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Development and analysis of the evaluation of Praktika@home

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Abstract

Aufgrund der Corona-Pandemie wurden viele Lehrveranstaltungen auf neue Formate umgestellt, häufig kurzfristig und ohne die Möglichkeit einer strukturierten Erprobung. Im Modul Mess- und Automatisierungstechnik wurden die Praktika@home entwickelt, die nach dem Blended-Learning-Konzept durchgeführt werden. Um zu evaluieren, wie gut das Lehrangebot die Studierenden bei der Erreichung der Lernziele unterstützt, wurde ein Fragebogen erarbeitet. Die Gestaltung und Auswertung der Ergebnisse werden anhand des erstmals im Sommersemester 2022 durchgeführten Experiments ‚Dehnungsmessung' beschrieben und kritisch diskutiert.
Die Ergebnisse der Evaluation zeigen, dass das Betreuungskonzept während der Praktika überarbeitet werden muss. Aus den Freitext-Kommentaren, die von den Studierenden ausgiebig genutzt wurden, konnten Ansatzpunkte für diese Veränderung identifiziert werden. Darüber hinaus kann abgeleitet werden, dass eine bessere Abstimmung zwischen Vorlesung und Praktikum notwendig ist. Zuletzt wurden Vorschläge zur Verbesserung des Fragebogens erarbeitet.

Due to the Corona pandemic, many courses were converted to new formats, often at short notice and without the possibility of structured testing. In the Measuring and Automation Technology module, the Praktika@home were developed, which are conducted according to the blended learning concept. A questionnaire was developed, to evaluate how well the teaching offer supports the students in achieving the learning objectives. The design and evaluation of the results are described and critically discussed on the basis of the experiment 'strain measurement', which was conducted for the first time in the summer semester 2022.
The results of the evaluation show that the supervision concept during the practical course needs to be revised. Starting points for this change could be identified by evaluating the free text comments, which were used extensively by the students. . Furthermore, it can be deduced that a better coordination between lecture and practical course is necessary. Finally, suggestions for improving the questionnaire were developed.

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1. Initial situation and motivation

The Corona pandemic has massively changed teaching at colleges and universities. Within a few weeks, the majority of courses had to be converted to a digital format, with little time for testing. This was both a challenge as well as an opportunity to modernize teaching and try new teaching-learning concepts. Now, that face-to-face teaching can again take place in many places, the question also arises in what form courses should be implemented. In this context, evaluations are an important tool for examining events and incorporating the learners' input as well as their perspective.

Students of mechanical engineering can evaluate their course at the end of the semester via the standardized 'Course Evaluation' developed by the Center for Quality Analysis. Although this offers a high degree of comparability between courses, it cannot take into account structural differences and individual issues. In the module Measurement and Automation Technology, so-called practical courses are offered in addition to the lecture and the calculation exercises, in which the students are to apply their knowledge experimentally.

Due to the severe restrictions during the Corona semesters, the concept of practical courses was significantly modified. The so-called Praktika@home were introduced [1, 2]. In the 'classical' implementation of practical courses, years of experience can be drawn upon. However, the change to Praktika@home meant a drastic change in teaching for both students and teachers. For this reason, an evaluation was developed to examine not the entire module, but specifically the practical courses.

The article presents the approach used to prepare the evaluation as well as the results of the evaluation. Finally, the evaluation is critically reflected. In the outlook, various approaches are discussed which can be used to remedy the problems that were identified.

The evaluation presented here is limited to one of the six experiments, the experiment on strain measurement.

2. Object of investigation

Praktika@home is part of the compulsory module 'Measurement and Automation Technology' of the diploma and bachelor courses Mechanical Engineering as well as Process Engineering and Natural Materials Technology of the Faculty of Mechanical Engineering at TU Dresden. This course is scheduled for students during their fifth and sixth semester and is attended on average by 400 students. The practical courses blend learning formats, with students conducting experiments at home in teams of two and coming to the university for supervision appointments. The students need to submit a handwritten report to collect the examination credit. A practical course begins with materials being made available online via OPAL (Online Platform for Academic Teaching and Learning) or YouTube. There is an introductory video for each experiment to help students get started with the topic and experiment on their own. The instructions include the task and a summary of the theoretical background.

After uploading the video and the instructions, the students have one week to execute the experiment. Afterwards, there is an interim discussion in which the students can clarify their questions among themselves or with the support of the supervisor. After another week, the protocol needs to be handed in. Finally, there is a debriefing session in which open questions can be discussed and the technical accuracy of the results is ensured. The sequence of events is depicted in Figure 1.

