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An “Agile” project planning course: Learning by doing in process engineering education

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ABSTRACT

Process engineering education requires a comprehensive foundation and practical application. To bridge the gap between theoretical education and market requirements, a "Project Planning Course” has been offered since 2018 as part of the MSc specialization in Chemical Engineering at the FHNW School of Life Sciences. The course didactics combines the principles of an “agile” teaching mindset and problem-based learning, which optimally support the experience of this module. Students had to work on unresolved real-world problems, make decisions based on incomplete information, and present their work in a board meeting role play with board members from industry. These situations represent typical real-world challenges for future chemical engineers. The results show that most of the students learned to cope with the unconventional teaching methodology. The students’ evaluations of the module have been very positive, especially the fact that the active participation of the students triggers the actual learning process - which means that the essential learning goal has been achieved.

1. Introduction

Process engineering education is based on teaching sound fundamental knowledge in the key subjects for this field of study, and transferring that knowledge to real-world applications. Supplementary internships with practical input support this education, at the end of which students are professionally qualified and can successfully start a job in this or related fields. However, the start of any career is often accompanied by a certain "practical shock". To fill the gap between the education offered and what the market requires, "Project planning courses" have been introduced at many universities – trying to combine the advantages of this practical approach in a familiar university teaching and learning environment and strengthen development in a group of like-minded people under the supervision of lecturers (Wilk et al., 2020).

The FHNW School of Life Sciences has offered such a course since 2018 as part of the Life Sciences Master’s programme: the "Process Development and Technology" module. The students’ academic background is a Bachelor’s degree in Life Sciences, Chemical Engineering, Pharmatechnology or Environmental Technologies.

The gratifying student feedback is partly due to the form of the module, based on an open agile mindset for higher education. The lecturer is no longer the unique source of knowledge but rather a coach and advisor to the students (MScLS Module Handbook).

An additional aim is to develop students’ 21st century skills such as collaboration, communication, critical thinking, creativity, IT skills, etc. The lecturer’s input is followed by active student work: after elaborating the content, the “lessons learned” focus is on identifying open issues – e.g. how to make good decisions given time pressure and a lack of information, analysing what impacts on decision making might be expected, and so on. Unlike in a classical engineering approach, the learning objective is not to generate a clear idea but rather to cope with tension and make decisions with incomplete information. Accepting existing inaccuracy and revising it when more information is available - this is the developmental step that students are expected to make in this module. Individual performance is evaluated based on grading of written work (group work) and a final written examination. The purpose of the final module examination is to check whether the knowledge acquired in class for one conceptual approach can also be applied to other issues.

To do this, students are confronted with (short) case studies, randomly selected from the topics covered in class, to which they are asked to give appropriate answers. For instance, the requirements for a production site are first asked in general and then for a specific task. The latter is of course different from the question developed in the concept phase; for example, students are asked about the special requirements

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for a pharmaceutical production site, while a bulk chemical production plant was discussed in the concept phase. Personal notes are expressly permitted as an aid during the exam with the intention that, as part of the exam preparation, they will be of such a quality that they can provide students with reliable help in future tasks even beyond the exam.

Due to time constraints, the examination is usually carried out in writing.

Outside the assessment, but particularly challenging for students, is the presentation of results in a Board Meeting role play: each group is asked to “pitch” their results to the “Board” – a group of 3–4 people consisting of at least one lecturer and 2–3 invitees from industry with experience of real board meetings. The pitches of the different groups have a “hidden agenda” – e.g. that the board members do not just listen until the end but also ask unexpected questions. This may irritate the students as it differs strongly from the known procedure of university presentations. The non-presenting groups are the “invisible audience” in the same room. After each pitch the “board members” provide feedback based on their industrial experience with real events, as do the other groups. Periodic surveys since the start of the module show that students find it helpful and more then 87% would like to see more courses like this.

2. Theory and applied methods

Learning is a highly complex process, which is realized very differently among students. Since new knowledge can be classified based on existing knowledge structures, and mental models can be modified or expanded according to new information, learning is an active, individual, and constructive process (Piaget, 1976, Seel, 1991, Kolb et al., 1984).

When planning a course or learning unit, the choice of a didactically appropriate combination of methods is crucial – a distinction is made between classical presentation and activating teaching strategies (Brinker and Schumacher, 2014). The content-related and didactic preparation of the course and its implementation is the inherent task of the lecturer. However, an activating teaching scenario implies that the lecturer is well prepared in terms of in-depth knowledge of the content, but initiates, accompanies and critically reflects on the students’ independent learning processes.

