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Sustainability competence mindset: building capacity with students

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Abstract

Purpose – While universities increasingly integrate sustainability content into curricula, guidance on how to teach sustainability remains limited. The purpose of this study is to introduce the Sustainability Competence Mindset Map (SCMM), a formative questionnaire designed to assess key sustainability competencies (KSCs) and enhance both teaching and learning experiences. This study also provides the first empirical test of the KSC framework within a business school context, supporting transitions towards sustainable futures.

Design/methodology/approach – Students from eight courses across four academic levels participated over one year. This study conducted validity and reliability tests, along with a structural equation model for confirmatory factor analysis. Teachers also shared reflections on using the SCMM tool in their courses.

Findings – The SCMM demonstrated strong validity and reliability, and confirmatory factor analysis results supported the KSC framework. Teachers reported that the tool helped apply sustainability concepts practically and facilitated communication with students. It can be integrated with various course activities and supports a shared language around sustainability.

Originality/value – This study contributes to theory and practice by offering a validated tool to facilitate sustainability competence capacity building. This study supports the KSC framework and competency-based education and enables tailored teaching strategies that improve student engagement and learning outcomes. The SCMM also fosters staff development, peer learning and provides measurable data for institutional monitoring, policy development and accreditation aligned with global goals, such as the UN SDG 4.7. By institutionalising its use, universities can ensure consistent and impactful integration of sustainability education across disciplines.

Keywords Sustainability competence, Mindset, Formative assessment, Higher education

Paper type Research paper

1. Introduction

The United Nations' Agenda 2030 and the Sustainable Development Goals (SDGs) have raised awareness about the importance of education for sustainable development, emphasised in SDG 4 (Opoku *et al.*, 2024). Higher education institutions have integrated sustainability into their policies, curricula and community engagement activities. Despite these efforts, educators face challenges in advancing student sustainability competencies in the classroom (McMillan and Overall, 2016; Berg and Lyngstadås, 2023). Building capacity for sustainability competence is essential for sustainable futures (Wiek *et al.*, 2011; Brundiers *et al.*, 2021; Redman and Wiek, 2021). The UNESCO report (2017) recognises



that building capacity in the key sustainability competencies (KSCs) can help to achieve the SDGs.

More specifically, SDG 4, target 4.7, asks educators to ensure that all learners acquire the knowledge and skills needed to promote sustainable development through education for sustainable development and global citizenship. To address this, a validation study of the Sustainability Competence Mindset Map (SCMM) tool is presented, designed to support teachers and students in developing sustainability competencies and enhancing the learning experience. The SCMM tool integrates sustainability into educational practices, facilitating practical application in the classroom and contributing to SDG 4 indicator, to measure the extent to which sustainability education is integrated into curricula and student assessment.

This study investigates the effectiveness of a formative assessment tool measuring student perceptions of sustainability competencies (Brundiery *et al.*, 2021; Redman and Wiek, 2021; Wiek *et al.*, 2011). Education is crucial in nurturing student competencies for sustainability (Gray and Collison, 2002; Dyball and Thomson, 2013; Botes *et al.*, 2014). Despite lecturers' commitment to preparing future leaders for global sustainability challenges (Gray, 2010; Khan, 2013; Joseph and Trubey, 2022; Tran and Herzig, 2023), student competency in sustainability needs more attention.

Educators aim to offer cohesive learning experiences rather than isolated sustainability-themed lectures (Wals, 2014). Many lecturers start by teaching about sustainability (De Silva and Nilipour, 2024), but there is a lack of focus on competencies that cultivate a sustainability mindset. This study addresses this gap by validating a formative assessment tool that measures student perceptions of sustainability competencies and their ability for integrated problem-solving.

The sustainability competency literature (Brundiery *et al.*, 2021; Redman and Wiek, 2021) suggests several KSCs that build capacity for a sustainability mindset. The SCMM tool is designed to integrate these KSCs. The tool was rigorously tested with business school students using statistical tests for internal and convergent validity, as well as internal consistency measures like Cronbach's alpha and composite reliability (CR) tests.

Evidence indicates that the SCMM tool provides educators with valid and reliable insights into students' sustainability competency mindset. Additionally, a second-order structural equation model confirmatory factor analysis (CFA) tested how well the KSC determines integrated problem-solving competency, showing strong statistical evidence supporting the KSC framework. Teacher feedback revealed that the tool can map students' mindsets over courses, semesters and programmes.

While the tool is currently in English and can be used internationally, it can also be translated into Swedish, as tested in this study. This indicates its applicability at universities worldwide. Teachers report that the tool helps communicate sustainability concepts and facilitates dialogue with students, enhancing the learning experience.

The evidence contributes to the literature on sustainability competencies by testing the eight KSCs suggested as vital in higher education (Brundiery *et al.*, 2021; Redman and Wiek, 2021; Bianchi *et al.*, 2022) within a business school programme. Scales for intrapersonal and implementation competencies are designed by the author based on literature (Redman and Wiek, 2021) and incorporate scales from previous studies (Savage *et al.*, 2015; Meza Rios *et al.*, 2018). With a statistically tested, valid and reliable tool, this study provides educators with the SCMM tool to advance sustainability education objectives throughout their curriculum. This tool enriches lesson plans tailored towards sustainability education in business programmes. Collaboratively using this tool across instructor groups can integrate sustainability into the curriculum through a learning progression approach.

Moreover, this tool complements existing assessment methods (Redman *et al.*, 2021) that measure students' sustainability knowledge and other skills vital for sustainability transformations. Teachers find they can apply the KSC tool with qualitative adaptations, such as communication, rubric assessments and reflective work. By leveraging the SCMM tool, educators can better understand and improve student competencies in sustainability, contributing to broader SDGs.

2. Literature review: sustainability competence as a mindset

2.1 The key sustainability competencies

UNESCO (2017) identified KSCs as crucial for achieving the UN's sustainable development goals, based on prior literature (Barth *et al.*, 2007; Wiek *et al.*, 2011; Rieckmann, 2012). Since the report, new frameworks outlining eight KSCs have been developed (Bianchi *et al.*, 2022; Brundiers *et al.*, 2021; Redman and Wiek, 2021), where seven of these KSCs are said to build capacity of the eighth competency, integrated problem solving in sustainability challenges. The eight KSCs have been named as systems, strategic, values, futures, interpersonal, intrapersonal and implementation thinking competencies that can build the capacity for an integrated problem-solving competency for sustainability challenges. These KSC frameworks have been derived from the dialogue in research about transformational learning theory (Mezirow, 2000). The language describing each KSC varies, leading to ongoing discussions about their meanings.