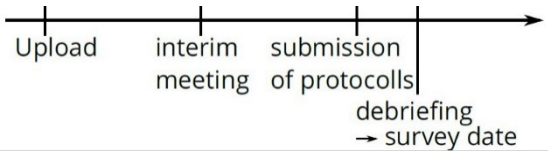

Figure 1: Sequence of events in the practical course

The aim of the practical courses is to let the students apply the lectures theoretical contents in practice. In the experiment 'Strain Measurement', the setting up of various electrical circuits with the Arduino microcontroller is planned. With these circuits, the diagonal

voltage of a Wheatstone's measuring bridge is recorded automatically and from this the mechanical stress in the component is determined. The data is then analyzed and interpreted by the students. The practical course 'Strain Measurement' was carried out by students for the first time in the summer semester of 2022. The evaluation results are presented below.

The implementation of the practical courses in a blended learning format is intended to support individualized learning (independent of time and location). The design of the interim and debriefing sessions aims to promote communication, collaboration and networking among students. Altogether, the teaching-learning opportunities are intended to introduce students to the scientific way of working.

The evaluation's interest is to find out whether the teaching-learning materials and supervision provided are designed such that they support students in achieving the learning objectives.

3. Study Design

The evaluation of Praktika@home is carried out by a follow-up survey. Due to the large number of students in the course, a questionnaire was developed.

Both closed questions and free texts were used in the questionnaire. The free texts were used, despite the higher evaluation effort, to obtain justifications for answers and a more precise representation of the mood. Furthermore, additional information or new aspects can be recorded that were not considered when the questionnaire was created.

A four-point Likert scale was used. The items (tasks or questions of a test) are formulated as positive or negative statements. The multilevel response scale is used to measure the respondents' personal attitude, i.e. how strongly they agree or disagree with the item. A symmetrical scale was chosen, as this means that no abstention is possible and the participants have to choose one side [3].

The questionnaire was handed out after the debriefing. Thus, the evaluation has both formative and summative character. For the students, the summative character is dominant, as they are only asked for feedback after the completion of the practical course and no longer benefit from the results of the evaluation themselves. For the development team, however, the survey is formative, since the results can be used continuously to improve the basic conception of the practical courses as well as the design of the teaching-learning materials of the respective experiments. Survey and processing are done using LimeSurvey, an online survey application supported by the TU Dresden [4]. The survey was anonymous.

The following aspects were derived from the overall evaluation objective, which, in addition to the socio-demographic data, should be determined by the survey:

(a) subject-specific declarative knowledge
(b) subject-specific procedural knowledge
(c) Usefulness of the provided teaching-learning materials.
(d) Supervision during interim and debriefing session
(e) Experience with guided learning activities
(f) Connection of the practical courses contents to the lecture
(g) Performance of the practical courses

It must be taken into account that the results of the survey do not provide information about the actual knowledge of the students. Instead, the self-assessment is surveyed.

Two to four items were formulated for each of the aspects to be recorded. The results of the evaluation are presented as examples.

4. Evaluation procedure

The qualitative content analysis method was used to evaluate the free comments. Therefor the content of the comments is summarized and categorized [5, 6]. Categories can be formed either deductively or inductively. In the analysis of this evaluation, the categories were not given deductively, but were derived inductively from responses. For this purpose, only a part of the data was categorized in a test run at the beginning. Subsequently, the remaining comments were classified into the preliminary category system. It can happen that several aspects are listed in comments. Accordingly,

these comments were assigned to multiple categories. After all comments were assigned to one or more categories, they were screened again to merge or subsequently differentiate similar categories. Finally, the categories were quantified.

With regard to the goal of the evaluation to further develop the practical courses, demands or instructions for action were derived from the categories that contribute to the improvement of the practical courses from the student's point of view. These instructions for action are discussed in the section 'free comments'.

The frequency distribution of the closed questions was used for the evaluation..

5. Results

Since up to 325 students (out of a total of 430) participated in the debriefing in the winter semester 2021/2022, the survey date of the evaluation was set to the end of this event. However, in the summer semester of 2022, the number of participants reduced drastically to 109, of which 91 completed the questionnaire in full (of which 65 were male, 19 female, 7 no response). In contrast to the previous semester, no additional points were awarded for attending the consultation during the period under consideration. This could be a reason for the lower participation.