To cope with the growing complexity of engineering work, problem-solving, interdisciplinary and predictive methodological skills are becoming increasingly important, in addition to a sound basic education (Wilk et al., 2020).

Problem-based learning (PBL) is an instructional method that fosters students’ problem-solving skills and critical thinking by working on real-world problems, enabling experience-based education and self-directed learning (Hmelo-Silver, 2004). It is also widely used in engineering education (Palmer and Hall, 2011; Ricaurte and Viloria, 2020). Thinking like an engineer involves a problem-analysis process that considers technical, economic and environmental aspects. In order to anchor the engineering mindset in students in the long term, practical experience is essential. Since all professors at universities of applied sciences have significant industrial experience, they are particularly able to transmit their practical knowledge and experiences to the students as required by Ricaurte and Viloria, 2020.

In addition to the student-oriented approach, didactic principles that promote and enhance students’ intrinsic motivation, as well as their self-regulated, exploratory and social learning, are also indispensable for the design of teaching. According to self-determination theory, autonomy, social involvement and the experience of competence are relevant factors for intrinsic motivation (Ryan and Deci, 2000) and reflect important aspects of an activating teaching strategy.

"Agile is the ability to create and respond to change. It is a way of dealing with, and ultimately succeeding in, an uncertain and turbulent environment.” (https://www.agilealliance.org/agile101/) Over the years, agile methodologies and their implementation in the workplace have gained a lot of attention. This way of working is characterized by an adaptive development of short planning cycles, design, possible correction and adaptation, in order to enable a valuable increase of (preliminary) results. In quality assurance, this iterative process is also known as the Deming/Shewhart cycle of ’Plan, Do, Check, Act’ (PDCA). Traditional project management methods such as waterfall models are being replaced by structured agile methodologies such as utilizing a Kanban board or Scrum (Schwaber, 2004, Sutherland, 2014).

An ’agile mindset’ has also been introduced in education (López-Alcarria et al. 2019). Agile teaching strategies such as eduScrum (Wijnands and Stolze, 2019) have already been successfully implemented in basic maths courses at university level (Čukić et al. 2020, Rausenberger et al. 2020).

An agile approach to a project planning course for chemical engineers implies flexibility and adaptive planning, collaboration and communication, and iterative and hands-on learning. It emphasizes adaptability to change, continuous feedback and improvement loops, and close collaboration within a team. This is in stark contrast with traditional approaches, where all the required information is made easily available to students, either during lectures or on learning platforms. In such an environment, at no point are students required to ‘think on their feet’ to the same degree, or factor in uncertainty in their project planning. They may be more ‘comfortable’, but the range of skills acquired – whether technical, business-focused, personal or social - is much more limited.

However, research and practice in the field of didactic concepts for agility in higher education are still in their early stages. In his book *Agile University Didactics*, the author compares classical, planned didactics with agile didactics (Arn, 2017). He defines the latter as a combination of planned and unplanned instruction, a didactic that emerges from dialogue and engagement and in which lecturers and students both engage in open communication (Schön et al. 2023). The shift towards agile didactics becomes obvious in the following way. Course preparation and planning are central in terms of classical didactics and the active presence of the lecturer in the teaching situation is indispensable. With an agile mindset, the rigid attitude of “What has to be done is what the prepared planning dictates” shifts to “Do what the situation / the moment demands”.

Thus, a problem- and process-based, active teaching strategy, combined with an agile mindset, i.e. with students working cooperatively and with feedback loops to solve problems and lecturers providing continuous feedback, fits well with the engineering context in general and with the intended learning outcomes of this Master’s module in particular.

3. MSc Module structure and content

In order to experience the project character of this module optimally and allow for “agile” teaching and learning in the classroom, it should be organised with 3–4 hours in a block once per week over 10–12 weeks, which corresponds to a 3 credit module. Due to the very short time available for development work, teaching units of 2 lessons each are just as inadvisable as a single block event lasting 1–2 weeks, as there is too little time for reflection and internalising.

For a 3 lecture/week 12-week module, the focal points of the individual sessions are chosen as follows (Table 1 and Fig. 1)

As shown in Fig. 1, each topic is introduced with a 20-minute keynote speech which outlines the key principles, most important issues and requirements to further explore the topic in the targeted manner. It is then up to the students to think about this further in their group work. A learning objective is already achieved when a) they realise what further information still needs to be obtained in order to be able to answer the question comprehensively and b) where they can obtain this information. If questions arise that the students cannot answer at this stage, they should learn how to deal with this. The usual way would be to ask the lecturer. However, this should be avoided as it contradicts the aims of

Table 1
Module structure.

