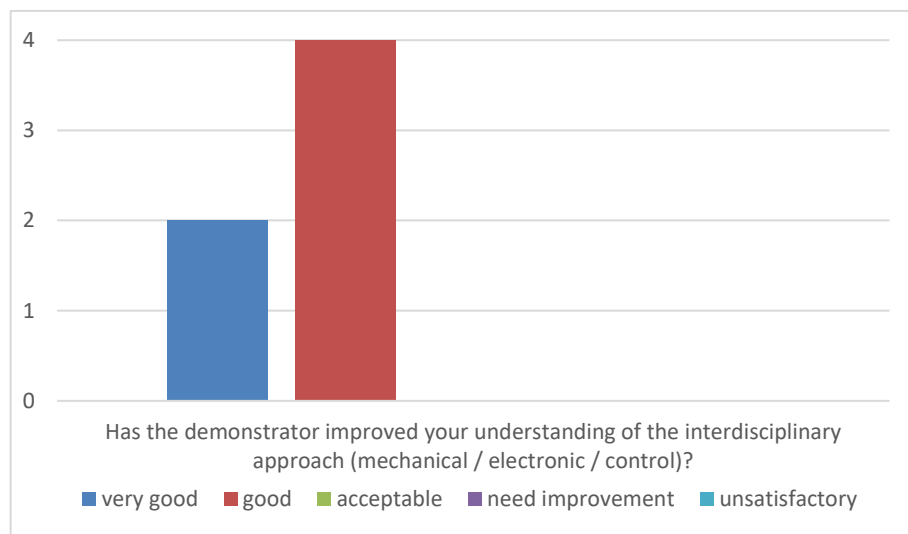
**Figure 3.6 Learning process (multiple response)**

## Annex A: Fachhochschule Voralberg

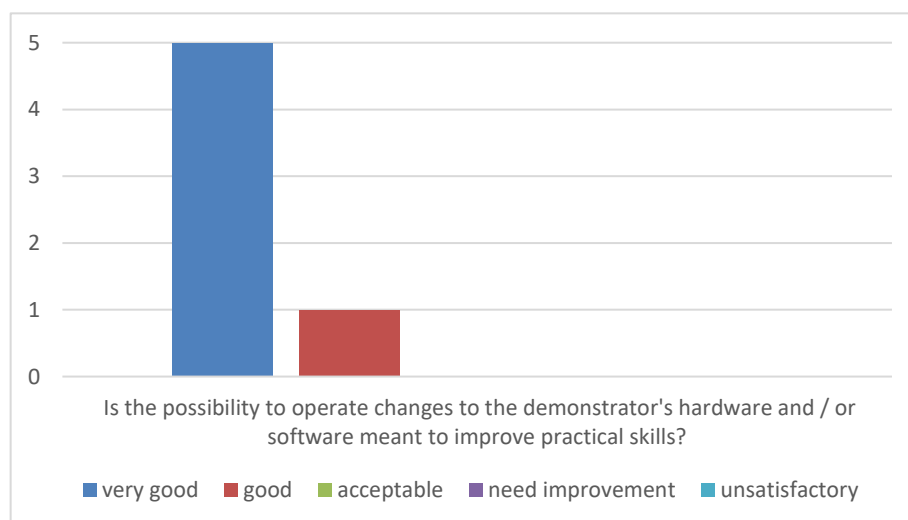
### A1. Evaluation results 1<sup>st</sup> Demonstrator

After the use of the first demonstrator from the FHV team, the so-called focus project for the demonstrator’s development process within the project, from the group of the first students that used the demonstrator, the invitation to complete the online questionnaire was followed by six.

The obtained output to the questions resulted on the given answers, are highlighted in the following graphic representations (Figure A.1 – 1.6):

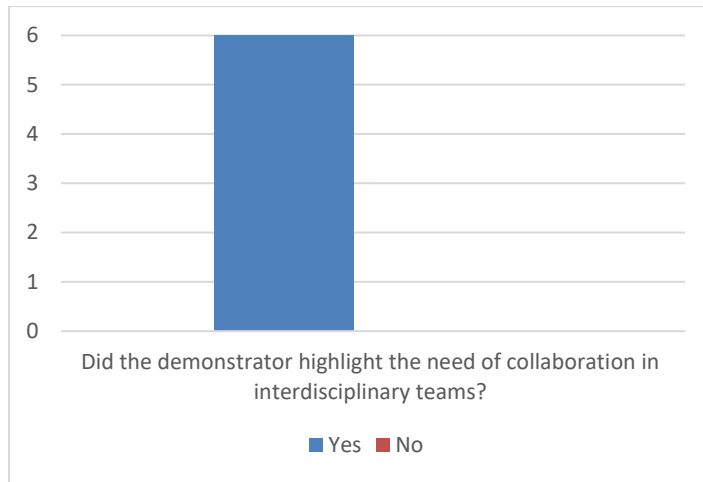


**Figure A.1 Interdisciplinary approach (single response)**

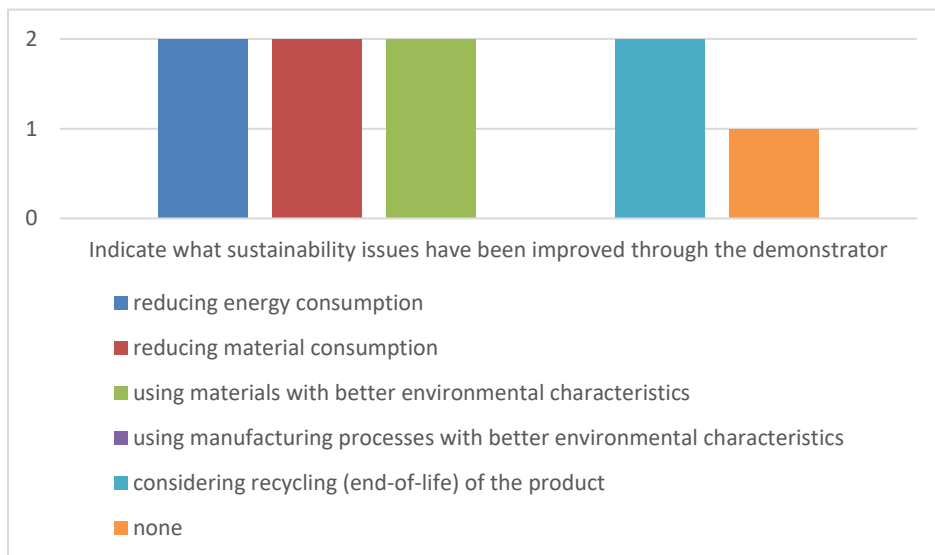


**Figure A.2 Practical skills (single response)**

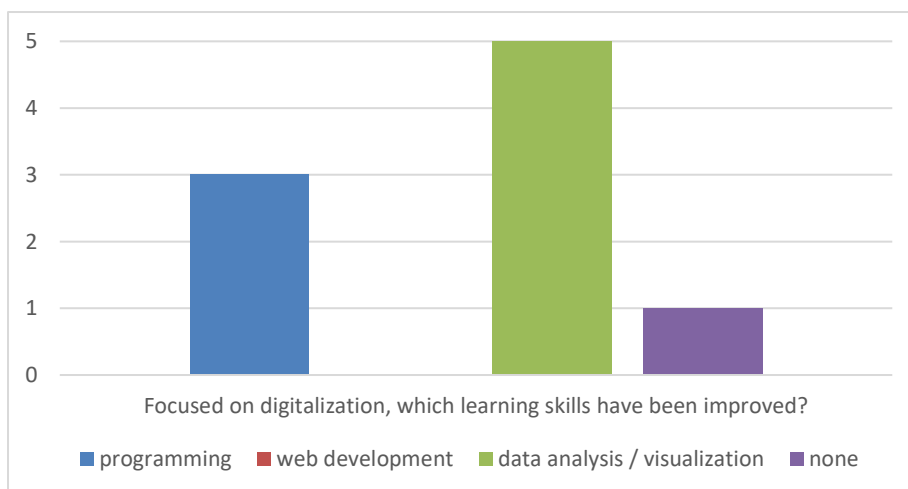
## Demonstrators impact assessment



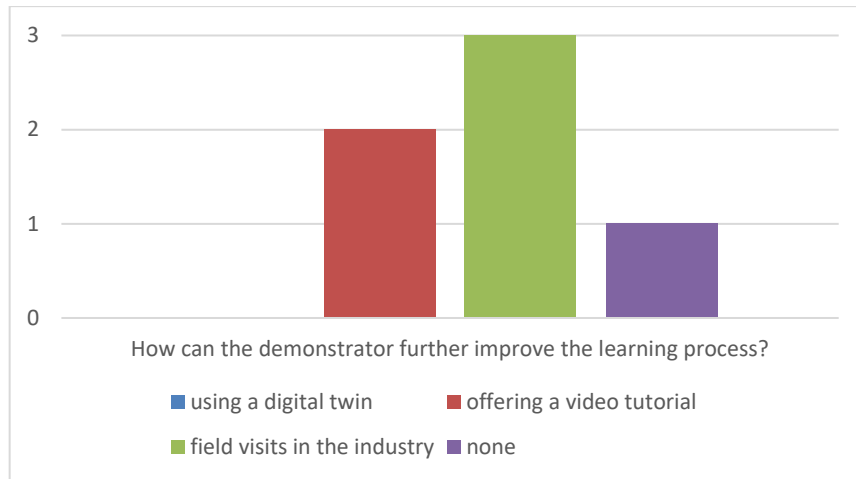
**Figure A.3 Collaboration (single response)**



**Figure A.4 Sustainability (multiple response)**



**Figure A.5 Learning skills (multiple response)**



**Figure A.6 Learning process (multiple response)**

The open question, focused on suggestions / comments, was used by a respondent: *I am actually more than satisfied with the learning outcomes, and as for now I could only suggest more of a practical introduction to the PLC part (as it's quite complicated for non-experienced).*

Based on the analysis of the received answers, the results show that the use of the demonstrator improves the understanding of the interdisciplinary approach: over 66% rated it as good and over 33% as very good, figure A.1.

The potential of improving practical skills by operating hardware and software changes on the demonstrators was rated as excellent by over 83% of the correspondents while nearly 16% appreciated it as good, figure A.2.

The need for an interdisciplinary team component to increase the understanding of the processes implemented through the demonstrator was indicated by 100 % of the correspondents, figure A.3.

Different sustainability issues have been emphasized, their weight being evenly, approx. 20%, distributed, figure A.4.

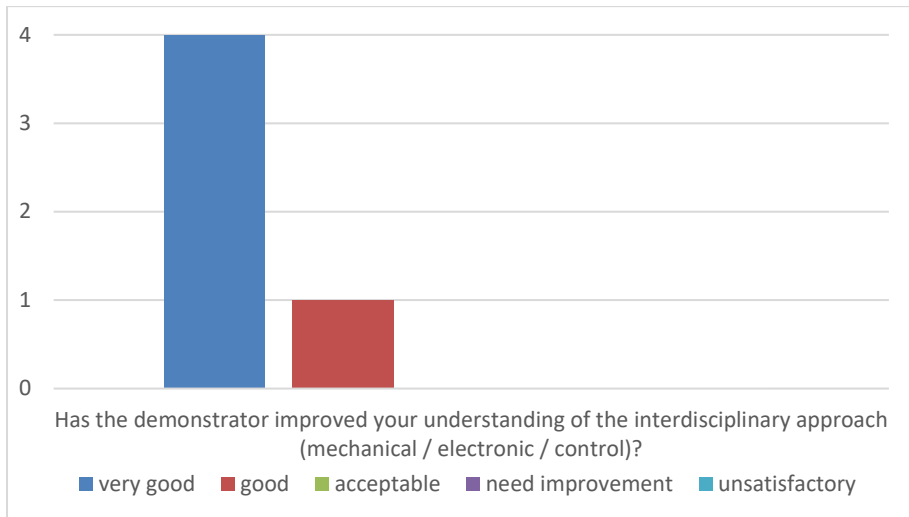
Learning skills orientated on digitalization have been deepened by almost 90% (programming - 33%, data analysis/visualization – 55%) while a share of 11% could not increase their competence in this direction with the help of this demonstrator, figure A.5.

In general, the understanding of the technical phenomena promoted by the use of the demonstrator as well as its handling could increase if it were associated with a tutorial video, 33%, or field visits in the industry would follow its use, figure A.6.

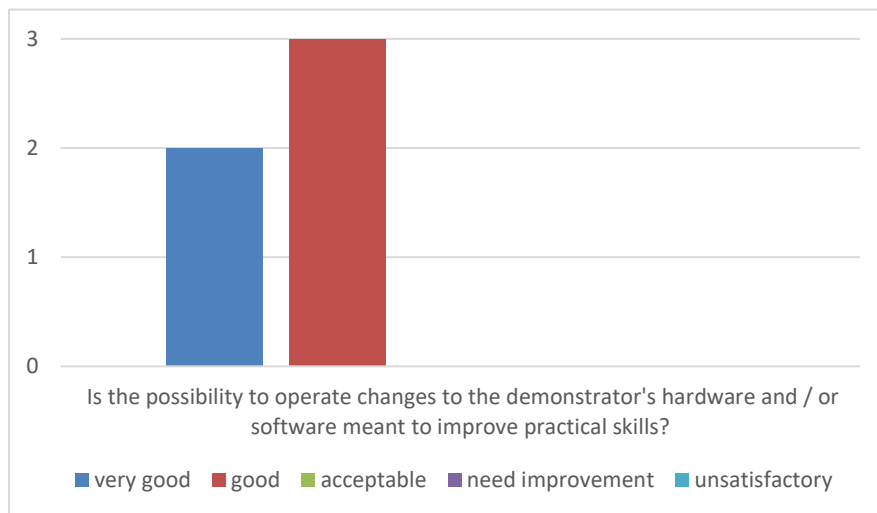
## A.2 Evaluation results 2<sup>nd</sup> Demonstrator

The second demonstrator developed by the FHV team and used in the teaching activity was the so-called *lift*. The obtained feedback from five correspondents is highlighted in the following, Figures A.7 – A.12.

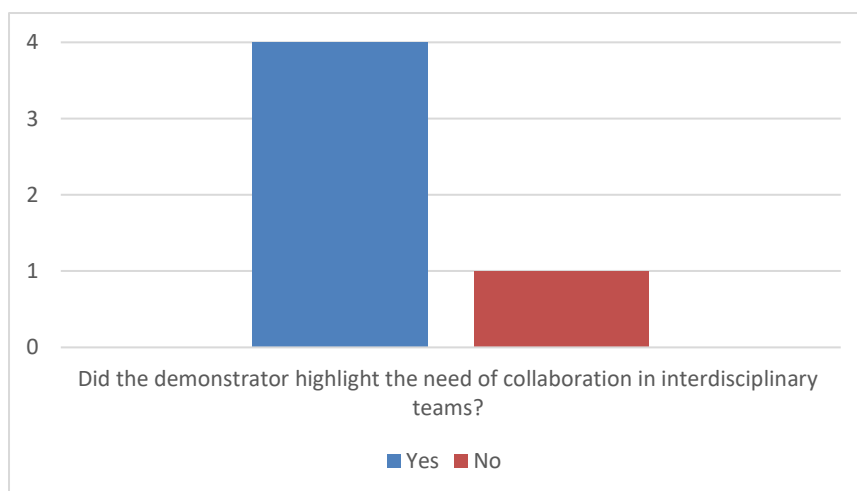
## Demonstrators impact assessment



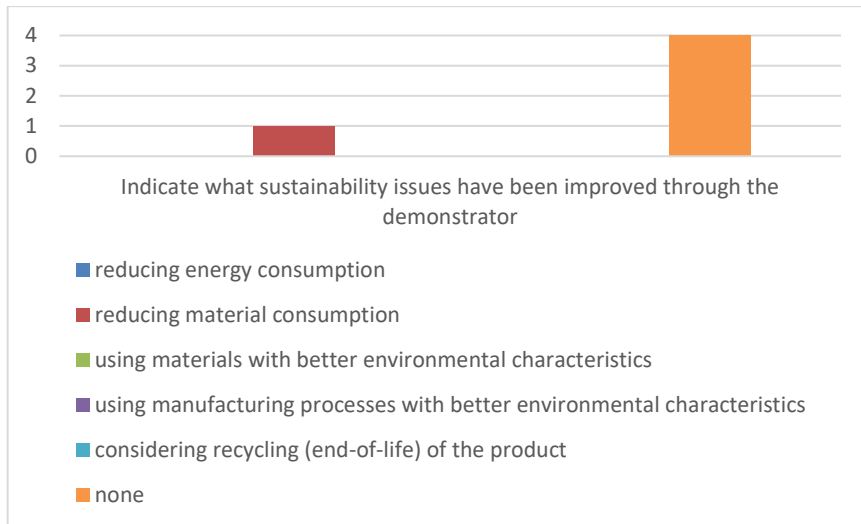
**Figure A.7 Interdisciplinary approach (single response)**



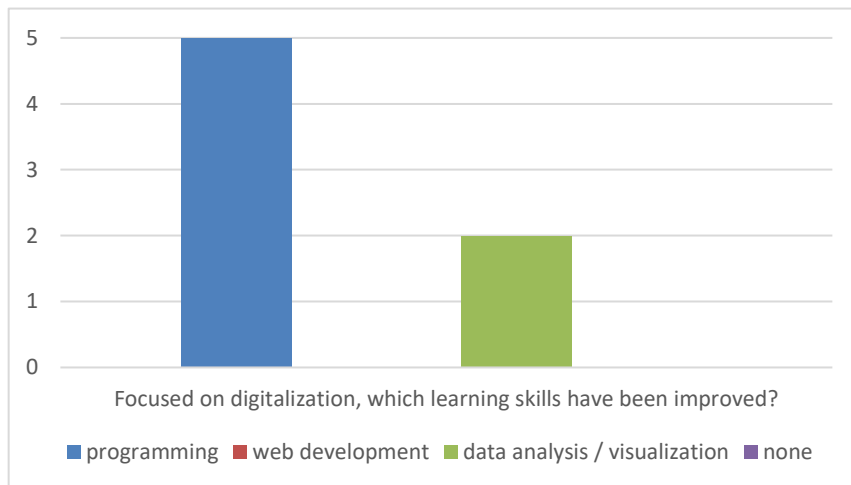
**Figure A.8 Practical skills (single response)**



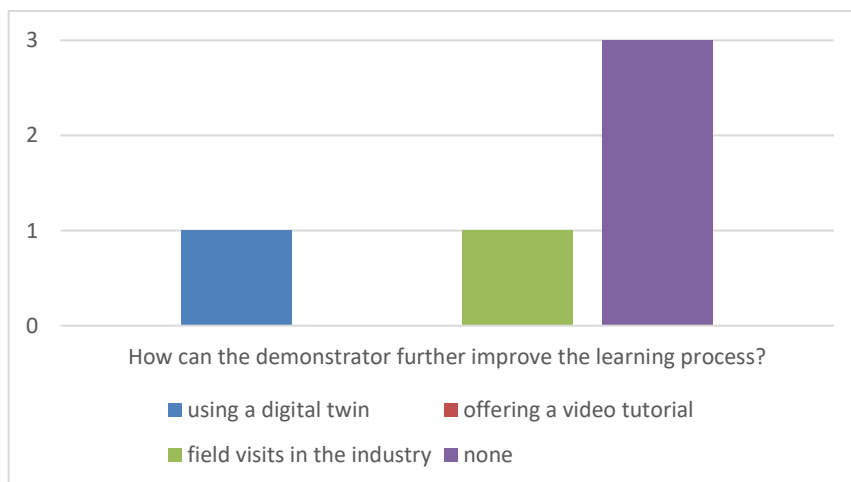
**Figure A.9 Collaboration (single response)**



**Figure A.10 Sustainability (multiple response)**



**Figure A.11 Learning skills (multiple response)**



**Figure A.12 Learning process (multiple response)**

## Demonstrators impact assessment

Analyzing the received answers, results that the use of the demonstrator improves the understanding of the interdisciplinary approach: 80% rated it as very good and 20% as good, figure A.7.

The potential of improving practical skills by operating hardware and software changes on the demonstrators was rated as excellent by 40% of the correspondents while 60% considered it as good, figure A.8.

The need for an interdisciplinary team component to increase the understanding of the processes implemented through the demonstrator was indicated by 80 % of the correspondents, figure A.9.

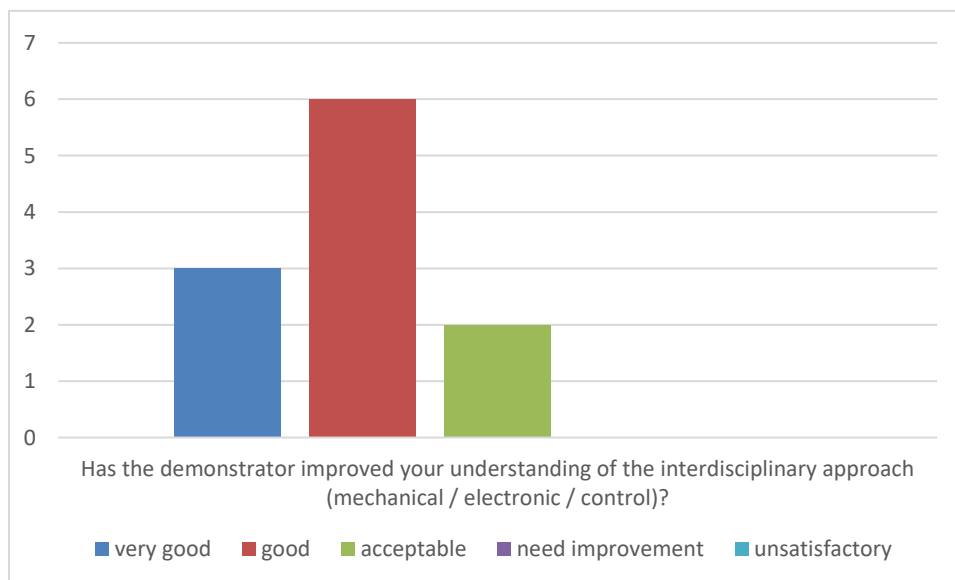
80% of the correspondents did not identify any improvement on sustainability in their approach, figure A.10.