Subject-specific declarative knowledge

First and foremost, the practical course is intended to pick up teaching content from the lecture and to deal with these main topics in more detail. The students thus acquire declarative knowledge ("knowledge that") in the practical course. Declarative knowledge comprises both individual facts (e.g. key figures, formulas) and complex contextual knowledge (e.g. understanding the influence of environmental conditions on the measurement result). Firstly, this is supported by the practical instructions, which tie in with the lecture content and in which the theoretical background of the experiment is summarized. In addition, the students experiment independently and acquire knowledge that was not made explicit in the lecture or the materials provided, but results from solving the problems. Based on the students' self-assessment of whether they possess subject-specific declarative knowledge, it is intended to verify whether the learning objectives have been achieved. Therefore, it was analyzed which knowledge the students should have acquired after carrying out the practical course. These were then formulated as items. Figure 2 depicts the results of the students' self-assessment of three queried pieces of knowledge. The construction and operation of strain gauges (SGs) are covered in both the lecture and the instructions.

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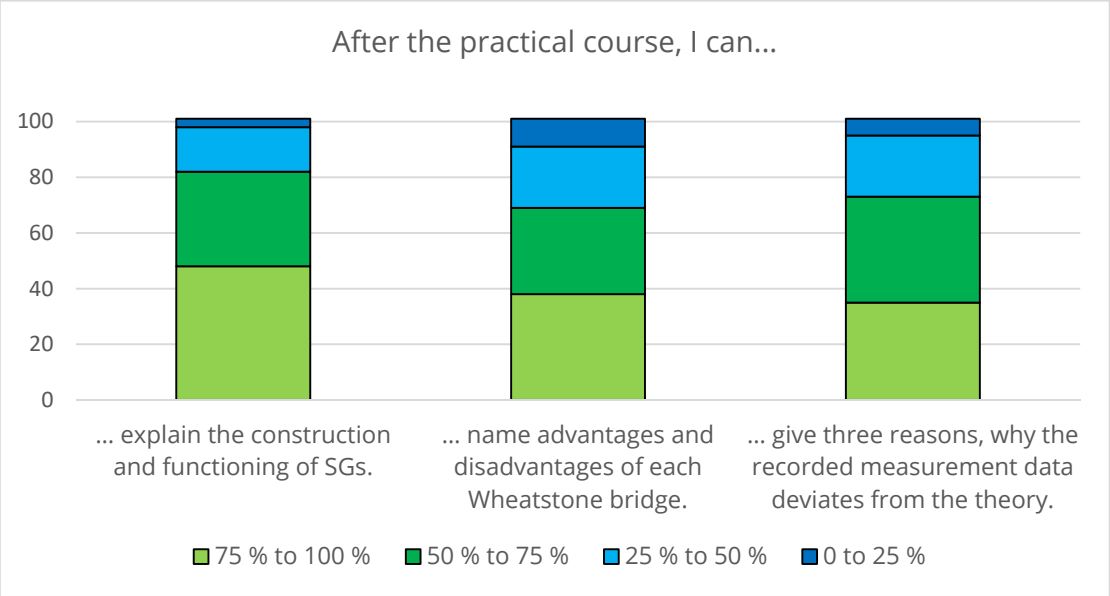

Figure 2: Self-assessment on declarative knowledge.

The advantages and disadvantages of the respective Wheatstone's bridge of measurement are addressed in the lecture and in the practical course, while the knowledge of why the recorded measurement data deviates from the theory is acquired only in the practical course by completing the tasks. It can be assumed that the effort required to acquire this knowledge varies. Furthermore, the queried knowledge differs in its complexity (pure factual knowledge compared to conceptual knowledge)

48% of the students rate their knowledge as particularly high (75% to 100%) for the question on structure and functioning. For the question on the advantages and disadvantages of bridge constellations, the percentage is 38 % and for the difference between theory and practice, the percentage is 35 %.
The number of students who rate their knowledge as high decreases as the complexity of the knowledge and the learning effort required increases. Here, the incremental knowledge gained by also covering topics in the lecture is minimal when compared with the knowledge acquired by only working on the practical course. . At this point it must be taken into account, that in the evaluation the previous knowledge of the students is not assessed. Therefore, based on the questionnaire, it is not possible to distinguish whether the respondents already knew, for example, the advantages and disadvantages of Wheatstone's measuring bridge before working on the practical course or whether this knowledge was acquired during the practical course.

Subject-specific procedural knowledge

In addition to declarative knowledge, students primarily acquire procedural knowledge ("knowing how") during the practical course. Procedural knowledge is also colloquially referred to as skill and thus describes the ability to link declarative knowledge and apply it as a course of action. Examples of this are calculating tasks or writing a protocol. Analogous to the procedure for declarative knowledge, the most important skills to be acquired in the practical course were defined.