Topic	Week (3 lectures each) 1	2	3	4	5	6	7	8	9	10	11	12	
Presentation of the task, division into groups	■												
Site scouting		■											
User requirement specification (URS)		■	■										
Process Flow Diagramm (PFD)				■	■								
Mass & Energy bilances					■	■							
Definition of production philosophy							■	■					
Equipment & Media List (EQML)								■	■				
Cost estimation									■	■			
Finalsation of the Concept Study										■	■		
Board Meeting												■	
Hand-out / Presentation		Site scouting	URS		PFD				EQML		**Concept Study**		**Final Exam.**
Weighing											**50%**		**50%**

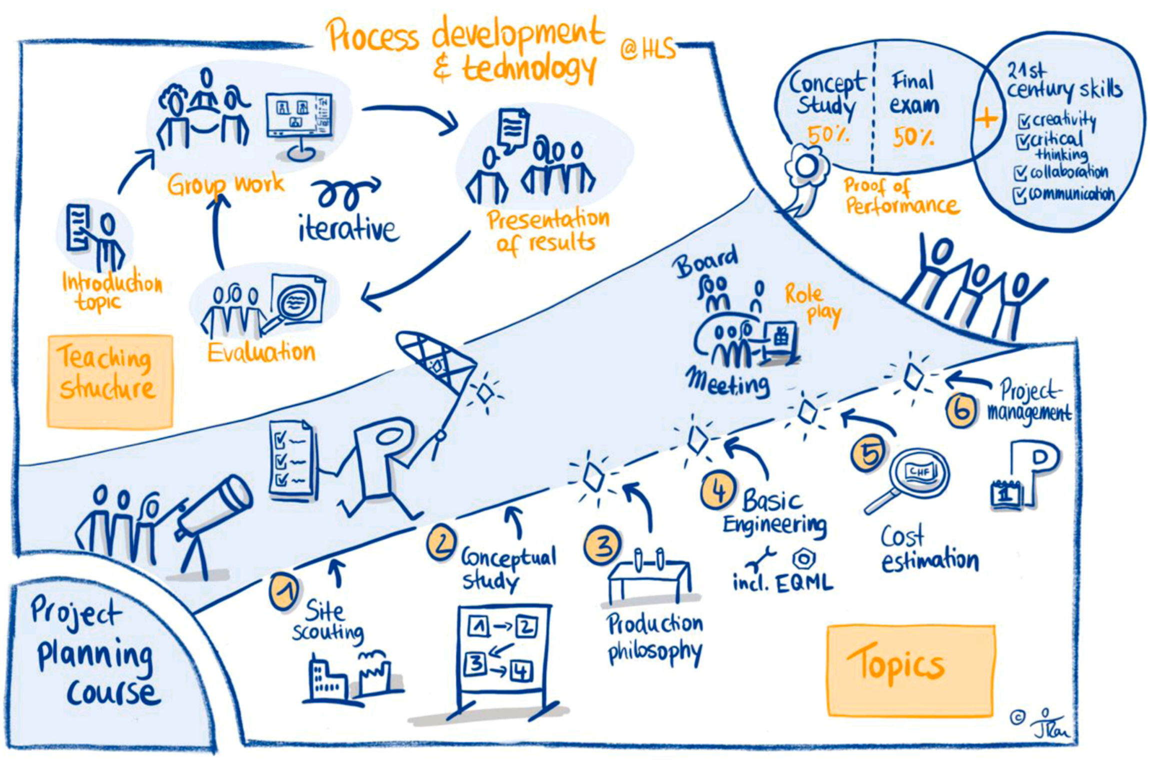

Fig. 1. Teaching structure of the "Process Development & Technology" Module.

agile learning. Only at an early stage of the course, when the aim is to set the right path for further work, may guidance from the lecturer be unavoidable. Rather, students should learn to accept a certain degree of missing information and trust that they will obtain it at a later date and incorporate it into their concept. For the time being however, they should make educated guesses and assumptions on which they can base their further actions.

At the end of each teaching unit, each group should present their interim results and discuss them with the others. The lecturer can and should provide moderate support in terms of content, but in any case, give feedback on what has already been worked out – especially with regard to scope and depth of detail, as well as any open points.

