An assessment of key sustainability competencies: a review of scales and propositions for validation

Alice Annelin and Gert-Olof Boström
Umeå School of Business, Economics and Statistics, Business Administration Department, Umeå University, Umeå, Sweden

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Abstract

Purpose – The purpose of this paper is to review and provide propositions about survey assessment tools of the key sustainability competencies (KSCs) of education for sustainability. UNESCO points out how education plays an important role in transforming societies towards a sustainable future and achieving the United Nations' sustainable development goals. To plan education for sustainability, teachers need to know the students' competencies for sustainability before they come to class. Thus, a formative assessment about student competence for sustainability is needed.

Design/methodology/approach – Firstly, a structured literature review of assessment tools used to measure sustainability competencies by questionnaire survey is presented. Secondly, the authors' conceptualise how the competencies influence each other and provide propositions for future research.

Findings – The literature demonstrates that there is much ambiguity between prior research about the scales used and what they represent. A lack of validation across disciplines is apparent and an assessment tool that includes all eight KSCs could benefit education for sustainability. Future research could investigate how the competencies influence each other and which drivers are stronger for each discipline across different countries. A formative assessment tool can address this need.

Originality/value – The findings provide a new analysis about questionnaire assessment tools used in prior research to measure sustainability competence. The authors' offer a discussion about the strengths and weaknesses found in prior research and propose suggestions for future research. Their conceptualisation also provides propositions for validating the KSCs presented in a recent framework.

Keywords Education, Assessment, Sustainable development goals, Scale validation, Sustainability competence

Paper type Literature review

1. Introduction

There is a need to develop an assessment tool that can better integrate sustainability into higher education curriculums across disciplines. As Agenda 2030 and the sustainable development goals (SDGs) were established, a higher education act law was drawn up in Sweden to ensure that education for sustainability would be implemented. This mandate includes teaching about the SDGs, so that future leaders can work towards achieving the

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goals. UNESCO (UNESCO, 2017) point out that education plays a vital role in the development of student competencies for sustainability and to achieve the SDGs.

Students consider learning for sustainability to be an important part of their education and show a keen interest in learning about sustainability (Boström, 2020). Thus, implementing sustainability into our modules and courses in higher education should be straightforward. Many universities in Sweden have already applied sustainability into their courses and several universities have designed whole degree programmes in different disciplines that emphasise sustainability. For some universities, the integration of sustainability into their education has been an easy continuance of what was already being taught, but for others teaching about or for sustainability is still considered irrelevant.

While these two extremes may be less commonly experienced, many teachers have also tried to integrate sustainability into the courses that they teach, even if sustainability is not considered the main perspective of the programme. If there is little understanding of how other teachers in the students' degree programme have taught for sustainability before or after their own modules, it can be difficult for individual teachers to apply sustainability to their course in a manner that can develop their students' competence (O'Byrne *et al.*, 2015). Thus, there is a need to better understand how learning progression of education for sustainability can be advanced, rather than only learning about sustainability.

There is rarely an overall curriculum for teaching sustainability, which risks teaching sustainability with no consideration of the students' prior knowledge in the field. For teachers to be better prepared for their lessons, the teachers need to be able to assess the students' competencies in sustainability before they come to class (Andrade, 2019). Otherwise, students will experience a weak development of their competence towards transforming society for sustainability.

In a report describing learning objectives, UNESCO (2017) released a set of key sustainability competencies (KSCs) that can help students to work towards the UN's SDGs and Agenda 2030. Several frameworks have emerged (Brundiers *et al.*, 2020; Redman and Wiek, 2021) that have developed our understanding of the KSCs. It is now understood that the competency for systems thinking, strategic thinking, futures thinking, values thinking, interpersonal thinking, intrapersonal thinking and implementational thinking can together lead to an integrated problem-solving competency for sustainability.

There is some ambiguity in the manner that sustainability competencies have been assessed (Redman and Wiek, 2021). A questionnaire that can provide valid KSC scales to assess these KSCs can help teachers to better understand their students' competence before they come to class. Teachers can then better plan for their lessons for sustainability, which facilitates the teachers' process of integrating sustainability into their curriculum.

Next, this article discusses the background to the SDGs in education and the KSCs. The method is then explained, and a literature review supports the discussion. Propositions are made for future research to advance our knowledge about the best ways to assess sustainability competencies in higher education.