The items for procedural knowledge are listed in Figure 3. Two of the items ask for skills that were practiced in the lectures "Measurement and Automation Technology" and "Technical Mechanics" by writing them down.

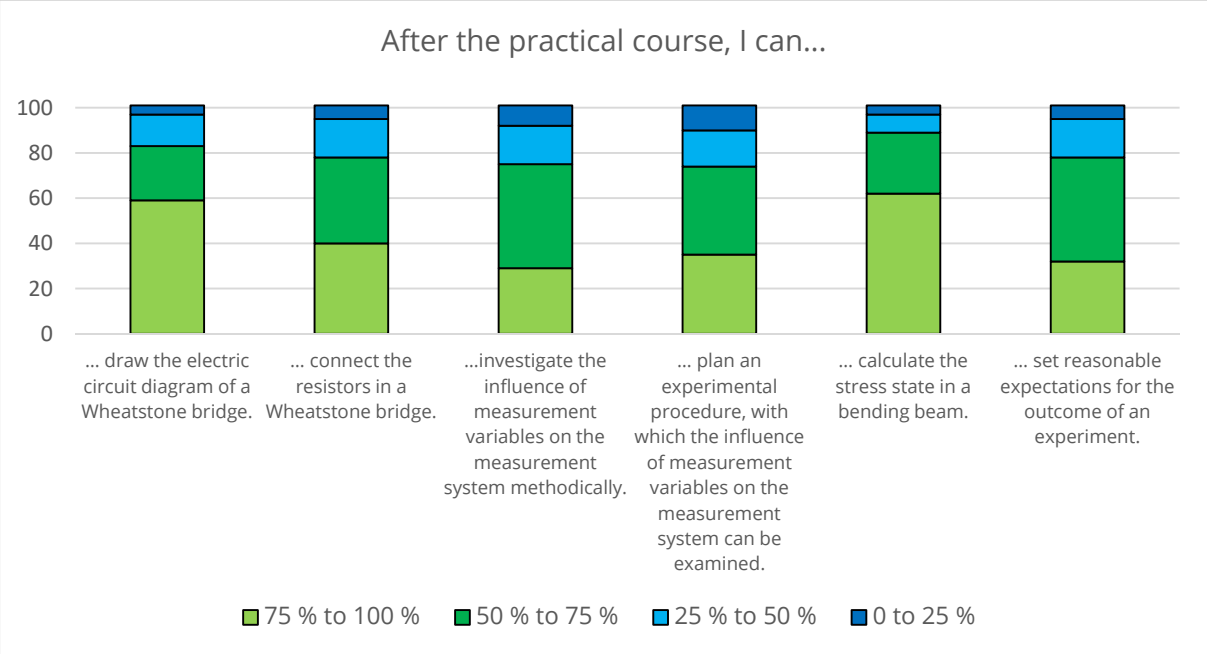

Figure 3: Self-assessment on procedural knowledge.

This concerns the ability to draw the circuit diagram of a Wheatstone measuring bridge and to determine the stress state in a bending beam by calculation. It is estimated by 59% and 62% of the students, respectively, that their knowledge of this is very high. The other ques-

tions relate to procedures that are only used in the practical course and have therefore not been practiced or trained beforehand. This is also reflected in the students' self-assessment. The ability to methodically investigate the influence of measurement variables on the measurement system is rated as very high by 29% of the students. The ability to plan an experimental procedure or to set reasonable expectations for the outcome of an experiment is also rated as very high by only 35% and 32% respectively

Overall, however, students rate both their declarative and procedural knowledge highly. These agreement values can have various causes. Since this is the first run of the evaluation, only the core contents of the practical course were formulated as learning objectives. Therefore, it is conceivable that these learning objectives were actually met by a majority of the students. This would mean that further learning objectives can be included in the evaluation in the future. At the same time, however, the formulation of the existing learning objectives should also be reviewed and consideration given to further specifying them.

In addition, the timing of the evaluation survey should be considered. Since this takes place at the end of the debriefing, only students who also attend this intervention participate in the survey. It can be assumed that these are predominantly motivated students. This suggests a selection bias that could be causing the high learning target rates.

Supervision in interim and debriefing sessions

An important aspect of the evaluation is the assessment of the interim and debriefing sessions by the students. Since the learning process of the students no longer takes place in presence at the university, but at home, the support services are of particular importance. Interim and debriefing meetings are the only times when there is direct contact between students and supervisors. The goal of the interim meeting is to guide students to resolve issues collaboratively. During the debriefing, open questions should be clarified with the students. In Figure 4 is the students' assessment of the supervision in the interim and debriefing sessions.

