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Development, implementation and evaluation of a hybrid study program for sustainability competencies and future skills

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Introduction: Industrialized countries face the challenge of an aging population and declining birth rates, leading to a shortage of qualified personnel. In addition, organizations are confronted with the need for a sustainable transformation, driven by factors such as customer expectations, regulatory requirements, legislative changes, competitive pressures, and societal demands. This leads to increasing demand for, and a shortage of, employees with relevant future skills, particularly in sustainability competencies. Universities are adopting their offers to address these evolving societal and business needs.

Methods: This study presents recent literature on workforce and student demands, with a particular focus on sustainability competencies and flexibility in education, also for addressing needs of lifelong learning. Based on these insights, we conducted a survey targeting current and potential students in a rural, industrial-dominated region in Germany to better understand their expectations and needs.

Results: The findings informed the development of a Master's program that emphasizes sustainable development through project-based learning and close collaboration with businesses and organizations. Key features include flexible, blended/hybrid learning approaches and a wide array of elective modules from related degree programs, allowing students to tailor their studies to personal and professional goals while accommodating part-time work or caregiving responsibilities. Student evaluations conducted after the program launch reveal its success in meeting regional and broader student demands. Students highlighted the importance of flexibility, interactive learning, and the integration of interdisciplinary topics. These preferences also underscore the challenges of implementing such a program, particularly the need for effective coordination by both students and the university.

Discussion and conclusion: We conclude that the program model is well-suited to addressing current demands. However, it requires ongoing adaptation to ensure sustainable success, also to meet lifelong learning demands by continuously including trends and topics of relevance for the target group.

KEYWORDS

project-based learning, sustainability competencies, inverted classroom, interdisciplinary studies, flexible learning, hybrid study program, blended learning

1 Introduction

Overlapping and complex global challenges, intensified by rapid technological advancements and profound societal shifts, underscore the need for educational frameworks that extend beyond traditional disciplinary boundaries. Research indicates that current academic structures, often rigidly discipline-specific, are inadequately preparing graduates for the multifaceted demands of the modern workforce, where interdisciplinary collaboration and applied knowledge are crucial (Brundiers and Wiek, 2017; Calloway and Langford, 2024; Newell and Bain, 2020). Emerging educational paradigms advocate for the integration of interdisciplinary, applied study courses that emphasize future-oriented competencies, such as critical thinking, digital literacy, adaptive expertise, and cross-functional teamwork (Binkley et al., 2012; Drake and Reid, 2020; Voogt and Roblin, 2012).

Moreover, project-based and experiential learning models have gained prominence in fostering students' ability to tackle complex, real-world problems, which demand both technical proficiency and socio-emotional skills (Kolb, 2014; Prince and Felder, 2006). Such curricula can be designed to align with the global push toward educational reform, as outlined by international frameworks such as UNESCO's Future of Education initiative or "The futures we build" report, calling for the development of "future skills" to address societal and economic uncertainty (International Commission on the Futures of Education, 2021; UNESCO and EIDOS, 2023). By adopting interdisciplinary approaches that emphasize applied learning, universities can better prepare students to navigate the rapidly evolving demands of the labor market, while simultaneously contributing to societal advancement through innovation and problem-solving (OECD, 2018).

In this manuscript, we present findings in developing and implementing a new Master's program at Albstadt-Sigmaringen University (ASU) that follows these new education paradigms by an interdisciplinary and project-based approach. This applied program is designed to equip students with the competencies required for addressing complex sustainability challenges. The curriculum is based on a hybrid teaching and learning model and integrates theoretical knowledge with practical experience, allowing students to incorporate insights from their professional work into their academic learning. Furthermore, the program integrates online learning as well as on-campus presence, and is structured to offer high flexibility, enabling students to balance their studies with ongoing responsibilities, thereby enhancing the practical applicability of the skills and knowledge acquired throughout the program.

While skills demand for a sustainable transition has been researched and similar study programs focusing on sustainability and project-based learning have been evaluated (Brundiers and Wiek, 2017; Oxenswärdh and Persson-Fischier, 2020), the perspective of the target group, particularly the perspective of potential students and businesses on sustainability education in rather rural and industrial-dominated regions, is missing. Yet, these should be considered since especially in less populated areas, resources to test and implement new ideas can be limited additionally (see for example Rundel, 2023). Moreover, we report on the actual development process of such a study program and add insights regarding the combined effects of a project-based study course with focus on sustainability while providing a flexible study program at the same time.

We therefore answer the following research questions by analyzing survey and evaluation results from students, prospective students and alumni, sharing insights from the development process and by taking current education paradigms into account:

1. How can a future-oriented education on sustainability issues in a predominantly rural and industrial-dominated region be achieved?
2. Which conditions do potential and actual students perceive important for a project-based study program in sustainability education?

In the following chapter, we first introduce our methods applied to answer these research questions, before we present relevant literature findings in chapter 3, our results in chapter 4 and discuss these further in chapter 5 and 6.

2 Materials and methods

To answer the research questions, we worked with a mixed methods approach. First, we identified relevant competencies and skills for sustainable development in businesses and the demand as well as the prerequisites for flexible and hybrid study program models.

Building on these findings a survey was designed and conducted to validate the respective literature findings, targeting Bachelor students in their last year and Master students at ASU. A survey was also sent out to alumni and shared in suitable groups on social media. Moreover, it was possible to share the questionnaire via the industrial network in the region. By doing so, insights from participants living or working beyond the region were gathered as well (original survey in Supplementary material). While this paper primarily focuses on potential and actual student perspectives, it is worth noting that we included questions related to business perspectives where appropriate. Moreover, before the launch of the study program, medium-sized enterprises of the region were consulted.