Students are then expected to incorporate this information into their preliminary report on this issue as homework, which they should complete by the next teaching unit. However, this step is not mandatory and can be integrated into the final concept document later. This means that students are free to organize their own time and learn how important good project time management is. If elements have already been well summarized after the corresponding teaching unit, the time required to create the final concept study is usually significantly less than if everything is created shortly before submission. In addition, due to the sometimes significant time gap from lecture to delivery date for the concept study, the depth of content is then less than when merging already well-developed sub-packages. With regard to preparation for typical processes in industry, this learning effect is a further training goal of the module. "Proper preparation prevents poor performance" (the "5-P rule") shows very nicely that – with the same level of training but differences in quality clever classification can identify which time and resources can contribute to rapid developments.

4. Maintaining didactics in challenging situations

Since students in this module usually only become aware of the impact of their decisions when they create the concept and present it in the board meeting, their evaluations during the module are sometimes very heterogeneous. Since most of them are used to being given clear learning goals and ways to achieve them, they sometimes have difficulty dealing with obvious gaps in information. This is consistent with a previous study using the agile framework eduScrum within a basic mathematics course (Rausenberger et al. 2020) where more self-discipline was reported. At the same time the students were more motivated to reach the learning objectives and positively evaluated the cooperation and improved communication during the teamwork, which represents a clear benefit of an agile teaching approach. The requirement for the MSc module, though, to work out "something" without knowing exactly "how", occasionally irritates them – while other students recognize and accept that at the moment things can only continue with a certain degree of vagueness and the use of assumptions. In this phase, the lecturer is particularly challenged: they must be able to tolerate being criticized for their teaching style and still stick to giving the students only supportive, but not didactic or rigid, instructions. The latter would undermine the students' self-learning process, which tends to be more time consuming. In previous studies, students have also reported spending more time during the semester but at the same time, the sustained learning towards the end of the semester means that less time is needed to prepare for the final exam (Čukić et al. 2020). Of course, it is helpful in any case from the lecturer`s point of view to highlight students' progress in a positive way and thus give them courage for the following tasks as well as to endure uncertainty, which can be seen as a challenge of an agile teaching approach.

To provide a certain orientation, the module is based on management documents typical for such projects, which are developed together and then "frozen" at certain points in time, i.e. they can no longer be changed significantly (see Fig. 2)

1) User requirement specifications as a multi-page document that contains the task, the general conditions and the possible perspectives for capacity expansion
2) Process flow diagram with the most important process steps and main apparatus
3) Equipment and media list, with at least the pre-specified main devices as well as the required energy and media
4) Cost Estimation: this gives students a framework on which to build their further work.

As Fig. 2 shows, all management documents are essentially created through editing by the students. The document structure here only provides a framework, which is limited to individual chapters, columns and the scope (page numbers) for example. However, examples from other projects can be used to show students clearly what expectations are placed on their work in this regard. Since the FHNW itself was involved in the development and construction of a Process Technology Center (PTC) with approval as a production company, realistic examples including the resulting implementation can also be shown for the above documents. The meaning of these documents can be "understood" in the truest sense of the word, during a tour of the PTC as part of a teaching unit (https://www.fhnw.ch/en/about-fhnw/schools/lifesciences/process-technology-center-ptc).

In any case, to achieve the learning goal it is helpful to maintain intrinsic motivation. The realization that other groups also have to deal with similar challenges prevents the feeling of being "left behind" and encourages people to continue working intensively on the project. How the project develops and how your own skills progress during the module can be nicely described using the example of inflating a balloon.

The phase boundaries between "not knowing" and "knowing" are those between the balloon and the filling. At the beginning of the project, when the topic is presented, this phase boundary is relatively small - since the question is usually already understood ("planning a production plant") but the effort required for this is actually not outlined at all (see Fig. 3 left). However, as soon as work on the question begins -