2. Background: challenges of assessing education for sustainability

2.1 Sustainable development goals

The UN's SDGS were introduced in 2015 and have been recognised by researchers and practitioners in higher education (Leal Filho *et al.*, 2021) as having some advantages and disadvantages. For example, the SDGs have several contradictory targets (Spaiser *et al.*, 2017) that have been considered problematic, and some disagree with the inclusion of economic growth (D'Alisa *et al.*, 2015) and the neo-liberal business as usual approach that drives the UN's goal for sustainable development (SD; Bolis *et al.*, 2014). The political nature of the perspective of SD and

sustainability can be unfavourable for many and cause problems when mandates require institutions to integrate a perspective with which some disagree. One example is integrating the SDGs into policy, curriculum and practice in higher education (Franco *et al.*, 2019).

However, some have found advantages in using the SDGs as a framework to develop a whole school approach (Wals, 2014) and enabling teachers and students to begin their critical thinking journey through the wicked problems of sustainability (Lönngren and van Poeck, 2021). Wals (2014) points out that teachers need to gain competence in education for sustainable development (ESD) to facilitate learners' competence for SD. The SDGs framework can be considered a tool to help teachers gain competence for ESD to facilitate students' competence for SD and for students to grasp the many overlapping and sometimes contradictory and wicked problems that are faced in work towards a sustainable future.

2.2 Key sustainability competencies

Researchers of sustainability in higher education (SHE) have investigated the different types of competencies that students require. Several have discussed student competency in terms of employability, which SHE researchers point out is needed in terms of the sustainability job market (McCarthy and Eagle, 2021). Some research has discussed student competency in terms of ability to change their futures and their communities, which Wals and Benavot (2017) recognise as a major goal of sustainability transformations. Some research (Barth *et al.*, 2007; Shephard, 2008) has discussed student competency to be able to adapt to different ways of life and the competency to live in a sustainable way.

Thus, the overall goal of sustainability competencies could be considered as a competency to find work due to sustainability demands in the workplace, a competency to transform societies towards a sustainable future, and a competency to live in a sustainable manner. Delving deeper into these three dimensions of sustainability competencies there is a need for practical tools to facilitate such competencies. Based on a literature review of sustainability competencies, Wiek *et al.* (2011a) developed a helpful framework for what is called the KSCs. This framework identified five competencies that are differentiated from other basic competencies taught in a programme.

A UNESCO (UNESCO, 2017) report adopted this framework to suggest that the KSCs are an important tool for education to develop so that students can work towards the UN's SDGs. Since this report, some researchers (Brundiers *et al.*, 2020; Redman and Wiek, 2021) have built on this framework to suggest that three more competencies should be considered. The eight KSCs that are considered relevant today include systems thinking, strategic thinking, future/anticipatory thinking, values/norms thinking, interpersonal thinking, intrapersonal thinking, implementational thinking and integrated problem-solving competencies for sustainability, and entail competencies for employability, transforming societies towards a sustainable future and as a new way of life.

3. Method

A structured literature review (Massaro *et al.*, 2016) was conducted to investigate what measurement tools were available to assess the KSCs discussed in SHE literature (Barth *et al.*, 2007; Brundiers *et al.*, 2020; Redman and Wiek, 2021; Wiek *et al.*, 2011a). Inclusion criteria for this review were articles written in English that focused on sustainability competencies and assessing sustainability competencies. Therefore, this review excludes articles that may have addressed sustainability competency in schools or other workplaces, as well as other qualitative methods of assessment. We acknowledge that with this exclusion there can be some limitations to results, such as generalisability to contexts other than higher education, as well as advantages that come with other methods of assessment.

The literature search was performed in the period from January 2022 to May 2022. The Web of Science, Scopus and Google Scholar search engines were used to match articles to the inclusion criteria. The terms used in the search engines were ("sustainab*" OR "sustainable development" OR "Green") AND ("higher education" OR "universit*") AND "competence" AND ("assessment" OR "survey" OR "questionnaire"). A search term for "Key Sustainability Competence" was also applied. The most recently published papers were chosen first (2012 and more recent) and then papers that were published before 2012 were also included. The final decision on which papers to include was based on relevance to the purpose of the paper, our subjective discretion and prior knowledge and experience with research about SHE.

The literature search process started with 1,731 articles in Scopus, 1,150 in Web of Science and 21,400 articles in Google Scholar. After sorting for relevance to self-assessment papers about key sustainability competence in higher education 19 articles were identified. We established reliability and validity of this literature review by coding the literature sources using the KSC framework by Redman and Wiek (2021), assisted by the software tool NVivo. The NVivo software tool helps the researcher to identify key words used, as well as correlations between words and short phrases in a qualitative and quantitative analysis. Each code applied in this analysis is represented in the subtitles used in the literature review sections. We developed insights and critique through analysing each paper and defined future research propositions from this review.