47 % of the students reported that their questions were not answered in the interim meeting[1] . This result contrasts with the indication that 66 % of students felt well supported by their supervisor. In comparison, 76 % of students indicated that they were able to complete their understanding of the practical course in the debriefing. This indicates that the design of this event is meaningful.

Another explanation may lie in the wording of the item. It is not clear from the wording whether feedback should be given for the supervisor’s performance during the interim or the debriefing session. For some students the supervisor may be consistent, but this is not necessarily the case.

Thus, it is possible that students only evaluated the supervisor in the context of the debriefing. In addition, students may be reluctant to rate their supervisor poorly after face-to-face contact. In addition, it may be unclear to respondents what the support is related to. The item should therefore be reworded to avoid these problems.

Experience with guided learning activities

The students assess the newly introduced group work phases very positively.. The results can be seen on Figure 5. 76% of the students agree that they have understood the purpose of the group work. This indicates that the instruction and motivation of this method was well done. Furthermore, 85% of the students state that it was easy for them to get involved in the group work. At the same time, 77% agree that they have intensively dealt with the practical courses contents through the group work.

The results indicate that the students had a positive experience with group work and gained a subjective benefit from the way of working. Therefore, this group work will also be used in future consultations.

[1] A statement is considered to be an agreement if "tends to agree" or "fully agrees" is ticked. This corresponds to levels 3 and 4 on the Likert scale.