Taking these different research findings into account, the new Master's degree program in Sustainability Studies was designed. It was officially started in the winter semester of 2024, and this study also presents first evaluation results from the students who enrolled in the study program in 2024. The authors were actively involved in the conceptualization and implementation of the new Master's program presented in this study and have assumed teaching responsibilities since its launch. One of the authors (CM) was appointed academic director of the program following its introduction.

2.1 Study area and context

Albstadt-Sigmaringen University (ASU), a state-owned University of Applied Sciences located in a rather rural region of Baden-Württemberg, Germany, plays a pivotal role in both the local community and economy (Neumeier and Osigus, 2025). With

approximately 3,000 students enrolled across 19 bachelor's and 18 master's programs, the university is organized into four faculties: Business Sciences and Management, Life Sciences, Engineering, and Informatics. ASU's strong emphasis on applied research and collaboration with local industries and organizations underscores its commitment to regional development and integration with the business sector. It is remarkable that in the study region, one finds a high share of businesses in manufacturing, with a share of 45% (2020) in the county of Sigmaringen, while the average in Germany is 26.6% (2021) (Orth, 2023).

ASU maintains accreditation through the German Accreditation Council (Akkreditierungsrat), and its internal quality assurance system, audited by AQAS, ensures that all academic programs meet rigorous quality standards with respect to their teaching and the organization of the study programs (Stiftung Akkreditierungsrat, 2024). In addition to its academic structure, ASU has implemented a range of support programs designed to foster student success. These include comprehensive tutoring services, mentoring initiatives for 1st-year students, and a personalized approach to learning, allowing students to define their individual educational trajectories.

The university's digital education infrastructure, significantly enhanced during the COVID-19 pandemic, has received national recognition for excellence in student satisfaction surveys, highlighting its progressive approach to digital learning and didactics (Hochschule Albstadt-Sigmaringen, 2022, 2024). In this context, ASU was recently ranked Germanys most popular university in 2025 (Oak - Online Akademie GmbH, 2025).

The new Master program Sustainability Studies started in October 2024 and offers students a project-based and interdisciplinary program with a highly flexible and individual setup based on blended learning approaches with active participation like flipped or inverted classroom concepts (Gannod et al., 2008) and project based learning (Belmekki, 2024; Gattegno, 1997; Lübben et al., 2016; Möller, 2013). The high project share is new at ASU, and meeting 2 weeks at campus only in the beginning and the end of the semester is a novelty as well. Moreover, while lecturers at ASU made use of flipped classroom concepts and online lectures beforehand, we have started to use Engage from Microsoft as an exchange tool among the students and especially focused on suitable examination strategies. For example, in the Onboarding and Methods module and the Sustainable and Sustainable Technology module, portfolios are used to stimulate especially the reflective skills of students and to provide a connection of the newly acquired knowledge with the projects they aim to realize. This, in the end, shall stimulate the recognition of relevance.

The program started with 10 students only to give the flexibility and opportunity to adjust learning methods if required, and to provide optimal supervision of the students. Sustainability topics are holistically approached, covering management topics as well as technical aspects relevant for industry. Among others, students work especially on sustainability projects with focus on technical and natural sciences. This is also in line with the different areas

of expertise at ASU (Gerhards et al., 2019; Hempel et al., 2022; Kruse et al., 2024; Loser et al., 2021; Möller et al., 2022; Otto et al., 2021; Tadesse et al., 2024; Uhlig et al., 2025). Various elective subjects from the different faculties are offered, so students can choose relevant courses for their projects. In addition to the elective modules, which may be chosen from a wide range of related programs across all faculties, three mandatory modules were specifically designed and introduced for the new study program. These are listed as Supplementary material. Finally, one semester is mainly used to, ideally together with businesses or research institutions, work on an individual sustainability project. Together with the other results presented in this study, we also briefly introduce the development process of this program in chapter 4.

2.2 Overview and characteristics of the survey participants

In the following Table 1, the number of completed questionnaires is shown. In total, 148 answers were received. Participation per gender is balanced as shown in Table 2.

Regarding their educational background, most alumni who participated in the survey held a bachelor's degree, which is also the case for external participants (see Table 3). Most of the participants were between 20 and 30 years old, with some aged 31–40 (see Table 4).

The area of expertise among students from ASU was mainly from engineering, economics and social sciences, informatics or natural/health sciences, which suits the profile of the institution (Table 5).

Among alumni as well as among external participants, the area of expertise is diverse with some dominance in for example metals/electronics or pharmacy/health, as can be seen in Table 6.

2.3 First evaluation results of enrolled students

To evaluate whether the study design meets expectations, 6 weeks after the start of the Master program we asked students ($n = 10$) for their feedback regarding the structure and content of their study in an anonymous survey. In total, seven questions (mainly Likert-scale) were included, allowing free text for more detailed feedback in between. The results are additionally presented and discussed in this paper, especially regarding the developed teaching concept tailored for this program. Moreover, at the end of the first semester, students provided anonymous feedback on the different modules. In this study, we also present the findings of the evaluation of mandatory modules, illustrating how students perceived online flipped classroom seminars in combination with online lectures on sustainable technology aspects and methodological approaches.

TABLE 1 Completed questionnaires.

	Students bachelor	Students master	Alumni	External
Amount of completed questionnaires	33	34	51	30

TABLE 2 Gender distribution.

Gender	Students bachelor	Students master	Alumni	External
Male	15	20	25	13
Female	16	14	23	16
Diverse				
No answer			3	1

TABLE 3 Level of education.

Education	Alumni	External
A-level		4
Occupational education		3
Bachelor	47	15
Master	4	6
Doctoral degree		1
No answer		1

TABLE 4 Age of participants.

Age	Alumni	External
<20		
20–30	47	19
31–40	4	8
41 +		2
No answer		1

TABLE 5 Area of expertise (1).

Area of expertise	Students bachelor	Students master
Engineering	13	10
Informatics	3	9
Economics and social sciences	7	9
Maths and natural sciences	5	3
Medicine and health sciences		3
No answer	2	

TABLE 6 Area of expertise (2).