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These KSCs have also been found relevant in business education (Brundiers *et al.*, 2021), as business students must be equipped to tackle interconnected global issues such as climate change, resource scarcity and social inequality, and integrate sustainability into decision-making. Sustainability competencies enable students to understand and manage these complexities in a business context. Business graduates with sustainability competence are better prepared to lead and manage change towards more sustainable practices within organisations, industries and communities (Sidiropoulos, 2014).

Redman and Wiek (2021) conducted a thorough systematic review of the literature, synthesising the language used to describe the competencies and illustrating how these competencies can overlap in meaning. They define systems thinking as the ability to analyse local and global systems across environmental, social and economic domains. While students already analyse systems at multiple scales, incorporating sustainability adds complexity, requiring knowledge application across societal, economic and environmental domains. Systems thinking methods addressing sustainability's "wicked problems" have proven useful with engineering students (Lönngren and Svanström, 2016). It can be beneficial for teachers to adapt approaches and to learn from other disciplines. Tools such as the circular economy and life cycle analysis are integrated into business education (Del Vecchio *et al.*, 2021), but much support is needed to help develop students' competence in the complexities of systems thinking.

Strategic thinking involves constructing viable strategies for transformations towards sustainability, while future thinking entails anticipating future states and dynamics of sustainability problems (Redman and Wiek, 2021). These competencies are commonly taught in business courses, where data analysis and strategy formulation are key to business work (Nik Abdullah *et al.*, 2022). Incorporating sustainability requires students to apply diverse knowledge, gather information from various sources and measure impacts in

complex ways. New educational requirements for accounting students, driven by global changes and the EU directive CSRD, emphasise diverse competencies (FAR, 2024). Teachers need to transition, providing opportunities for students to embrace diverse resources and knowledge, transforming traditional education into a sustainability-focused approach.

Values thinking is having the mindset to identify and apply sustainability values (Redman and Wiek, 2021). Traditionally, business education has focused on shareholder value and agency theory (Sheehan *et al.*, 2024). Nurturing sustainability values in education has been controversial, as it is often viewed as a political agenda that should not be applied in educational settings (Hess and Maki, 2019; Annelin and Boström, 2024a). This can be addressed by developing critical thinking skills (Bérubé and Gendron, 2022) and providing an opportunity to consider different values (Sidiropoulos, 2014). Students need to be critical thinkers about all values, even when not necessarily aligning with sustainability values.

Interpersonal thinking involves collaborating successfully in diverse stakeholder teams to address sustainability challenges (Redman and Wiek, 2021). Collaboration is already part of business work, and teaching teamwork is crucial (Daff, 2013). However, sustainability requires engaging a broader range of stakeholders to measure business impacts. Daff (2013) notes that students may experience anxiety about oral communication, making interpersonal skills training essential. Interdisciplinary and transdisciplinary courses (Scholz and Steiner, 2015) provide a safe space for practicing these skills. Additionally, cooperative learning [1] is documented as an effective tool for enhancing students' interpersonal thinking skills (Mcvay *et al.*, 2008; Ballantine and McCourt Larres, 2009).

Implementation thinking involves the mindset to effectively put sustainability strategies into action (Redman and Wiek, 2021). Applying and controlling strategies is a significant part of business roles (Carvalho and Almeida, 2022). As businesses transition to using rapidly developing technologies, students will be expected to perform more functions with these technologies (Daff, 2021). However, there is little discussion about how these technologies will help professionals or students better act on their sustainability activities, but innovative modes may emerge from these technologies. Therefore, it is vital that universities stay informed about current and emerging technologies and provide internships for experiential learning in implementation thinking (Beard, 2007). Developing sustainability programmes that can support local projects and initiatives can build student capacity in implementation competence.

Intrapersonal thinking involves advancing sustainability transformations through personal resilience and self-awareness (Redman and Wiek, 2021). While business students should be aware of the profession's need for personal resilience and self-awareness (Dolce *et al.*, 2020), much more can be achieved through intrapersonal development in higher education. Self-reflection is not often incorporated into business course tasks or projects, yet developing compassion in business is vital (Powell and McGuigan, 2024). Training students through reflective work, journaling and engaging workshops are some examples that universities can apply in the classroom.

Altogether, the seven KSCs described above are essential and building capacity in all areas is crucial to attain the integrated problem-solving competency for a sustainability mindset (Bianchi *et al.*, 2022; Brundiens *et al.*, 2021; Redman and Wiek, 2021). Integrated problem-solving competency involves applying collective problem-solving procedures to sustainability challenges (Redman and Wiek, 2021). This suggests that with encouragement from higher education facilitation, students can more easily transform towards a sustainability mindset. However, applying all competencies to provide integrated problem-solving for sustainability challenges can be complex and may be met with resistance.

[Redman and Wiek \(2021\)](#) model of sustainability competencies demonstrates how the KSCs function alongside the disciplinary and professional competencies already taught in higher education, highlighting the implementation competency as crucial for building capacity with a sustainability mindset. Additionally, [Brundiers et al. \(2021\)](#) and [Bianchi et al. \(2022\)](#) present the same eight KSCs but offer an alternative model that emphasises the importance of intrapersonal and implementation competencies as main drivers of mindset transformations. This work suggests that teachers in higher education need to adopt a holistic approach to education, nurturing both inner competencies and practical abilities and skills.

While many teachers in higher education may feel that they include practical application of knowledge to create opportunities for learning by doing ([Dewey, 1963](#); [Öhman and Sund, 2021](#)), teaching sustainability competence can be more challenging in some disciplines. [Powell and McGuigan \(2024\)](#) suggest that cultivating compassion in students is integral to fostering an understanding of the broader role of business in society and addressing sustainability challenges. Thus, it is expected that each KSC will be equally influential on the students' capacity building for integrated problem-solving competence for a sustainable future.

2.2 Formative assessments

The pedagogical approaches teachers have applied to teach sustainability ([Lozano et al., 2017](#); [Backman et al., 2019](#); [Birdman et al., 2020](#)) can influence the success of classroom activities aimed at fostering engagement with sustainability and cultivating a positive mindset ([Shephard, 2008](#)). Teachers have called for knowledge about students' sustainability competencies before class to plan classroom activities for sustainability education more effectively ([Annelin and Boström, 2024a](#)). Various quantitative and qualitative assessments have been used to measure student competencies for sustainability ([Redman et al., 2021](#)), but none have included all eight KSCs.