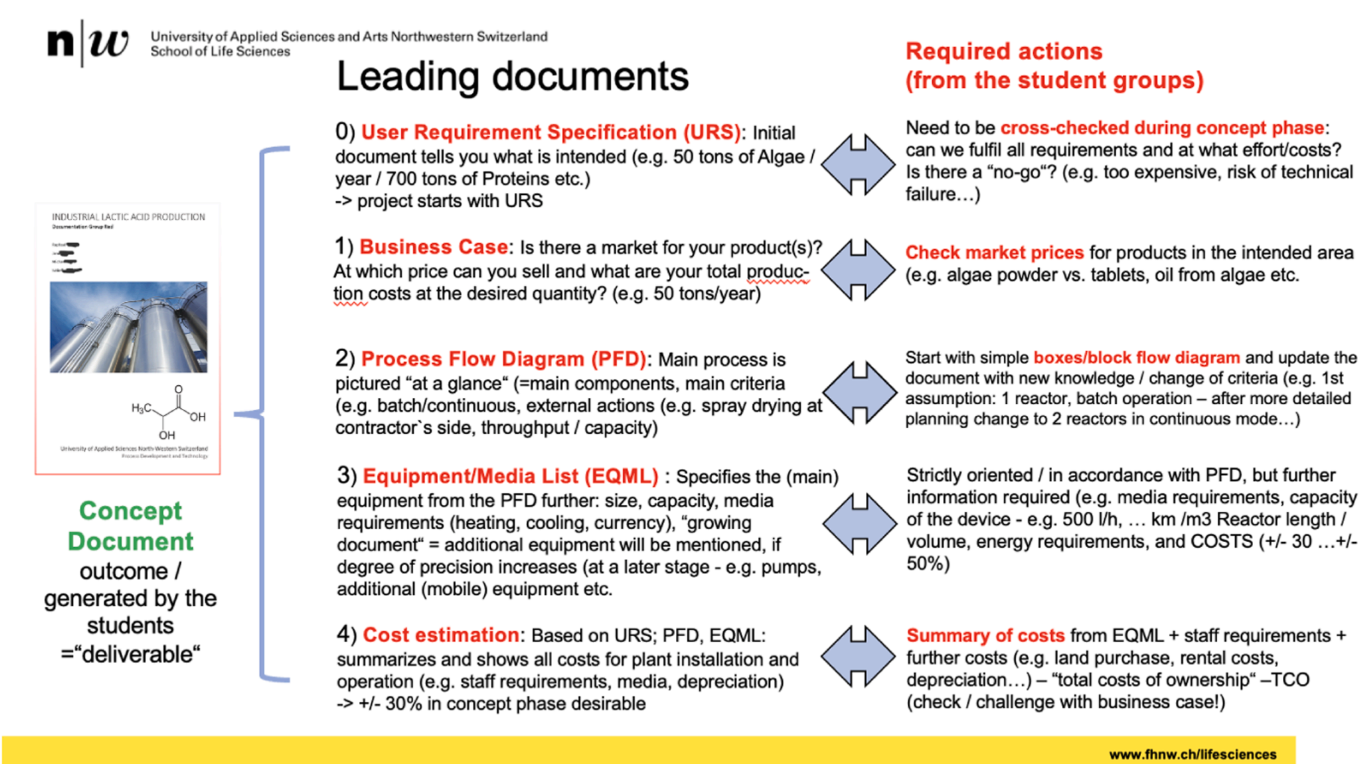

Fig. 2. Leading documents as framework for the concept study.

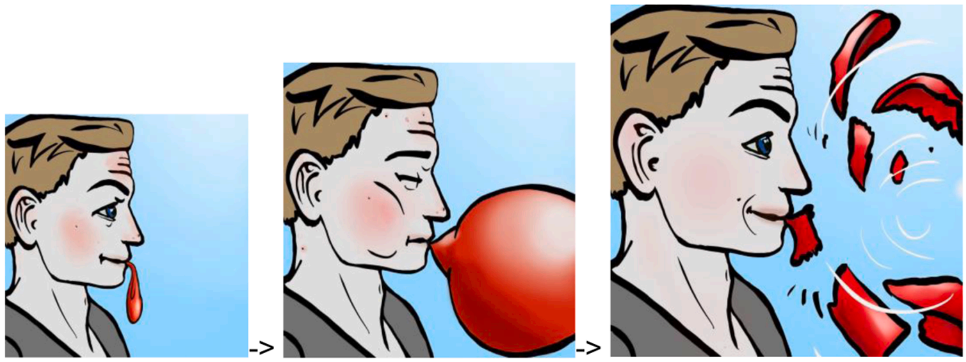

Fig. 3. Balloon inflation as example of knowledge generation (drawing: L. Daum).

i.e. "input" into the balloon envelope - this limit increases. It is often reported that students in this phase, when they have already become familiar with the subject, have the feeling that they know even less than they did at the beginning. At this crossroads, it is important to maintain motivation. The management documents mentioned above then provide a certain level of orientation and at the same time act as a fallback. With the realization that progress can only be achieved through further concentrated and focused work ("blowing in more air"), over time a state will arise in which more well-founded knowledge has emerged and the open questions will become fewer and fewer. The phase boundary has disappeared, although not always with a “bang” like an overfilled balloon.