Learning skills orientated on digitalization have been deepened by 72% - programming, while a share of 28% indicated improvement in data analysis / visualization, figure A.11.

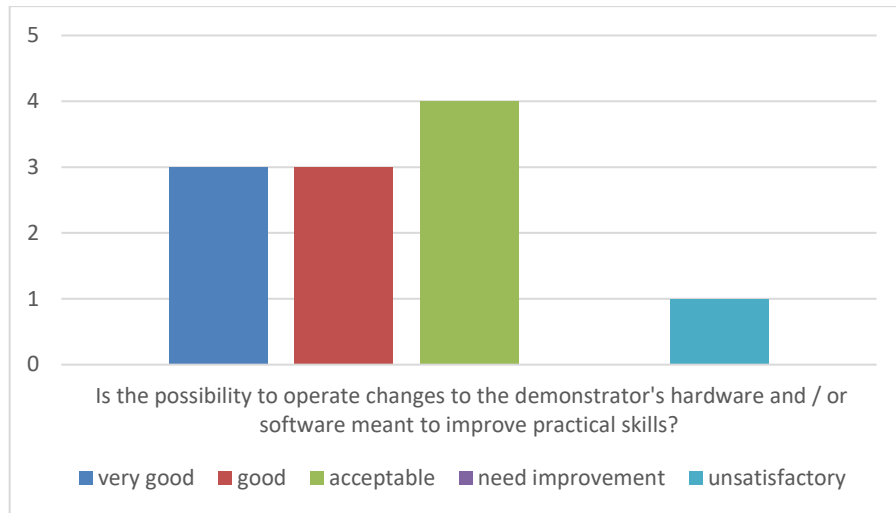
In general, the understanding of the technical phenomena promoted by the use of the demonstrator has been considered as being clear - 60%, figure A.12.

### A.3 Evaluation results 3<sup>rd</sup> Demonstrator

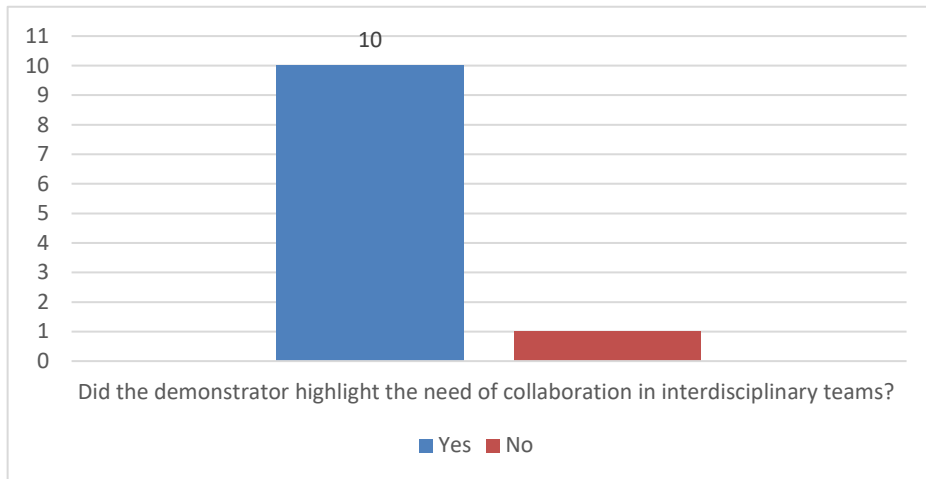
The third demonstrator developed by the FHV team and used in the teaching activity was the so-called *lift*. The obtained feedback from five correspondents is highlighted in the following, Figures A.13 – A.18.



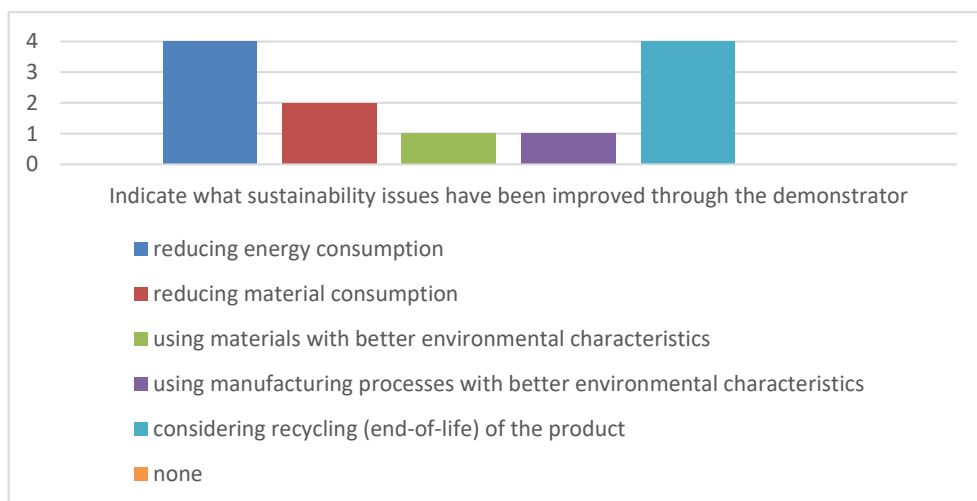
**Figure A.13 Interdisciplinary approach (single response)**



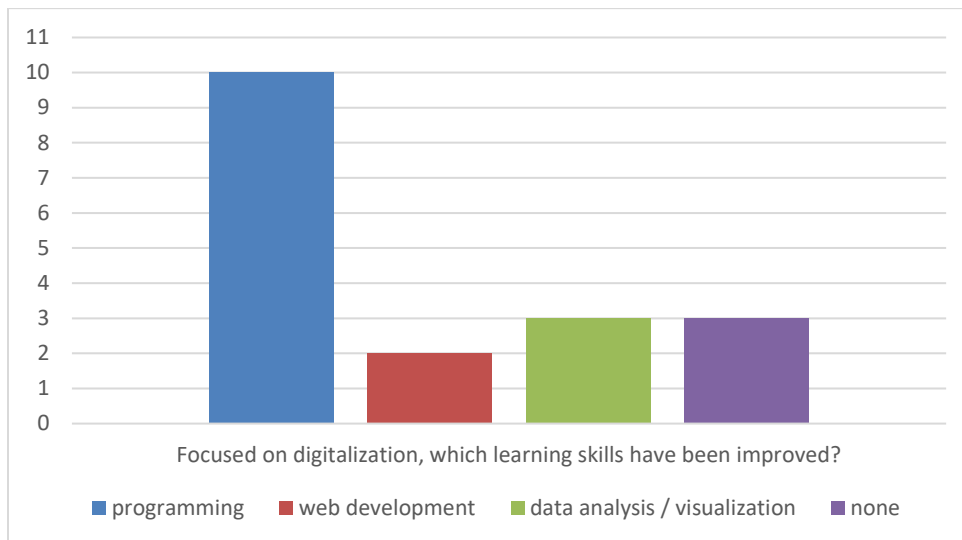
**Figure A.14 Practical skills (single response)**



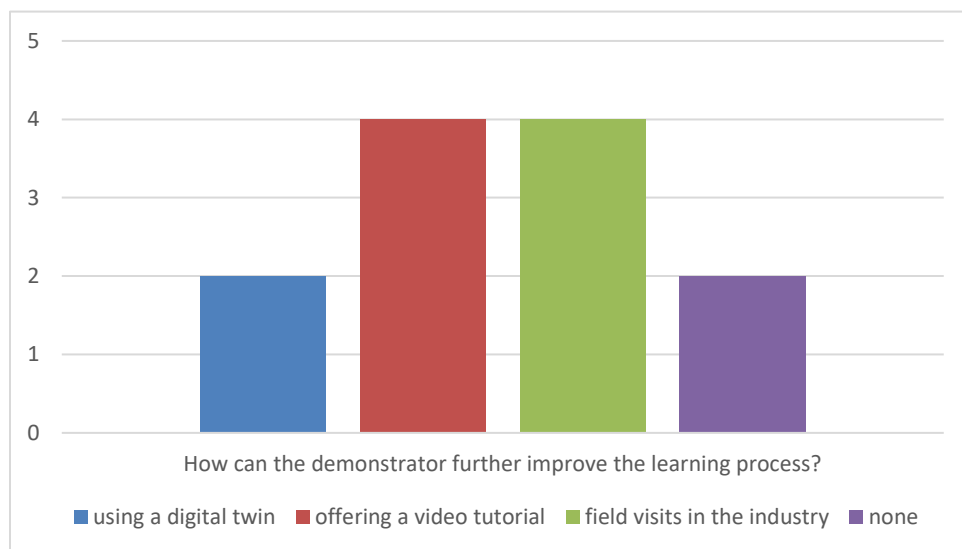
**Figure A.15 Collaboration (single response)**



**Figure A.16 Sustainability (multiple response)**



**Figure A.17 Learning skills (multiple response)**



**Figure A.18 Learning process (multiple response)**

The interdisciplinary approach, reflected in Figure A.13, shows that it was rated "good" by 54.55%, and as "very good" by (27.27%) from the correspondences. As "acceptable" it was considered by 18.18% in the survey. No respondents rated the response as "need improvement" or "unsatisfactory".

Referring to practical skills, Figure A.14, the distribution of responses offers following image: more than half, 54%, rated it as "very good" and "good"; 36.36% considered it as "acceptable". Additionally, 9.09% of the total responses were classified as "unsatisfactory". These findings indicate that the majority of the respondents rated these targets with "very good" and "good" ratings following closely. However, it is worth noting that one response was considered "unsatisfactory."

Considering collaboration, the information reflected in Figure A.15, reflects that more than 90% of the respondents indicated the need for an interdisciplinary team component to increase their understanding of the processes implemented through the demonstrator.

Referring to sustainability, Figure A.16 illustrates the improvements in various sustainability issues through the demonstrator. The data reflects that 42.86% of the respondents indicated the consideration of recycling (end-of-life) of the product as the sustainability issue that has been improved the most. Additionally, 28.57% of the responses highlighted the reduction in energy consumption as a significant improvement. Furthermore, 14.29% of the respondents noted the reduction in material consumption, while another 7.14% mentioned the use of materials with better environmental characteristics and manufacturing processes with better environmental characteristics.

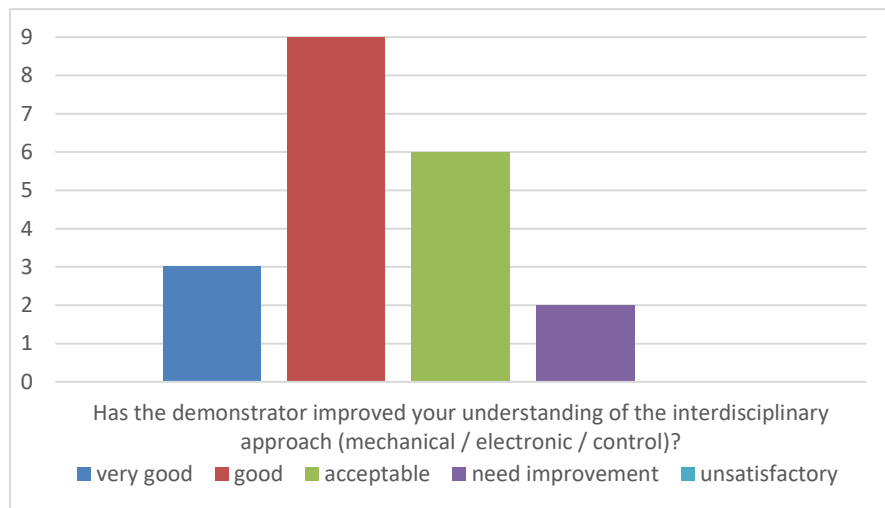
The information provided in Figure A.17 illustrates the improvement of learning skills focused on digitalization. The data indicates that 55.56% of the respondents reported an improvement in programming skills as a result of the demonstrator. Additionally, 11.11% of the responses mentioned improvement in web development skills, while 16.67% of the respondent's highlighted improvement in data analysis and visualization skills.

Considering the information provided in Figure A.18, the data illustrates the responses regarding how the demonstrator can further improve the learning process. The data indicates that 16.67% of the respondents suggested using a digital twin, while 33.33% mentioned offering a video tutorial and organizing field visits in the industry as potential ways to enhance the learning process. Additionally, 16.67% of the respondents indicated that none of the mentioned options would contribute to further improvement.

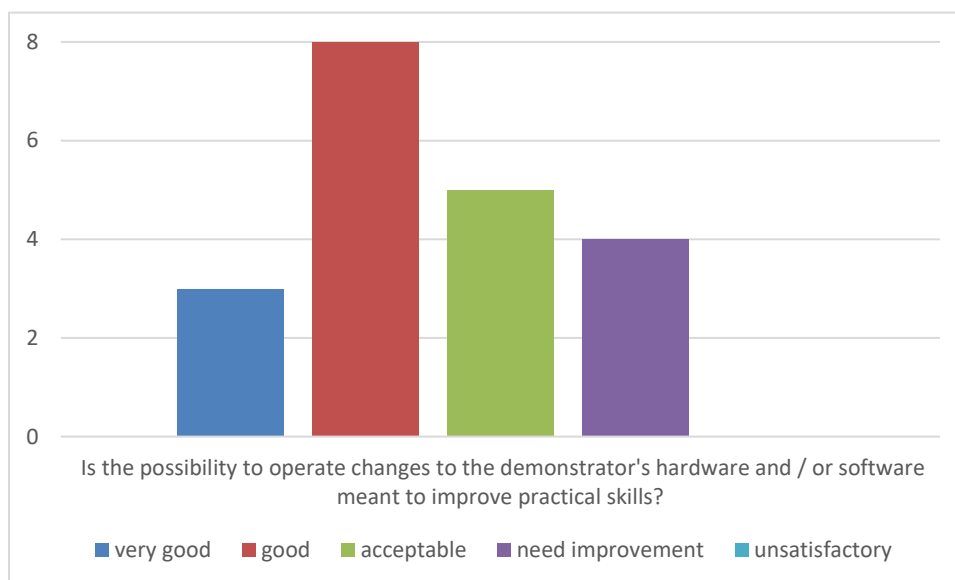
## Annex B: École Supérieure des Technologies et des Affaires

### B.1 Evaluation results 1<sup>st</sup> Demonstrator

The first demonstrator developed by the ESTA team and used in the teaching activity was the *Smart heating thermostatic valve*. The obtained feedback from twenty correspondents is highlighted in the following, Figures B.1 – 5.6.



**Figure B.1 Interdisciplinary approach (single response)**



**Figure B.2 Practical skills (single response)**

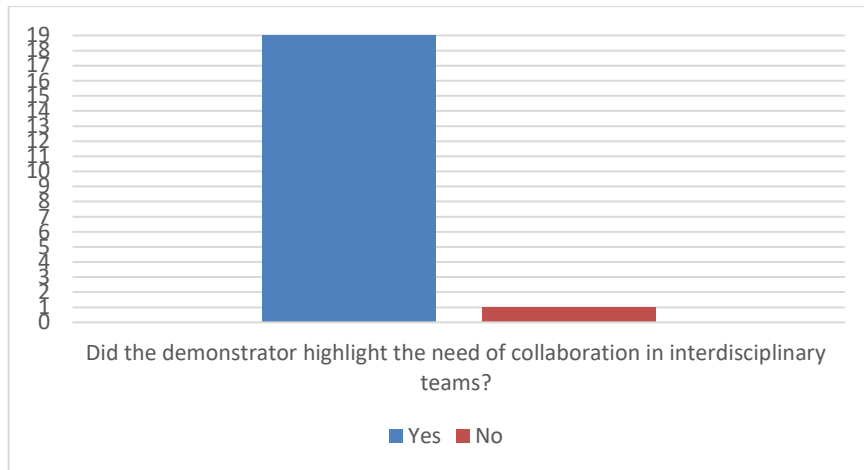


Figure B.3 Collaboration (single response)

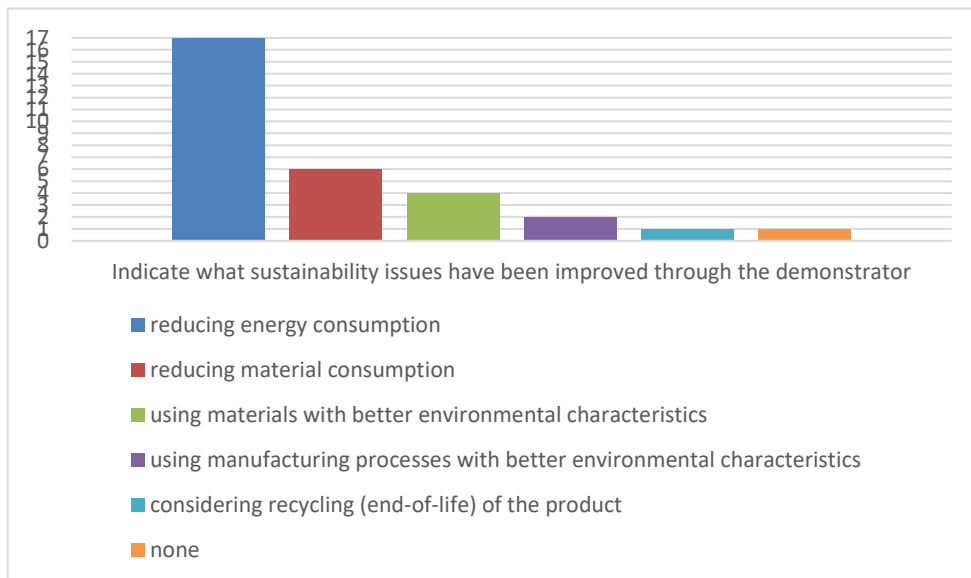


Figure B.4 Sustainability (multiple response)

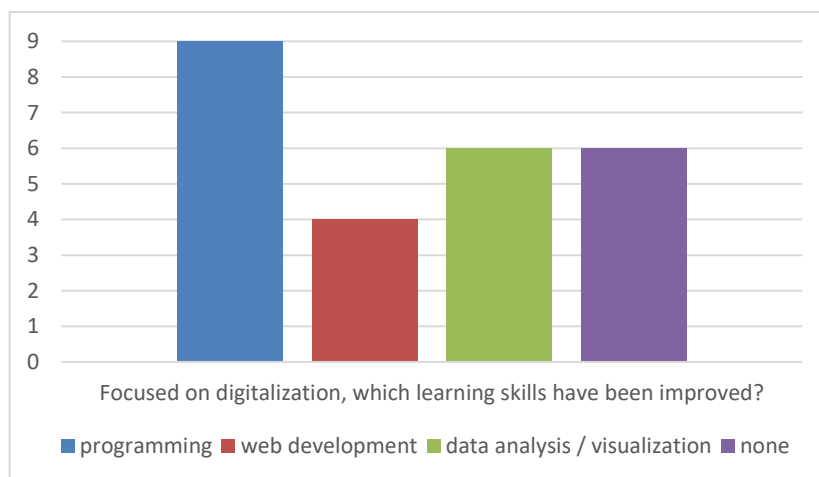
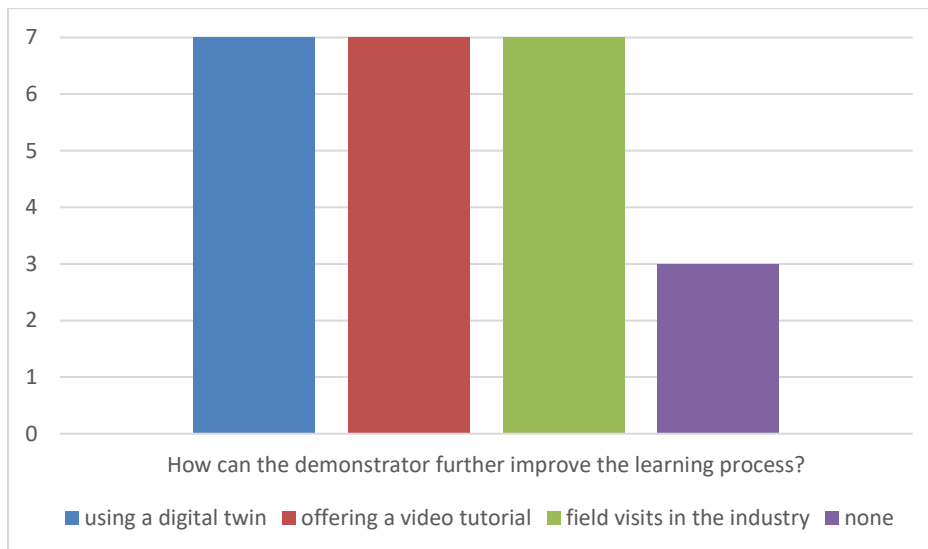


Figure B.5 Learning skills (multiple response)



**Figure B.6 Learning process (multiple response)**

Analyzing the received answers, results that the use of the demonstrator improves the understanding of the interdisciplinary approach: 60% rated it as very good and good, figure B.1.

The potential of improving practical skills by operating hardware and software changes on the demonstrators was rated as very good and good by 55% of the correspondents while the rest considered it acceptable or needed to be improved – 20%, figure B.2.

The need for an interdisciplinary team component to increase the understanding of the processes implemented through the demonstrator was indicated by 95 % of the correspondents, figure B.3.