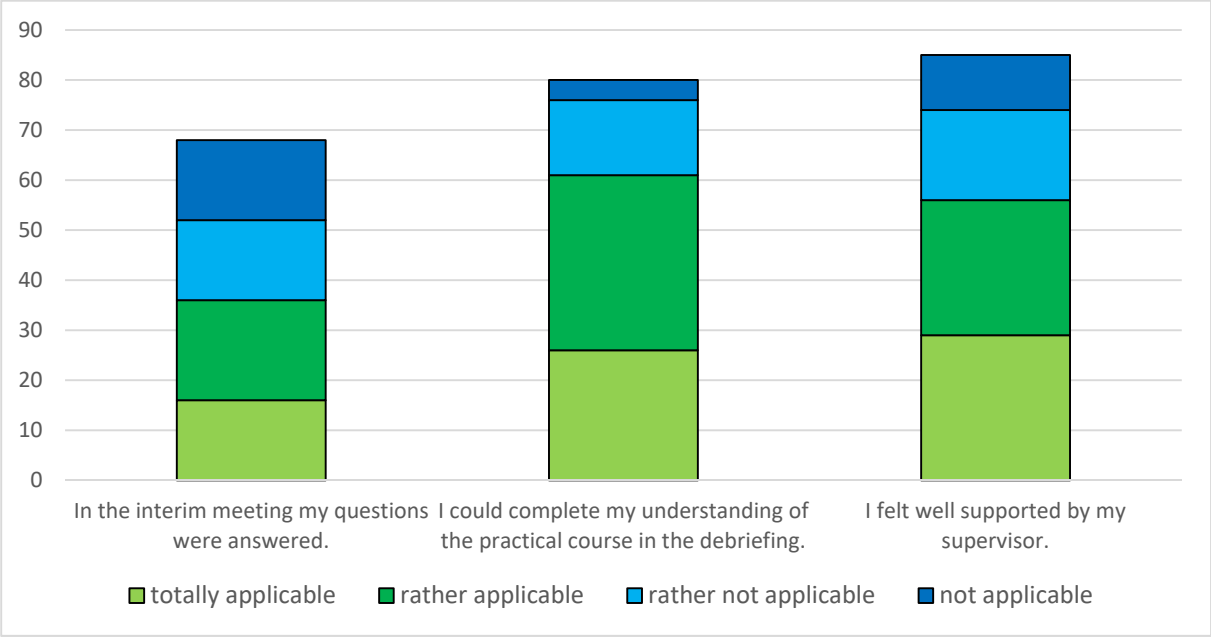

Figure 4: Supervision in interim and debriefing

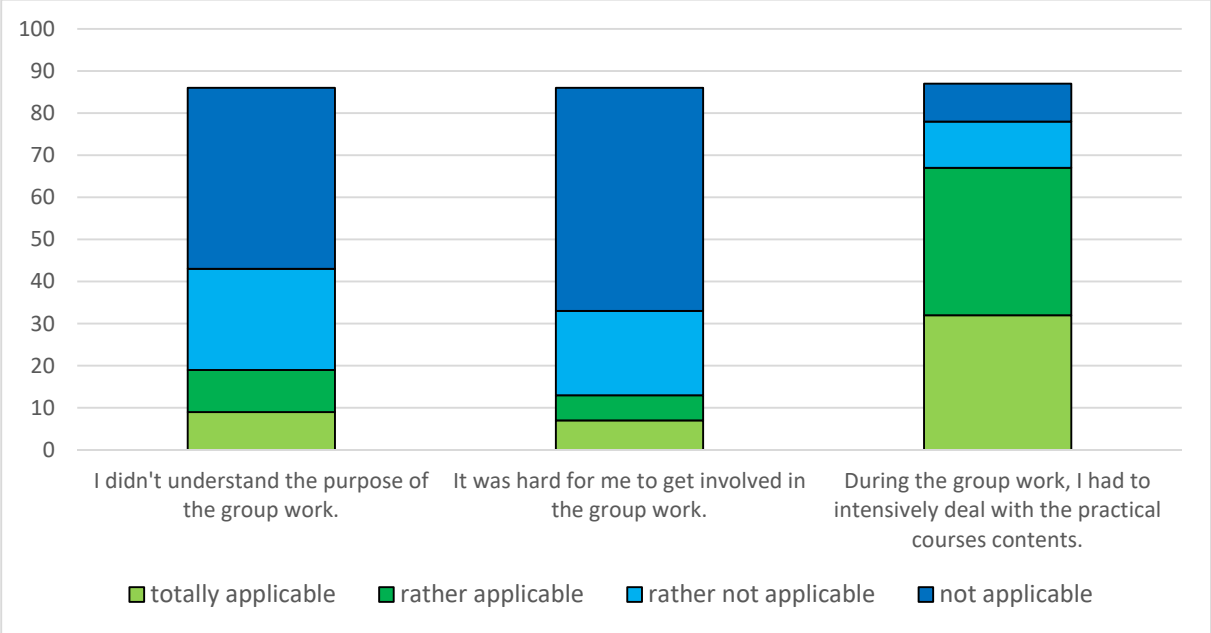

Figure 5: Students' experience with group work

Performance of the practical courses

When implementing the practical courses, it is important to consider how students accept the course. To achieve this, the content must be integrated into the lecture context and be of practical relevance to the students. This is reflected by the first two items shown in Figure 6 "I understood why the practical course is useful" and "In the practical course I was able to deepen my understanding of the lectures content." These statements are agreed to by 78% and 67% of the students, respectively. The result indicates that the students recognize the relevance of the practical courses content. The linking of the practical course to the lecture also seems to have been successful, but can still be strengthened. This can be achieved by making stronger references to the practical course in the lecture and by making more references to the lecture in the practical courses instructions.