Anticipating the “Evaluation” section, most students retrospectively rated the module as very positive, especially because of how they mastered these demanding learning phases leading up to the crowning conclusion: the Board Meeting. When developing this MSc module, it was planned from the outset that industry would be involved. In addition to specifying an industrially relevant topic - with a more or less concrete connection to actual planning - the presentation to industry of the concepts developed was a declared goal. Having the “final word” come from the industry representatives involved should further break down the teacher-student connections, which are already not very strong due to the didactics used. Industry experience in evaluating concepts is the measure by which students’ concepts must ultimately be measured - and not just assessment by the lecturer. Since both industry representatives and lecturers generally have no particular interest in excessively criticizing the concepts presented by the students, the board meeting was designed as a role play. Both the invited industry representatives and the lecturer take part in this role play as “board members”; the students know this in advance. For example, the lecturer is the Chief Technology Officer of the company for which the concept study was developed, while an industry representative takes on the role of “CEO”. If possible, the location of the board meeting should be similar to that in industry: a larger meeting room where the students present their concept to the “C-levels” who sit at tables. Each group presents its concept to the board, while the remaining groups attend this board meeting as a “hidden audience”. What the speakers don’t know however, is that "the board" has a strategy for each group, which it communicates to the other groups in the room but not to the one presenting. For example, if the speakers are asked critical questions during the presentation do they become unsettled? It can also happen that one of the board members picks up their cell phone and leaves the room so that they can continue the call. The speakers’ reaction to these unforeseen events is closely observed by the other students present. At the end of the presentation, the role play is officially ended by the lecturer and then reflected upon together. First, the students who have just presented should say what impression they had of this board meeting. Did they have the feeling that they were able to convey their core statements? Did they think that their work was valued? Were they able to respond adequately to unforeseen situations? They will then receive feedback from the industry representatives, other students and the lecturer. In courses with several groups, an additional learning curve is usually observed. In particular, the groups that are the last to present in front of the board were able to experience many special situations by attending the previous presentations and were then able to react even better to the unexpected. Overall, the board meeting shows the students that sometimes there are different processes at such special events than at the final presentations of graduation theses that they are familiar with. These prepare them better for their future professional life, as the evaluations so far underline. To make the board meeting as realistic as possible, it is necessary that it is clearly communicated to the students that the usual (decency) rules, e.g. for the presentation of results as part of bachelor’s and master’s theses, do not (cannot) apply here. If this makes them uncomfortable or they don’t want to take part in this role play, they don’t have to, and without any negative impact on their performance rating in the module. It happens that individual group members decide to do this: they then usually take part in observing the role plays as a “hidden audience” and give valuable feedback to the presenting groups.

In the evaluation of the module, the role play was therefore not asked about in depth. The direct feedback from all those involved - students, industry representatives and lecturers - at the end of the role play day is in full agreement with the feedback in the evaluation (see below).

5. Evaluation by the students

Whether the didactics presented for this topic and the intended learning goal ultimately have an effect can of course only be shown through an extensive evaluation. Building on experiences with evaluation of agile didactics in applied mathematics in bachelor’s degree programs, a yearly - anonymous - survey of a total of 58 participants has been carried out in this master’s module from 2020 – 2023. The overall response rate was 52% ($n = 30$); the documentation of the responses over the years is summarized in Table 2. Among other things, the points shown in Fig. 4 were asked and had to be rated from “not at all true (1)” to “yes, absolutely (5)”.

As Fig. 4 shows, the module is rated very highly in all aspects. In particular, the fact that the active participation of the students triggers the actual learning process was assessed as “absolutely correct” – which is in strong agreement with the expected enhanced intrinsic motivation (Ryan and Deci, 2000). What is also interesting is the fact that the

Table 2
Details about number of participants and survey response rates 2020 – 2023.

year	number of participants	number of responses	response rate
2020	15	10	67%
2021	15	6	40%
2022	18	9	50%
2023	10	5	50%
total	**58**	**30**	**52%**