[Redman et al. \(2021\)](#) highlight the strengths and weaknesses of different assessment tools used to understand student learning in the context of sustainability competence capacity building. While qualitative assessments provide a deeper understanding and richer learning experience compared to quantitative assessments, quantitative assessments offer quick, easily analysable information and can be applied to different class sizes. Problems with qualitative assessments include the need for sincerity from students, time consumption and interpretation of input. On the other hand, quantitative assessments often require reliable and valid scale items designed for students to accurately rate their understanding of the scale statements.

Questionnaire surveys have proven beneficial in business classes, as they can efficiently reach larger samples and yield actionable results ([Redman et al., 2021](#)). However, the sustainability competencies have not been robustly tested. The most frequently used quantitative assessment tool by teachers and action researchers is the questionnaire survey, which provides evidence about student perceptions of their competence for sustainability through various perspectives of the sustainability competencies ([Lans et al., 2014](#); [Azeiteiro et al., 2015](#); [Savage et al., 2015](#); [Ateskan and Lane, 2018](#); [Meza Rios et al., 2018](#); [Molderez and Fonseca, 2018](#); [Ploum et al., 2018](#); [Cabral and Lochan Dhar, 2019](#)).

[Andrade \(2019\)](#) points out that the self-assessment questionnaire tool is effective in the formative assessment process. Additionally, as students can reflect on sustainability, they could develop reflective intrapersonal competency for sustainability ([Galt et al., 2013](#)). Thus, an SCMM questionnaire tool ([Annelin and Boström, 2024b](#)) can enhance the student learning experience and support teachers in planning activities for their current classes.

As discussed above, questionnaire surveys have been criticised (Holdsworth *et al.*, 2018; Cebrián *et al.*, 2019) for not providing information about the learning process and assuming participants understand the language and can provide accurate perceptions. Improving the language by using simple terms and avoiding convoluted statements can help address these issues. Moreover, formative self-evaluation can provide valuable insights from the students' perspective (Andrade, 2019; Cebrián *et al.*, 2019), leading to a better understanding of student mindsets towards sustainability. Additionally, supplementing quantitative assessments with qualitative assessments throughout the course period can enhance the overall evaluation process.

There is also support for questionnaire tools (Hair *et al.*, 2020; Redman *et al.*, 2021) when statistical tests and concrete use of the questionnaire are applied. Meza Rios *et al.* (2018) tested the previous KSC framework (Wiek *et al.*, 2011) with a scale designed for leadership programmes and found valid and reliable results. Despite extensive efforts to understand student sustainability competencies, little is known about students' perceptions of their KSC mindset to achieve capacity for integrated problem-solving competency for sustainability. Furthermore, little is known about students' perceptions of their KSC mindset with the updated frameworks (Bianchi *et al.*, 2022; Brundiars *et al.*, 2021; Redman and Wiek, 2021). Hence, the research question is as follows:

RQ1. How well can students' perceptions of their key sustainability competencies determine their integrated problem-solving capacity building for sustainability?

3. Method.

The main data collection and analysis in this study was the design and validation of a questionnaire survey assessment tool. A questionnaire survey was determined as the best method to assess formative perceptions of the KSCs that can be provided efficiently, to help facilitate the teacher with support for lesson planning and communicate information with students during class time. In short, the SCMM tool was designed and tested for validity and reliability through statistical analysis (Hair *et al.*, 2019). Also, a second-order CFA (Schumacker and Lomax, 2010; Byrne, 2016) was conducted to analyse factor loadings of each KSC factor and statistically confirm that the KSC scales can measure integrated problem-solving competency for sustainability.

However, it is acknowledged that other forms of assessment can help a teacher's understanding of the students' learning experience (Redman *et al.*, 2021), which, together with the SCMM, can improve facilitation of sustainability education. Therefore, teachers also provided feedback after using the tool with their class, informing about its usability and suggesting possible improvements for the formative SCMM assessment with students. I discuss this information in the analysis as a form of triangulation and to provide a deeper understanding of the participants' experience when applying the SCMM tool.

3.1 Questionnaire design

The questionnaire was designed to capture the students' perception of the KSCs. In all, 36 pilot tests at three different universities across two countries in the Nordic region and 11 disciplines have been performed between 2020 and 2022, to understand the face validity of the questions on an interdisciplinary scale and how students respond to the statements. During pilot tests, researchers and practitioners in higher education reviewed the questionnaire for content validity and suggested that the items accurately reflect the constructs and cover relevant aspects of the KSC framework.

Feedback was given on the clarity of the wording, whether the questions are free from ambiguity or bias and the appropriateness of the language for students at university. The logical flow of questions was also commented on and the suitability of the background questions, as well as the Likert scales, and whether the length and format are manageable for student participants. Consequently, there have been two different designs of this questionnaire before the current version used in this study.

Changes were made to the statements to improve face validity and construct validity. The first set of questions provides background information about the participants to help control for demographic characteristics. The second set of questions includes the sustainability competence scales, which are taken from previously tested research to reduce context-induced bias (Savage *et al.*, 2015; Meza Rios *et al.*, 2018). However, the scale for intrapersonal thinking competence and implementation thinking competence is designed by the author, which considers the language used to describe the competencies (Redman and Wiek, 2021). You can read more about this in the next section: Section 3.2 variable measurements, and the questionnaire is presented in the appendix.

The student and teacher participants were provided with a short introduction to the project, assuring them of anonymity, voluntary participation and that data would only be used for research purposes. No information that could reveal the response identity was collected. Anonymity helps reduce desirability bias in participants' responses to the questionnaire. The design and ethical conduct of the study mean that an Internal Review Board investigation is not needed, as no sensitive information about the participants is collected, as defined in Sweden's Act (2003: 460).

3.2 Variable measurements

A comprehensive review of sustainability competence questionnaire assessment scales (Annelin and Boström, 2022) helped identify the KSC scales used in this study. In pilot tests, the systems, strategic, futures, values and interpersonal thinking scales, initially designed by Savage *et al.* (2015) and Meza Rios *et al.* (2018), were tested along with the well-tested NEP scale (Dunlap, 2008; Zhu and Lu, 2017) as a proxy for intrapersonal thinking. The scale for implementation thinking was designed by the author based on the language used in the Redman and Wiek (2021) review.

Following preliminary testing, concerns were raised regarding the statistical validity and reliability of the NEP scale. Efforts were subsequently made to enhance face validity by modifying the language and the number of items included in each scale. For example, the Savage *et al.* (2015) study used the item "See both the whole system and its parts, as well as the extent to which you can place yourself within the system" for systems thinking. As this item requires students to consider at least two aspects, it could cause confusion about how to answer. To address this, simpler language was used, and items were adapted to measure one concept at a time. This adaptation was guided by the Redman and Wiek (2021) review on sustainability competence and the literature cited therein. Finally, the intrapersonal and implementation thinking competency scales for sustainability are designed by the author, drawing inspiration from the discourse on sustainability competence outlined in Brundijs *et al.* (2021) paper and the definitions provided by Redman and Wiek (2021).