4. Review of self-assessment tools of the key sustainability competencies

4.1 Assess: scales review

In this section, we review the scales that have been used in prior literature (and made available) that could be considered for measurement of the KSC (see Table 1 of reviewed work). As can be seen in Table 1, most studies have not simultaneously applied measures for all of the eight KSC currently under discussion in the framework designed by

Table 1. Key sustainability competency scales

Key sustainability competence	Measurement
Systems thinking	Anderson (2000), Cebrián *et al.* (2019), Ceulemans and Severijns (2019), Lans *et al.* (2014), Mehren *et al.* (2018), Meza *et al.* (2018), Molderez and Fonseca (2018), Ploum *et al.* (2018b), Savage *et al.* (2015)
Strategic thinking	Faham *et al.* (2017), Lans *et al.* (2014), Meza *et al.* (2018), Molderez and Fonseca (2018), Ploum *et al.* (2018b), Savage *et al.* (2015)
Futures thinking	Bianchi *et al.* (2022), Lans *et al.* (2014), Meza *et al.* (2018), Molderez and Fonseca (2018), Ploum *et al.* (2018b), Savage *et al.* (2015)
Values thinking	Bianchi *et al.* (2022), Lans *et al.* (2014), Meza *et al.* (2018), Molderez and Fonseca (2018), Ploum *et al.* (2018b), Savage *et al.* (2015)
Interpersonal thinking	Lans *et al.* (2014), Meza *et al.* (2018), Molderez and Fonseca (2018), Ploum *et al.* (2018b), Savage *et al.* (2015)
Intrapersonal thinking	Besong and Holland (2015), Brandt *et al.* (2019), Cabral and Lochan Dhar (2019), Faham *et al.* (2017), Ploum *et al.* (2018a)
Implementational thinking	Bianchi *et al.* (2022), Brandt *et al.* (2019), Brundiers *et al.* (2020), Holdsworth *et al.* (2020), Ploum *et al.* (2018b)
Integrative problem-solving	Bianchi *et al.* (2022), Brundiers *et al.* (2020), Hull *et al.* (2016), Redman and Wiek (2021)

Redman and Wiek (2021). There is an apparent need to synthesize this prior work and investigate which measurements best represent the eight KSCs.

4.1.1 Systems thinking. Systems thinking competency (Connell *et al.*, 2012; Gray, 2018) is described as the ability to analyse complex systems that include all three dimensions of economic, social and environmental sustainability problems, on a local to global scale. This competency includes the ability to understand a system's challenges of cascading effects, inertia and other changing dynamics. Therefore, systems thinking is quite a complex competency that requires a student to be able to analyse a sustainability problem from a holistic perspective.

Systems thinking can be best learnt through applying knowledge in real-life experiences (Meza *et al.*, 2018; Sterling, 2010). Training students in the ability to analyse the interconnected systems between the different dimensions and scales of sustainability is a skill already being taught in several disciplines, such as subjects that teach about the circular economy (Bassi *et al.*, 2021) and information systems (Checkland, 2000). Thus, teachers and students may be able to recognise how they have developed their competence in systems thinking and compare this learning to what they have learnt from the sustainability perspective.

Several studies have attempted to measure systems thinking either from the perspective of their own discipline, from the sustainability perspective or a combination of both. These studies have contributed well to the early measurements of systems thinking from a sustainable perspective in line with the definition provided by Wiek *et al.* (2011a, 2011b) and developed by Redman and Wiek (2021). However, many of the items used in these studies do not explicitly include the aspect of systems thinking across scales, on a local, national or global scale.

For example, Savage *et al.* (2015) measured systems thinking from the sustainability perspective and their discipline perspective of leadership. Three items were used to describe how students have the confidence in their competence to analyse complex systems, understand potential consequences and interconnected relations. Meza *et al.* (2018) tested the same items in different formal and informal educational contexts, but in the same subject of leadership and found different results.

Molderez and Fonseca (2018) also designed a survey based on the five competencies paper of Wiek *et al.* (2011a). Their survey largely uses items that do not specifically indicate the sustainability perspective but do describe such competency in general. The systems thinking concept is measured with nine items, which is unbalanced compared to some of the other competencies that only have two items. Similar to the studies of Savage *et al.* (2015) and Meza *et al.* (2018), the nine items in Molderez and Fonseca's (2018) study also capture the complex nature and interconnected relations of competence.

Redman *et al.* (2021) recommend that systems thinking competence should consider the teacher assessment approach validated in the study by Mehren *et al.* (2018), which considers the complex nature of geographical systems thinking in a two-dimensional model. This teacher's assessment reflects similar items to the leadership-influenced items of Savage *et al.* (2015) and Meza *et al.* (2018), as it describes the identification of interconnected relations, flows and cycles and understanding potential consequences.