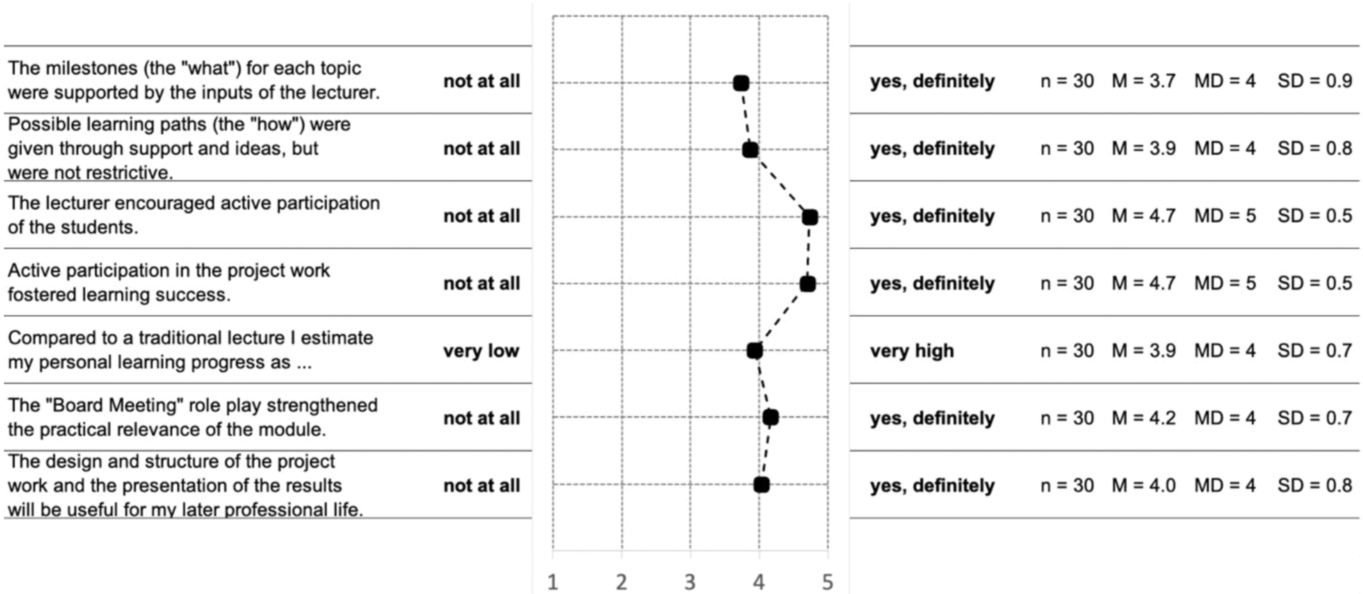

Fig. 4. Results of the students' evaluation with n = 30 responding participants in years 2020–22. (M = mean, MD = median, SD = standard deviation).

lecturer's work, even though she or he does not actually take on a leadership role in agile didactics, was perceived as encouraging more active participation in the project work. This is certainly also due to attractive tasks and the promotion of intrinsic motivation, combined with regular determination of positions with encouraging feedback on progress.

The most interesting feedback however came from the question "would you like more modules like this", to which 90% of students answered "yes".

The evaluation of the module after its implementation is a logical approach, as the students' individual learning success can best be assessed on the basis of the concept paper generated, the successfully completed board meeting and the final module examination. Since the students were able to generate proper concept studies in all modules completed so far – sometimes with less, sometimes with more support – achieving the learning goal was a positive experience that was reflected in the evaluation ("we finally did it!").

What is not depicted in this retrospective assessment is the helplessness that some students sometimes feel – mostly during the first third of the course. Depending on the degree of self-organization in the working groups, some students experience progress in concept development as stagnating, if not declining. To stay with Fig. 3, they are "out of breath". It is in the nature of things that students rarely communicate this fact. It is therefore particularly important that the lecturer carefully checks the current development level of the groups, but also of the individual group members, and intervenes to provide support where stagnation is suspected or obvious.

The support, however, should be limited to encouraging further active participation rather than providing concrete solutions – which in turn was rated positively by the students (see Fig. 4: "the lecturer encouraged active participation of the students").

If no progress at all seems possible, predetermined solutions can be given for certain topics, which the students have to incorporate into their concept and then be able to (re)concentrate on other aspects. This assistance must of course be included in the evaluation of the students' own performance and leads to points being deducted in this aspect.

However, this measure has not yet had to be applied in modules carried out so far, which underlines the high intrinsic motivation of the students in (and thanks to) this form of module.

6. Conclusions

The "Process Development and Technology" MSc module at the FHNW School of Life Sciences, which has been offered since 2018, combines a problem-based learning methodology with an agile teaching approach. Working on real-world problems, the students were supported to develop practical skills and thus could enhance their knowledge of professional performance in real-world engineering projects. The module has proven to be well-attended and highly rated by students. This can certainly be attributed to its special didactics – agile learning – which is particularly suitable for such a topic.