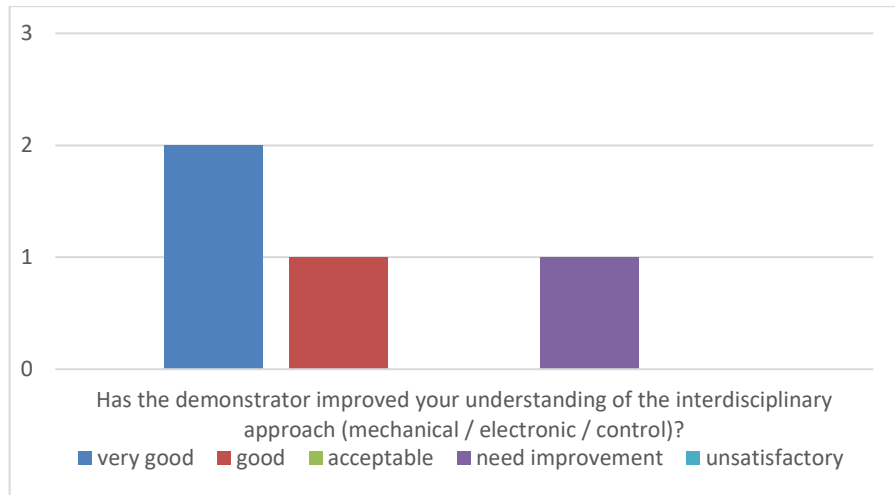
The main indicated sustainability issue of the correspondents was the reduction energy consumption – 54%, followed by reducing the consumption of materials – 19% and the use of environmentally friendly materials – 13%, figure B.4.

Learning skills orientated on digitalization have been deepened by 36% - programming, a share of 24% indicated improvement in data analysis / visualization and another 16% increased their skills in web development, figure B.5.

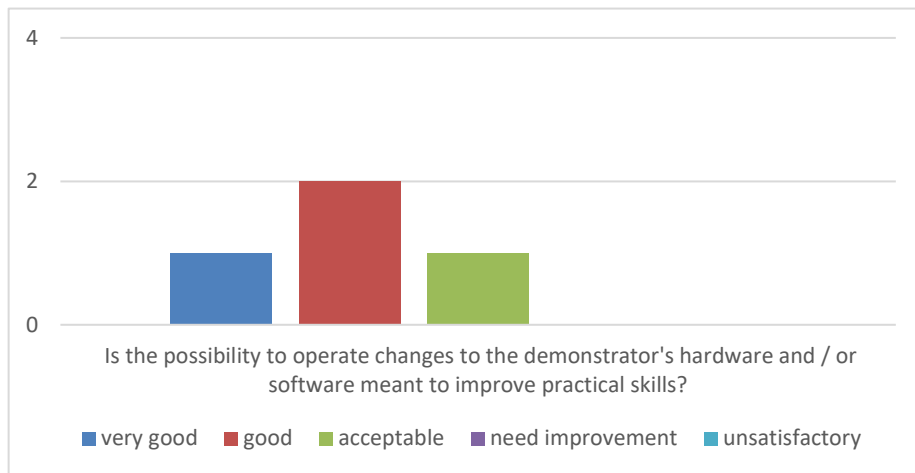
The understanding of the technical phenomena promoted by the use of the demonstrator could be supplementary increased if a digital twin is used – 29%, the operation modus would be described with a video tutorial – 29% or industry field visits would support the learning process by palpable case studies - 29%, figure B.6.

## B.2 Evaluation results 2<sup>nd</sup> Demonstrator

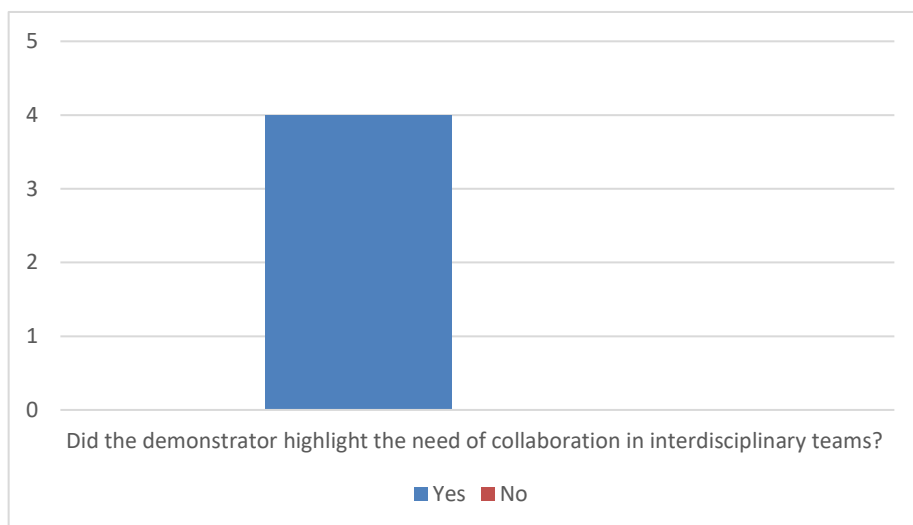
The second demonstrator developed by the ESTA team and used in the teaching activity was the *Smart heating application IoT*. The obtained feedback is highlighted in the following, Figures B.7 – B.12.



**Figure B.7 Interdisciplinary approach (single response)**

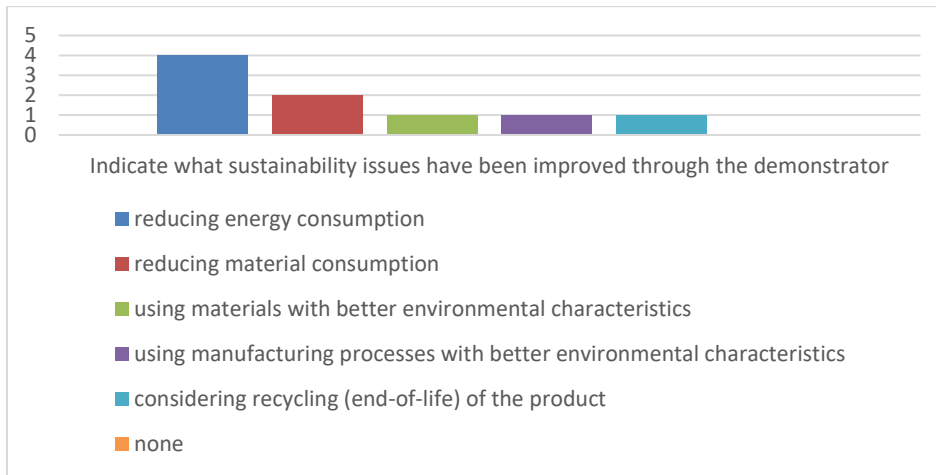


**Figure B.8 Practical skills (single response)**

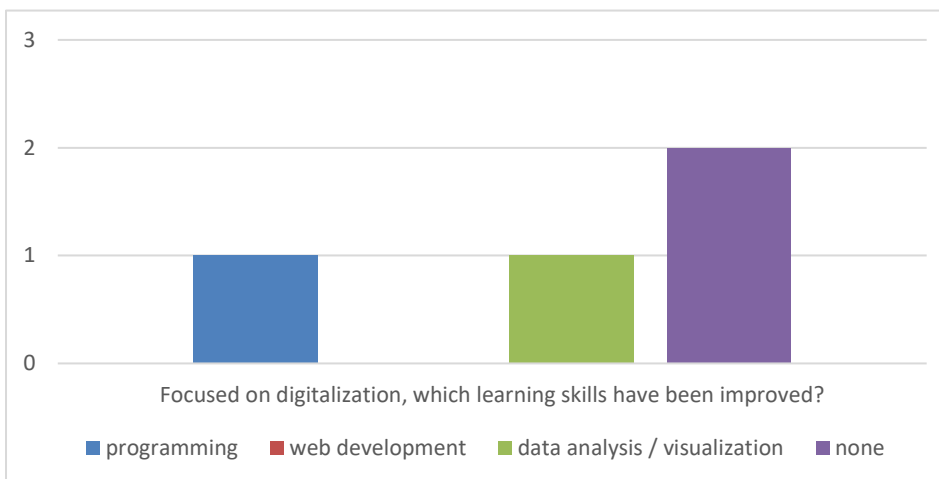


**Figure B.9 Collaboration (single response)**

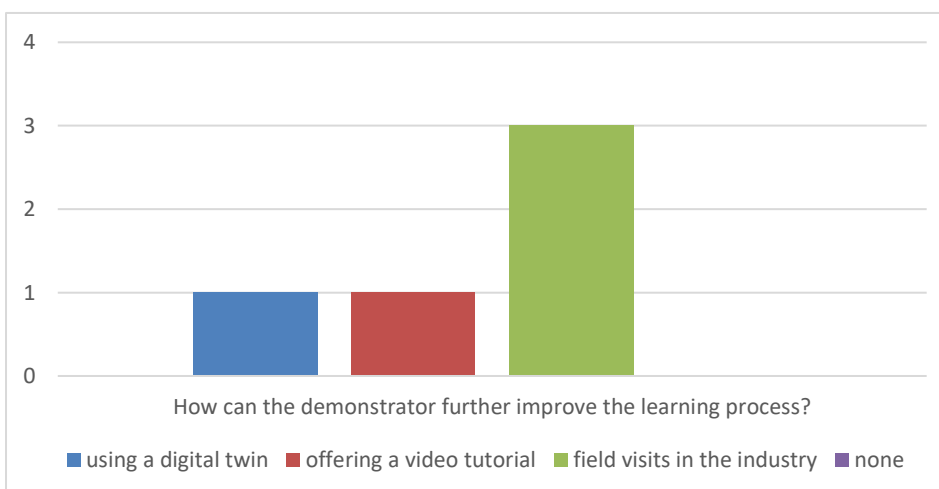
## Demonstrators impact assessment



**Figure B.10 Sustainability (multiple response)**



**Figure B.11 Learning skills (multiple response)**



**Figure B.12 Learning process (multiple response)**

The responses regarding the improvement of understanding in the interdisciplinary approach, Figure B.7, indicates that 50% of the respondents rated their understanding as "very good" while 25% rated it as "good". Additionally, 25% of the respondents indicated a need for improvement in their understanding of the interdisciplinary approach. It is worth noting that no responses were categorized as "acceptable" or "unsatisfactory".

Figure B.8 illustrates the responses meant to improve practical skills. The data indicates that 25% of the respondents rated the possibility as "very good," while 50% rated it as "good".

The need for an interdisciplinary team component to increase the understanding of the processes implemented through the demonstrator was indicated by 100 % of the correspondents, figure B.9.

The improvement of sustainability issues through the demonstrator is reflected in figure B.10: 44.44% of the respondents mentioned the reduction of energy consumption as a sustainability issue that has been improved while 22.22% highlighted the reduction of material consumption and other 11.11% indicated the use of materials and manufacturing processes with better environmental characteristics.

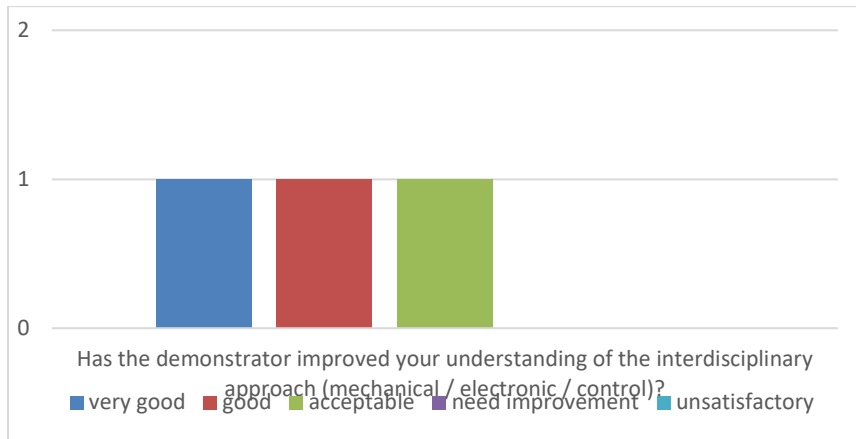
Considering the improvement of learning skills focused on digitalization, the data from figure B.11 indicates that 25% of the respondents reported an improvement in programming skills through the demonstrator. Additionally, 25% of the responses mentioned improvement in data analysis and visualization skills.

Considering the information provided in Figure B.12, the data illustrates the responses regarding how the demonstrator can further improve the learning process. The data indicates that 20% of the respondents suggested using a digital twin to enhance the learning process, while another 20% mentioned offering a video tutorial. Additionally, 60% of the respondents indicated that field visits in the industry would contribute to further improvement.

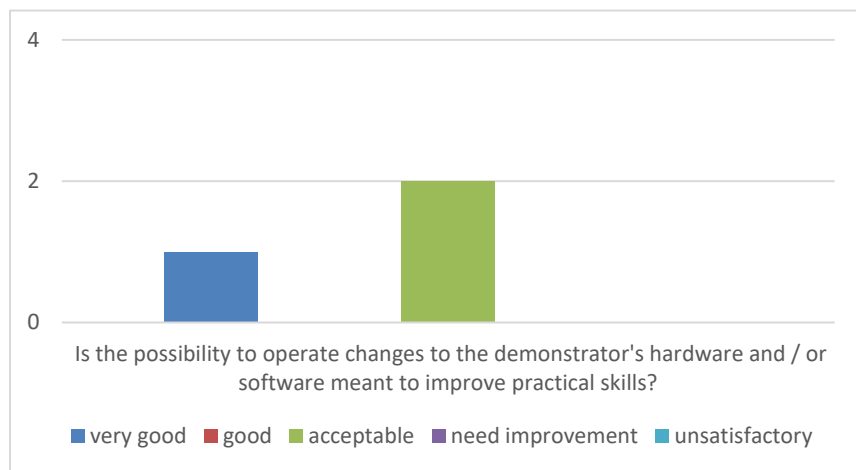
### **B.3 Evaluation results 3<sup>rd</sup> Demonstrator**

The third demonstrator developed by the ESTA team and used in the teaching activity was the *Digitalization of a drilling machine*. The obtained feedback is highlighted in the following, Figures B.13 – B.18.

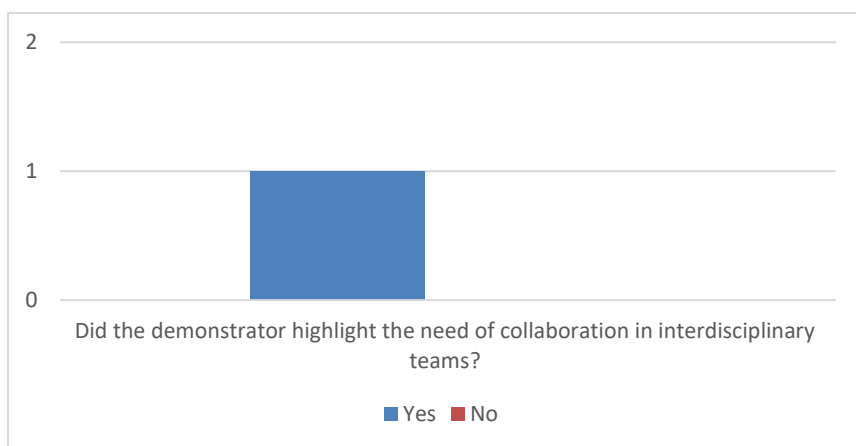
## Demonstrators impact assessment



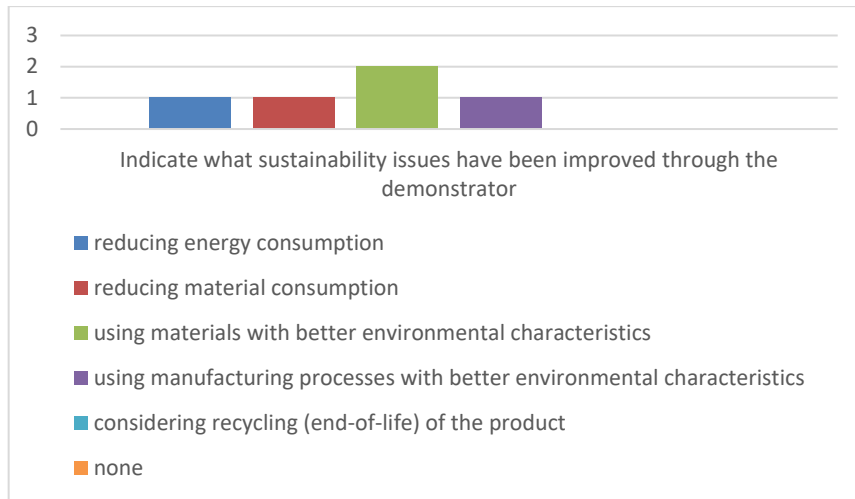
**Figure B.13 Interdisciplinary approach (single response)**



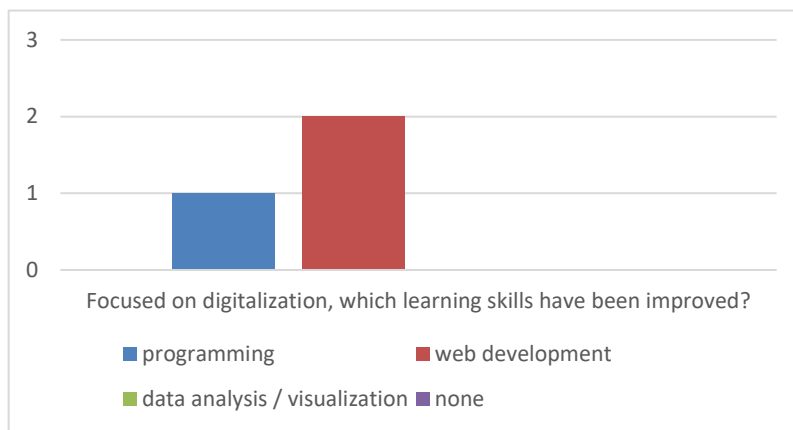
**Figure B.14 Practical skills (single response)**



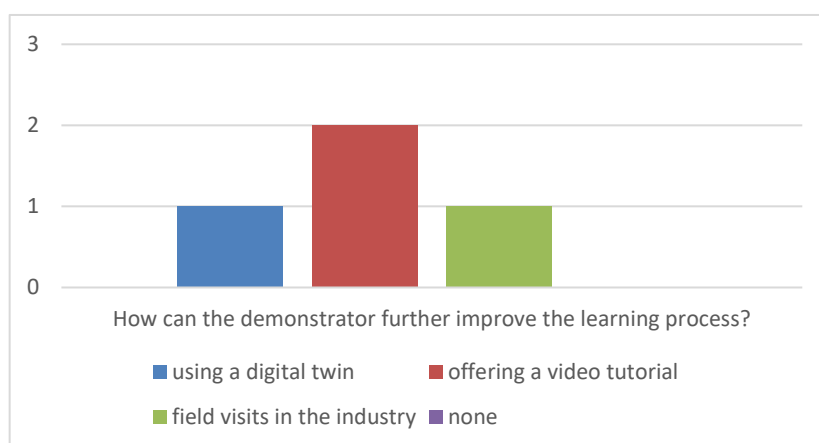
**Figure B.15 Collaboration (single response)**



**Figure B.16 Sustainability (multiple response)**



**Figure B.17 Learning skills (multiple response)**



**Figure B.18 Learning process (multiple response)**

The improvement of understanding in the interdisciplinary approach indicates a balanced distribution between "very good," "good," and "acceptable", by 33.33% each, figure B.13.

The possibility to improve practical skills indicates that 33.33% of the respondents rated the possibility as "very good," while 66.67% categorized it as "acceptable", figure B.14.

Considering the information provided in Figure B.15, the data illustrates the responses regarding whether the demonstrator highlighted the need for collaboration in interdisciplinary teams. The data indicates that 100% of the respondents answered "Yes," indicating that the demonstrator did highlight the need for collaboration in interdisciplinary teams. It is worth noting that no responses were recorded for the option "No."

The main indicated sustainability issue of the correspondents was the use of materials with better environmental characteristics – 40%, followed by reducing the consumption of materials – 20%, reducing of energy consumption 20% and the use of manufacturing processes with better environmental characteristics – 20%, figure B.16.

Considering the information provided in Figure B.17, the data illustrates the responses regarding the improvement of learning skills focused on digitalization. The data indicates that 33.33% of the respondents reported an improvement in programming skills through the demonstrator. Additionally, 66.67% of the responses mentioned improvement in web development skills.

Considering the information provided in Figure B.18, the data illustrates the responses regarding how the demonstrator can further improve the learning process. The data indicates that 25% of the respondents suggested using a digital twin as a way to enhance the learning process. Additionally, 50% of the responses mentioned offering a video tutorial as a potential improvement. Furthermore, 25% of the respondents suggested field visits in the industry as a means to further improve the learning process.

### B.3 Evaluation results 4<sup>th</sup> Demonstrator

The fourth demonstrator developed by the ESTA team and used in the teaching activity was the *Smart lighting system*. The obtained feedback from twenty correspondents is highlighted in the following, Figures B.19 – B.24.