Participants were tasked with evaluating their agreement with a set of statements using a five-point Likert-type scale, ranging from strongly disagree to strongly agree. Each scale pertaining to sustainability competence consisted of three items per competency, beginning with the phrase "I feel competent to [...]". Examples of the items created by the author include, for intrapersonal thinking, "advance sustainability transformations through personal

resilience” and, for implementation thinking, “put sustainability strategies into action in effective ways”. The whole KSC scale consisted of 21 items ([Appendix](#)).

3.3 Data collection and sample

This research was carried out at a business school in a university in Sweden, as business students play an important role in the leadership and decision-making of future business, institutions and communities ([Brundiers et al., 2021](#); [Sidiropoulos, 2014](#)). Data for the pilot studies were collected at the onset of the Autumn term in 2020, with subsequent pilot tests administered each semester. Final data for this study were collected in the Autumn term of 2023 and the Spring term of 2024, from a possible population of about 4,000 students and a sample of 691 students and eight facilitating teachers.

The sample was first selected from the course at the beginning of the business administration programme, then from the first course in all other semesters, to provide teachers with formative information. Students finish the programme by conducting an independent thesis. Access to class participation was limited to lecturers willing to provide time during a lecture to administer the questionnaire. Each questionnaire was administered to one class per semester using an online survey tool. Students were presented with the questionnaire at the commencement of a lecture and allotted 10–15 min to complete. Before completing the questionnaire, students were offered a three-minute video introduction to familiarise themselves with the project. The questionnaire was available in both English and Swedish, ensuring accessibility for all participants, as both Swedish and international students study in the business programme. Response rates and sample size for each cohort are detailed in [Table 1](#).

Teachers provided feedback after each class through one-hour informal interviews, during which the researcher took notes. Each teacher had the option to decline the feedback session. All participating teachers chose to participate. The interview feedback data was used for triangulation purposes, helping to support the findings and assess the usability of the questionnaire tool in a practical teaching environment. The information provided was then analysed for commonalities and divergences between participants’ perspectives to better understand the experience of applying the questionnaire from a teacher’s perspective.

3.4 Data credibility tests and analysis

All data tests and analyses are conducted using Smart-PLS 4 software. The advice by [Hair et al. \(2019\)](#) research on tests for ordinal data to conduct validity and reliability tests was followed in this study for the KSC scales. Initially, indicator loadings were scrutinised for statistical significance (p -value = 0.001) and to ensure they exceeded 0.50, ideally reaching 0.78, while avoiding excessively high values. Subsequently, internal consistency was tested through reliability testing to gauge the extent to which items measure the intended construct. An acceptable outcome was determined by a Cronbach’s alpha exceeding 0.70 ([Cronbach, 1950](#)) or a CR value between 0.60 and 0.90 ([Hair et al., 2019](#)).

Convergent validity was then assessed by examining the average variance extracted value, which should surpass 0.50 ([Hair et al., 2019](#)). Discriminant validity was tested using the heterotrait-monotrait (HTMT) ratio, considered satisfactory when the value is not significantly different from 1 or is below 0.90 ([Hair et al., 2019](#)). Furthermore, the variance inflation factor was used to assess collinearity of the formative indicators, deemed acceptable at values above 1 and below 3 ([Hair et al., 2019](#)).

A second-order CFA ([Schumacker and Lomax, 2010](#); [Byrne, 2016](#)) is then conducted to test the KSC framework. As the framework suggests that an integrated problem-solving capacity building (as a higher-order latent variable) has a relation with its lower-order sub-

Table 1. Response rates

Module	Semester	2023	2024	N
International business and global challenges	1	75% (56/75)		56
Service marketing	2	52% (64/123)		64
Management accounting	3	61% (49/80)		49
Financial accounting	4	51% (83/163)		83
Auditing	5		58% (41/71)	41
Research methods	6		63% (43/68)	43
Advanced management accounting	7		64% (38/59)	38
Thesis writing	8		71% (37/52)	37

Note(s): *n* = number of students that responded to the questionnaire

constructs (the seven KSC scales measured), this analysis is the first to confirm the theoretical model of multiple interconnected dimensions of the KSCs, which are measured by specific items on the questionnaire in a business school.

4. Results

4.1 Descriptive statistics

Table 2 displays the mean scores, standard deviations and Spearman correlation coefficients across sustainability competence constructs, aimed at testing for discriminant validity issues. Most correlated coefficients for each item fall below $r = 0.70$, which suggests minimal discriminant validity concerns within the sustainability competence scales. This provides initial evidence that the constructs capture distinct facets of sustainability competence and that they together can be a valid KSC construct for integrated problem-solving competency for a sustainability mindset. Additional scrutiny using the HTMT ratio is warranted to delve deeper into the discriminant validity of these constructs.

4.2 Reliability and validity tests of the key sustainability competence scales

Firstly, the factor indicators were checked for a level of 0.50 and above, which were all found to be acceptable. Secondly, the internal consistency reliability was checked with the Cronbach's alpha test and the CR test (Tables 3–5). Results of the reliability tests for KSC scales (Table 3), tested with four different modules in 2023 and four different modules in 2024, show that the Cronbach's alpha and CR are acceptable.

The average variance extracted test for convergent validity scores is also acceptable at a cut-off level of 0.50 (Table 3). The discriminant validity test HTMT ratio (Table 4) indicates acceptable scores with the cut-off level below 0.90 for all sustainability competences. Also, the variance inflation factor is then used to test the collinearity between the item indicators for each structure. Results for the sustainability competence scales show acceptable scores between 1 and 3. Thus, evidence indicates that there are no critical collinearity problems between the indicators of the sustainability competence constructs.

4.3 A confirmatory factor analysis

Firstly, the indicator loadings (items for each statement) were tested for each KSC factor with each data set (each participating class). Results of the test revealed that each indicator loaded on its own factor (all three items loaded on the KSC it represented), which is a different result from prior studies (Meza Rios et al., 2018). While some loadings are a little high (close to 1), there were no loadings under 0.70. The indicator factor loadings are shown in Table 5.