Area of expertise	Alumni	External
Currently studying	8	4
Construction	2	1
Chemistry and raw materials		1
Services and crafts	4	3
Trade/e-commerce	1	1
Energy and environment	2	
Finances, insurances, and real estate	2	2
Societal matters	1	2
IT/telecommunications	6	2
Media, marketing		3
Metals, electronics	7	2
Pharmacy/health	8	2
Traffic and logistics		1
Other	9 (mainly food industry, technical textiles, medical technology, unemployed)	5 (various, e.g., textile industry or mechanical engineering)
No answer	1	1

The didactical blended learning framework provides insights into the topic of sustainability in the first semester. This is done by providing learning material prior to online discussion rounds to work with the flipped classroom concept. Professional deepening is secured by involving lectures from experts in their fields. Exchange and collaboration among students are fostered by respective tasks and 1 week at campus each, at the beginning and the end of the semester. In the mandatory subjects, the connection to their project semester is guaranteed by working with respective guiding questions, bridging theory by setting it in relation to their project topics. Furthermore, the students can choose suiting electives from almost all other Master programs offered at ASU. While some of the individually chosen elective modules require to be present at campus to some extent, a predominant part of the study can be followed in an asynchronous and self-paced manner, independent of place and time.

3 Literature overview

3.1 Identification of relevant competencies and skills for sustainable development in businesses

With a focus on the German context, one in two companies now state that they have dealt intensively with ecological change, more often large companies than SMEs (Risius et al., 2023). Despite crises, companies are increasingly adopting sustainability considerations in their strategy and operations. While regulations are often complex, there are difficulties with data consolidation, and shortcomings in digitalization can make sustainability reporting more difficult. At the same time, it is stated: "The young generation is the most important driver of sustainability in business" (Edinger-Schons et al., 2023).

This raises the question of which competencies and skills are considered essential in this context. The concept of so-called "green skills" comprises the following elements: A sustainable mindset (why), green knowledge of sustainable technologies (what) and transfer skills (how) are central. It should be emphasized that these are relevant for all employees and in all areas of activity. Areas of activity are: management, location, value creation, the product and the customer. Specific skills required include creativity, intercultural competence, the ability to work in a team, knowledge of the circular economy, life cycle assessment, design, process and procedural knowledge, design thinking, project management and digitalization (Schiermeier et al., 2023).

As many employees as possible should be continuously trained/retrained, otherwise the desired sustainable development

will be hampered. The following skills are listed in the Green General Skill Index: Engineering and technical skills, scientific skills, management skills, monitoring skills and soft skills (Haufe Akademie, 2022).

Internationally, the following areas of responsibility are identified that require CSR experts with in-depth knowledge: Comprehensive reporting, sustainability controlling, implementation of standards, coordination of suppliers, establishment of appropriate management systems and stakeholder management. The following core competencies of a CSR manager are also specified: Knowledge of specific instruments, multidimensional thinking, broad specialist knowledge of sustainable development, leadership skills, process competence, personality-related skills (communication skills, persuasiveness, moderation, etc.). In summary, it can be said that generalists are needed who can take a holistic approach, develop long-term strategies and stimulate innovation. They should also be able to implement complex processes in a cooperative and motivating manner. This is particularly relevant with regard to the most common obstacles to implementation: A lack of understanding of sustainability, costs/economics and additional demands on company processes (Leusmann and Nölting, 2015).

Additional skills are therefore needed in companies to drive sustainability forward, with one in five companies even stating that completely new job profiles will emerge or that the occupational mix will change. (Further) training is therefore seen as very important. The focus here is on training and developing employees rather than hiring new ones, as the shortage of skilled workers is causing difficulties in filling new positions. 60% state that the skills shortage is slowing down change and that there is a lack of knowledge on the subject. Only around 40% of companies know which skills are really needed for more sustainability in the company. Holistic change processes are necessary, as with digitalization, and these challenges can in some cases also be tackled in combination (Risius et al., 2023).

This is the reason why universities are called upon to promote sustainability skills, as in principle all graduates can be confronted with sustainability issues. To this end, it is particularly important to be able to shape organizational action accordingly. Graduates are required to apply the following different perspectives: Expanding the mode of observation, overcoming strategic uncertainty and realizing what is intended. They should therefore be able to assess the scope for action to realize sustainability. Instead of focusing on problems, more attention should also be paid to opportunities. Graduates should be enabled to assess the possibilities and the scope for action to make an organization sustainable. This is why case-based learning is recommended at universities, allowing experience to be gathered and reflected upon. In addition, areas of friction in the process and the position or power can be experienced (Schweizer, 2022).

3.2 Reasons and preconditions for flexible and hybrid study program models

A fundamental problem today is that student numbers are declining, especially in the technical fields. At the same time, the number of people in employment is predicted to decrease over the next 10 years. This is leading to a shortage of skilled workers, which requires more flexibility from study program models (Anger et al., 2024; Vogler-Ludwig and Düll, 2013).

At the same time, the number of students at German private universities has increased. One of the reasons for this can be found in the practical and student orientation: Private universities often offer closer supervision and smaller group sizes, and there is also a strong focus on labor market relevance (Engelke et al., 2017).

During COVID-19, there was a massive focus on online learning. This has several advantages: It can be implemented at home, is not tied to one location and study material can be accessed at any time (Fatoni et al., 2020; Su and Guo, 2021). The online learning method has therefore proven to be beneficial for many learners, as it offers flexibility and convenience (Fatoni et al., 2020; Su and Guo, 2021). However, care should also be taken to encourage interaction and, where possible, to schedule face-to-face sessions for the exercises (Fatoni et al., 2020).

