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Sustainability education in information systems' curricula: A conceptual research framework

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Abstract

In recent years, "sustainability education" in Higher Education has become an increasingly popular topic among researchers driven by the constant calls for the research community to contribute novel research that can aid in building a sustainable world. The objective of this paper was to explore how sustainability concepts have been integrated in Information Systems (IS) curricula, to determine the state of knowledge in this area and provide guidance for future research. Using Arksey and O'Malley's five-stage scoping review process, the current landscape of sustainability in IS classrooms is mapped and key themes and factors which were found to influence sustainability education in IS are identified. Eight databases were searched for relevant papers published on this topic. Fifteen articles were selected and deemed high quality for a thematic analysis. As a result, nine themes emerged from the thematic analysis, and key research gaps and directions for future research are presented. The findings show that there is currently no unified approach to sustainability education in IS. This paper presents the themes in a novel conceptual research framework which can guide the incorporation of sustainability concepts in IS education. In addition, the framework can be used as the basis for future research in this area.

Keywords Sustainability education · Information systems · Higher education · Conceptual framework · Scoping review

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1 Introduction

Sustainability, as a concept, has been excessively examined in the literature. It is broadly understood as "meeting the resource and services needs of current and future generations without compromising the health of the ecosystems that provide them" (Morelli, 2011, p. 5). Sustainability is often associated and used interchangeably with the term "Sustainable Development (SD)" (Ruggerio, 2021). The Brundtland Commission defines SD as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Abd-Elwahed & Al-Bahi, 2021, p. 634). Since its emergence in the 1970s, SD has become a pressing need and challenge with far-reaching concerns surrounding the achievement of the sustainability goals of the 21st century. In 2015, the United Nation (UN) General Assembly endorsed the 2030 agenda for SD, which includes 17 Sustainable Development Goals (SDGs) (Leal Filho et al., 2023). The goals pursued are integrated in nature, broad and complex, with considerable coverage of the economic, social and environmental dimensions of sustainability (Allen et al., 2019). At the centre of such sustainability initiatives are Information Systems (IS) which were shown to have an "increasing impact on individual well-being, the environment, and our society" (Winkler & Spiekermann, 2019, p. 42).

Lately, a number of new subfields and areas of investigation emerged including "Green IS" (Pernici et al., 2012), "Responsible IS" (Davison et al., 2019), and "Energy Informatics" (Watson et al., 2010) among others. Nonetheless, IS researchers have been urged to play an active role in the continuing efforts to tackle UN's SDGs (Pan & Zhang, 2020), as well as building capabilities in digital sustainability (Vassilakopoulou & Hustad, 2023). Researchers such as (Baskaran, 2022) posit that IS, namely Geographic Information Systems (GIS) are essential to creating and sharing SDG data, thus significantly aiding in monitoring and accessing the goals. Moreover, the literature shows that there has been a rising trend towards investigating sustainability issues in various Information Communication Technology (ICT) contexts, such as analysing the dynamic linkages between technology factors and carbon emission (Anser et al., 2021).

Despite the proliferation of studies that examine sustainability from an ICT lens, there is currently a lack of sufficient empirical studies that investigate sustainability education in ICT settings, including IS programmes (Angelaki et al., 2023). This limited effort in IS education has inevitably contributed to the inadequate changes in the practice of IS to address sustainability issues, given that graduates finish their programs with a minimal understanding of sustainability concerns (Corbett, 2023). Integrating sustainability in the IS curriculum can promote a sustainable society (Klimova et al., 2016), which would increase the number of IT professionals with sustainable and eco-friendly knowledge and practices. In addition, sustainability inclusion in IS design and development courses will help students apply sustainability concepts in core IS practices such analysis processes, ultimately achieving different dimensions of sustainability and reducing long-term impacts on the environment and society (Mishra & Mishra, 2020).

Accordingly, there is a need for more in-depth exploration of how sustainability can be incorporated in the IS domain and the role that universities and other Higher

Education Institutions (HEIs) can play to support this initiative. So far, few attempts have been made to sustainability awareness, training, and education, which could enable its implementation in the broader IS community (Watson et al., 2021). While many channels can be explored to enhance sustainability awareness and training, this study focuses on how the IS community integrates sustainability concepts in IS curricula at HEIs.