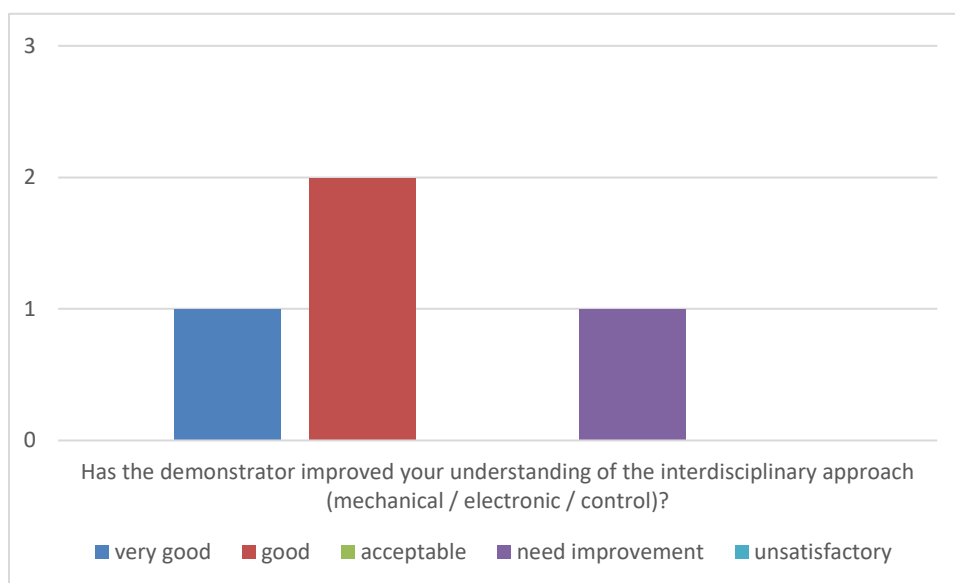
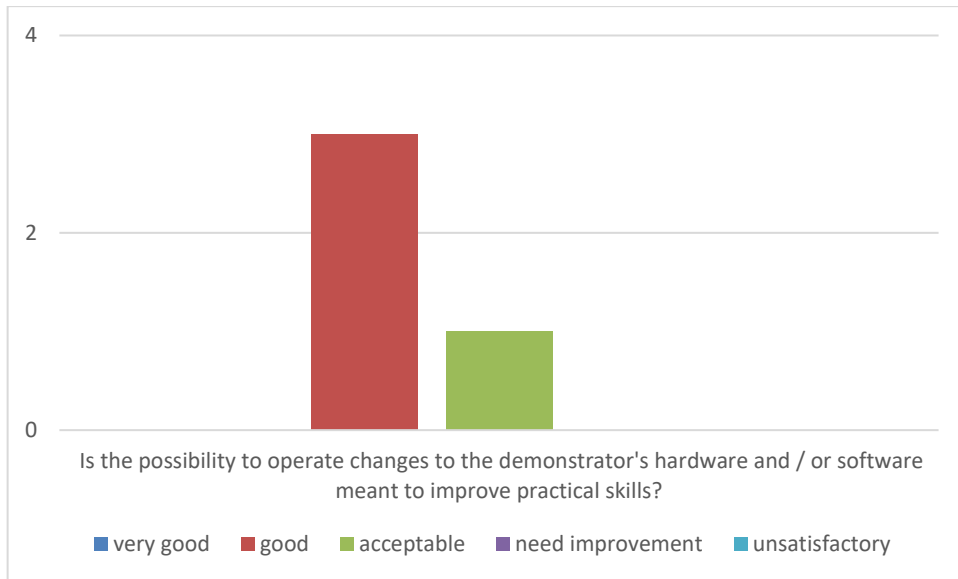
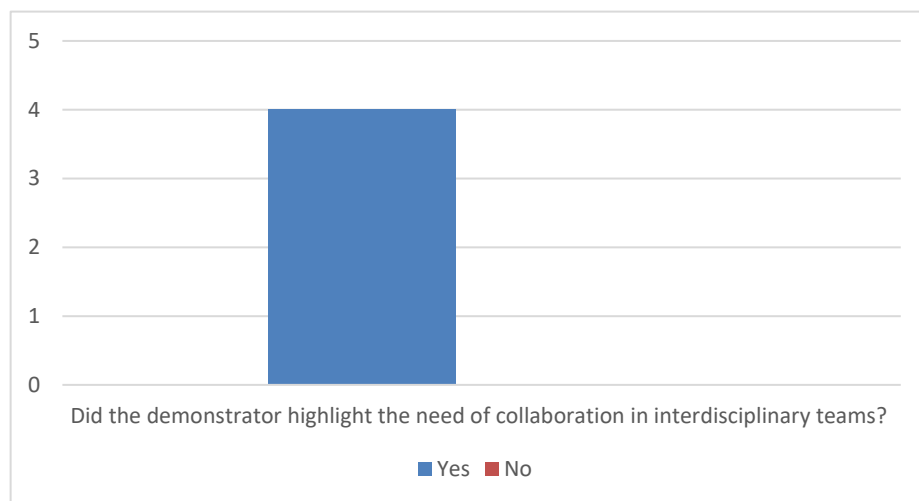


Figure B.19 Interdisciplinary approach (single response)

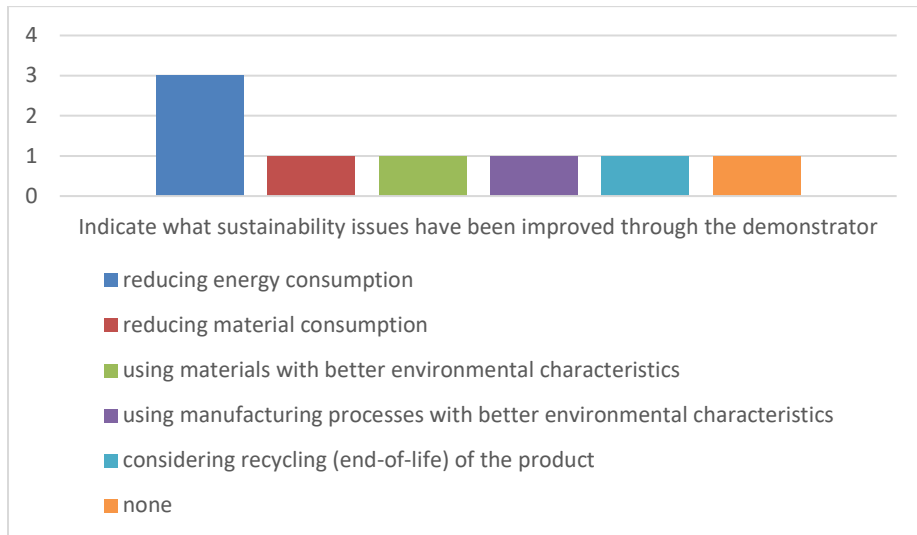


**Figure B.20 Practical skills (single response)**

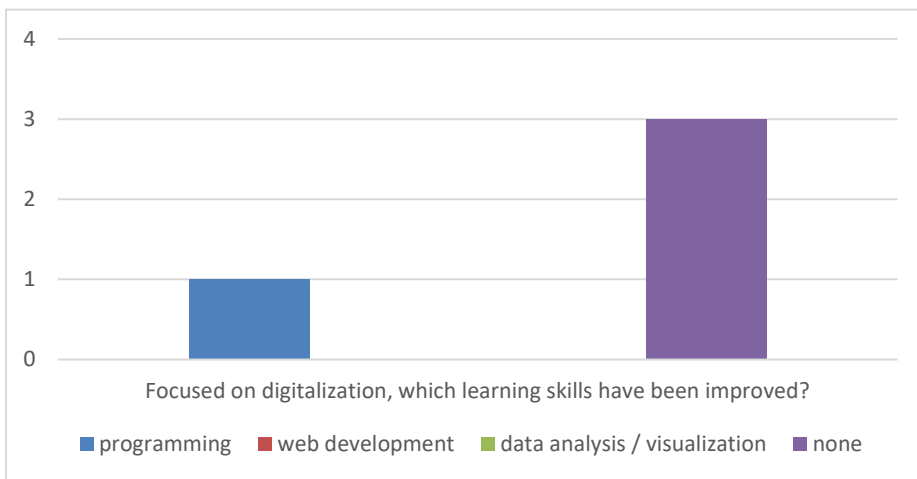


**Figure B.21 Collaboration (single response)**

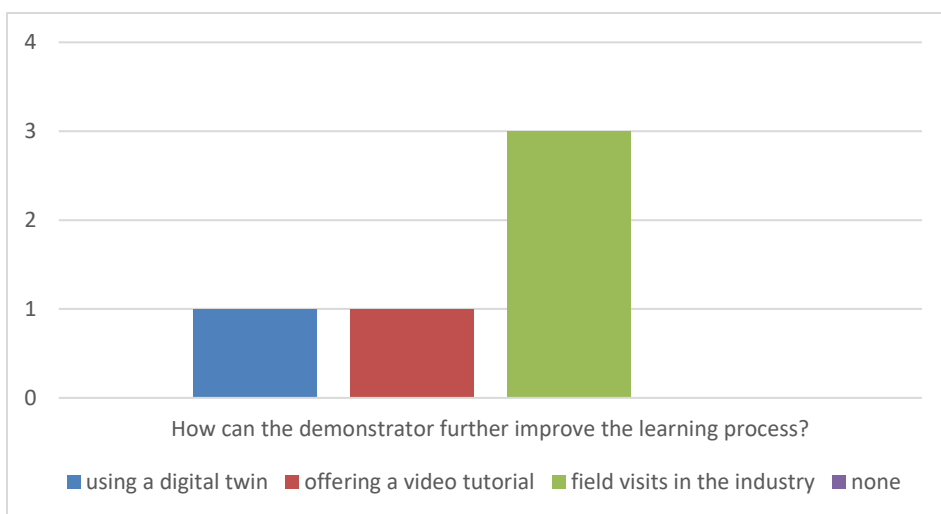
## Demonstrators impact assessment



**Figure B.22 Sustainability (multiple response)**



**Figure B.23 Learning skills (multiple response)**



**Figure B.24 Learning process (multiple response)**

Considering the received answers, results that the use of the demonstrator improves the understanding of the interdisciplinary approach: 75% rated it as very good and good, figure B.19.

The potential of improving practical skills by operating hardware and software changes on the demonstrators was rated as very good and good by 75% of the correspondents while the rest considered it acceptable – 25%, figure B.20.

The need for an interdisciplinary team component to increase the understanding of the processes implemented through the demonstrator was indicated by all correspondents, figure B.21.

The main indicated sustainability issue of the correspondents was the reduction energy consumption – 37%, followed, in equal measure, by reducing the consumption of materials – 12%, the use of environmentally friendly materials – 12%, manufacturing processes with better environmental characteristics – 12%, the recycling of the product (end of life) – 12%, figure B.22.

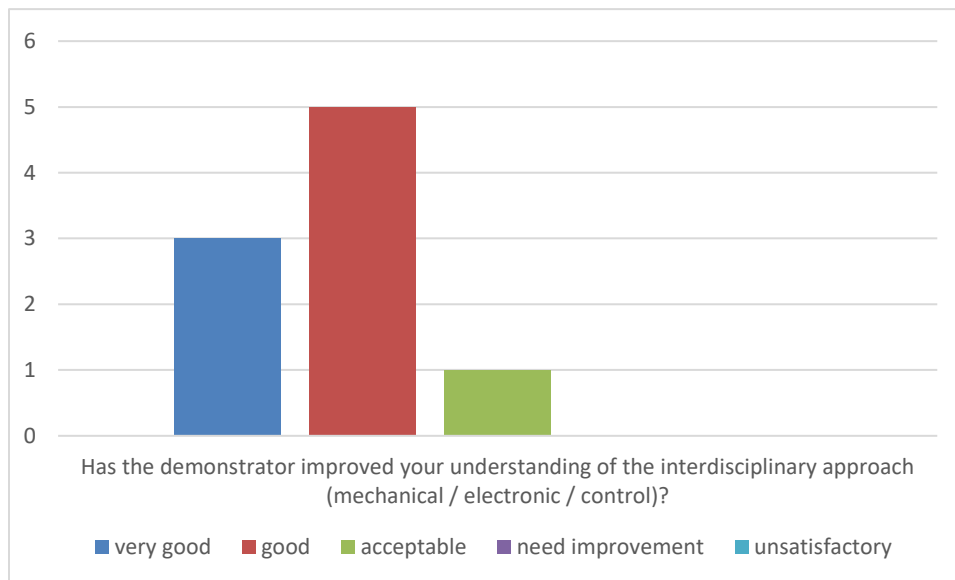
The learning skills orientated on digitalization have been deepened by 25% - programming, while the rest of the correspondents did not identify any improvement of their digital skills, figure B.23.

The understanding of the technical phenomena promoted by the use of the demonstrator could be supplementary increased through field visits - 60%, if a digital twin is used – 20%, or the operation modus would be described with a video tutorial – 20%, figure B.24.

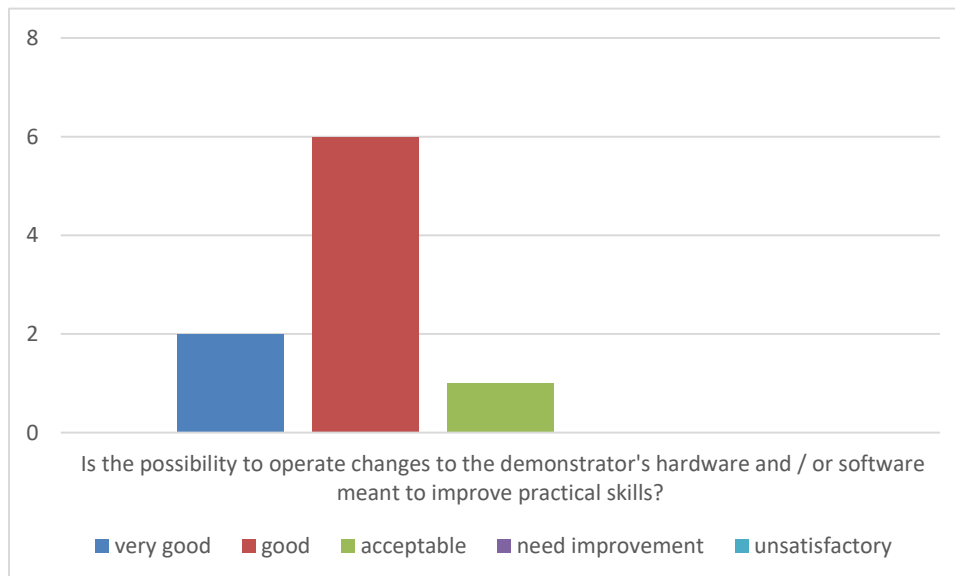
## Annex C: Babeş-Bolyai University. Faculty of Engineering

### C.1 Evaluation results 1<sup>st</sup> Demonstrator

The first demonstrator developed by the BBU Faculty of Engineering team and used in the teaching activity was the *CNC Machine*. The obtained feedback from the correspondents is highlighted in the following, Figures C.1 – C.7.



**Figure C.1 Interdisciplinary approach (single response)**



**Figure C.2 Practical skills (single response)**

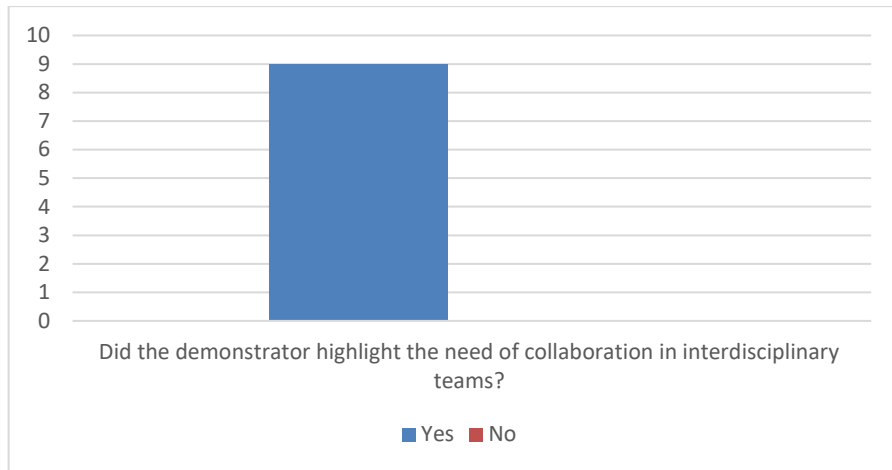


Figure C.3 Collaboration (single response)

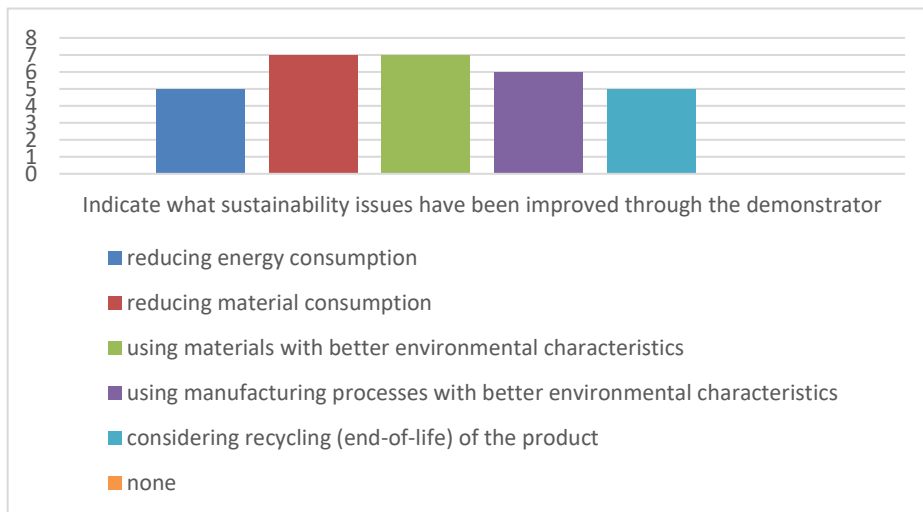


Figure C.4 Sustainability (multiple response)

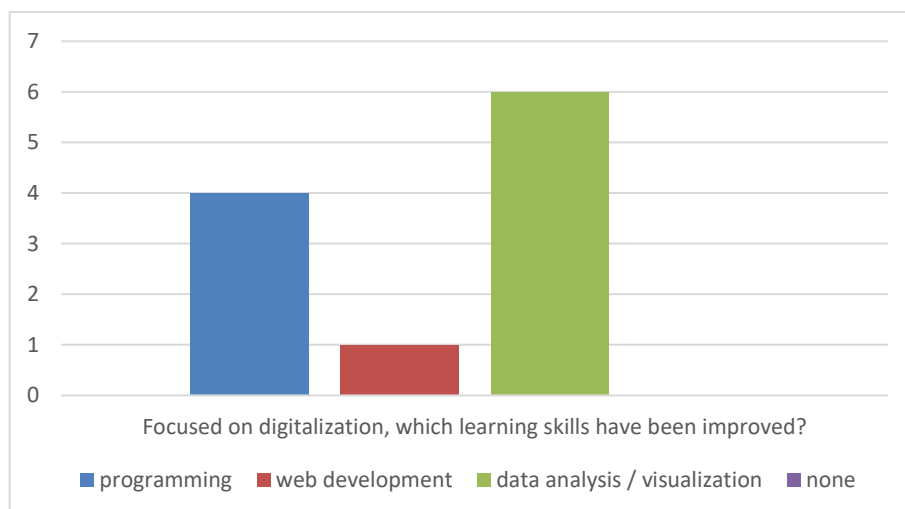
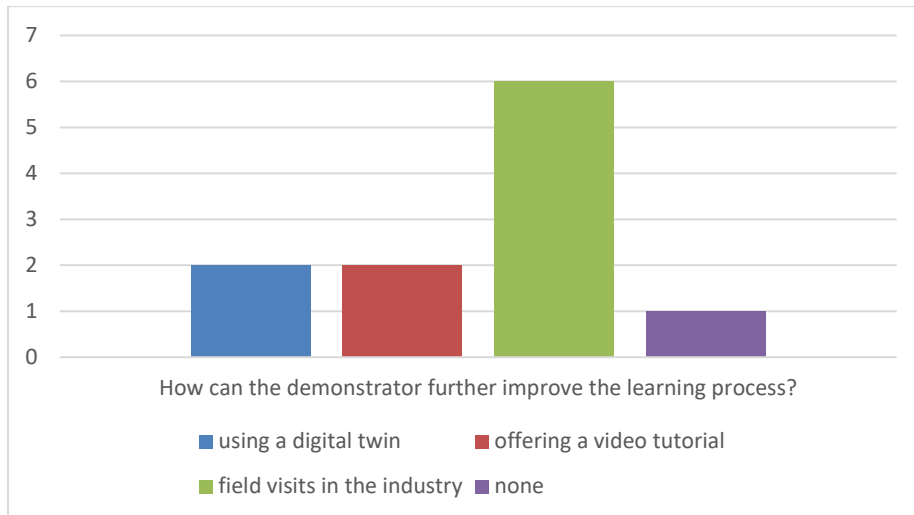


Figure C.5 Learning skills (multiple response)



**Figure C.6 Learning process (multiple response)**

According to Figure C.1, the improvement of understanding in the interdisciplinary approach through the demonstrator are as follows: 33.33% of the respondents rated their understanding as "very good". Additionally, 55.56% of the respondents rated their understanding as "good". Furthermore, 11.11% of the respondents categorized their understanding as "acceptable". No responses were recorded for the options "need improvement" or "unsatisfactory." From the data, it can be observed that the majority of respondents rated their understanding as either "good" or "very good," indicating a positive impact of the demonstrator on their interdisciplinary approach understanding.

Figure C.2, reflecting the improvement of practical skills are: 22.22% rated it as "very good", additionally, 66.67% of the respondents rated it as "good". Furthermore, 11.11% categorized it as "acceptable". From the data, it can be observed that the majority of respondents rated the possibility to make changes to the demonstrator's hardware and/or software as either "good" or "very good" indicating a positive perception of its potential to improve practical skills.

Figure C.3 indicates that all respondents (100%) answered "Yes" indicating that the demonstrator highlights the need for collaboration in interdisciplinary teams.

According to the data presented in Figure C.4, the responses regarding the sustainability issues that have been improved through the demonstrator are as follows: reducing energy consumption, accounting for 16.67% of the total; reducing material consumption, representing 23.33% of the total; using materials with better environmental characteristics, also representing 23.33% of the total; using manufacturing processes with better environmental characteristics, representing 20% of the total; and considering recycling (end-of-life) of the product, making up 16.67% of the total.