Lans *et al.* (2014) measured KSCs from an entrepreneurial management perspective and used four items to describe systems thinking competency. These items describe systems thinking through an entrepreneurship perspective and also leave out an explicit measurement of systems thinking across scales. The validation study by Ploum *et al.* (2018b) of the same survey items and constructs showed that these items load on one factor with good discriminant validity. However, the study by Ceulemans and Severijns (2019),

based on student perceptions on a science and sustainability course, uses only two of the systems thinking items from this same scale.

Ceulemans and Severijns (2019), also define the competencies in a different way, suggesting that the items that Lans *et al.* (2014) and Ploum *et al.* (2018b) described for several different KSC represent the attitude, knowledge and general competence for sustainability, in line with the discussion by Wiek *et al.* (2011b) about the development of the KSCs. One of the systems thinking competence items defined in the Ceulemans and Severijns (2019) study is defined as a futures thinking competency in the Ploum *et al.* (2018b) study. Therefore, there is some indication that the scale for systems thinking can have different results in different disciplines (contexts).

Contrary to these previously discussed studies, some research (Anderson, 2000; Cebrián *et al.*, 2019) has explicitly used the definition of systems thinking competence and asked participants to rank their proficiency in the competence. These studies were applied after participants experienced learning for, or teaching in, an educational course or programme. Some research (Ateskan and Lane, 2018) has also used more general systems thinking scales, not particular to the sustainability perspective. Thus, there are several measurement studies that have developed a measurement for systems thinking competency for sustainability, but these attempts vary in definition and method.

If assessments conducted by the students' own perceptions or conducted by the perception of the teacher are not clear about all the elements of systems thinking (complexity, interconnected relations and across scales), bias could be found when the participant interprets the questions. For example, the competence to develop interconnected relations could be interpreted as something occurring at one level within their own local environment, and not across scales. More explicit items designed to capture systems thinking across scales from a sustainability perspective could help to measure the students' competence in systems thinking.

4.1.2 Strategy thinking. Strategy thinking competency (de Haan, 2006; Wesselink *et al.*, 2015) is the ability to construct action plans that can help solve sustainability problems and create transformation for sustainability. Therefore, strategic thinking competency is a well-recognised competency already developed in many educational programmes, especially management and project planning, spatial planning or political planning. However, perhaps not all programmes teach from the sustainability perspective, which can add several new complex levels of strategic analysis to models already applied, for example, tackling the three dimensions of economic, social and environmental strategy.

There are a few studies identified that have attempted to assess the students' strategic competency for sustainability. All the items on the strategic competency scales have identified the general nature of the competence as defined above and each have applied the items to their specific discipline. This indicates that some of the scales may not be valid or reliable in different contexts and therefore require some more investigation.

For example, Savage *et al.* (2015) measured the strategic thinking competency by using three items that depict assessing resource availability, design actions and development of tools to advance sustainability. Lans *et al.* (2014) used four items to measure strategic thinking competency that describes skills for entrepreneurial management. The validation study of Ploum *et al.* (2018b) of the same survey items and constructs as the Lans *et al.* (2014) study showed that these items load on one factor with good discriminant validity. However, two other items meant to measure action thinking competence also loaded on the strategic thinking competence factor, which means that six items can be used to measure the strategic thinking competence in a leadership and management context.

Faham *et al.* (2017) used several items that measure student competency in strategic thinking, alongside other competencies. However, these items do not represent a close measurement of the defined strategic thinking competency for sustainability (described above) that UNESCO follows. Molderez and Fonseca (2018) have only used two items to measure strategic thinking competency and both items do not describe the strategic thinking definition, which weakens the face validity of these items.

Much more can be done in research to test and validate strategic thinking competence for sustainability so that this competence can be better applied in an assessment tool. It is possible that a measurement for strategic competency for sustainability could be developed from an alternative source of inspiration, such as strategic competency outside the sustainability perspective. It is also possible to follow the examples of the studies of Anderson (2000) and Cebrián *et al.* (2019), which follow the definition explicitly in the design of their items.

4.1.3 Futures thinking. Futures thinking competence (Gardiner and Rieckmann, 2015; Ojala, 2017) is defined as the ability to forecast possible sustainability problem scenarios and anticipate how sustainability systems and strategies develop in the future. The ability of students to anticipate future scenarios by considering whole systems, strategies both past, present and in multiple possible futures, while also considering knowledge for sustainability is a complex and immense task. Futures thinking competence indicates that it requires teachers to build the students' competence in systems and strategic thinking for sustainability beforehand. Teachers who train in prediction analysis, such as finance and technology, politics and management, may have models ready to be adapted to the sustainability perspective.