2 Sustainability education in IS curricula

HEIs are hubs for knowledge creation and dissemination, hence the implementation of sustainability concepts in HEIs is crucial "as it creates awareness of environmental challenges, supports knowledge about sustainability and raises critical thinking among students" (Alm et al., 2022, p. 61). In the context of Higher Education (HE), IS courses can play a pivotal role in educating students to adopt an interdisciplinary approach to understanding and solving complex problems such as sustainability (Hamadi & El-Den, 2024). Integrating sustainability in IS courses can improve awareness among students and IT professionals (Penzenstadler & Bauer, 2012) and generate sustainability ambassadors (Klimova et al., 2016). The literature includes various attempts that have been made such as TERI university's integration of SD principles and philosophies of learning for SD in its courses on applied sciences and policy studies (Jain et al., 2013). The University of Cape Town integrated Green IS theory and practice into the curriculum of undergraduates majoring in IS (McGibbon & Van Belle, 2015). Other universities have developed courses and degrees including green computing, environmental informatics, and pervasive computing and communications for SD, all aiming at developing skills and competence in ICT, green ICT, and ICT for greening (Klimova et al., 2016).

IS educators can integrate sustainability concepts, dimensions, and applications across core IS courses to promote the inclusion of sustainability in IS development, design, and management (Mishra & Mishra, 2020). For instance, teaching the traditional Systems Development Life Cycle (SDLC) – a major learning topic in IS courses aims to equip students with the knowledge about the analysis, design, and development of systems to address business needs. However, it does not necessarily include sustainability as part of its core processes and activities (Nyström & Mustaquim, 2014). Incorporating the concept of sustainability in the SDLC will not only support an effective digital transformation, but can also reduce the environmental problems caused by ICT (Huang, 2009), thereby enabling the achievement of organisations' strategic SDGs including the UN's SDGs. Although the majority of available research focus on the sustainability of end products, i.e., systems (McGuire et al., 2023), the literature includes several studies which examine the impacts of software/systems' development life cycle on the environment (Kern et al., 2013). Studies such as (Kern et al., 2015) proposed carbon footprint calculation methods in the development processes. Others such as (Capra et al., 2012) found that different designs can have a propound impact on the energy efficiency of software applications. This finding is corroborated by others studies such as (Venters et al., 2023) which argues

that design decisions at the development stage, which are manifested by software architectures, are fundamental to the development of sustainable software systems.

It is evident that the IS community has emphasised the integration of sustainability in IS research and the transformation of institutional practices towards using IS sustainably (Pan & Zhang, 2020). However, there is little concrete direction on how to integrate sustainability topics in IS curricula (Corbett, 2023), which raises critical questions about the optimal integration approaches of sustainability concepts in IS education (Klimova et al., 2016). As a result, the literature includes constant calls for the IS community to focus efforts on identifying core skills, knowledge and competences that must be developed through sustainability education in IS (Watson et al., 2021). This research aims to thoroughly investigate the integration of sustainability in IS's HE programs. The paper adopts a rigorous scoping review approach to synthesise and organise the knowledge in this area to inform educational initiatives on IS sustainability.

3 Methodology

This paper follows a scoping review approach to map and explore the available literature on sustainability education in IS. Given the complex nature of this area and since this topic has not been reviewed comprehensively before, a scoping review approach was found to be appropriate as it covers a preliminary evaluation of the extent and potential size of the body of the research that is currently available (Arksey & O'Malley, 2005; Mays et al., 2001). The methodology for this review was adopted from (Arksey & O'Malley, 2005)'s framework as well as available scoping review guidelines (Munn et al., 2018; Peters et al., 2015). Arksey and O'Malley (2005) described five stages for conducting a scoping study (below) which were integrated throughout this paper:

- Identifying the research question
- Identifying relevant studies
- Study selection
- Charting the data
- Collating, summarising, and reporting the results

3.1 The research question

This study focuses on the integration of sustainability concepts in HE IS classrooms. The scoping review addresses the following question:

- What is known from the literature about sustainability education in IS curricula and the key factors shown to influence sustainability in IS classrooms?