Another study shows that system quality, course design, learner-learner interaction, learner-content interaction and self-discipline are key motivators for learning outcomes and satisfaction in this context. However, the success of online learning does not depend solely on technology and course design, but also on student self-discipline and responsibility, especially when many face-to-face courses are converted to online courses in a short period. System administrators or institutions should consider providing comprehensive, convenient, and timely system or service support for student interaction that is conducive to maintaining an optimistic learning experience (Su and Guo, 2021).

The results of another study show that course design, the quality of the teacher, rapid feedback and student expectations are relevant for performance and satisfaction in online courses. Above all, the teacher is important, whose enthusiasm results in better quality online learning. The content of the course should be designed to be effective and easy for students to understand. Online teachers should develop authentic teaching materials that actively engage learners and motivate them to perform as required. Feedback should also be sought for future courses (Gopal et al., 2021).

3.3 Research on sustainability related study programs

Various articles have taken sustainability education in higher education institutes (HEI) in focus. Publications on project-based or active learning in combination with education for sustainable development (ESD) and study programs with a focus on sustainability exist (Kalamas Hedden et al., 2017; Serhan and Yannou-Lebris, 2021). Some thereby focused on the assessment of such problem- and project-based learning activities (Kricsfalusy et al., 2018). Similarly, service learning for SDG learning has been studied and found that by applying this teaching approach, empathy can be trained and the self-perception of students improved. Yet, such approaches can also require a lot of time, which is not necessarily always available (Samino García, 2023).

In general, there a quite some publications on developing suitable teaching methodology and with a focus on competencies

or skills (e.g., Novy et al., 2021). For example, one paper recommends flipped classroom for sustainability and circular economy learning (Rodríguez-Chueca et al., 2020). Others suggest balancing support and student independence (Birdman et al., 2022) and applying a whole person learning for responsible management and leadership (Cripps and Smith, 2024). Additionally, it was also reported on transdisciplinary skills being fostered through project-based learning (Barth et al., 2014). One study found missing social competencies in engineering studies (Winkens and Leicht-Scholten, 2022) and another reports on competencies for sustainability fostered via PBL, for example collaboration, interdisciplinarity and systemic thinking (d'Escoffier et al., 2024). Further, modularization of curricula is recommended, although not in direct relation to sustainability competence (Liu and Murphy, 2021). Finally, when switching to online learning, a study finds that it can result in less confidence and a need for interaction, since discussion and group work may be disrupted. Therefore, the role of educators is key to support students in such learning environments (by creating opportunities to share and discuss and supporting with building networks) (Mielmann, 2021).

In literature, there is also quite some focus on sustainable business educational programs (e.g., Lindvert, 2023) and on regional analysis of SDG or sustainability integration in HEIs (e.g., Aleixo et al., 2020). Yet, especially the development and implementation of study programs has received less attention. General success factors have partly been mentioned, like the commitment by high level strategy and from the management of departments, since there is sometimes more support needed in such study programs. Therefore, this also has an impact on the allocated time per student (Vemury et al., 2018). Program directors have been found to need additional support by their universities, for example through faculty training, teaching materials or sustainability incorporated in quality assessments (Leifler and Dahlin, 2020). Moreover, a regional match of programs is recommended (no one-fits-all approach) (Vermeulen et al., 2014) and it was suggested to consult possible employers early in the process. One study also stressed that there is still subject-specific specialization needed and that the dynamic demand for competencies has to be considered (Bagoly-Simó et al., 2018). Key competencies for sustainability are still not necessarily seen as essential skills for the professional world by HEIs. Complex skills as needed for sustainable approaches take also more time to be trained, so these are often not integrated. Moreover, it has been found that the awareness and knowledge about these competencies should be raised among professors (Matesanz et al., 2023).

4 Results

4.1 Perception of the relevance of project-based learning for future and sustainability skills in a rather rural context

Figure 1 presents data from our survey, examining interest in a hybrid and flexible project-based study program on sustainability. It shows that the majority of participants showed interest in the presented study model.

FIGURE 1
Own interest in study program.

FIGURE 2
General interest in study program.
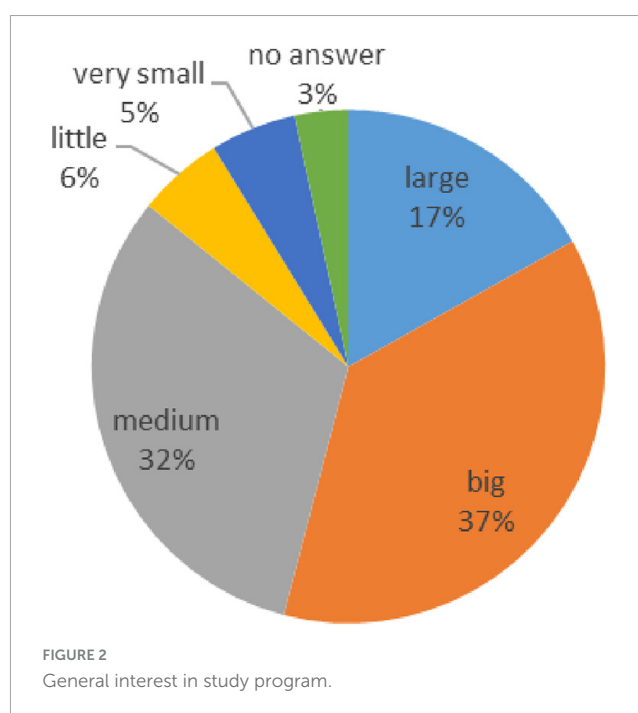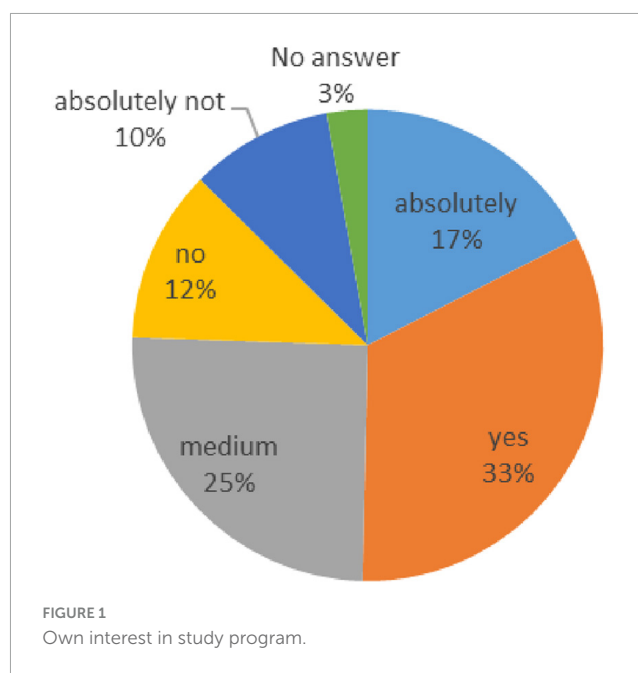
In the additional comments, some explain that they do not see themselves as the target group, others appreciate at least parts of the concept, for example the project work, collaboration with businesses, flexibility to study next to their work and the sustainable aspect of it. Others have difficulty with the concept, for example have concerns regarding the development of a project idea or to keep up motivation. Moreover, some missed the pre-defined content and specialization.