Table 2. Descriptive statistics and correlation: Spearman's rho

Semester 1	Mean	SD	Future	Implementation	Interpersonal	Intrapersonal	Strategic	Systems	Values
Future	3.37	0.76	1.0000						
Implementation	3.46	0.83	0.3183*	1.0000					
Interpersonal	3.50	0.90	0.5298*	0.5440*	1.0000				
Intrapersonal	3.37	0.69	0.2472	0.4619*	0.3760*	1.0000			
Strategic	3.15	0.83	0.4639*	0.6035*	0.5305*	0.3856*	1.0000		
Systems	3.45	0.88	0.3474*	0.6036*	0.3812*	0.3579*	0.5933*	1.0000	
Values	3.11	0.78	0.4544*	0.4706*	0.4532*	0.5209*	0.6484*	0.5421*	1.0000
<i>Semester 2</i>									
Future	3.64	0.79	1.000						
Implementation	3.57	0.92	0.5627*	1.000					
Interpersonal	3.71	0.88	0.6555*	0.7407*	1.000				
Intrapersonal	3.57	0.71	0.4247*	0.6541*	0.6014*	1.000			
Strategic	3.61	0.88	0.7163*	0.8878*	0.7958*	0.5834*	1.000		
Systems	3.60	0.95	0.5202*	0.7819*	0.5775*	0.5870*	0.7451*	1.000	
Values	3.59	1.00	0.7594*	0.5516*	0.4411*	0.4345*	0.7032*	0.5657*	1.000
<i>Semester 3</i>									
Future	3.28	0.60	1.000						
Implementation	3.51	0.54	0.5642*	1.000					
Interpersonal	3.30	0.74	0.4280*	0.5567*	1.000				
Intrapersonal	3.63	0.50	0.3566*	0.1221	0.2639*	1.000			
Strategic	3.36	0.54	0.4874*	0.5890*	0.4773*	0.3954*	1.000		
Systems	3.28	0.61	0.4479*	0.3606*	0.4293*	0.2253	0.5725*	1.000	
Values	3.19	0.65	0.5231*	0.3622*	0.3346*	0.2428	0.5197*	0.6576*	1.000
<i>Semester 4</i>									
Future	3.19	0.81	1.000						
Implementation	3.33	0.77	0.6100*	1.000					
Interpersonal	3.24	0.99	0.6290*	0.6227*	1.000				
Intrapersonal	3.72	0.77	0.5326*	0.5524*	0.5065*	1.000			
Strategic	3.06	0.93	0.6520*	0.7269*	0.7407*	0.5307*	1.000		
Systems	3.00	0.98	0.6992*	0.6555*	0.5437*	0.3002*	0.6318*	1.000	
Values	2.92	0.96	0.7114*	0.6344*	0.5814*	0.4315*	0.6354*	0.6461*	1.000
<i>Semester 5</i>									
Future	3.38	0.71	1.000						
Implementation	3.27	0.95	0.3258	1.0000					
Interpersonal	3.43	0.87	0.4690*	0.8023*	1.0000				
Intrapersonal	3.57	0.6	0.2519	0.2024	0.3012	1.0000			
Strategic	3.16	0.73	0.3528	0.7416*	0.7629*	0.2874	1.0000		
Systems	3.18	0.77	0.5239*	0.6303*	0.6599*	0.0116	0.7264*	1.0000	
Values	3.24	0.77	0.4346*	0.7435*	0.8478*	0.4038*	0.7032*	0.6003*	1.0000
<i>Semester 6</i>									
Future	2.98	0.73	1.000						
Implementation	3.21	0.73	0.5071*	1.000					
Interpersonal	3.20	0.96	0.4694*	0.6208*	1.000				
Intrapersonal	3.17	0.82	0.2960	0.1617	0.3140	1.000			
Strategic	2.80	0.88	0.6676*	0.6703*	0.6030*	0.5427*	1.000		
Systems	2.79	1.05	0.5076*	0.7448*	0.6053*	0.3272	0.6893*	1.000	
Values	2.82	0.89	0.8030*	0.5219*	0.4595*	0.4477*	0.6939*	0.5639*	1.000
<i>Semester 7</i>									
Future	3.54	0.95	1.000						
Implementation	3.58	1.03	0.8750*	1.000					

(continued)

Table 2. Continued

Semester 1	Mean	SD	Future	Implementation	Interpersonal	Intrapersonal	Strategic	Systems	Values
Interpersonal	3.54	1.14	0.7669*	0.8934*	1.000				
Intrapersonal	3.43	0.78	0.6042*	0.5513*	0.4066*	1.000			
Strategic	3.49	1.06	0.8204*	0.9073*	0.8299*	0.4275*	1.000		
Systems	3.66	1.02	0.7344*	0.8636*	0.8815*	0.277	0.7754*	1.000	
Values	3.31	1.21	0.7473*	0.8876*	0.7765*	0.246	0.8696*	0.8738*	1.000
<i>Semester 8</i>									
Future	3.60	0.84	1.000						
Implement	3.61	0.80	0.4341*	1.000					
Interpersonal	3.81	0.76	0.4622*	0.6621*	1.000				
Intrapersonal	3.63	0.76	0.126	0.253	0.109	1.000			
Strategic	3.46	0.96	0.5742*	0.7804*	0.5922*	0.132	1.000		
Systems	3.73	0.83	0.318	0.6753*	0.5628*	0.206	0.5688*	1.000	
Values	3.63	0.92	0.6349*	0.5121*	0.282	0.167	0.5711*	0.4120*	1.000

This result suggests that a second-order CFA (Schumacker and Lomax, 2010; Byrne, 2016) could help to test the KSC framework theory, to test whether each KSC can measure the integrated problem-solving competency of the KSC framework. Results show good model fit statistics for all data sets with non-significant chi-square, a CFI level above 0.95 and an RMSEA level below 0.05 (Byrne, 2016; Hair et al., 2019). Also, the R^2 is greater than 40% for each latent variable (each KSC). Results of the CFA path coefficients can be seen in Table 6.

5. Discussion

Previous research on sustainability competence (Cebrián et al., 2019; Redman et al., 2021) has highlighted the need for a valid and reliable assessment tool. Sustainability education is emphasised across various professions and lecturers recognise the importance of addressing the necessary sustainability competencies (Brundiers et al., 2021). It is recommended that a formative assessment tool can help educators understand their students’ perceptions of sustainability competence and tailor their teaching strategies accordingly. This study builds on that foundation, demonstrating that the scales designed to measure KSC provide a valid and reliable assessment of students’ perceptions and attitudes towards their sustainability competence. Consequently, teachers reported that the formative tool aids in preparing class activities that meet the specific needs of their students.

Additional CFA has provided new insights into the KSC framework, suggesting that each competency contributes to capacity building for integrated problem-solving. This finding builds on previous discussions in the KSC frameworks (Bianchi et al., 2022; Brundiers et al., 2021; Redman and Wiek, 2021) regarding the importance of including intrapersonal and implementation competencies. It also supports the notion that each individual KSC is crucial for enhancing sustainability competency in integrated problem-solving.