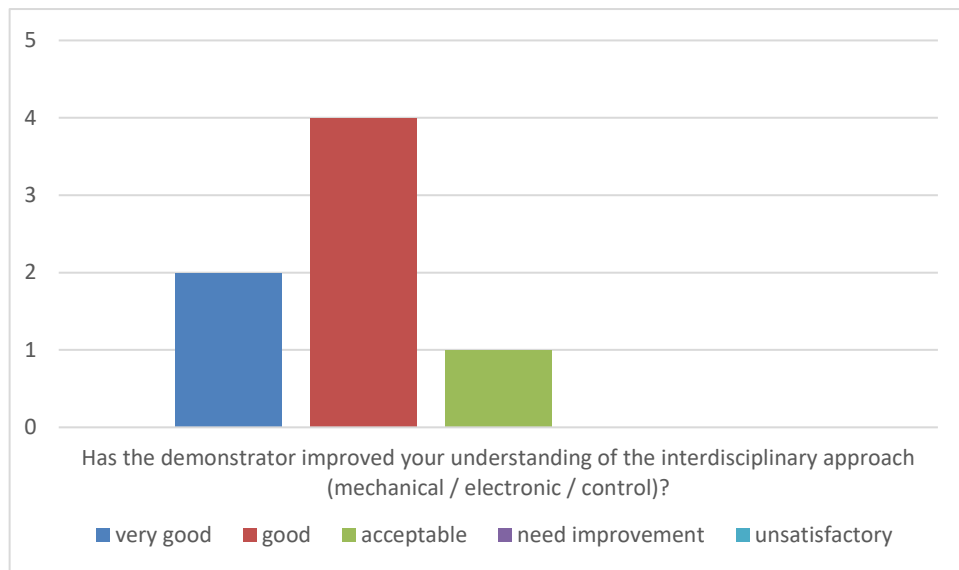
According to the data presented in Figure C.5, the responses regarding the improvement of learning skills focused on digitalization are as follows: 36.36% of the respondents reported an improvement in programming skills. Additionally, 9.09% of the respondents mentioned an improvement in web development skills. The majority of the respondents (54.55%) indicated an improvement in their learning skills related to data analysis and visualization. No responses were recorded for the option "none." From the data, it can be observed that the demonstrator has

played a significant role in enhancing skills related to programming, web development, and data analysis/visualization in the context of digitalization.

According to the data presented in Figure C.6, the responses regarding how the demonstrator can further improve the learning process are as follows: 18.18% of the respondents suggested using a digital twin. Similarly, 18.18% of the respondents mentioned offering a video tutorial as a potential improvement. The majority of the respondents (54.55%) recommended field visits in the industry as a way to enhance the learning process. From the data, it can be concluded that incorporating field visits in the industry is a prominent recommendation to further improve the learning process through the demonstrator, while options such as using a digital twin and offering video tutorials also received attention.

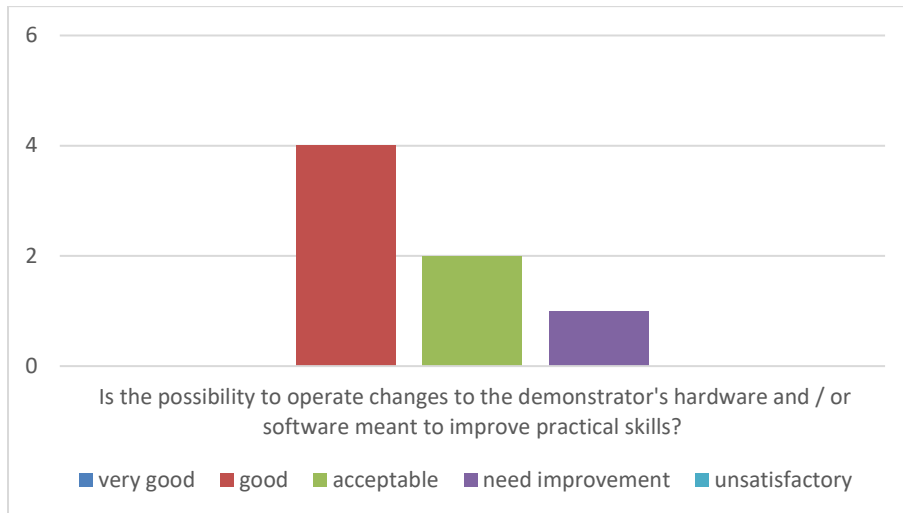
### C.2 Evaluation results 2nd Demonstrator

The first demonstrator developed by the BBU team and used in the teaching activity was the *Structural health monitoring*. The obtained feedback from twenty correspondents is highlighted in the following, Figures C.7 – C.12.

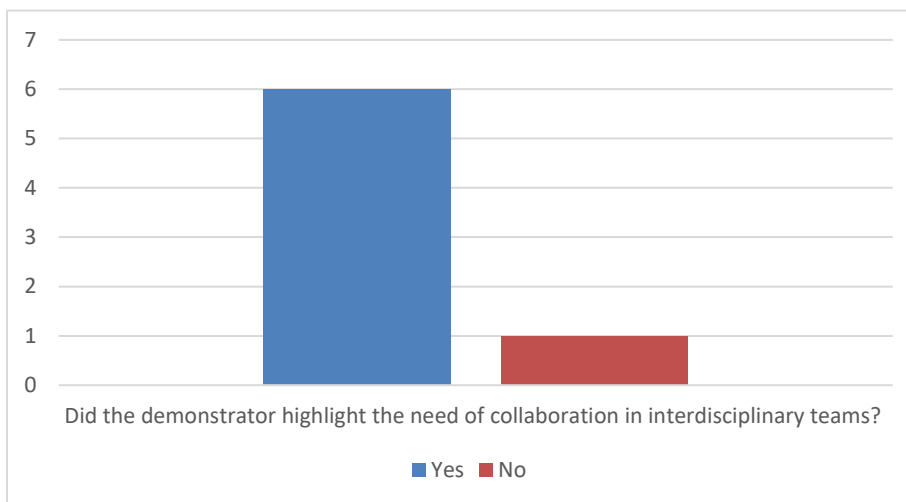


**Figure C.7 Interdisciplinary approach (single response)**

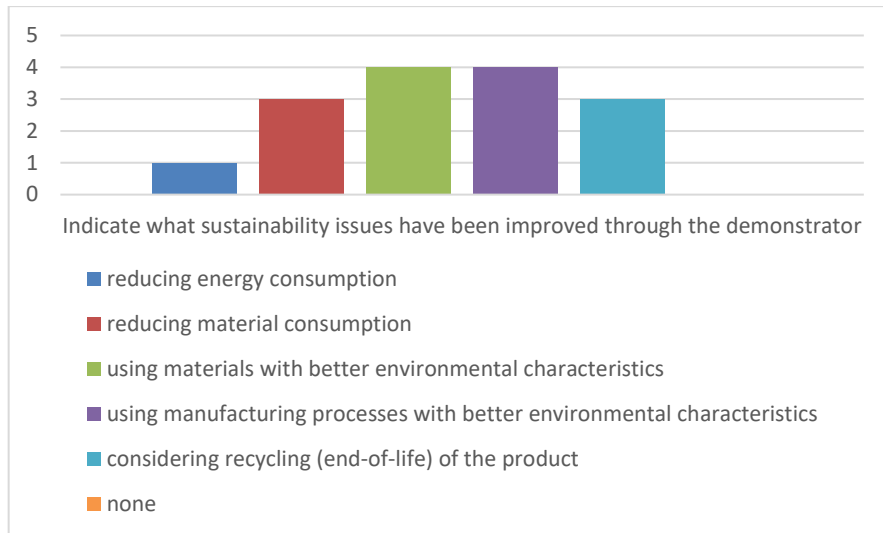
## Demonstrators impact assessment



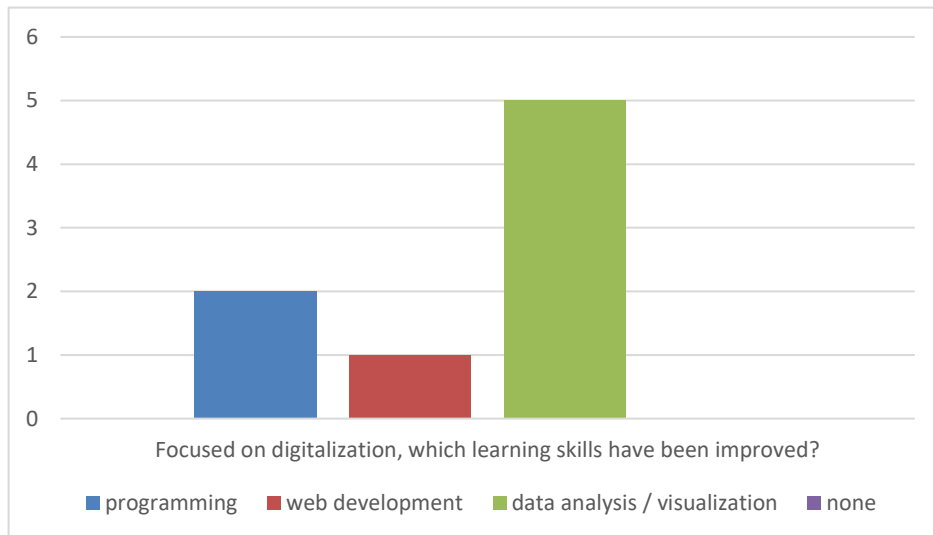
**Figure C.8 Practical skills (single response)**



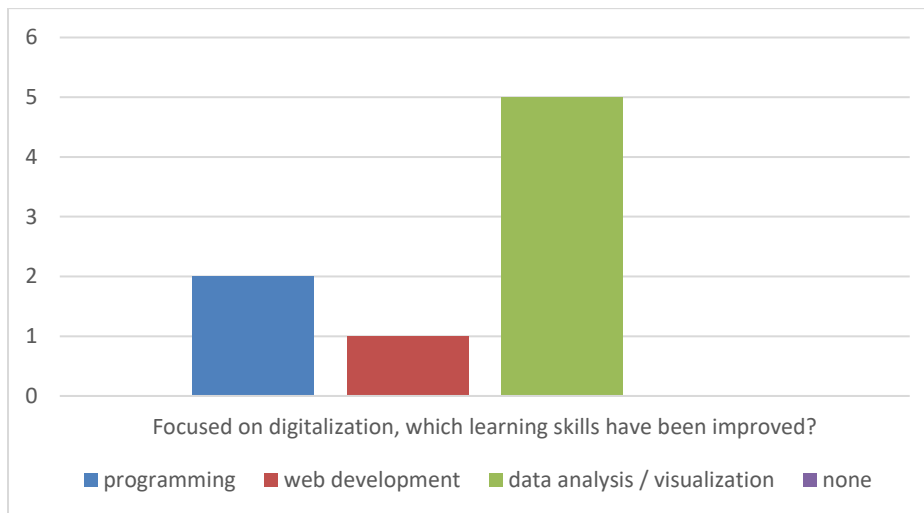
**Figure C.9 Collaboration (single response)**



**Figure C.10 Sustainability (multiple response)**



**Figure C.11 Learning skills (multiple response)**



**Figure C.12 Learning process (multiple response)**

Considering the received answers, results that the use of the demonstrator improves the understanding of the interdisciplinary approach: 85% rated it as very good and good, figure C.7.

The potential of improving practical skills by operating hardware and software changes on the demonstrators was rated as good by more than half, 57% of the correspondents, while the rest considered it acceptable – 28%, but also, 14%, as improvable, figure C.8.

The need for an interdisciplinary team component to increase the understanding of the processes implemented through the demonstrator was indicated by more than 85% of the correspondents, figure C.9.

The main indicated sustainability issues of the correspondents was, in equal measure, the use of environmentally friendly materials – 26% and manufacturing processes with better environmental characteristics – 26%, followed by reducing the consumption of materials – 20%, the recycling of the product (end of life) – 20% and the reduction energy consumption – 6%, figure C.10.

The learning skills orientated on digitalization have been deepened by 25% - programming, data analysis / visualization by 62%, figure C.11.

The understanding of the technical phenomena promoted by the use of the demonstrator could be supplementary increased through field visits - 71%, if a digital twin is used – 14%, figure C.12.

### C.3 Evaluation results 3<sup>rd</sup> Demonstrator

The first demonstrator developed by the UBB team and used in the teaching activity was Robotic. The obtained feedback from twenty correspondents is highlighted in the following, Figures C.13 – C.19.

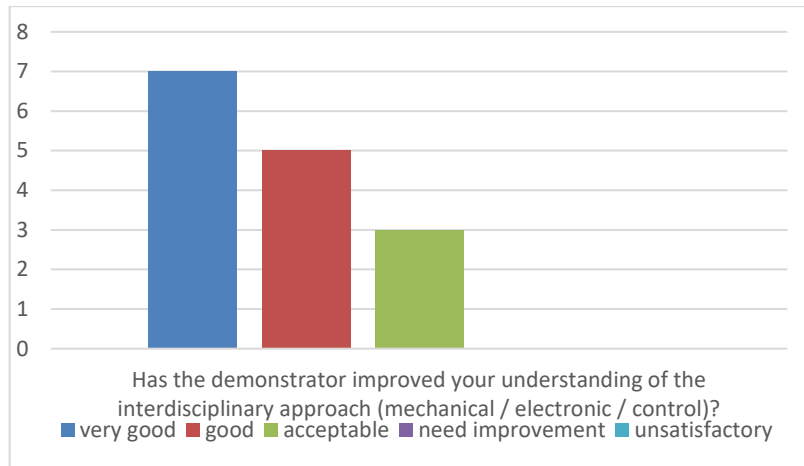


Figure C.13 Interdisciplinary approach (single response)

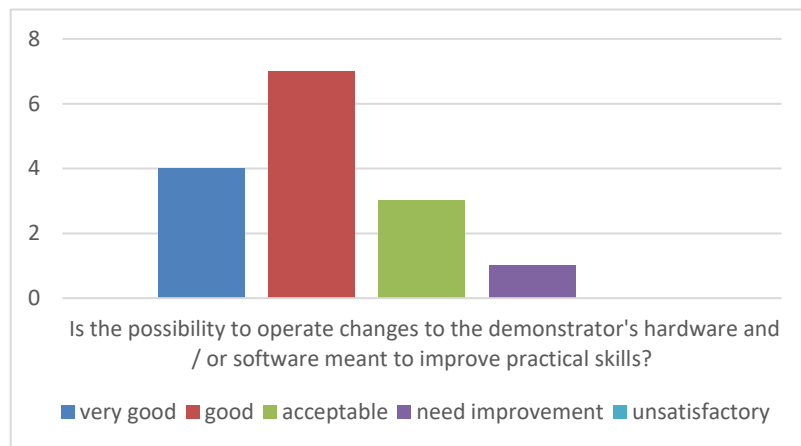


Figure C.14 Practical skills (single response)

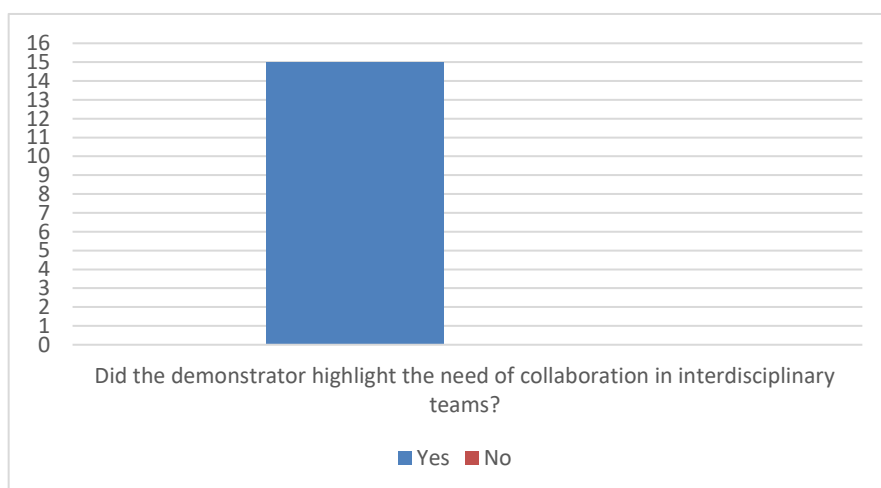
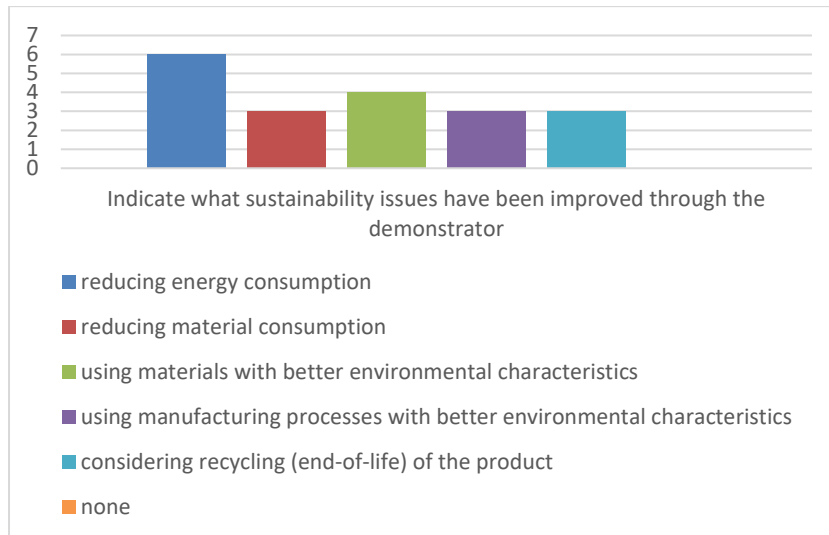
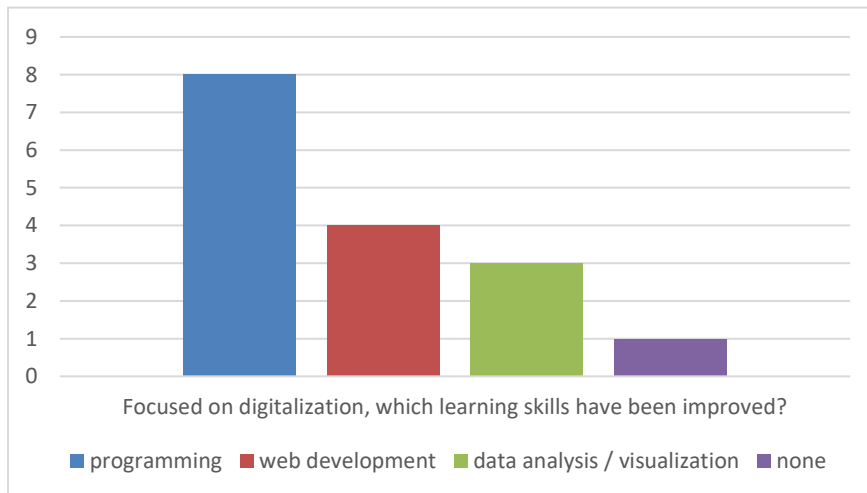


Figure C.15 Collaboration (single response)

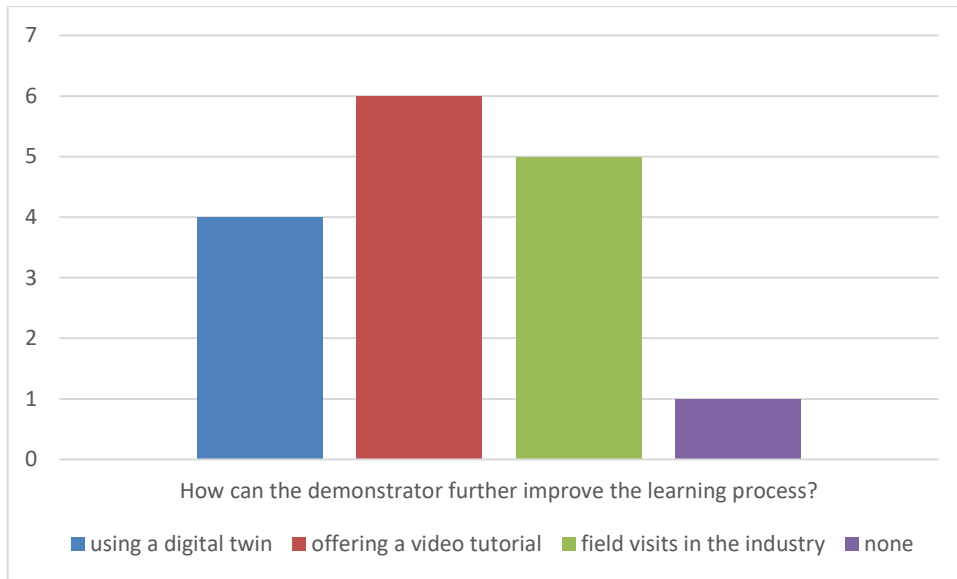
## Demonstrators impact assessment



**Figure C.16 Sustainability (multiple response)**



**Figure C.17 Learning skills (multiple response)**



**Figure C.18 Learning process (multiple response)**

According to the data presented in Figure C.13, reflecting the improvement of understanding in the interdisciplinary approach are as follows: 46.67% of the respondents rated their understanding as "very good". Additionally, 33.33% considered their understanding as "good". Furthermore, 20% of the respondents categorized their understanding as "acceptable". No responses were recorded for the options "need improvement" or "unsatisfactory." From the data, it can be observed that the majority of respondents reported a high level of improvement in their understanding of the interdisciplinary approach.

Figure C.14 reflects the possibility of improving practical skills. Those are as follows: 26.67% of the respondents rated it as "very good". Additionally, the majority of respondents (46.67%) rated it as "good". Furthermore, 20% of the respondents categorized it as "acceptable". A small percentage of respondents (6.67%) indicated a need for improvement in this aspect. No responses were recorded for the category "unsatisfactory".

According to Figure C.15, all respondents (100%) agreed that the demonstrator effectively highlighted the need for collaboration in interdisciplinary teams.

The sustainability issues that have been improved through the demonstrator are, based on Figure C.16: 31.58% of the respondents reported improvements in reducing energy consumption. Additionally, 15.79% of the respondents indicated improvements in reducing material consumption, using materials with better environmental characteristics, and using manufacturing processes with better environmental characteristics. Furthermore, 15.79% of the respondents mentioned improvements in recycling at the end-of-life of the product.