Judging the interest of the general public, the results were similar, with a big share suggesting that there is a large to medium interest in the program, as shown in Figure 2.

FIGURE 3
Interest by employers.

FIGURE 4
Time preferences.
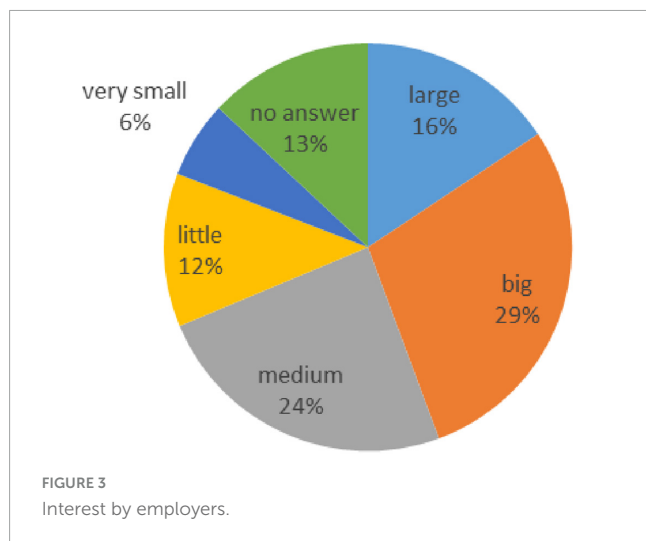
The additional comments show that participants partly see a growing interest in businesses, among young people and sometimes in politics. At the same time, some argue that it is still only applicable for a limited number of people and businesses or that positions are filled with persons from other areas/without a master's degree.

We also let the survey participants evaluate which factors of the study concept are appealing to them. Among the Bachelor and Master students at ASU, the study concept was the most appealing factor (project-orientation and flexibility), followed by sustainability and studying at ASU. Among Alumni and external participants, the close connections to businesses, a flexible study program and many options was most often evaluated positively. This was followed by project-orientation and sustainability. Interdisciplinarity was seen as less important for the participants, next to studying at ASU.

Regarding the interest of their employers in such a study program (if applicable), most participants judged it either with big or medium, as shown in Figure 3.

In the comments, participants refer to the external pressure businesses experience regarding sustainable development. Moreover, some mention the opportunity for businesses to work with students as affordable labor and to possibly continue employing them after their studies. Other priorities or little capacities in their companies were stated, for example, when referring to a rather small business. Others see it critically in the sense that some businesses tend to do greenwashing campaigns and do not want to take necessary steps to change. These participants stress the need to work on truly sustainable solutions.

In this context, we also examined the qualification options for sustainability topics at their employers and whether they are interested in such options. Most survey participants expressed strong interest, but saw little possibilities, followed by either much interest and many opportunities or the opposite: little interest and little opportunities.

Finally, we asked in how far participants can imagine choosing for the study, ideally with their current employer. Here, most were not sure, followed by the answer no. Only 12% decided here for a clear yes. Some commented, arguing that they are already studying,
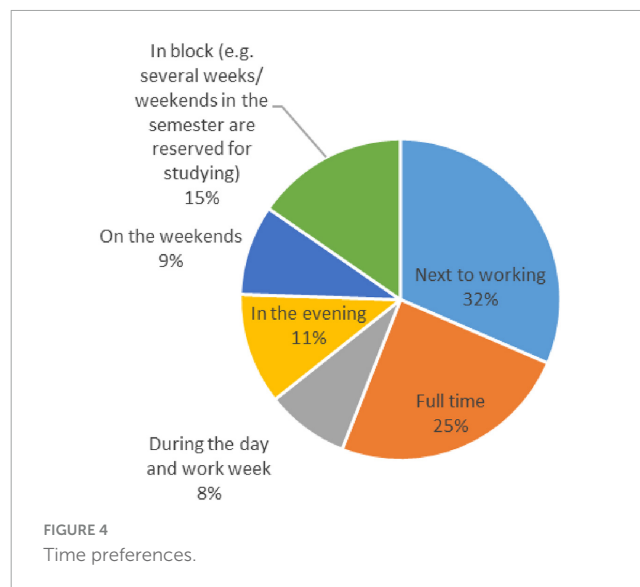
finished their studies or are at least currently not interested in a Master program. Some also explained that they prefer a different focus than sustainability. Others explained their answer with the fact that they have currently no employer. Interestingly, one also mentioned the costs, although this is a state-funded study program not involving additional costs next to the usual fees.

In additional qualitative interviews with business stakeholders prior to the start of the study, the concept of the study program was rated positive and highly relevant.