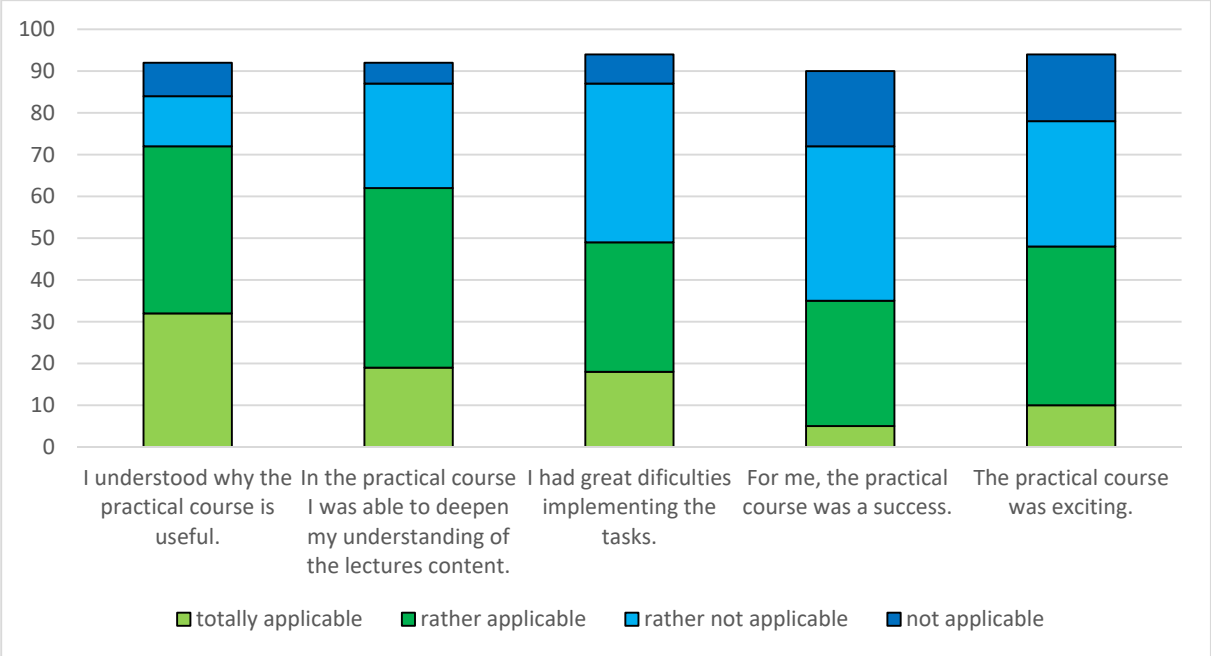

Figure 6: General evaluation of the practical course

The next item asks whether the students had difficulties in implementing the tasks. 52% of the students state that they had great difficulties. Some causes for this could be identified from the free text comments, which will be discussed in the following section.

While 51% of the students found the practical course exciting, only 39% of respondents rated it a success. It can be assumed that this assessment is related to the difficulties in executing the practical courses tasks.

Free comments

As a conclusion to the questionnaire, an open-ended question was posed that explicitly asked students to name problems: "What did you particularly like about the practical course and what didn't you like? What would you want to change?" A total of 37 % of the respondents used this opportunity and 120 comments were written. In addition to criticism, there was also positive feedback, but this will not be described further due to the small number. As explained in the 'Evaluation Procedure' section, the free texts were categorized and improvement items were formulated from the identified categories. Claims derived from the largest categories are listed below. The number of comments is noted in parentheses:

1. Reduce time spent in practical course (69)
2. Provide more stable measurement system (21)
3. Fix bugs in the code or communicate better (20)
4. Use digital protocols (12)
5. Answer questions during the interim meeting (6)
6. Answer questions also outside the interim meeting (4)

By far the most frequent comment refers to the excessive amount of time required for the practical course ("Implementation was far too time-consuming"). The students indicated an average processing time of 18 hours. This is indeed more than the twelve hours per course, allotted by the module description. However, it must be taken into account that the processing time of the practical courses varies and that the workload for the practical courses as a whole is still within the planned scope. Next semester, the workload should be communicated to the students at the beginning of the lecture so that they can plan their time accordingly.

The high time expenditure is additionally related to items 2 and 3 in the list of improvements. A major problem was the reproducibility of results due to the unstable measurement system: "In some cases, entire test series had to be recorded several times due to somewhat unreliable plug-in connections". Item 3 refers to the fact that during the practical course an error was discovered in the Arduino program

provided, but this was not communicated to all students. This error caused massive deviations between the measured data and the theoretical comparison values, which is why the students invested a lot of time in troubleshooting. The error could already be corrected, which reduces the amount of work.

In the semester under review, the protocol was to be submitted in analog form on a trial basis. However, this was perceived by the students as "not up to date" and "unnecessary [additional] effort". Accordingly, a digital protocol will be implemented in the future.

Item 5 addresses a problem that has already been discussed in the section 'Supervision in midterm and debriefing'. Students state that their questions were not answered in the interim meeting. This should be solved by an adapted concept of the interim meeting in the winter semester 2022/2023.

This is followed by the request from item 6. The students would like to be able to ask questions outside of the consultation dates. However, this cannot be realized due to the large number of participants. However, this problem should still be taken into account. Before the next run of the practical courses, the challenge of supervising up to 400 students should be communicated transparently. In addition, guided preparation for the consultation is planned. This should enable students to identify difficulties in processing before the consultation, which will then be solved together in the face-to-face meetings.

6. Summary

A lot of insight could be gained even from the first evaluation. These insights will enable improvement of the practical courses and the design of the evaluation itself.

The students' assess their own declarative and procedural knowledge as very high. This can be attributed to various causes. On the one hand, only the central learning content of the practical course was surveyed. On the other hand, the timing of the survey has to be considered. Since the questionnaire was used at the end of the debriefing, a positive selection bias may have occurred. About a quarter of the enrolled students participated in the debriefing. Therefore, it is possible that the survey only captured the motivated and possibly higher performing students. Thus, the result of the evaluation cannot be considered representative for the students of the Measurement and Automation Technology module.