Table 1 Boolean expressions used in the search process

Combination 1:	Combination 2:	Combination 3:
[Title: sustainability] AND [[Abstract: "higher education"] OR [Abstract: "university"] AND [Abstract: information system]	[Title: sustainability] AND [[Abstract: "higher education"] OR [Abstract: "university" OR [Abstract: "learning"]] AND [Abstract: information system]	[Title: "sustainability"] AND [[Abstract: "higher education"] AND [Anywhere: information system]

Table 2 The predefined inclusion criteria

Question	Check
1. Was the focus of the study on Sustainability in Higher Education (HE) settings?	
2. Did the study directly address Sustainability issues in HE classroom environments?	
3. Did the study address sustainability issues in IS curricula?	
4. Were the sources used in the build-up for the study considered credible, and relevant for the purpose of addressing current sustainability issues in HE environments?	
5. Were the study's methods considered credible and valid for the purpose of addressing the research questions?	
6. Was the data gathering methods used in the study (if applicable) considered appropriate, reliable, and accurate?	
7. Did the findings address the research question directly?	
8. Has the study produced/supported unique results in this area of research?	

3.2 Identifying relevant studies

This scoping review used eight electronic databases, namely, ACM, Web of Science, IEEE Xplore, AIS eLibrary, Scopus, Springer, Proquest and ScienceDirect. The scoping review started with a literature search which was conducted to identify peer-reviewed, papers published in English language and relevant academic literature. Due to the sheer number of irrelevant articles captured in the initial search, the Boolean search expressions, as shown in Table 1, were used to narrow down the search results. Nonetheless, the search queries were formatted according to the requirements of each database to ensure appropriate search results. For screening and data abstraction of the articles, a manual process was applied in examining preliminary and full-text screening based on the following stages:

- Initial screening: title, abstract and aims were examined and assessed to determine the relevance to the research question of this study.
- Full-text screening: the full text of each manuscript was examined and assessed according to the inclusion criteria as in Table 2. Only articles that met the specified criteria in Table 2 were included in the thematic analysis.

3.3 Study selection

The initial search produced a sample of articles including a large number of irrelevant and duplicate studies. Articles were excluded before initial screening if they were

duplicates, not in English language, or due to document type and resource availability. Articles were excluded if they focussed on sustainability in non-computing courses, or general ICT and computing degrees but did not sufficiently examine sustainability in IS courses. Before inclusions and exclusions, the authors decided on the article selection and discussed discrepancies. The studies were included for review if they met the predefined inclusion criteria shown in Table 2. In total, 15 articles that were identified for inclusion in this review after screening the full text as shown in (Fig. 1).

4 Findings and discussion

The sample of selected studies examined sustainability education in IS from various perspectives. This section provides a summary of the review, outlining the distribution and categorisation of articles, the methods adopted, as well as the themes identified in the thematic analysis.