4.2 Time and location preferences identified for a successful and suitable study program

Figure 4 shows that most participants prefer to study next to working or full time when asked for the preferences regarding the time. As also shown in the graph below, around 15% can imagine studying in block, 11% in the evening and 9% on the weekends.

Regarding the place and setup of study, alumni from the Albstadt-Sigmaringen University chose most often for the possibility to study in Sigmaringen or Albstadt. Their second choice was the option to study with online courses and meetings during the week at the campus. On third place, alumni chose the option to study in another, bigger city.

In contrast, among the external study participants, studying completely via digital media received the most votes, followed by the option to study in a bigger city or with mainly online courses, accompanied by meetings during the week and on weekends.

In total, opinions are quite diverse, with some preferring a study in place in Sigmaringen/Albstadt or in another, bigger city. As also shown in Figure 5, others rather choose for online courses with either meetings/attendance weeks or weekends or completely online.

Finally, we wanted to analyze how students perceive the option of a study program that would be available by digital media, therefore enabling a flexible and mobile study setup ("University at
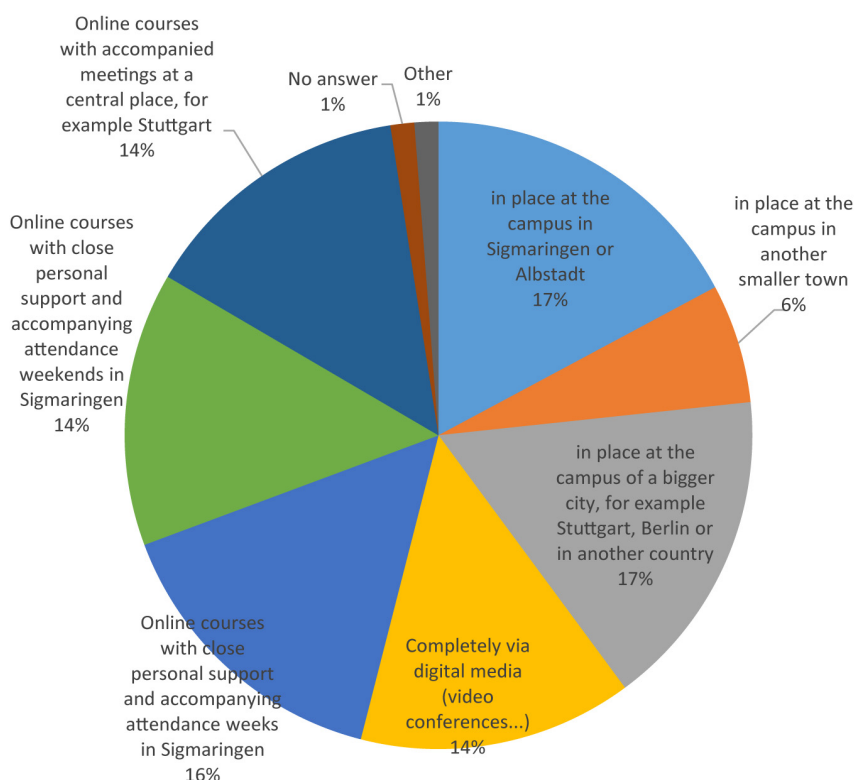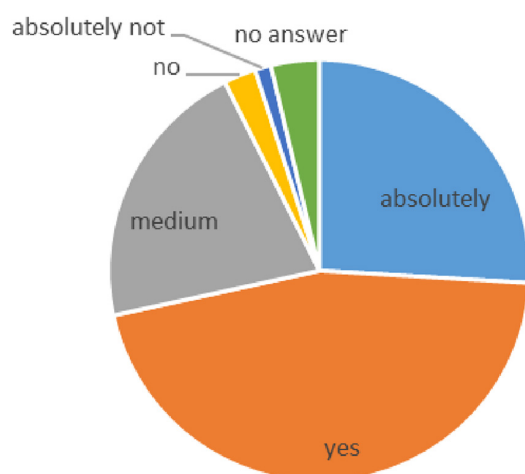
FIGURE 5
Place and setup of study.

FIGURE 6
Mobile and flexible study setup.

your Fingertips"), accompanied by in-person meetings. Over 70% support such a study approach (see Figure 6).

In comments, several mentioned relevant preconditions in such a study context: Regular exchange and incentives to study independently, especially to safeguard student life and connections. Moreover, high quality of the material (still providing sufficient and in-depth content) and early planning of the meetings were mentioned. Additionally, structure and duties were seen as relevant,

also accessibility, guidance and simplicity. A few mentioned their preference for study models in place and face-to-face, at least to some extent.

4.3 Setting up a new study program on sustainability studies—process insights

Between 2021 and 2023, under the influence of the COVID-19 pandemic, ASU developed its Structural and Development Plan 2023, which outlines the institution's strategic priorities through 2027. While the development of the plan was responsibly led by the university's Rectorate, the plan was collaboratively created and discussed across all relevant academic bodies—most notably the University Senate—and incorporated stakeholder perspectives through multiple rounds of internal dialogue. It was formally approved by the Ministry of Education of Baden-Württemberg in 2023.

Among its strategic goals, the Development Plan explicitly committed the university to designing a new interdisciplinary study program with a strong emphasis on future-oriented skills and topics. This commitment marked the formal launch of the program development process. The decision to initiate such a program was also shaped by the broader context of global uncertainty, including the disruptive effects of the COVID-19 pandemic and the geopolitical instability triggered by the Russian—Ukrainian war. These developments amplified existing questions about what forms of education and competencies would be most relevant and resilient

in an increasingly volatile, uncertain, complex, and ambiguous (VUCA) world (Bennett and Lemoine, 2014). The new program was thus conceived not only as a response to institutional goals but also as an attempt to provide students with the capabilities needed to navigate and contribute meaningfully within such dynamic and unpredictable environments.