While a 30 out of 58-student response proportion certainly gives some valuable insights about the course, it does come with a few inherent limitations: 1) a non-response bias implies that those students who chose not to respond have different views about the course; 2) generalizability: with just over half the participants responding, the sample might not represent the entire participant population; and 3) in small data samples, outliers can have a disproportional effect. These limitations might influence the interpretation of the results; however, the positive evaluations of the course can be considered as guiding indicators of the course effectiveness.

Another learning effect of the module with particular practical relevance comes from presenting the concepts developed as part of a "board meeting" role play. In addition to the pure presentation technique, the ability to improvise is also trained, which is important for presentations outside the university environment, in order to leave a positive impression. The collaborative approach ensures that the heterogenous skills of the students can be positively used in different tasks. Therefore, students learn in a sustainable manner how to effectively manage a diversified team with different behaviours and skills, which reflects their future working environment.

We are currently evaluating which other MSc modules can be converted to this didactic approach.

CRediT authorship contribution statement

Julia Rausenberger: Writing – review & editing. **Andrew Brown:** Writing – review & editing. **Wolfgang Riedl:** Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

Arn, C., 2017. Agil. Hochschuldidaktik. Beltz-Juv.
Brinker, T. und Schumacher, E.-M., 2014. Befähigen statt belehren. Neue Lehr- und Lernkultur an Hochschule, hep-Verlag.
Čukić, P., Pinkernell, G., Werft, W., Luther, A., 2020. Mathematikvorlesungen für Maschinenbaustudierende als Projektmanagement. die hochschullehre Prax.
Hmelo-Silver, C.E., 2004. Problem-Based Learning: what and how do students learn? Educ. Psychol. Rev. Vo. 16 (3), 235–266.
Kolb, D.A., 1984. Experiential learning: Experience as the source of learning and development. Prentice-Hall, Englewood Cliffs, NJ.
López-Alcarria, A., Olivares-Vicente, A., Poza-Vilches, F., 2019. A Systematic review of the use of agile methodologies in education to foster sustainability competencies. Sustainability *11* (*10*). https://doi.org/10.3390/su11102915.
Palmer, S., Hall, W., 2011. An evaluation of a project-based learning initiative in engineering education. Eur. J. Eng. Educ. 36 (4), 357–365. https://doi.org/10.1080/03043797.2011.593095.
Piaget, J., 1976. Die Äquilibration der kognitiven Strukturen. Klett-Verlag, Stuttgart.
Rausenberger, J., Gilgen, L., Mülken, O., Feiler, S., Burkhard, R., Erb, N., Luther, A., Hölscher, M., Bock, S. and Pude, F., 2020. How to Strengthen Today's Math Skills of Tomorrow's Engineers – Practical Experiences with Agile Approaches to Innovative University Math Lectures. In {C}S. Hloch et al. (Eds.){C}: Proceedings of the International Conference on Manufacturing Engineering and Materials 2021, LNME, pp. 3–11, Springer Verlag. DOI.
Ricaurte, M., Viloria, A., 2020. Problem-based learning as a strategy for multi-level training applied to undergraduate engineering students. Educ. Chem. Eng. 33, 102–111.
Ryan, R.M., Deci, E.L., 2000. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am. Psych. 55 (1), 68–78.
Schön, E.-M., Buchem, I., Sostak, S., Rauschenberger, M., 2023. Shift Toward Value-Based Learning: Applying Agile Approaches in Higher Education. In: Marchiori, M., et al. (Eds.), WEBIST 2022, LNBIP, 494. Springer Verlag, pp. 24–41 (DOI).
Schwaber, K., 2004. Agile project management with Scrum (1. Aufl.). Microsoft press.
Seel, N.M., 1991. Weltwissen und mentale Modelle. Hogrefe-Verlag. Göttingen.
Sutherland, J., 2014. Scrum: The Art of doing Twice the Work in Half the Time. Cown Business, New York.
Wijnands, W., Stolze, A., 2019. Transforming Education with eduScrum. In: MacCallum, D., Parson, K. (Eds.), Agile and Lean Concepts for Teaching. Springer Verlag.
Wilk, M., Rommel, S., Liauw, M.A., Schinke, B., Zanthoff, H.-W., 2020. Bildung 4.0: herausforderungen für die Aus- und Fortbildung. Chem. Ing. Tech. Vol. 92 (7)).