Assessing students on an engineering programme, Molderez and Fonseca (2018) used five items that describe the futures thinking competency definition quite well. However, the items are written in a general manner that does not specifically present competency from a sustainability perspective. While on a leadership course, Savage *et al.* (2015) assessed students with a measure for futures (or anticipatory) thinking using three items that describe the definition of futures thinking competency well, by addressing the ability to actually act on plans and designs to solve sustainability dilemmas.

Lans *et al.* (2014) measured futures thinking competency using four items that describe the definition well, but also included words that help to incorporate the other competencies. The validation study of Ploum *et al.* (2018b) of the same survey items and constructs as the Lans *et al.* (2014) study showed that these items load on one factor with good discriminant validity. This indicates that these items may better represent the nature of the futures thinking competency for the sustainability construct and therefore its face validity.

Bianchi *et al.* (2022) also incorporate several competencies into nine potential items that could address futures thinking competency for sustainability. Their study describes the competencies that they identify for sustainability as three dimensional, explaining that each competency has literacy, adaptability and exploratory elements. Each of the three dimensions includes their own knowledge, skills and abilities assessments, thus each competency is said to have three levels of assessment. This type of analysis indicates the complexity of capturing each competence for such an assessment tool.

4.1.4 Values thinking. Values thinking competency (Komasinski and Ishimura, 2017; Remington-Doucette *et al.*, 2013) is the ability to reflect and apply sustainability norms, principles and goals to solve sustainability problems. Values thinking competence is considered a major driver for transformations towards a sustainable future. Disciplines that traditionally develop values thinking include those in the social science and humanities areas, such as philosophy, politics, sociology and psychology. However, values and norms

can be considered for all disciplines, as ethical behaviour and equity of information for all is important to understand for every educational programme.

Values thinking competence for sustainability may be the most sensitive [1] to teach of the eight KSCs, as it implies that students may have to reconsider their own values, which could differ or contradict the values of the sustainability perspective. Teaching students the ability to understand a problem or task through perspectives other than their own is therefore a vital element of education for sustainability (Wals, 2010). Resistance or lack of motivation to properly apply sustainability teaching or assessment could also be true for the teacher asked to apply such an assessment tool. It could therefore be beneficial to assess the teacher's approach and the student's learning experience to control for such influences (Faham *et al.*, 2017).

Ploum *et al.* (2019) found that among students of entrepreneurship, values thinking competence (having a moral competence) has a significant and positive relation with idea generation and recognition of opportunities for SD. Bianchi *et al.* (2022) also highlight values thinking for sustainability and describe the competency in a similar way to the definition in the KSC framework (Brundiers *et al.*, 2020; Redman and Wiek, 2021). Although they do not empirically test their conceptual framework, their research provides several items that could be used for assessment in a questionnaire survey. They define values thinking as the knowledge, skills and abilities to respect, support and advocate for all species.

Moreover, Lans *et al.* (2014) used four items for values or normative competence on a sustainability competence scale that represent the definition above well. The validation study of Ploum *et al.* (2018b) of the same survey items and constructs showed that these items load on one factor with good discriminant validity. However, two other items meant to measure action thinking competence also loaded on the values thinking competence factor, which means that six items can be used to measure values thinking competence.

Savage *et al.* (2015) used the leadership perspective in their three items for normative thinking. This largely reflects on values rather than showing how the student may be able to apply values thinking. As the ability to apply a sustainability competence to an action that is transformative towards a sustainable future is of utmost importance, it is crucial that an assessment tool can capture how well the application of all KSCs has been developed during a student's education.

In an assessment of engineering students, Molderez and Fonseca (2018) only used two items to measure values thinking competency. These items do not reflect the values thinking definition of the KSC framework (Brundiers *et al.*, 2020; Redman and Wiek, 2021), but rather seem to capture a futures/anticipatory competence. Therefore, the face validity of the items could be improved. Altogether, these studies have contributed well to the assessment of values thinking competence for sustainability and much can be learnt from the different contexts that have applied these assessments. However, further work is needed to better assess the students' competence for values thinking for sustainability across disciplines.

4.1.5 Interpersonal thinking. Interpersonal thinking competency (Brundiers and Wiek, 2017; Sarpin *et al.*, 2018) is the ability to collaborate with diverse stakeholders, so that everyone can transform through a sustainability perspective. The ability for students to collaborate with others is usually trained in all disciplines at universities, as group work, investigations and practical internships are quite common, especially in applied sciences. Therefore, building competence for interpersonal thinking through a sustainability perspective should be one of the easier aspects of integrating sustainability into the curriculum.

Interpersonal thinking competency has been measured by Lans *et al.* (2014) using seven items that use the definition of competency from the sustainability perspective well. The

validation study of Ploum *et al.* (2018b) of the same survey items and constructs showed that these items load on two factors, which are called interpersonal competency and diversity competency, with good discriminant validity. The authors reason that since the items relate to each other by describing skills for collaboration, and that interpersonal competency gave weaker results for validity, the items could be combined to measure one construct.