One of the authors, CM, held formal responsibility for the development of the new study program. Throughout the development phase—and informed by insights from preliminary consultations and stakeholder dialogues—the continuous monitoring of the following three key aspects proved to be particularly critical and significantly influenced and shaped the evolving structure of the program:

1) Integration of stakeholder feedback: Insights from interviews and surveys with key stakeholders—including local businesses, industry representatives, students, and prospective students—were continuously integrated. Shared digital documents served as dynamic workspaces where data were fed in regularly and used to iteratively refine learning objectives, curriculum design, and program structure.

2) Transparent communication and governance, incorporation of feedback: Beyond informally talking with members of the university and incorporating their feedback as well as feedback from interviews and questionnaires, given the interdisciplinary ambition of the program and its aspiration to involve all university faculties, progress reports were regularly presented to institutional governance bodies. These included the Rectorate, Faculty Committees, the University Senate, and the University Council. In total, over 20 official reports were delivered in committee sessions, and feedback from these committees was gathered and incorporated. Open communication also extended to the broader university community, contributing significantly to institutional support for the program.

3) Accreditation and internal quality assurance: Alongside internal reporting, the development process was closely aligned with the university's quality assurance procedures and national accreditation standards. This involved meticulous preparation of documentation related to curriculum structure, ECTS credit allocation, and workload estimation, following the formal criteria of the German Accreditation Council (Stiftung Akkreditierungsrat, 2024).

This structured and participatory development process laid the foundation for a robust and broadly supported academic program that reflects both institutional strategy and stakeholder expectations. Sustaining the program's success in the long term continues to rely on a relatively complex and resource-intensive coordination effort across faculty lines.

4.4 First evaluations of the new study program with focus on the underlying teaching concepts

To get an initial insight into how the designed study program was perceived, we performed a first evaluation of lectures in the middle of the first semester. Overall, the teaching concept was evaluated positively. Students saw the content taught as the right amount and at the right level, while a few students also experienced a rather high workload.

The wide range of various relevant sustainability topics covered was seen positively, just as the weekly exchanges regarding the teaching materials. This helped students to stay connected with the content, the lecturers and their fellow students. Also, the flexibility offered within the study program was appreciated, next to the mixture of lectures and self-study. The mandatory subjects paid attention to teaching scientific working and writing, something which was also honored. Support as well as competency by the teachers and exciting topics were other positive points mentioned. Moreover, the group size was described as ideal, and the relation to the project work mainly following in the second semester was seen as valuable.

Interaction and discussion were seen as an important component, and the challenge to cover a broad content and at the same time in depth was pointed out. Moreover, it was stressed that plannability is of extra relevance for the ones already (partly) working, which can sometimes be a challenge with relocated lessons. While many were offered online, some lecturers do not provide lecture recordings. Moreover, the bridge of the core study subjects and electives can be seen as a challenge, since these were often integrated in and related to their own study programs. The same was partly noticeable due to the differing background of the Master students- while this was seen as interesting, it can also feel distant from one's own topic and (research) questions.

The official evaluation of courses at the end of the first semester provided us with additional, interesting insights regarding the mandatory subjects taking place in the first semester (anonymous Likert scale survey with additional open questions). Students evaluated mandatory modules with a final grade between 1.3 and 1.9 on a Likert scale between 1 and 5, with 1 being the best possible result. Each individual question concerning individual aspects of the modules reached a ranking between 1 and 2 on average on a Likert scale with 1 being the best possible result (see also Supplementary material). Interestingly, the students were more critical about the deepening lecture part (mostly delivered in the form of speech-like lectures) than the interactive, online flipped classroom seminar. The seminar introduced them to sustainability and relevant concepts as well as methods, and they especially appreciated to work through the exercises beforehand. For this, a discussion forum from Microsoft was used, which was evaluated positively as well.

> *"Engage was new to me, but it worked great."*

> *"The active self-processing of the tasks for discussion the following week and the resulting independent deepening and acquisition of the material."*

The open discussion rounds, using a whiteboard to work together during discussions, was also received well:

> *"I found the interactive collaboration with the other students through the whiteboards and sessions very good."*

> *"It was a relaxed atmosphere, in which one can always share his or her opinion."*

Room for improvement for this interactive session was mentioned as well. Some were demanding for more or different content during lectures, for example regarding legal requirements or working more in smaller groups and with small presentations, so everyone is actively contributing.

> *"Maybe add new tasks from the topics from Engage to the discussion group, as I also read through the contributions of the others and dealt with the topic on my own, so that the topic in the lecture sometimes became a bit 'tough'."*

In general, for the students relevant topics coming up were the provision of structure, the availability of the lecturers and organizers of the program, exchange with peers accompanied with a respectful atmosphere.

For example, especially for the part with the deepening lectures, students asked for a better interrelation of topics:

> *"It would be helpful if the lectures were organized according to general topics."*

Yet, others also appreciated the variety of topics:

> *"The practical relevance of the individual topics through the specialist lectures on Tuesday. The variety of topics. I particularly liked the fact that you could gain so many different insights into topics that were initially unfamiliar to you and that the professors conveyed their passion for their subject area in an inspiring way."*

Moreover, relating the lecture material to one's own work was valued. Finally, the exchange at place was considered important for the formation of a community, and this is also reflected in the quote of a student from one of the evaluations:

> *"The Onboarding in presence in the beginning I found to be very good and helpful for us as a group. With this, a good basis for further digital collaboration was created."*

5 Discussion

Our findings clearly show that also in a predominantly rural and industrial-dominated region in Germany, future-oriented education on sustainability issues is demanded by both, potential students and employers. Our survey results confirmed earlier findings that most see relevance of such study programs for their employers or other industry partners (Risius et al., 2023). This also fits the results we gathered in qualitative interviews with businesses prior to this study. Yet, possible shortcomings were also mentioned, such as a lack in capacity or other priorities preventing to approach this topic, fitting the findings of Leusmann and Nölting (2015). This again suits our approach to facilitate student projects, while at the same time allowing for an integration into the day-to-day business. Our findings are also of relevance for other rural and industrial regions considering better integrating sustainability competencies in their study programs. By doing so, for example also social competencies can be strengthened in engineering studies (Winkens and Leicht-Scholten, 2022). We agree that a regional match of programs is required and that an early consultation of possible employers in the region is a prerequisite (Bagoly-Simó et al., 2018; Vermeulen et al., 2014).