The results show, a correlation between the complexity of the knowledge as well as the effort required to achieve the knowledge and the students' self-assessment. The more complex and time-consuming the acquisition of knowledge, the fewer students indicate that they have this knowledge. However, it cannot be deduced from the survey whether the acquisition of knowledge is due to the design of the practical course or corresponds to the respondents' prior knowledge. Therefore, the set of items only indirectly allows conclusions to be drawn about the quality of the teaching-learning materials as well as the supervision. The results can be used as a starting point to record and assess the development of the practical courses across semesters. Thus, it can be measured whether the adjustments in the design of the practical course have a long-term influence on the self-assessment of the students.

Since more than half of the respondents state that their questions could not be clarified during the interim meeting, the concept should be revised. However, the group work phases were particularly well received. Both the guidance and the students' experience with this method received positive feedback.

It can be concluded from the evaluation that the students recognize the relevance of the practical course. The connection of the practical course to the lecture is also rated well, but can be further improved.

Almost half of the students had difficulties in implementing the practical courses tasks. Several reasons for this could be deduced from the free comments. One problem frequently encountered by the students was the reproducibility of results due to the unstable measurement system. In addition, an error in the Arduino code provided caused significant deviations between the measurement data and the values calculated. theoretically .

The open-ended question at the end of the questionnaire was used by 37 % of the respondents to give feedback on the practical course. This additionally revealed that the analog form of the protocol was rather rejected by the students and that they would prefer a digital version. Furthermore, it was pointed out in the free comments, that not all questions were answered in the interim meeting. Furthermore, there is a wish that additional questions can be asked and clarified outside of the consultation meetings.

Ultimately, the evaluation has shown how intricate the design of the course Praktika@home is. It is complex to formulate both the research interest as well as the corresponding items unambiguously and “to-the-point". During the evaluation it became clear that a great deal was asked, but the formulation of the items was sometimes too unspecific. As a result, the findings in these cases did not relate to the interest in knowledge.

The development of the evaluation alone has already triggered an intensive self-reflection of their course by the teachers. Many additional approaches for the further development of the practical course and the questionnaire could be gained from the evaluation of the first instance.

7. Outlook

One topic that was raised in both the closed questions and the open question concerns the answering of questions during the practical course. Here, on the one hand, there was criticism that questions were not answered during the interim meeting and, on the other hand, that there was no opportunity to ask questions outside of the consultation dates. Therefore, the supervision is to be adapted in the winter semester 2022/2023. In doing so, the documents for all practical courses will already be uploaded at the beginning of the semester. The dates for consultations and submissions will also be communicated at the start of the semester. In this way, students will be able to freely allocate their time and better plan work phases.

The structuring of the self-learning phases is to be supported by the use of logbooks (reading logs [7, 8]). If the logbooks are uploaded before the consultation, the students receive additional points. This is to allow students to think about the experiments in advance and formulate their questions. Supervisors can prepare for these questions and adjust the design of the consultation dates accordingly. This is also intended to increase the number of participants in the interim meeting.

From the free comments it became additionally clear that the students have no idea of the amount of work planned for the practical courses. It therefore suggests itself to integrate the practical courses more into the lecture. This would allow the workload for the practical courses to be put into the context of the entire module and be better understood by the students.

The design of the questionnaire should also be revised before the next use. For each item, it should be checked whether there is a relationship to the research interest "Are the teaching/learning materials provided and the supervision designed in such a way that they support the students in achieving the learning objectives?". Items that do not meet this requirement should be reworded or shortened.

In addition, the questionnaire should be tested before use by colleagues who were not involved in the development process to check if the items are understandable. Even during the evaluation of this first sample, problems or inconsistencies may already be noticed that can still be remedied.

Furthermore, a different evaluation time should be chosen. It has been shown not only that the number of participants varies greatly between semesters, but also that a group of students is systematically excluded from the survey. Students who do not participate in the final meeting have not yet had the opportunity to provide feedback on the evaluation. However, it would be of interest to understand why these students do not participate in the teaching-learning opportunities and how they would need to be designed to support students in their learning process.

It would be advisable to examine how the evaluation of teaching-learning opportunities differs when students indicate that they have subject-specific knowledge. This may provide

information on how to better support lower-performing students.

A challenge with developing the questionnaire is the different perspectives of teachers and students. The teachers create the evaluation. In some cases, assumptions are made about student behaviors and challenges. To make the survey truly learner-centered, it would be beneficial to involve students in its development.

Acknowledgement

We thank the students of the Measurement and Automation Technology module who participated in the survey, as well as to all the instructors who supported and facilitated the evaluation.

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