In addition, three items in the Savage *et al.* (2015) study and eight items in the Molderez and Fonseca (2018) study were used, where the items describe the definition well but do not specify sustainability. Interestingly, Molderez and Fonseca (2018) found that the competence for interpersonal thinking drives all other competences, which differs from most others who suggest it is values thinking competence that is the driver of the other KSCs. They reason that if students have not built the competence to collaborate, they cannot build the competence for all other sustainability thinking skills because we need to work together to take action for our sustainable future.

Therefore, this prior research has been relatively successful in capturing the interpersonal thinking competency for sustainability. There is also some indication that the eight KSCs may have different significance in different disciplines or contexts. Teachers could benefit from future research that could test how and when each KSC supports the other competencies. Knowledge about the relationships between teaching all eight KSCs could improve plans for pedagogical approaches to teaching sustainability throughout a programme. This work could also lead to an enhanced progression for students' education for sustainability across a university programme.

4.1.6 Intrapersonal thinking. Intrapersonal thinking competency (Glasser, 2016; Lozano *et al.*, 2017; Redman and Wiek (2021) is the ability to build the capacity for self-awareness and resilience with sustainability transformations. It is not as common for many disciplines to consider self-awareness and affective learning capacity as a skill to develop during a module or course. However, some may use this skill to help students understand their own capabilities as a learner of the information provided. Self-awareness towards the subject and profession could be a skill with the potential to be developed in many disciplines. However, some subjects may already delve deeper and take the student to a different level of intrapersonal reflections, such as philosophy, psychology, language, art, music and teacher training.

Intrapersonal thinking competency is a relatively new addition to the KSC framework and could be measured by the many scales about attitudes and self-awareness to sustainability. For example, Cabral and Lochan Dhar (2019) measured green competencies, which include knowledge, skills, abilities, behaviour, attitude and awareness. Similarly, Besong and Holland (2015) conducted a survey study which measured student ability, action and attitudes to sustainability problems. While some scales were newly designed, the attitudes scale was taken from the revised new environmental paradigm (NEP) scale and can be considered a way in which student's intrapersonal competence to solve sustainability problems can be measured. The NEP scale is well tested in prior research used to assess student affective learning and self-awareness (Besong and Holland, 2015; Brandt *et al.*, 2019; Ploum *et al.*, 2018a; Shephard *et al.*, 2015).

Furthermore, Faham *et al.* (2017) designed several scales that could represent intrapersonal competency. Empathy was measured with four items that depict how one identifies with others, which could be considered as a measurement for social identity instead of empathy. The construct attitude was measured with 13 items that depict how committed the student is to different sustainability aspects. Belief is also measured with four items that depict how the student feels the education influences sustainability in society.

Therefore, these scales for empathy, attitude and belief may need adapting and validating in different disciplines and contexts.

As the competence for intrapersonal thinking for sustainability is a relatively new addition to the KSC framework, much could be learnt from future studies about how to best measure this competence. Starting from prior research could help a validation study to begin this journey, but it is likely that results will differ between disciplines and contexts. However, much could be learnt about how best to address intrapersonal competence for sustainability from the research that has discussed pedagogical approaches to develop self-awareness skills for sustainability (Shephard, 2008; Sipos *et al.*, 2008).

4.1.7 Implementational thinking. Implementational thinking competency (de Haan, 2006; Salgado *et al.*, 2018) is the ability to act on sustainability strategies to provide valuable transformation solutions to sustainability problems. The competence to act for sustainability has been readily discussed in SHE research (Brundiers *et al.*, 2020; Holdsworth *et al.*, 2020; Lozano *et al.*, 2017; Wals, 2014). Implementational competency, however, is a relatively new addition to the KSC framework.

The competence to act for sustainability can be found in the applied science disciplines, such as engineering, law and business. If students cannot use what they have learnt to actively transform society towards a sustainable future, then the education for sustainability that the students received would be less valuable. Thus, the implementational thinking competence for sustainability could be considered the most important competence of the whole framework.

Holdsworth *et al.* (2020) applied the theory of planned behaviour (Ajzen, 2015; Ajzen and Fishbein, 1980) to assess how students' attitudes, norms and intentions to act can lead to actual behaviour for sustainability. The actual behaviour for sustainability in their model (Holdsworth *et al.*, 2020) is described in a similar manner to that in the discussion of Brundiers *et al.* (2020) about applying implementation competency for sustainability in the KSC framework. Ploum *et al.* (2018b) and Brandt *et al.* (2019) also incorporated several self-efficacy scales from prior research because they stated that motivational and attitude changes for sustainability action are most important when developing sustainability competencies in students.