According to the data presented in Figure C.17, the learning skills that have been improved through the focus on digitalization are as follows: 50% of the respondents reported improvements in programming skills. Additionally, 25% of the respondents indicated enhancements in web development skills. Furthermore, 18.75% of the respondents mentioned improvements in data analysis and visualization skills. From the data, it can be observed that the demonstrator has effectively contributed to the enhancement of various learning skills, particularly in the areas of programming, web development, and data analysis/visualization.

According to the data presented in Figure C.18, the suggestions for further improving the learning process through the demonstrator are as follows: 37.5% of the respondents emphasized the importance of offering video tutorials. Additionally, 31.25% of the respondents highlighted the value of field visits in the industry. Furthermore, 25% of the respondents suggested the use of a digital twin to enhance the learning process. One respondent indicated that they didn't require any specific improvements. From the data, it can be observed that the respondents provided valuable suggestions for enhancing the learning process, including the provision of video tutorials, field visits in the industry, and the use of a digital twin.

#### C.4 Evaluation results 4<sup>th</sup> Demonstrator

The first demonstrator developed by the UBB team and used in the teaching activity was the *Solar Tracker*. The obtained feedback from twenty correspondents is highlighted in the following, Figures C. 19–24.

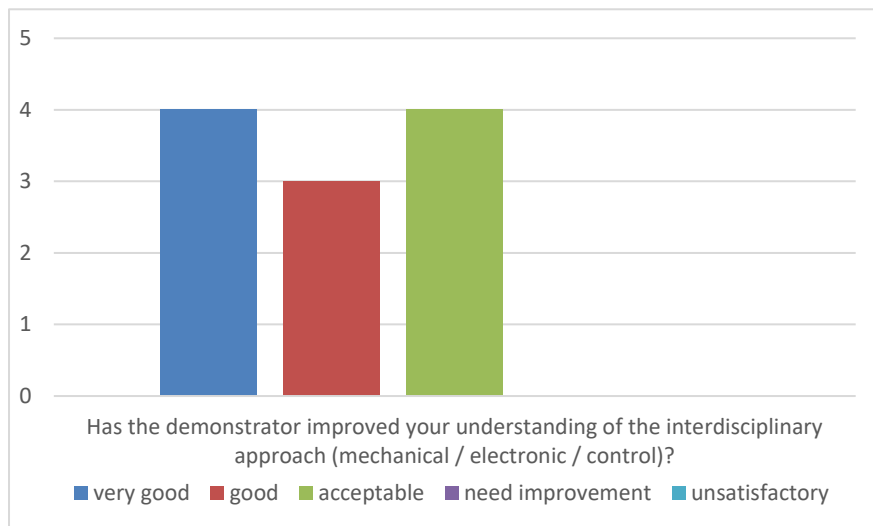


Figure C.19 Interdisciplinary approach (single response)

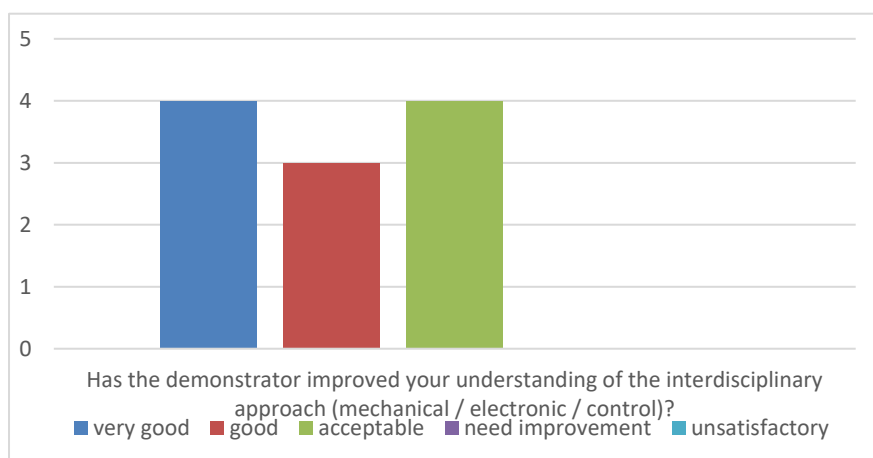
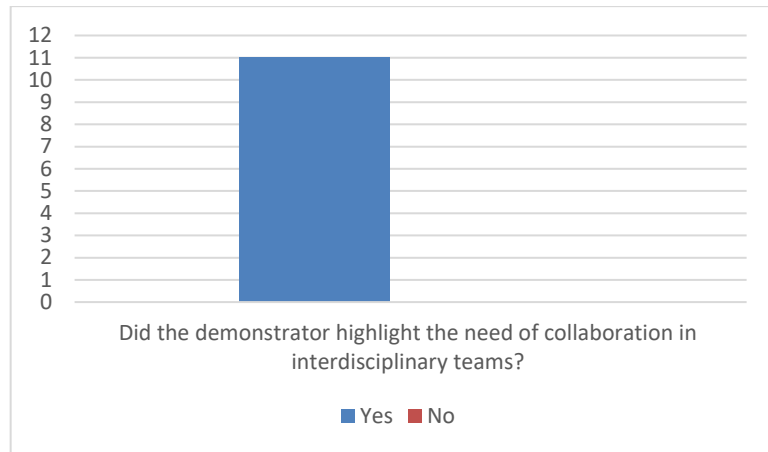
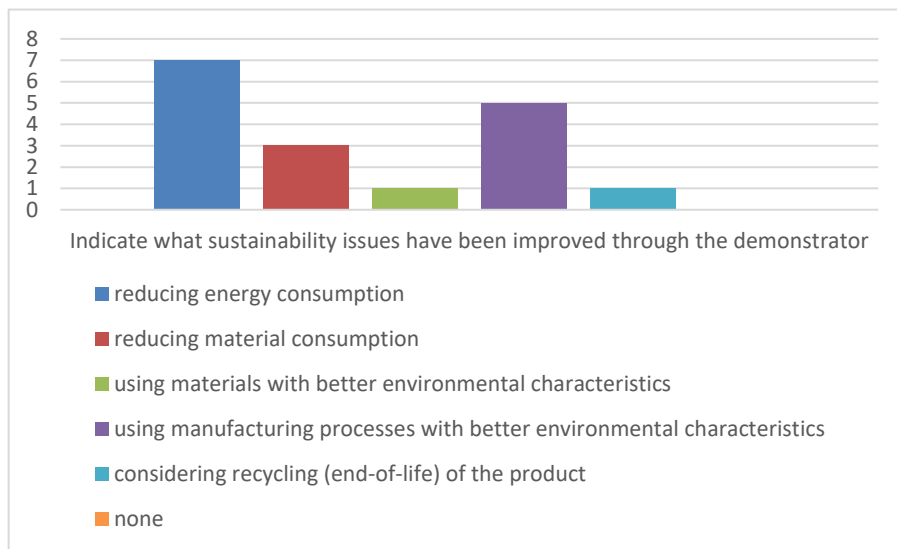


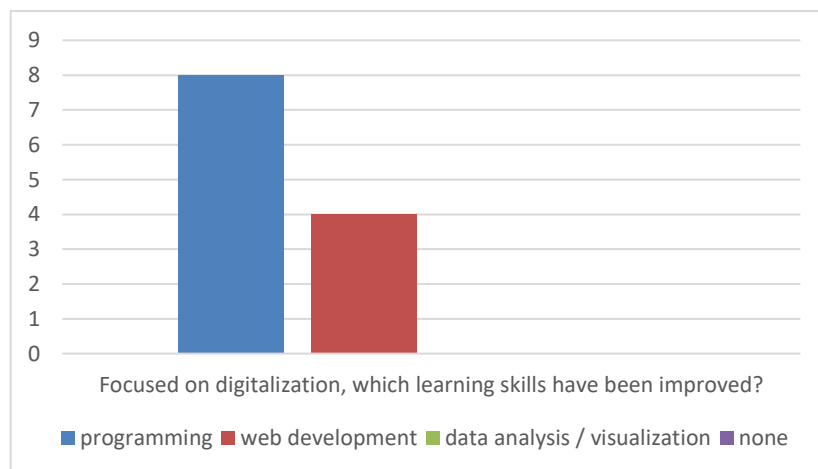
Figure C.20 Practical skills (single response)



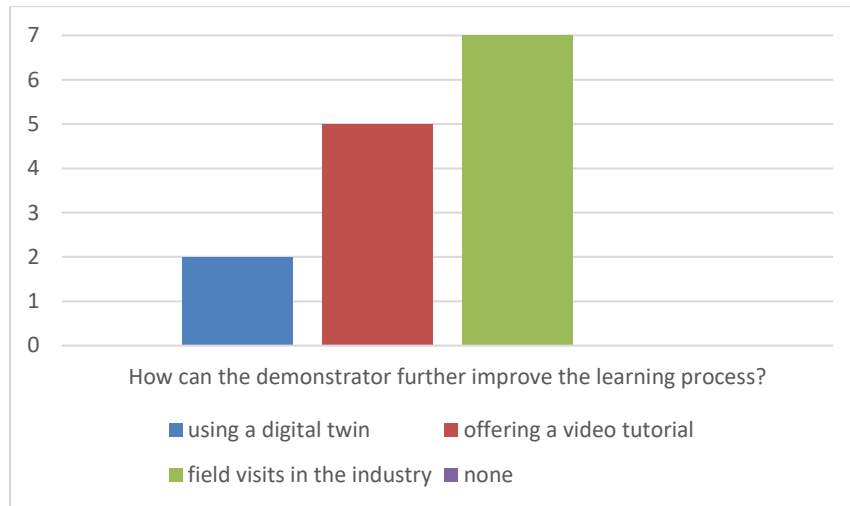
**Figure C.21 Collaboration (single response)**



**Figure C.22 Sustainability (multiple response)**



**Figure C.23 Learning skills (multiple response)**



**Figure C.24 Learning process (multiple response)**

Considering the received answers, results that the use of the demonstrator improves the understanding of the interdisciplinary approach: 63% rated it as very good and good, figure C.19.

The potential of improving practical skills by operating hardware and software changes on the demonstrators was rated as good by more than half, 72% of the correspondents, while 27% considered it as improvable, figure C.20.

The need for an interdisciplinary team component to increase the understanding of the processes implemented through the demonstrator was indicated by all respondents, figure C.21.

The main indicated sustainability issues of the correspondents were reduction of energy consumption – 41% followed by manufacturing processes with better environmental characteristics – 29%, reducing the consumption of materials – 17%, figure C.22.

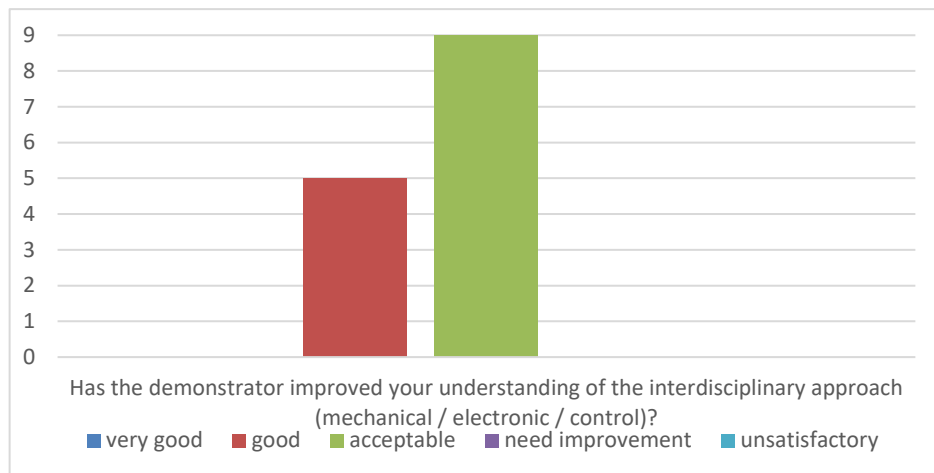
The learning skills orientated on digitalization have been deepened by 66% - programming, data analysis / visualization by 33%, figure C.23.

The understanding of the technical phenomena promoted by the use of the demonstrator could be supplementary increased through field visits - 50%, as well as through a video tutorial – 35%, figure C.24.

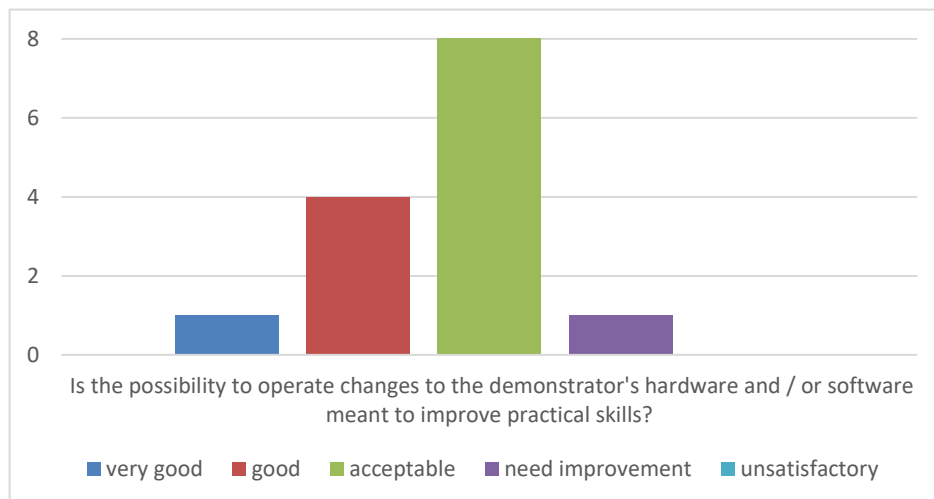
## Annex D: University College of Northern Denmark (UCN)

### D.1 Evaluation results 2<sup>nd</sup> Demonstrator

The second demonstrator developed by the team and used in the teaching activity was the *Air quality monitor*. The obtained feedback from twenty correspondents is highlighted in the following, Figures D.1 – D.6.

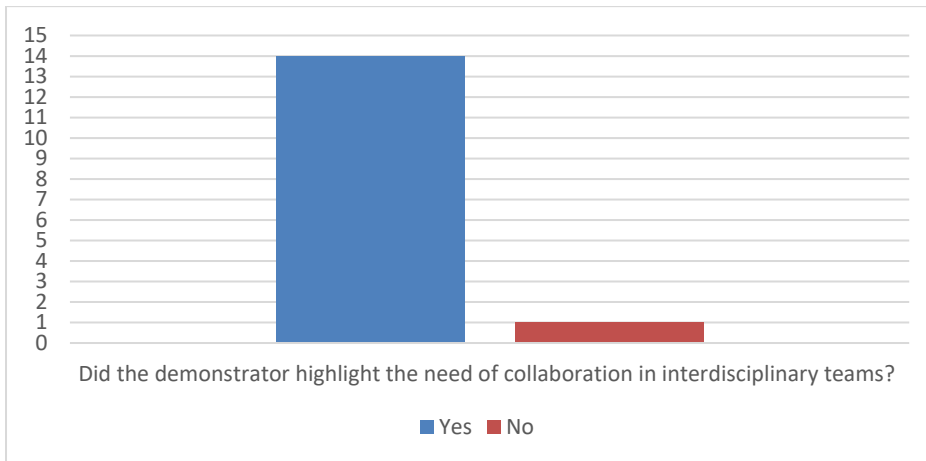


**Figure D.1 Interdisciplinary approach (single response)**

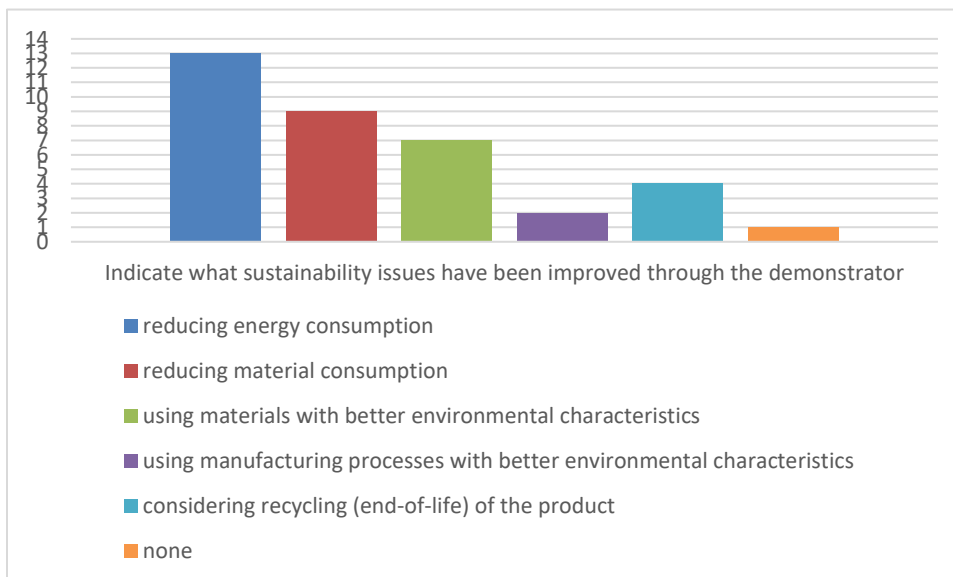


**Figure D.2 Practical skills (single response)**

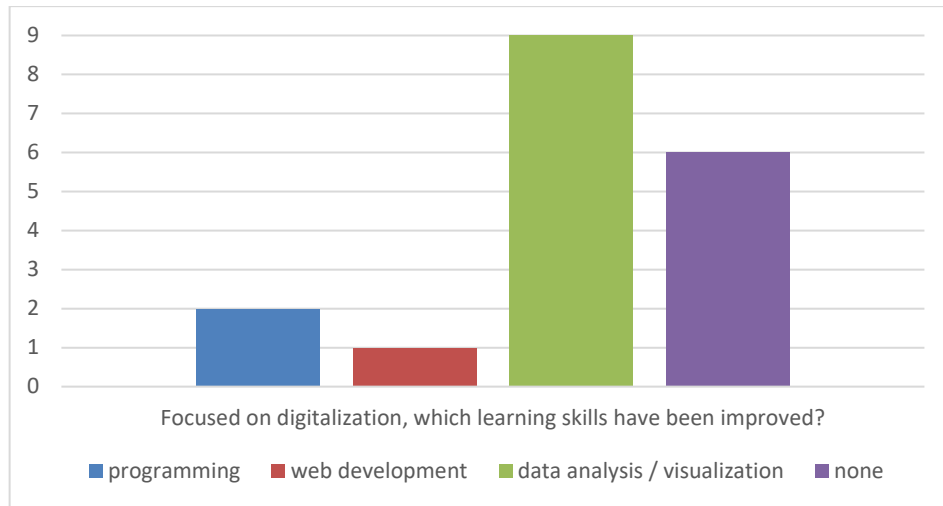
## Demonstrators impact assessment



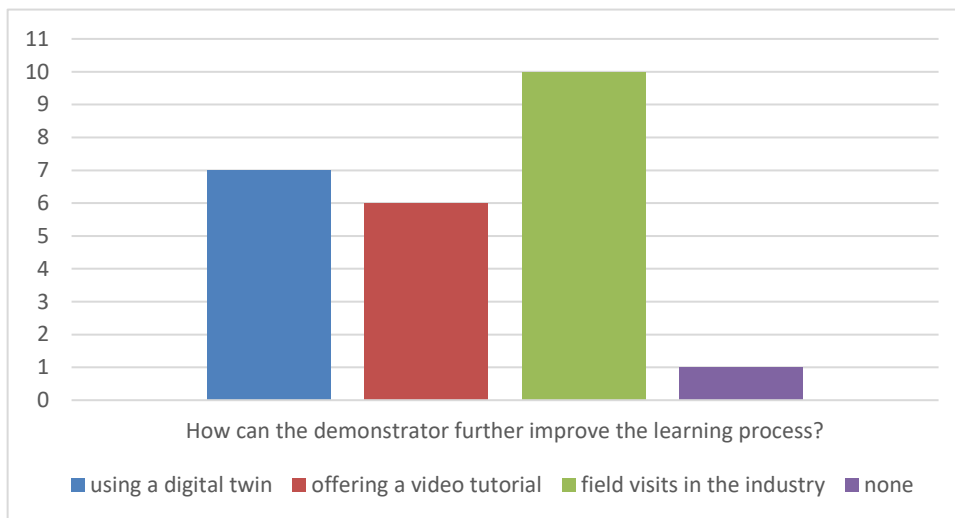
**Figure D.3 Collaboration (single response)**



**Figure D.4 Sustainability (multiple response)**



**Figure D.5 Learning skills (multiple response)**



**Figure D.6 Learning process (multiple response)**

In Figure D.1, respondents were asked to evaluate the extent to which the demonstrator had improved their understanding of the interdisciplinary approach (mechanical / electronic / control). Among the respondents, 33.33% acknowledged a good improvement in their understanding. Furthermore, the majority of respondents (66.67%) rated their improvement in understanding as acceptable. Notably, no respondents reported a very good rating, and none expressed the need for improvement or dissatisfaction with their understanding. Based on the obtained answers, it can be inferred that the majority of respondents experienced an acceptable level of improvement in their understanding of the interdisciplinary approach through the demonstrator.

Respondents were asked to evaluate the possibility of operating changes to the demonstrator's hardware and/or software to improve practical skills, figure D.2 Among the respondents, 6.67% rated the possibility as very good. Additionally, 26.67% of the respondents considered the possibility to be good for improving practical skills. The majority of respondents (60%) rated the possibility as acceptable. A ratio of (6.67%) suggested the need for improvement in this aspect.