Yet, the conditions perceived as important by potential and actual students for a study program working with project-based learning for sustainable development and a flexible curriculum are manyfold. These should be considered when designing and implementing such a study concept. While survey participants in general valued flexibility, it is especially interesting that they at the same time stressed the importance of connection, availability and certain guidance as well as high quality of material. This fits the literature findings (Fatoni et al., 2020; Gopal et al., 2021; Su and Guo, 2021) and was also one of the results when asking the enrolled students to evaluate the first weeks and first semester of their study. We have therefore established an online campus with asynchronous interaction possibilities through forums, as well as regular video conferences. Interaction, discussion and interconnection of topics was seen as highly relevant for the students, and this approach was rated highly positive, next to flexibility in time and place. This shall also prevent that students miss interaction and lose confidence, but can continue discussions and group work instead (Mielmann, 2021).

This study has also demonstrated the associated requirements for such a program: considerable time is needed to coordinate and organize the program, as well as to meet the expectation of interactive and suitable teaching approaches, such as online interaction formats (see e.g., also Carruana Martín et al., 2023). This can so far not completely avoid conflicting interests, for example due to differing prior knowledge and different preferred study modes, which will require further evaluation in follow-up studies. In addition, the desire for flexibility in selecting individual learning paths and the freedom to choose personalized areas of specialization often conflicts with the simultaneous need for a clearly structured academic progression. Addressing this inherent tension requires extensive explanation to the students, which we provide through our dedicated onboarding module. Furthermore, it necessitates continuous guidance and support throughout the students' academic journey.

The literature research and survey results presented in this study informed the conceptualization and realization of the Master program introduced in this study. Moreover, the results of exchanges with businesses of the area were considered. This, in the end, has led to a Master program with a high flexibility offered for students and accompanying new teaching approaches at ASU. Based on our experience, we can recommend the partial modularization with input from other faculties of such a program (Liu and Murphy, 2021). Moreover, this study has clearly demonstrated the

importance of high level management commitment (Vemury et al., 2018). One has to be aware that the development and implementation takes effort and time. We have no evaluation of the project semester yet, but expect that time needs to be allocated by the supervisors to support the students. This would be in line with the finding that complex skills take also more time to be trained (Matesanz et al., 2023).

This study is limited in the number of respondents, which can be partly explained by the comparatively small target group, also since this program was established and evaluated at a smaller HEI with a partly rural catchment area which comes with a lower population density. While this study does not contain the results from direct business consultations, we intend to follow up on this in the context of the new Master program, also to keep updated about changing demands. Moreover, it will be interesting to observe the projects of the students and report relevant findings later on, also since organizing such projects with several faculties is new at our university. No sharable information and results were yet available when writing this article, since the completion of projects mainly takes place in the second semester.

6 Conclusion

In this study, we present the development and evaluation of an innovative interdisciplinary, project-based study program with a flexible hybrid learning approach. The literature review conducted beforehand clearly demonstrated the need for sustainability competencies and at the same time a shift toward more flexible and interdisciplinary programs. A survey among students at and alumni of ASU and beyond has clearly shown considerable interest in a study program combining these aspects. It can be concluded that such a flexible study concept requires a structured and self-disciplined approach to studying and can therefore not be recommended for all students. Most respondents appreciated the design and saw in general a high demand for such a Master program. This is relevant, especially looking at the profile of ASU and the region's socio-economic characteristics and future challenges. Another interesting finding is the diversity in needs and preferences regarding time and place of study. Some students prefer working next to their studies, while others rather see themselves studying on campus or online with regular meeting sessions. Flexibility, however, was in general rated positive, for example when presenting the option to partly use mobile phones for studying. To satisfy student needs, we especially found interactive online formats and exchange possibilities, partly also on campus, relevant success factors. Next to that, the provision of structure and a good availability of lecturers and study organizers are key.

The successful development of the program in a public university in Germany required not only strong support from high-level university management, but also the continuous involvement of relevant governance bodies and close collaboration with academic colleagues. Regular communication, systematic feedback loops, and ongoing reflection within institutional committees proved essential. Importantly, these discussions were consistently informed by empirical data, particularly stakeholder surveys, ensuring that decisions were evidence-based and responsive to the needs of future students and partners.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

This study was conducted at Albstadt-Sigmaringen University (ASU) and involved a voluntary online survey among adult (aged 18 years or older) participants. Prior to participation, all participants were fully informed about the purpose, content, and voluntary nature of the study. Informed consent was obtained digitally before the commencement of the survey. Participants were also informed that their responses would be processed anonymously and that they could withdraw from the study at any time without any consequences. No personally identifiable or sensitive data were collected. All responses were recorded and analyzed in anonymized form. No ethics committee review was required, as this type of non-interventional, anonymized educational research is exempt from formal review under the university's internal guidelines and applicable national regulations (e.g., GDPR). The study adhered to the general ethical principles of academic integrity, voluntariness, transparency, and data protection.

Author contributions

CT-R: Conceptualization, Data curation, Formal Analysis, Methodology, Visualization, Writing – original draft, Writing – review and editing. CM: Conceptualization, Methodology, Supervision, Validation, Writing – original draft, Writing – review and editing.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The authors declare that no Generative AI was used in the creation of this manuscript.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2025. 1568233/full#supplementary-material

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