Lans *et al.* (2014) used four items that describe an ability to act on strategies for sustainability. Also, in the validation study of Ploum *et al.* (2018b) of a KSC survey first designed by Lans *et al.* (2014) with students of entrepreneurship, two of the items that measured action thinking competence loaded on the strategic thinking competence factor and two other action thinking competence items loaded on the values thinking competence factor. This result suggests that the action thinking competence items are not discriminately valid as an individual factor. Bianchi *et al.* (2022) also designed several items for action competence, but most do not address an ability to take action. Further validation studies in different contexts are needed.

4.1.8 Integrative problem solving. Integrative problem-solving competency (Hull *et al.*, 2016; Jegstad and Sinnes, 2015) is the ability to apply all other sustainability competencies in a collective and coherent manner to solve complex, and sometimes wicked (Lönngren and van Poeck, 2021), sustainability problems. This competence is yet to be measured but could be considered the summative total of all other measurements. Barth *et al.* (2007) discussed how problem-solving competencies can be acquired through the process of gaining all other sustainability competencies, best achieved through practical and interdisciplinary means.

Hull *et al.* (2016) suggest that the competence for integrative problem-solving is its own competence and could be considered as the ability to define the wicked problem of sustainability challenges; resist professional bias; and negotiate, test and redefine for what

is needed and emerges. Bianchi *et al.* (2022) define what they call the problem framing competence as the knowledge, skills and abilities to identify, formulate, mitigate and adapt to sustainability problems. Therefore, integrated problem-solving competence could be considered the ability to:

- identify the values, the system, collaborators and possible futures of the problem;
- formulate the strategy that can solve the problem; and
- draw from the intrapersonal skills and act to mitigate and adapt to the problem for sustainability.

Although the studies of Savage *et al.* (2015) and Meza *et al.* (2018) did not measure intrapersonal and implementational competencies with their questionnaire survey, the pedagogical activities used to teach the students had helped to develop personal reflections and the confidence for students to want to act for sustainability transformations. Savage *et al.* (2015) suggested that this type of intrapersonal thinking competence is therefore key when building the students KSC. The framework of Brundiers *et al.* (2020) also suggests that intrapersonal thinking competency for sustainability has an influence on how all other competencies develop.

However, in an empirical study, Meza *et al.* (2018) showed that interpersonal thinking competency is reflected in all other competencies (the items loaded across other competencies) and suggest that collaboration is most important for sustainability transformations. Molderez and Fonseca (2018) also state that collaborating with multidisciplinary diverse groups with multiple stakeholders is essential for sustainability education. In addition, the Redman and Wiek (2021) framework for KSC suggests that interpersonal and intrapersonal thinking competency both independently influence integrating problem-solving competency, while systems, strategic, futures and values thinking competencies together influence integrative problem-solving competency.

The validation study of Ploum *et al.* (2018b) of the Lans *et al.* (2014) competency framework showed support for the findings that action competence overlaps with strategic competence (the items loaded on the same factor). This result suggests that strategic competence is vital for students to build the confidence to act for sustainability transformations. However, this could be discipline-specific, as the students are in entrepreneurship, which is a discipline that trains students to plan for an idea to be put into action.

Moreover, Lans *et al.* (2014) showed that it is the values thinking competency that differentiates sustainability competency to other disciplinary competencies, in their case with entrepreneurship competence. The authors suggested that it is therefore values thinking competency that can drive the other competencies, as students need to be able to reflect on problems from a sustainability perspective. Bianchi *et al.* (2022) provide a beehive visualisation of their KSC discussion, showing that the beehive home is where values thinking can be developed and support the bee's intrapersonal and interpersonal competence learning. In turn, the bees will gain the confidence to leave the beehive to act on the sustainability problems using their systems, strategic and futures thinking competencies. Thus, Bianchi *et al.* (2022) support the notion that values thinking competence is the main driver of all other sustainability competence-building.

However, as there is a difference in opinion about how integration of problem-solving competency for sustainability may be influenced, more needs to be investigated in regard to this competency. The competency is rarely considered its own competency in the research that has produced measurable scales for the KSCs. While several of the other competencies

may influence each other in the journey that is taken to learn more for sustainability, all seven competencies influence, and may be influenced by, integrated problem-solving competency for sustainability.

4.2 Proposal for future research

To provide teachers with a transferable and comparable assessment tool between disciplines, measures for the KSCs need to be validated. Much of the SHE research (Redman *et al.*, 2021) has assessed students through field work observations and in-class assignments where teachers have graded their students' outcomes after a sustainability lesson, assignment or real-life experience. Although this research has been informative and has built on how teachers can best provide ESD, comparability and transferability between disciplines can be difficult.