Lecturers who have used the formative SCMM assessment tool found it beneficial for communicating results with students and to address sustainability challenge topics throughout the class period. This builds on the dialogue in literature (Gonglewski and Helm, 2014; Sela and Luke, 2020) about challenges of communicating sustainability education with students. Teachers noted that they could explain how course activities would build capacity for KSCs. For example, some teachers used simple concept connections on their

Table 3. Reliability tests of sustainability competence scales across all semesters

Semester 1	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Future	0.735	0.845	0.840	0.638
Implementation	0.834	0.842	0.901	0.751
Interpersonal	0.872	0.879	0.921	0.795
Intrapersonal	0.783	0.719	0.788	0.577
Strategic	0.823	0.830	0.894	0.738
Systems	0.883	0.886	0.928	0.811
Values	0.838	0.845	0.902	0.755
<i>Semester 2</i>				
Future	0.822	0.861	0.894	0.740
Implementation	0.849	0.852	0.909	0.768
Interpersonal	0.836	0.866	0.900	0.750
Intrapersonal	0.746	0.777	0.855	0.665
Strategic	0.862	0.871	0.916	0.784
Systems	0.909	0.910	0.943	0.846
Values	0.908	0.910	0.942	0.844
<i>Semester 3</i>				
Future	0.771	0.772	0.868	0.687
Implementation	0.581	0.730	0.769	0.553
Interpersonal	0.850	0.856	0.909	0.769
Intrapersonal	0.742	0.721	0.798	0.576
Strategic	0.770	0.700	0.765	0.523
Systems	0.740	0.751	0.851	0.657
Values	0.824	0.829	0.895	0.739
<i>Semester 4</i>				
Future	0.835	0.835	0.901	0.752
Implementation	0.768	0.826	0.867	0.689
Interpersonal	0.945	0.947	0.965	0.901
Intrapersonal	0.896	0.927	0.934	0.826
Strategic	0.905	0.908	0.94	0.84
Systems	0.946	0.949	0.965	0.903
Values	0.941	0.941	0.962	0.894
<i>Semester 5</i>				
Future	0.790	1.033	0.861	0.677
Implementation	0.937	0.942	0.960	0.888
Interpersonal	0.900	0.905	0.938	0.834
Intrapersonal	0.777	0.831	0.790	0.575
Strategic	0.821	0.846	0.894	0.740
Systems	0.831	0.846	0.899	0.748
Values	0.862	0.878	0.915	0.783
<i>Semester 6</i>				
Future	0.777	0.788	0.869	0.690
Implementation	0.745	0.825	0.848	0.653
Interpersonal	0.927	0.927	0.954	0.873
Intrapersonal	0.777	0.719	0.738	0.573
Strategic	0.942	0.943	0.963	0.896
Systems	0.934	0.934	0.958	0.883
Values	0.897	0.897	0.936	0.829

(continued)

Table 3. Continued

Semester 1	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
<i>Semester 7</i>				
Future	0.847	0.854	0.907	0.765
Implementation	0.833	0.893	0.902	0.758
Interpersonal	0.937	0.938	0.96	0.889
Intrapersonal	0.768	0.803	0.801	0.592
Strategic	0.946	0.95	0.965	0.902
Systems	0.949	0.96	0.967	0.907
Values	0.963	0.965	0.976	0.931
<i>Semester 8</i>				
Future	0.782	0.784	0.873	0.696
Implement	0.793	0.796	0.879	0.708
Interpersonal	0.755	0.755	0.859	0.670
Intrapersonal	0.791	0.799	0.804	0.596
Strategic	0.890	0.893	0.932	0.820
Systems	0.869	0.869	0.920	0.793
Values	0.822	0.820	0.895	0.740

Note(s): All acceptable at cut off levels

slides to show where a KSC is linked to discussions and activities. Others incorporated KSC into their grading rubrics to demonstrate how project work relates to these competencies.

Several teachers observed that students better understood the connection between business and sustainability through adapted course activities, such as reflective journal writing assignments and peer opposition discussions. Thus, participant teachers supplemented the questionnaire with a qualitative approach to understand students' sustainability competency mindset, which supports recommendations suggested in Redman *et al.*'s (2021) study on assessment techniques. Higher education could benefit from interdisciplinary learning environments to help students develop interpersonal skills (Scholz and Steiner, 2015).

Therefore, it is beneficial to test the SCMM tool in various environments beyond leadership courses and business students. Applying the SCMM tool across all disciplines will enable teachers and universities to better understand how to integrate sustainability competencies into complex environments and systems (Lönngren and Svanström, 2016). Additionally, the evolving inclusion of technologies and communication tools can have both positive and negative impacts on students. Using the SCMM tool can help educators understand student perceptions of KSCs by facilitating communication about these competencies and fostering dialogue to build capacity through continuous use of technologies (Daff, 2021).

The call for practical experience and the importance of creating experiential learning opportunities for students (Beard, 2007) suggest that teachers need to facilitate off-campus environments for sustainability capacity building. The SCMM tool could be applied in workplace settings where transdisciplinary knowledge can enhance sustainability competencies for all stakeholders. Additionally, Powell and McGuigan (2024) point out that it is crucial for teachers to provide a compassionate and safe educational environment. With student anxiety increasingly evident in classrooms, teachers need to facilitate intrapersonal

Table 4. Heterotrait-monotrait ratio for discriminant validity of sustainability competence scales