The need for collaboration in interdisciplinary teams is highlighted in Figure D.3. Among the respondents, the majority (93.33%) acknowledged that the demonstrator effectively highlighted this need. From the responses, it can be inferred that the majority of respondents recognized and appreciated the demonstrator's efforts in highlighting the importance of collaboration in interdisciplinary teams.

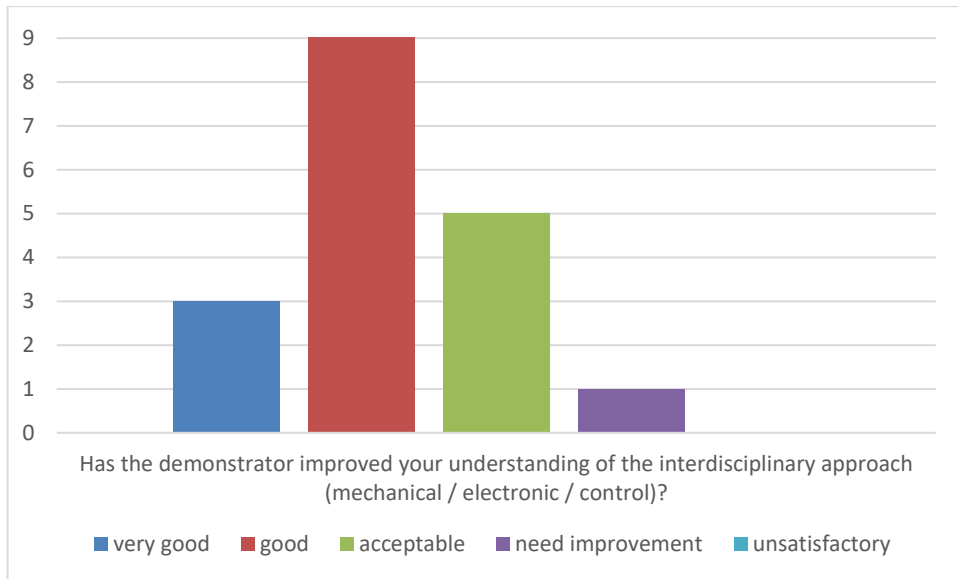
The sustainability issues that have been reached through the demonstrator are reflected in Figure D.4. Multiple sustainability aspects have been positively impacted: the majority of respondents (36.11%) identified the reduction of energy consumption; similarly, reducing material consumption was recognized by 25% of the respondents, as well as the use of materials with better environmental characteristics and manufacturing processes with better environmental characteristics, indicated by 19.44% and 5.56% respectively.

Figure D.5 centralizes the learning skills that have been improved through the demonstrator, specifically focusing on digitalization. The data reveals that respondents experienced various levels of improvement in their learning skills. Among the reported skills, data analysis and visualization stood out, with 50% of the respondents mentioning enhancements in this area. Programming skills also saw improvements, as mentioned by 11.11% of the respondents while web development skills were reported to have improved by 5.56% of the respondents. However, it is important to note that a considerable portion of the respondents (33.33%) did not perceive any improvement in their learning skills through the demonstrator in the context of digitalization.

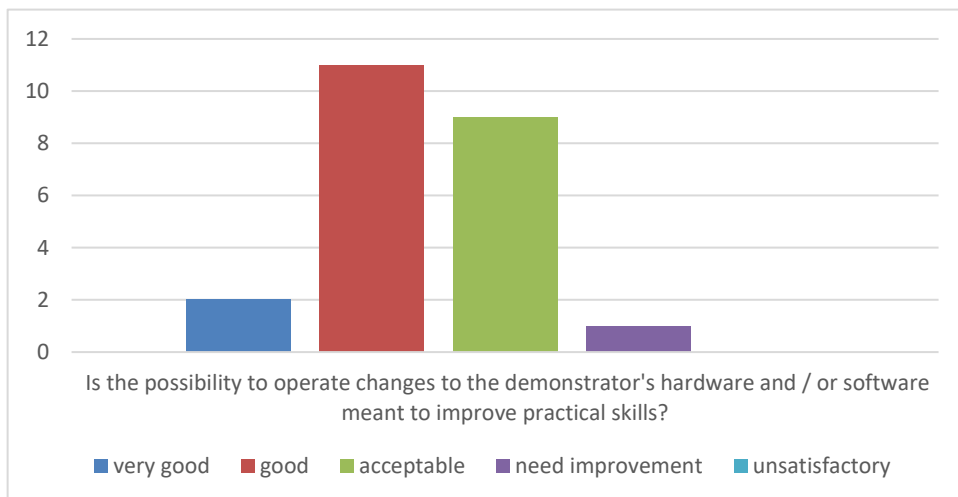
Figure D.7 reflects the respondent's perception of the demonstrator's impact on their understanding of the interdisciplinary approach. The data reveals that respondents' understanding varied across different levels: 33.33% rated their understanding as "good" indicating a positive impact on their comprehension of the interdisciplinary approach; additionally, 66.67% rated their understanding as "acceptable" suggesting that the demonstrator had a moderate impact on their understanding. It is worth noting that no respondents indicated a need for improvement or reported their understanding as "unsatisfactory." This suggests that the majority of respondents found the demonstrator effective in enhancing their understanding of the interdisciplinary approach. These findings indicate that the demonstrator has generally succeeded in improving the understanding of the interdisciplinary approach among the respondents, with a significant number perceiving their understanding as "acceptable" and a notable portion perceiving it as "good." This suggests that the demonstrator has played a valuable role in fostering interdisciplinary knowledge and comprehension among the participants.

## D.2 Evaluation results 4<sup>th</sup> Demonstrator

The first demonstrator developed by the team and used in the teaching activity was the *Pipe temperature sensor*. The obtained feedback from twenty correspondents is highlighted in the following, Figures D.7– D.12.

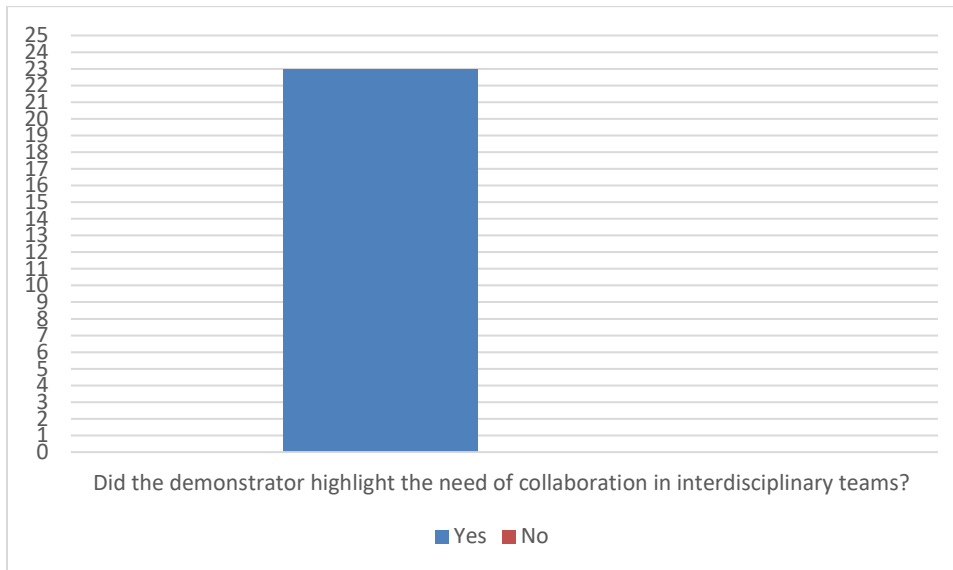


**Figure D.7 Interdisciplinary approach (single response)**

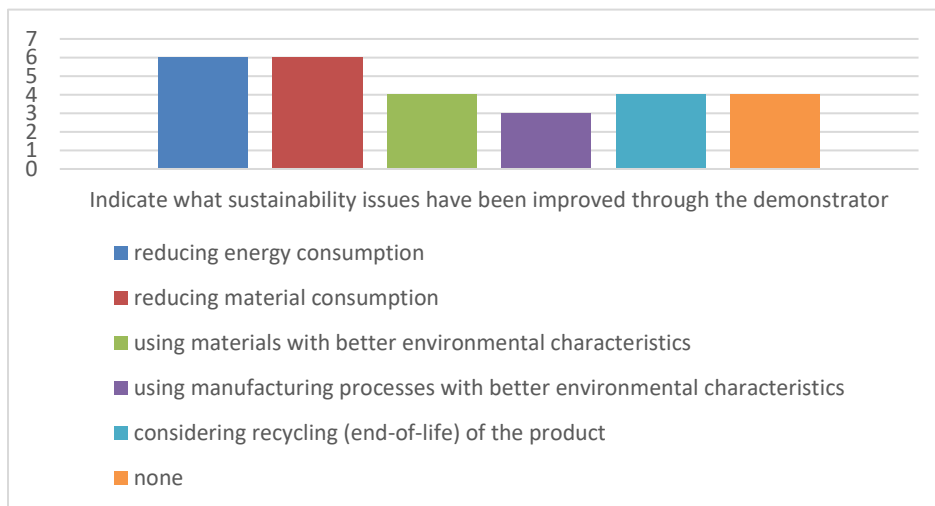


**Figure D.8 Practical skills (single response)**

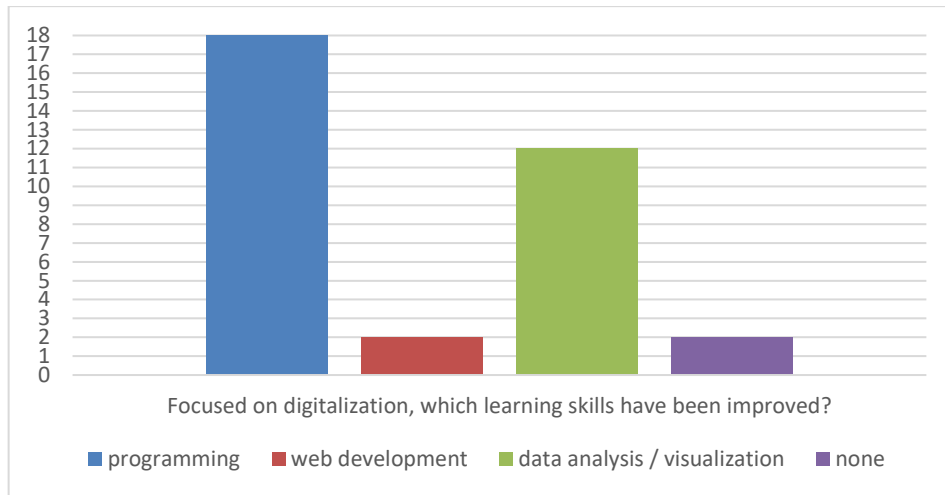
## Demonstrators impact assessment



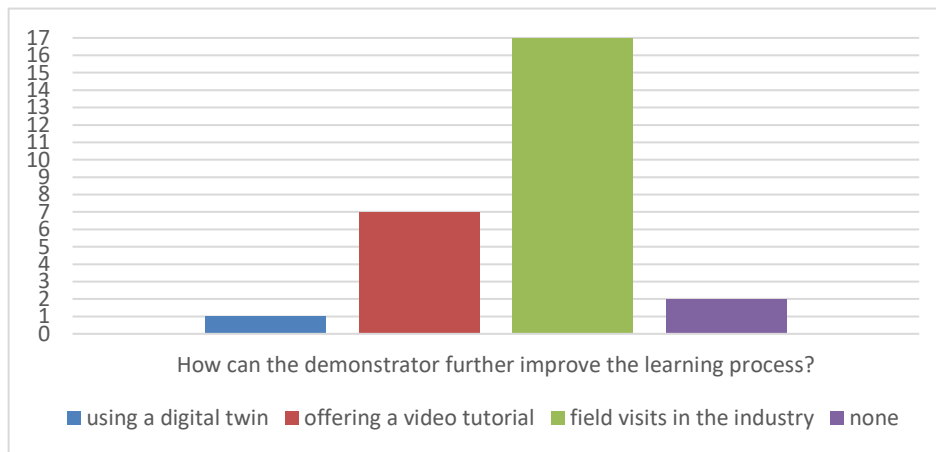
**Figure D.9 Collaboration (single response)**



**Figure D.10 Sustainability (multiple response)**



**Figure D.11 Learning skills (multiple response)**



**Figure D.12 Learning process (multiple response)**

Considering the received answers, results that it has had a positive impact on the understanding of the interdisciplinary approach: 73% rated it as very good and good, figure D.7.

The potential of improving practical skills by operating hardware and software changes on the demonstrators was rated as very good and good by more than half, 56% of the respondents, while 39% considered it as acceptable, figure D.8.

The need for an interdisciplinary team component to increase the understanding of the processes implemented through the demonstrator was indicated by all respondents, figure D.9.

The main indicated sustainability issues were reduction of energy consumption and reducing material consumption, both with – 22% followed by using materials with better environmental characteristics and recycling of the product, both with 14%, figure D.10.

The learning skills orientated on digitalization have been deepened by 52% - programming, data analysis / visualization by 35%, figure D.11.

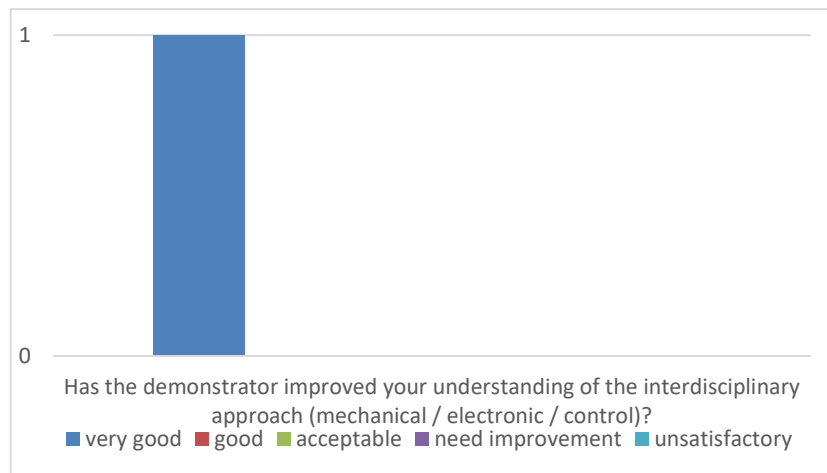
## Demonstrators impact assessment

The understanding of the technical phenomena promoted by the use of the demonstrator could be supplementarily increased through field visits - 63%, as well as through a video tutorial – 26%, figure D.12.

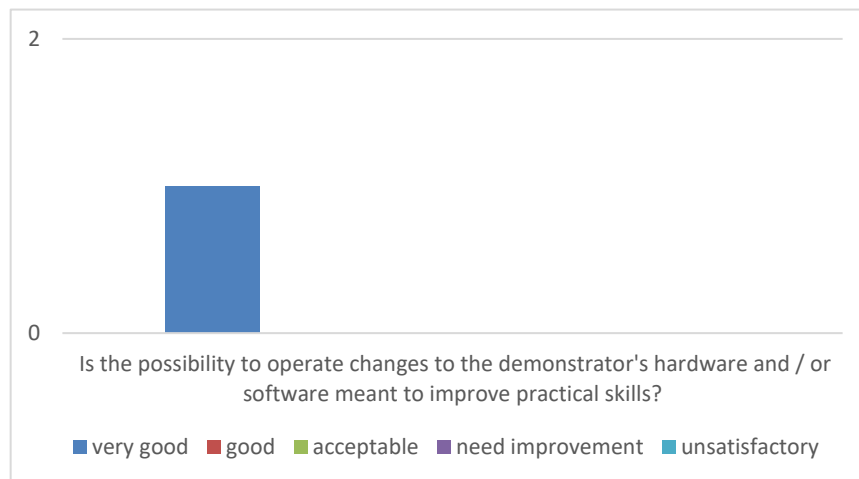
## Annex E: Fagskolen i Viken

### E.1 Evaluation results 1<sup>st</sup> Demonstrator

The first demonstrator developed by the team and used in the teaching activity was the *Snow dept sensor*. The obtained feedback from the respondents is highlighted in the following, Figures E.1– E.6.

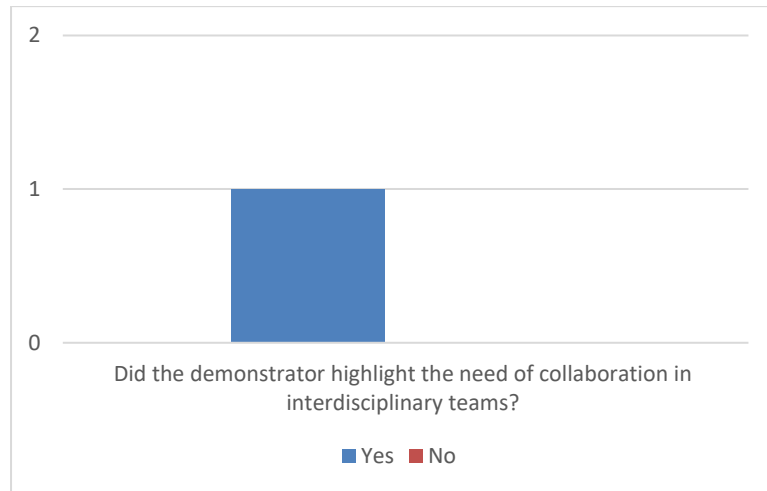


**Figure E.1 Interdisciplinary approach (single response)**

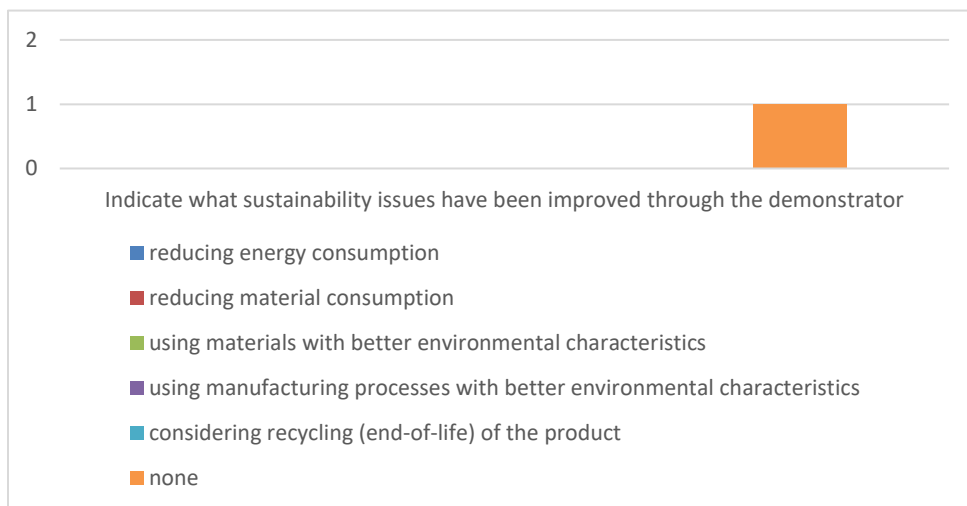


**Figure E.2 Practical skills (single response)**

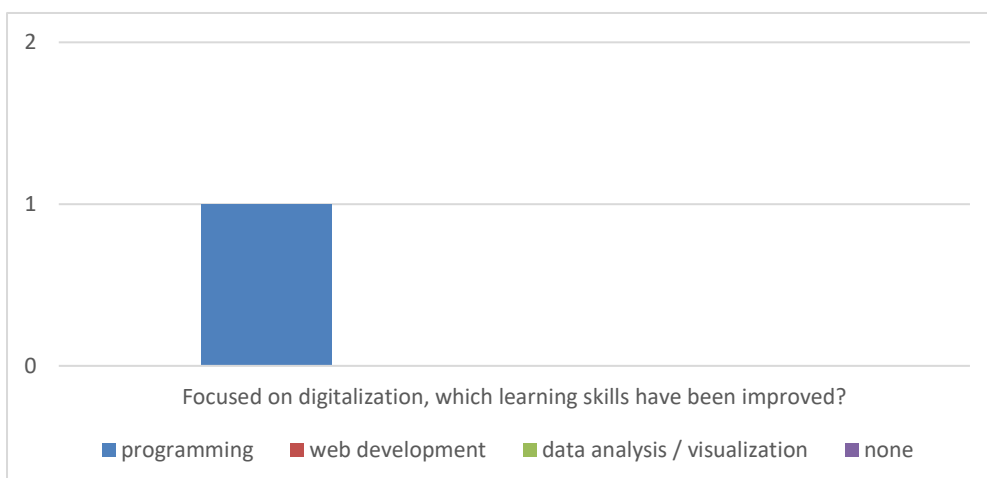
## Demonstrators impact assessment



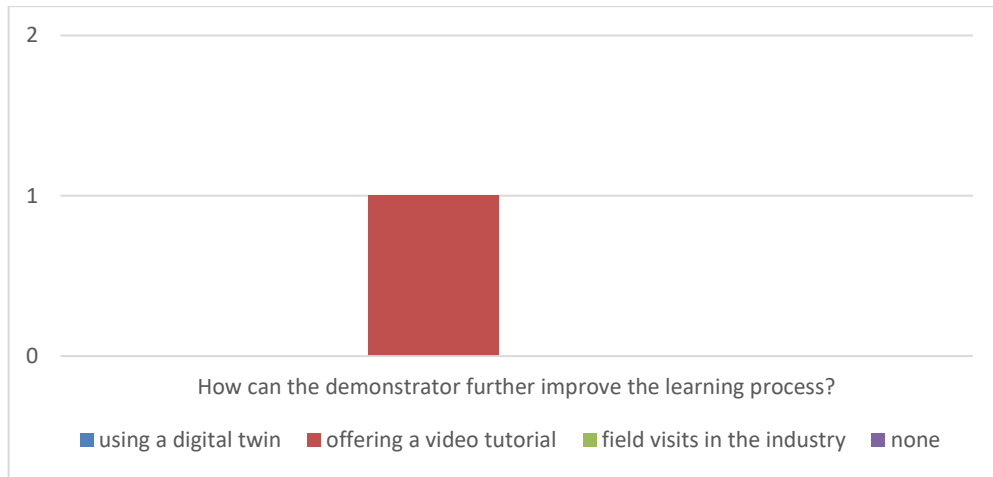
**Figure E.3 Collaboration (single response)**



**Figure E.4 Sustainability (multiple response)**



**Figure E.5 Learning skills (multiple response)**



**Figure E.6 Learning process (multiple response)**

Considering the received answers, results that it has had a positive impact on the understanding of the interdisciplinary approach, figure E.1.