There has been some work done to assess student perceptions of their sustainability competence through questionnaire surveys, but much of the research has used different scales that apply items based on general competency for substantiality or more subject-specific competency (Ateskan and Lane, 2018; Besong and Holland, 2015; Cabral and Lochan Dhar, 2019; Faham *et al.*, 2017; Kricsfalusy *et al.*, 2018). We propose that a survey built on validated scales could be beneficial for teachers to be able to provide a formative assessment of their students' KSCs. In this way, teachers can act on what they learn to develop their lessons for the same student group that takes the formative assessment survey.

There has been some research that has recognised the KSCs and has begun to create assessment tools that represent some of the KSCs. However, there is much space to improve on these assessments, especially to validate the tool in different contexts. We first propose that an assessment tool that can be adaptable to different contexts would be able to deliver information relevant for all teachers.

In addition, more is needed to properly assess intrapersonal and implementation competencies for sustainability across disciplines in higher education. While the new additional KSC competencies can learn from prior research outside the field of education for sustainability research, the studies conducted so far have been based on different scales that have derived different meaning across disciplines. Therefore, our second proposal is that a valid scale that can be comparable between universities within the same discipline, or even comparable across disciplines, will help teachers and institutions gauge how well they have developed their students' competencies for sustainability in their programmes.

Moreover, very little research has begun to measure how integrated problem-solving competency for sustainability can be addressed. It may be suggested that by building all other seven KSCs, the teacher is able to develop integrated problem-solving competency for sustainability. However, we propose that integrated problem-solving competency for sustainability is a separate competence (Figure 1) and therefore requires its own measurement in a scale of all eight KSCs. Furthermore, future research could study all eight KSCs to investigate how the competencies influence each other in different contexts.

An assessment tool for the KSCs can complement the assessments of competencies for the discipline, the professional and general competencies (Redman and Wiek, 2021). An assessment tool can therefore be part of the learning progression (Wilson, 2018) of sustainability within the curriculum of the discipline. Our last proposition is that by developing a valid KSC assessment tool, teachers can be better prepared to develop instruction for their classroom activities to develop the needed student KSC and better

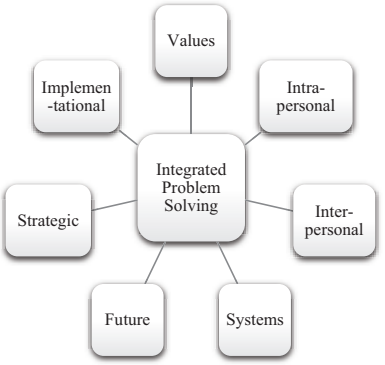

Figure 1.
Eight key sustainability competencies

integrate education for sustainability into the curriculum, thereby working with a learning progression approach.

Consequently, we propose that a validation study for assessment scales about the eight KSCs based on the updated framework of Redman and Wiek (2021), which can be used across disciplines, would greatly benefit teachers and students of higher education. An adaptable formative questionnaire survey could help teachers to learn about what the students already know, so that they can adjust their lesson plans to their students' needs. Students can then receive an informed education for sustainability, which develops their competencies within their discipline.

5. Conclusions

UNESCO has pointed out the importance of the role that education plays in working towards a sustainable future and in achieving the UN's SDGs. In this study, we have discussed the problem of lack of knowledge about student competency in sustainability that educators in higher education face while attempting to integrate sustainability into their education. A formative assessment tool that can measure student KSC could be one way to address this problem and support teacher development.

A review of the current situation regarding education for sustainability survey assessment tools within research has been discussed. We recognise that formative assessments of student KSC can help to support teacher knowledge about student KSC. We also found that although some research has provided some early information about how assessments could be made about student KSC, much more can be done to improve the assessments towards an adaptable and comparable tool that can be relevant for all higher education disciplines.

Several propositions were presented for further validation studies for future research. Further research could benefit the higher education community towards an advance in integration of education for sustainability. A validation study could help higher educators to compare their work with others, so that teachers can learn from each other within our own disciplines and across disciplines and countries.

Note

1. It is, of course, an extremely necessary competence to enable students to transform society towards a sustainable future.

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About the authors

Alice Annelin is an assistant professor working at the School of Business, Economics and Statistics at Umeå university, Sweden. She holds a PhD in Business Administration, and her research interests are in education for sustainability, social innovation and team behaviour. Alice Annelin is the corresponding author and can be contacted at: alice.annelin@umu.se

Gert-Olof Boström is an associate professor working at the School of Business, Economics and Statistics at Umeå university, Sweden. He holds a PhD in Business Administration, and his research interests are in education for sustainability in both the academic and business environments.