Semester 1	Future	Implementation	Interpersonal	Intrapersonal	Strategic	Systems
Implementation	0.550					
Interpersonal	0.793	0.716				
Intrapersonal	0.730	0.839	0.769			
Strategic	0.728	0.832	0.773	0.773		
Systems	0.552	0.767	0.573	0.771	0.818	
Values	0.802	0.675	0.674	0.856	0.835	0.714
<i>Semester 2</i>						
Implementation	0.735					
Interpersonal	0.856	0.92				
Intrapersonal	0.796	0.875	0.865			
Strategic	0.836	0.844	0.875	0.944		
Systems	0.724	0.824	0.706	0.848	0.882	
Values	0.813	0.695	0.637	0.731	0.872	0.792
<i>Semester 3</i>						
Implementation	0.819					
Interpersonal	0.599	0.840				
Intrapersonal	0.458	0.485	0.369			
Strategic	0.777	1.126	0.630	0.670		
Systems	0.643	0.748	0.544	0.346	0.973	
Values	0.745	0.598	0.391	0.384	0.784	0.823
<i>Semester 4</i>						
Implementation	0.838					
Interpersonal	0.715	0.794				
Intrapersonal	0.711	0.742	0.632			
Strategic	0.832	0.811	0.829	0.644		
Systems	0.772	0.828	0.626	0.426	0.712	
Values	0.837	0.761	0.670	0.538	0.760	0.712
<i>Semester 5</i>						
Implementation	0.389					
Interpersonal	0.657	0.764				
Intrapersonal	0.606	0.225	0.422			
Strategic	0.499	0.771	0.787	0.533		
Systems	0.678	0.811	0.836	0.247	0.821	
Values	0.616	0.750	0.856	0.528	0.816	0.735
<i>Semester 6</i>						
Implementation	0.627					
Interpersonal	0.639	0.764				
Intrapersonal	0.521	0.328	0.453			
Strategic	0.798	0.781	0.700	0.667		
Systems	0.621	0.835	0.656	0.440	0.773	
Values	0.745	0.622	0.619	0.596	0.794	0.706
<i>Semester 7</i>						
Implementation	0.821					
Interpersonal	0.815	0.899				
Intrapersonal	0.821	0.825	0.546			
Strategic	0.821	0.886	0.859	0.554		
Systems	0.808	0.898	0.830	0.577	0.769	
Values	0.793	0.814	0.824	0.433	0.873	0.846

(continued)

Table 4. Continued

Semester 1	Future	Implementation	Interpersonal	Intrapersonal	Strategic	Systems
<i>Semester 8</i>						
Implementation	0.636					
Interpersonal	0.809	0.776				
Intrapersonal	0.345	0.522	0.336			
Strategic	0.745	0.796	0.721	0.512		
Systems	0.509	0.702	0.767	0.442	0.624	
Values	0.702	0.671	0.565	0.452	0.753	0.679

Table 5. Factor loadings for indicators

Semester	s1	s2	s3	s4	s5	s6	s7	s8
Future 1	0.796	0.900	0.772	0.785	0.819	0.774	0.776	0.738
Future 2	0.769	0.798	0.761	0.759	0.753	0.752	0.706	0.817
Future 3	0.710	0.864	0.770	0.825	0.775	0.772	0.885	0.789
Implementation 1	0.822	0.842	0.782	0.892	0.903	0.895	0.973	0.777
Implementation 2	0.793	0.744	0.721	0.771	0.967	0.716	0.770	0.774
Implementation 3	0.865	0.837	0.726	0.851	0.866	0.753	0.932	0.810
Interpersonal 1	0.896	0.731	0.816	0.904	0.909	0.887	0.947	0.825
Interpersonal 2	0.754	0.831	0.766	0.913	0.829	0.991	0.953	0.792
Interpersonal 3	0.856	0.811	0.850	0.955	0.842	0.827	0.861	0.771
Intrapersonal 1	0.809	0.803	0.795	0.858	0.906	0.839	0.772	0.713
Intrapersonal 2	0.840	0.793	0.798	0.925	0.753	0.936	0.896	0.842
Intrapersonal 3	0.722	0.726	0.761	0.805	0.783	0.707	0.759	0.724
Strategic 1	0.776	0.820	0.769	0.885	0.768	0.945	0.968	0.852
Strategic 2	0.787	0.876	0.722	0.939	0.978	0.897	0.976	0.862
Strategic 3	0.776	0.791	0.764	0.795	0.755	0.924	0.844	0.849
Systems 1	0.933	0.866	0.719	0.882	0.808	0.848	0.906	0.766
Systems 2	0.848	0.915	0.847	0.920	0.883	0.993	0.908	0.873
Systems 3	0.784	0.849	0.779	0.966	0.767	0.841	0.983	0.853
Values 1	0.814	0.923	0.716	0.867	0.803	0.882	0.941	0.894
Values 2	0.848	0.898	0.897	0.945	0.810	0.929	0.957	0.899
Values 3	0.742	0.817	0.744	0.945	0.842	0.798	0.943	0.793

thinking supported by tools like the SCMM to foster dialogue and engage students in self-reflective activities.

6. Implications for theory, practice and policy

This study provides empirical support for the KSC framework in a business school context, reinforcing its theoretical robustness and practical relevance in higher education. By validating the SCMM, this study operationalises abstract sustainability constructs into measurable components, advancing capacity-building theory and bridging the gap between theory and practice. The SCMM tool contributes to the discussion about how to implement competency-based education models in interdisciplinary education by providing a structured way to assess and develop sustainability competencies. This study thereby supports the idea that effective sustainability education requires not only content knowledge but also pedagogical strategies that are responsive to learner profiles.

Table 6. Confirmatory factor analysis path coefficients

Semester 1	Path coefficients (standardised)	SE	t-values	p-values
Intergrated p-s → future	0.800	0.174	4.031	0.000
Intergrated p-s → implementation	0.852	0.178	4.235	0.000
Intergrated p-s → interpersonal	0.806	0.187	5.159	0.000
Intergrated p-s → intrapersonal	0.806	0.177	4.567	0.000
Intergrated p-s → strategic	0.938	0.189	5.255	0.000
Intergrated p-s → systems	0.775	0.177	5.251	0.000
Intergrated p-s → values	0.871	0.175	4.973	0.000
<i>Semester 2</i>				
Intergrated p-s → future	0.850	0.160	5.305	0.000
Intergrated p-s → implementation	0.788	0.164	5.255	0.000
Intergrated p-s → interpersonal	0.673	0.154	4.365	0.000
Intergrated p-s → intrapersonal	0.649	0.137	4.723	0.000
Intergrated p-s → strategic	0.958	0.156	6.151	0.000
Intergrated p-s → systems	0.960	0.191	5.028	0.000
Intergrated p-s → values	0.951	0.187	5.079	0.000
<i>Semester 3</i>				
Intergrated p-s → future	0.848	0.207	4.106	0.000
Intergrated p-s → implementation	0.798	0.223	4.018	0.000
Intergrated p-s → interpersonal	0.914	0.237	3.855	0.000
Intergrated p-s → intrapersonal	0.427	0.181	2.362	0.022
Intergrated p-s → strategic	0.713	0.216	3.303	0.002
Intergrated p-s → systems	0.892	0.213	4.186	0.000
Intergrated p-s → values	0.818	0.218	3.748	0.000
<i>Semester 4</i>				
Intergrated p-s → future	0.793	0.106	7.481	0.000
Intergrated p-s → implementation	0.878	0.127	7.725	0.000
Intergrated p-s → interpersonal	0.960	0.120	8.031	0.000
Intergrated p-s → intrapersonal	0.544	0.094	5.808	0.000
Intergrated p-s → strategic	0.980	0.107	9.121	0.000
Intergrated p-s → systems	0.889	0.117	7.606	0.000
Intergrated p-s → values	0.849	0.110	7.691	0.000
<i>Semester 5</i>				
Intergrated p-s → future	0.603	0.194	3.114	0.004
Intergrated p-s → implementation	0.670	0.155	4.438	0.000
Intergrated p-s → interpersonal	1.070	0.185	5.776	0.000
Intergrated p-s → intrapersonal	0.599	0.144	4.556	0.000
Intergrated p-s → strategic	0.580	0.140	4.148	0.000
Intergrated p-s → systems	0.825	0.188	4.386	0.000
Intergrated p-s → values	0.879	0.191	4.605	0.000
<i>Semester 6</i>				
Intergrated p-s → future	0.797	0.208	3.824	0.001
Intergrated p-s → implementation	0.899	0.225	0.412	0.000
Intergrated p-s → interpersonal	0.861	0.215	4.009	0.000
Intergrated p-s → intrapersonal	0.737	0.242	3.038	0.005
Intergrated p-s → strategic	1.062	0.205	5.191	0.000
Intergrated p-s → systems	1.168	0.260	4.495	0.000
Intergrated p-s → values	1.001	0.226	4.426	0.000