The potential of improving practical skills by operating hardware and software changes on the demonstrators was rated as very good, figure E.2.

The need for an interdisciplinary team component to increase the understanding of the processes implemented through the demonstrator was indicated as welcome, figure E.3.

As sustainability issues the respondents did not identify any, figure E.4.

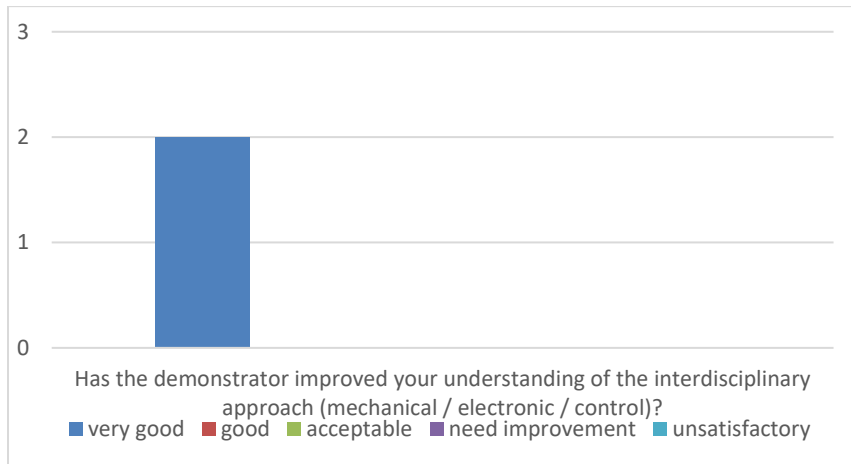
The learning skills orientated on digitalization have been focused on programming, figure E.5.

The understanding of the technical phenomena promoted by the use of the demonstrator could be supplementarily increased through a video tutorial, figure E.6.

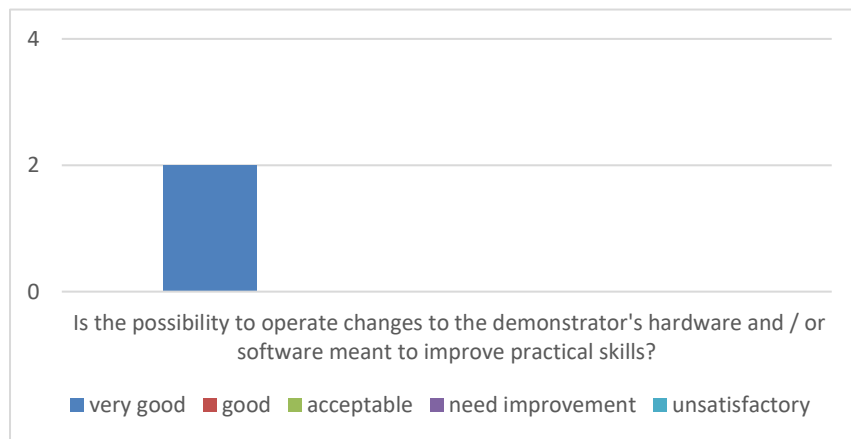
## E.2 Evaluation results 3<sup>rd</sup> Demonstrator

The first demonstrator developed by the team and used in the teaching activity was the *Modular PLC System*. The obtained feedback from twenty correspondents is highlighted in the following, Figures E.7– E.13.

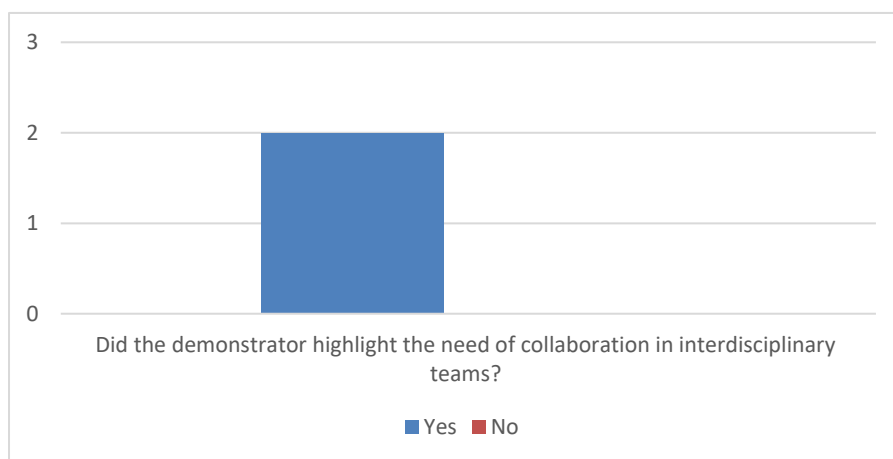
## Demonstrators impact assessment



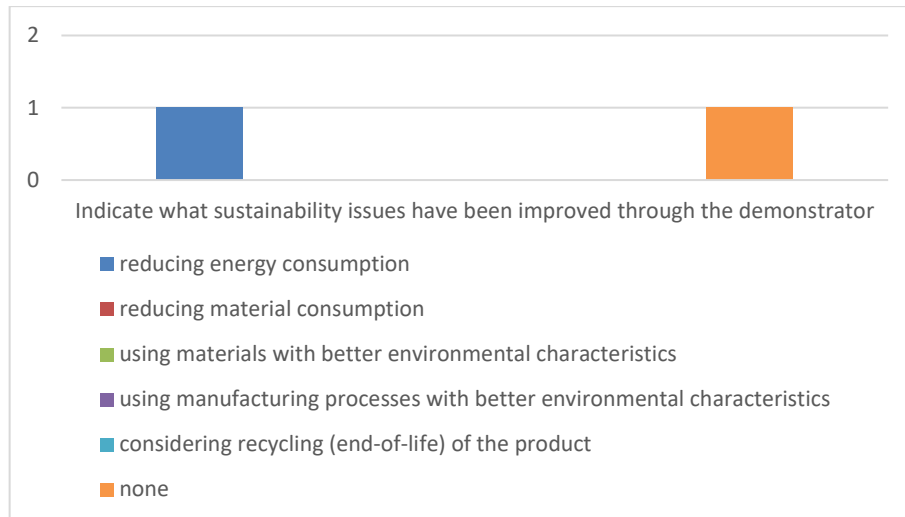
**Figure E.7 Interdisciplinary approach (single response)**



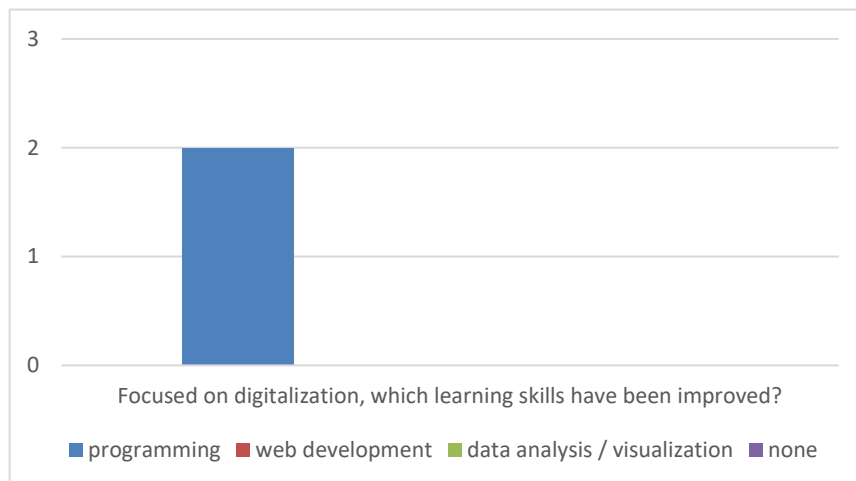
**Figure E.8 Practical skills (single response)**



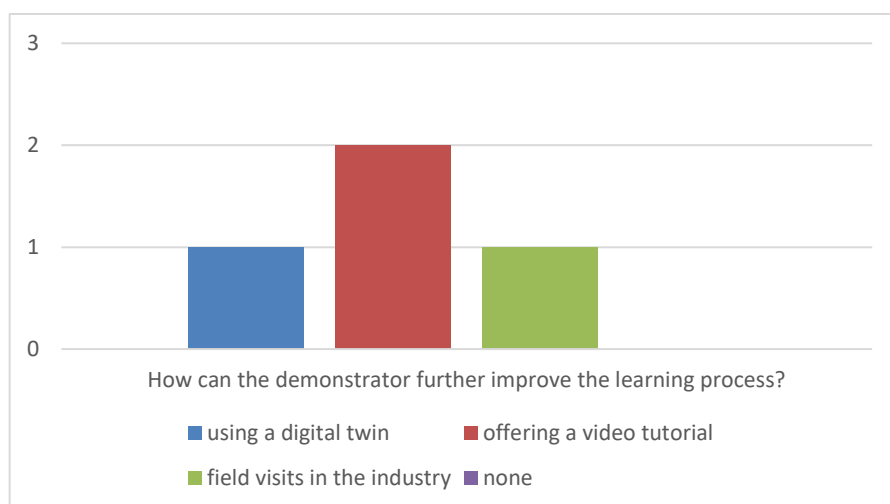
**Figure E.9 Collaboration (single response)**



**Figure E.10 Sustainability (multiple response)**



**Figure E.11 Learning skills (multiple response)**



**Figure E.12 Learning process (multiple response)**

Based on Figure E.7, all respondents reported that the demonstrator has improved their understanding of the interdisciplinary approach (mechanical/electronic/control). No respondents rated their understanding as "good", "acceptable", "need improvement" or "unsatisfactory". This indicates a positive impact of the demonstrator on enhancing the understanding of the interdisciplinary approach among the participants.

All respondents, based on Figure E.8, agreed that the possibility to operate changes to the demonstrator's hardware and/or software is meant to improve practical skills, indicating a unanimous recognition of the potential of making changes to the demonstrator's hardware and/or software for enhancing practical skills for the end users.

The need for collaboration in interdisciplinary teams was highlighted by all respondents, Figure E.9. The demonstrator effectively conveyed the significance of working together in interdisciplinary teams to achieve common goals.

Based on the data provided in Figure E.10, the main sustainability issues identified as being improved through the demonstrator was reducing energy consumption.

Based on the data provided in Figure E.11, the respondents reported that their programming skills were improved through the demonstrator.

According to the data in Figure E.12, out of the four respondents, (25%) suggested using a digital twin to further improve the learning process, (50%) recommended offering a video tutorial and (25%) of respondents indicated that field visits in the industry could be beneficial.

### E.3 Evaluation results 4<sup>th</sup> Demonstrator

The first demonstrator developed by the team and used in the teaching activity was the *Accelerometer*. The obtained feedback from twenty correspondents is highlighted in the following, Figures E.13 – E.18.

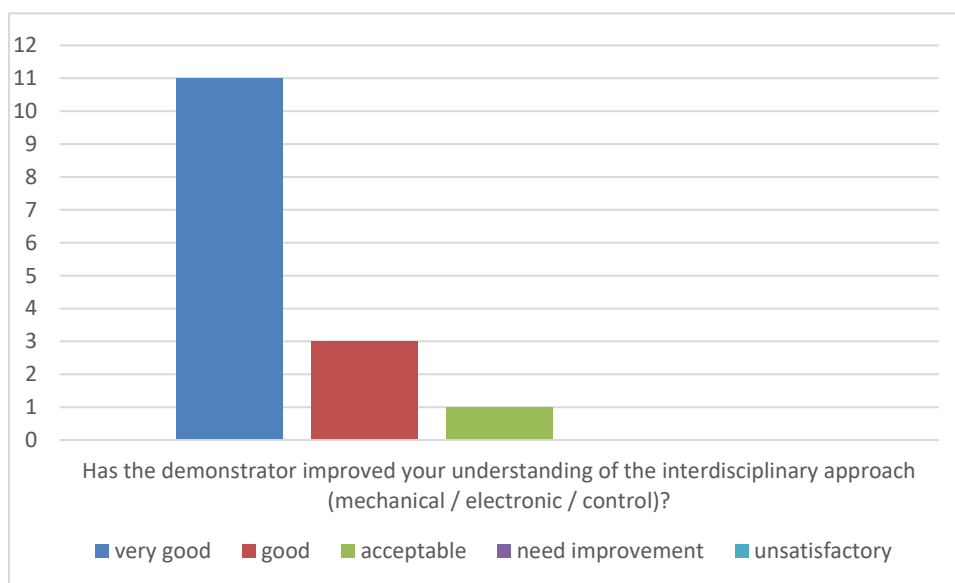
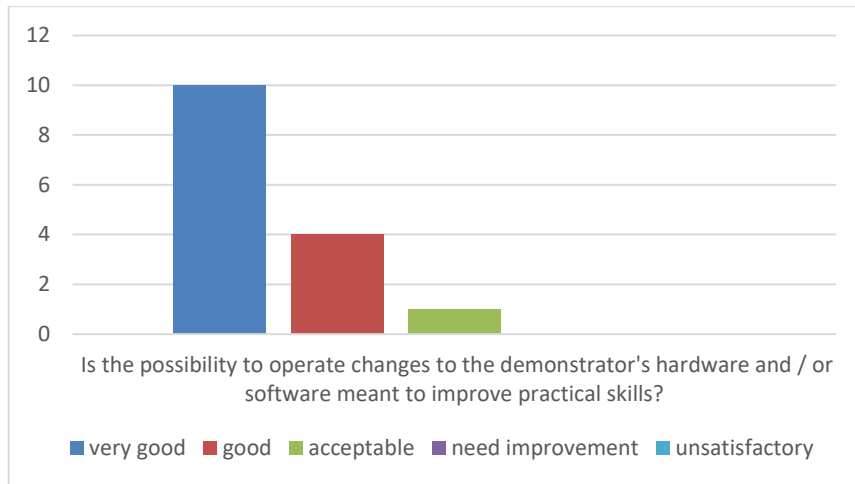
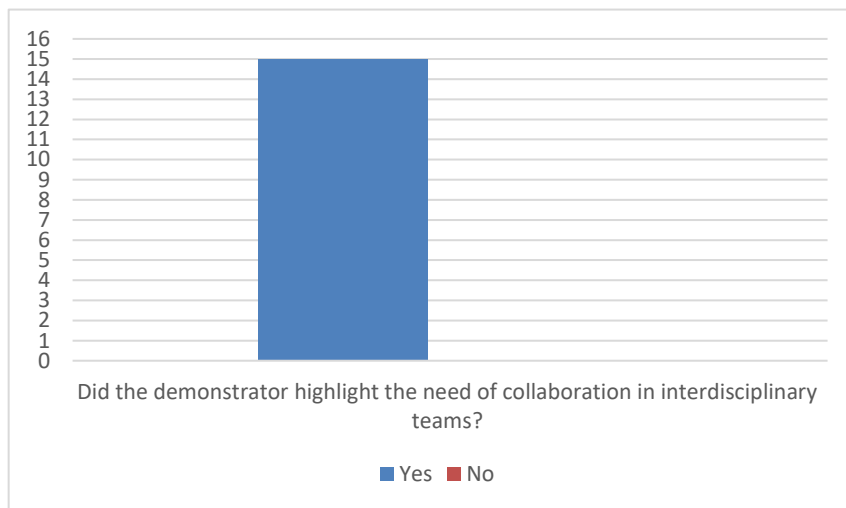


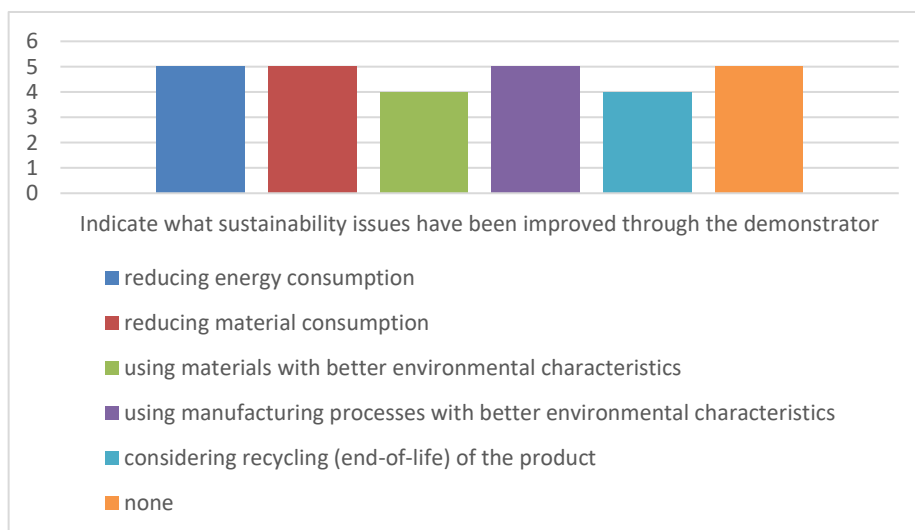
Figure E.13 Interdisciplinary approach (single response)



**Figure E.14 Practical skills (single response)**

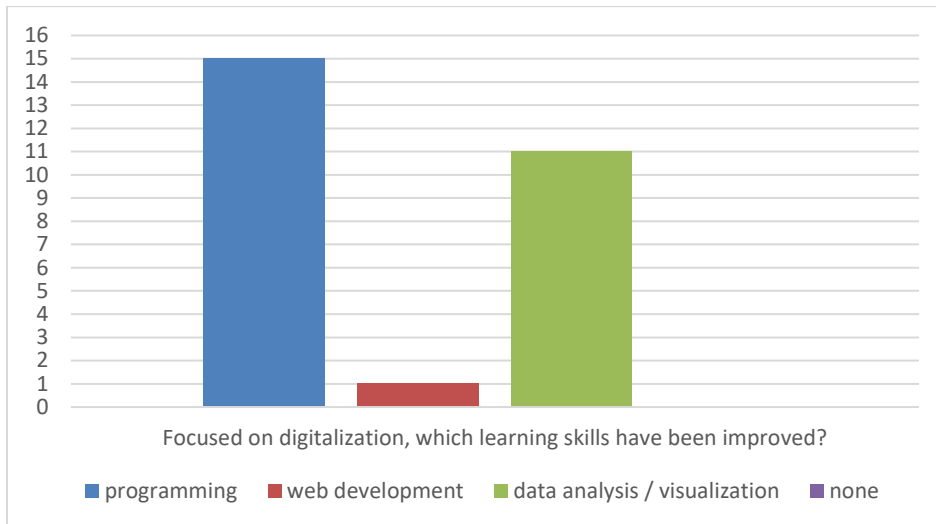


**Figure E.15 Collaboration (single response)**

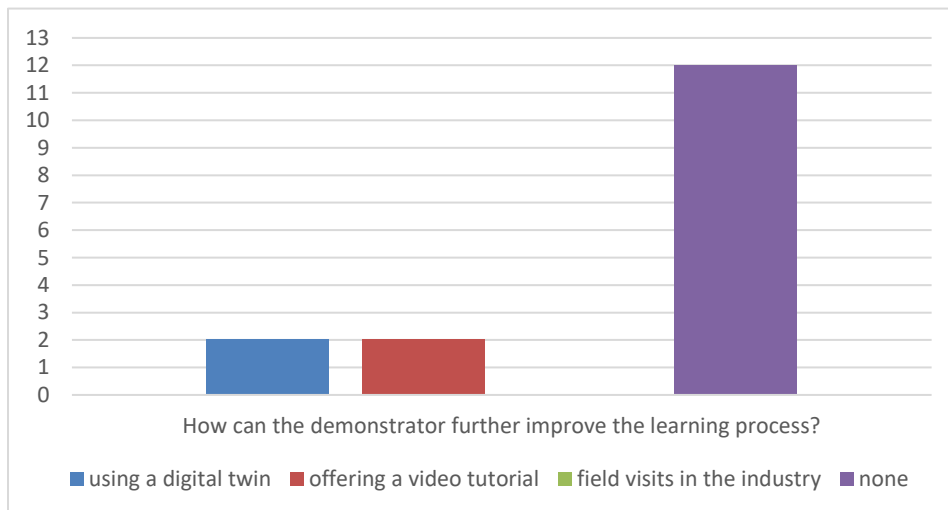


**Figure E.16 Sustainability (multiple response)**

## Demonstrators impact assessment



**Figure E.17 Learning skills (multiple response)**



**Figure E.18 Learning process (multiple response)**

Considering the received answers, results that it has had a positive impact on the understanding of the interdisciplinary approach: 73% rated it as very good, 20 % as good, figure E.13. This indicates that the majority of participants found the demonstrator to be highly effective in enhancing their understanding of the interdisciplinary approach.

The potential of improving practical skills by operating hardware and software changes on the demonstrators was rated as very good and good by more than 90% of the respondents, figure E.14.

The need for an interdisciplinary team component to increase the understanding of the processes implemented through the demonstrator was indicated by all respondents, figure E.15.

The main indicated sustainability issues were reduction of energy consumption, reducing material consumption, using manufacturing processes with better environmental characteristics, all three with – 18% followed by using materials with better environmental characteristics and recycling of the product, both with 14%, figure E.16.

The learning skills orientated on digitalization have been deepened by 55% - programming, data analysis / visualization by 40%, figure E.17.

The understanding of the technical phenomena promoted by the use of the demonstrator could be supplementarily increased by a digital twin - 13%, as well as through a video tutorial – 13%, figure E.18. 75% Considered the demonstrator well enough developed to support the learning process.