(continued)

Table 6. Continued

Semester 1	Path coefficients (standardised)	SE	t-values	p-values
<i>Semester 7</i>				
Intergrated p-s → future	0.520	0.104	5.013	0.000
Intergrated p-s → implementation	0.788	0.099	0.787	0.000
Intergrated p-s → interpersonal	0.816	0.094	8.684	0.000
Intergrated p-s → intrapersonal	0.338	0.113	2.995	0.005
Intergrated p-s → strategic	0.746	0.098	7.596	0.000
Intergrated p-s → systems	0.664	0.078	8.478	0.000
Intergrated p-s → values	0.802	0.093	8.635	0.000
<i>Semester 8</i>				
Intergrated p-s → future	0.603	0.205	2.944	0.006
Intergrated p-s → implementation	0.810	0.201	0.326	0.000
Intergrated p-s → interpersonal	0.775	0.187	4.143	0.000
Intergrated p-s → intrapersonal	0.470	0.221	2.128	0.040
Intergrated p-s → strategic	1.035	0.218	4.746	0.000
Intergrated p-s → systems	0.807	0.209	3.860	0.000
Intergrated p-s → values	0.909	0.247	3.678	0.001

The SCMM tool enables educators to assess students’ sustainability competencies early in a course, allowing for tailored teaching strategies that align with learners’ existing knowledge, skills and confidence. This personalised approach enhances engagement, learning outcomes and the overall effectiveness of sustainability education. The tool also empowers educators, regardless of prior experience, to integrate sustainability themes confidently. Its structured feedback loop supports reflective teaching and continuous improvement through pre- and post-course assessments. In academic staff development, the SCMM encourages peer learning and a community of practice.

Students benefit from feeling recognised and supported, which boosts motivation and deeper engagement with sustainability topics. Adapted for student-level language, the SCMM is suitable across disciplines, promoting a whole-institution approach and fostering a shared language around sustainability. Institutionally, the SCMM can also provide measurable data for monitoring, evaluation and policy development. It can support accreditation processes and align with global goals like UN SDG 4.7. Formalising its use can ensure consistent, impactful integration of sustainability education across programmes, embedding it as a structured and supported component of teaching practice rather than relying on individual initiative.

7. Conclusion

The purpose of this study is to provide a valid and reliable formative questionnaire tool to capture KSCs in sustainability education research. Given the importance of business education in developing student competencies, this study also tested the KSC framework. Validity and reliability tests showed significant evidence that each KSC scale is valid, reliable and loads on each competency factor. CFA provided new insights, supporting the notion that developing each KSC enhances capacity for sustainability competence in integrated problem-solving.

Designing a questionnaire requires acknowledging limitations. Participants may overestimate or underestimate their competence, as perceptions are less reliable than task-related competence. Varying question formats can reduce bias (Podsakoff *et al.*, 2003). This assessment focuses on students' perceptions to help teachers and students facilitate a learning experience that boosts confidence in addressing sustainability challenges. While additional methods could enhance the assessment tool, the questionnaire method remains recognised for understanding participants' perceptions.

While feedback from teachers was collected, its use was for triangulation purposes and questionnaire design during pilot stages. Teachers pointed out the tool's effectiveness alongside qualitative assignments, such as reflective discussions and role-playing activities. Using the questionnaire with qualitative assessments maximises benefits and builds sustainability competency capacity in student learning plans.

Despite limitations, tests show that modifications to the sustainability competence scales – enhancing face validity and adding intrapersonal and implementational competencies – improved overall validity. The assessment tool should be tested across various disciplines and countries to account for cultural and language challenges, as language influences students' reactions to sustainability education (Gonglewski and Helm, 2014; Sela and Luke, 2020). Further investigation is needed to enhance the tool's usability, but the SCMM tool can help business teachers understand students' perceptions of their sustainability competence mindset and capacity-building experience. This opens avenues for comparative and longitudinal studies that can further evolve the theoretical model.

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Data availability

Data not available – participant consent.

Note

- [1.] Cooperative learning includes positive interdependence, individual accountability, face-to-face interaction, develop interpersonal and small group skills and group members monitor performance.

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Appendix: Key sustainability scales: questionnaire tool

In the following statements, rate on a scale of 1, not competent to 5, very competent. I feel competent to...

Systems thinking:

- analyse systems on a local and a global scale;

- analyse systems of environmental, social and economic domains; and
- analyse the impact of sustainability action plans.

Strategic thinking:

- design integrated actions that draw on resources from across disciplines;
- construct viable strategies to advance sustainability transformations; and
- test strategies for transitions towards sustainability.

Futures thinking:

- anticipate future states of sustainability problems;
- predict possible repercussions of actions before they are implemented; and
- construct forecasts for sustainability.

Values thinking:

- identify sustainability values to assess systems;
- apply sustainability values to construct sustainability systems; and
- map sustainability values to assess sustainability action plans.

Interpersonal thinking:

- collaborate successfully in interdisciplinary teams to advance sustainability transformations;
- collaborate successfully in professional teams to advance sustainability transformations; and
- work with diverse stakeholders to advance sustainability transformations.

Intrapersonal thinking:

- advance sustainability transformations through personal resilience;
- advance sustainability transformations through self-awareness; and
- avoid personal health challenges while advancing sustainability transformations.

Implementation thinking:

- put sustainability strategies into action in effective ways;
- adapt to emerging challenges; and
- scale action plans to advance sustainability transformations.

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