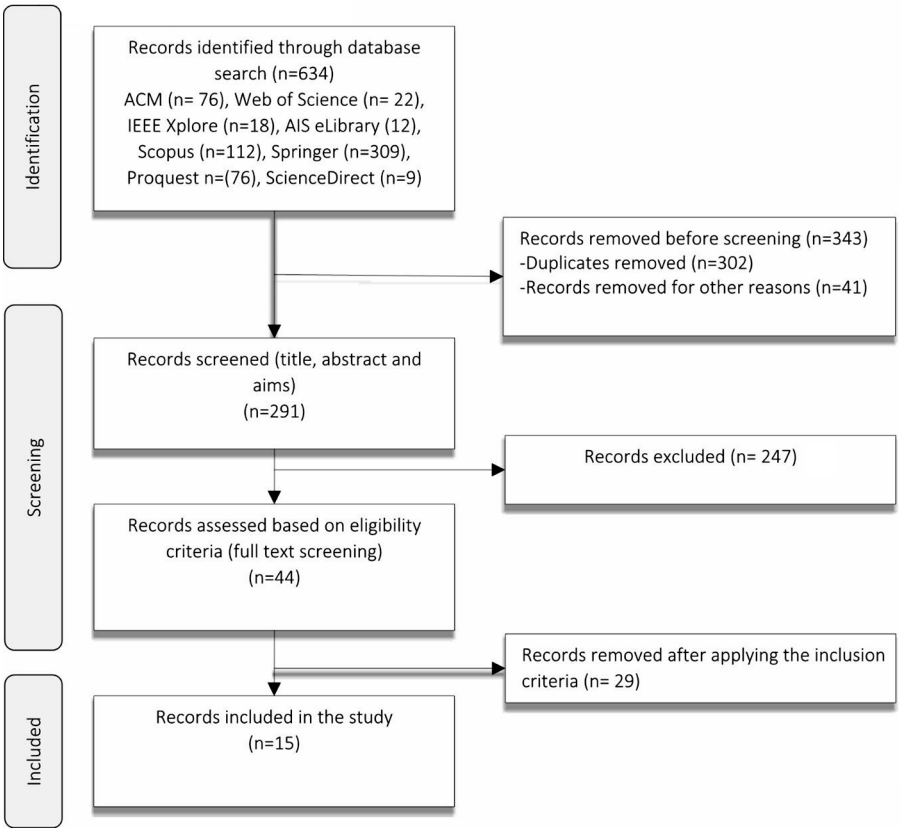

Fig. 1 Search and selection process

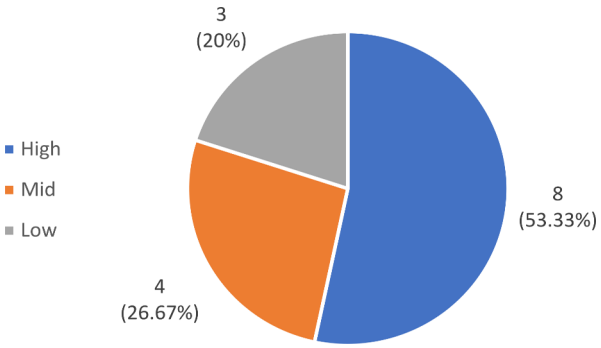

Fig. 2 Relevance rating for the reviewed papers

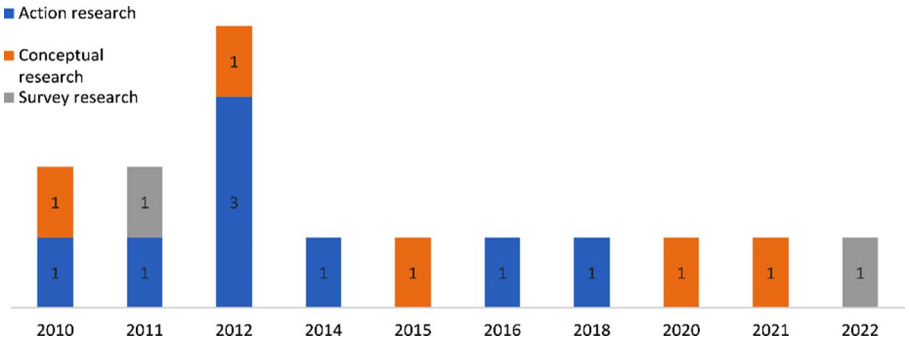

Fig. 3 Yearly distribution and type of research of the reviewed papers

4.1 Current landscape of research focusing on integrating sustainability in IS curricula

Figure 2 shows the distribution of papers based on the ?relevance? ratings assigned by the authors. Papers with a High rating (53.33%) corresponds to articles that explicitly investigated the integration of sustainability in IS courses or majors within HE?s undergraduate and/or postgraduate degrees. These studies incorporated strategies, techniques, and recommendations with explicit aims to integrate and/or evaluate sustainability education in IS classrooms. Papers rated as Mid (26.67%) do not directly investigate sustainability in IS majors but address sustainability education in general IT/Computing degrees with a sufficient discussion of the implications on IS majors. Lastly, papers rated as Low (20%) do not belong to the IS discipline as they primarily focus on sustainability in software engineering courses, however they include highly relevant aspects of ISs and systems development learning content. Nonetheless, both mid and low rated papers contain highly relevant elements that contributed valuable insights and knowledge on the topic.

Figure 3 depicts the yearly trajectory of published articles focusing on sustainability in IS curricula. It is evident from the figure that the year (2012) saw the highest volume of published papers, with Action Research methods taking the lead in terms of dominant research approach. The authors of the research sample originated from

several countries including USA (5 papers), European countries (5 papers), Australia (2 papers), Indonesia (1 paper), T?rkiye (1 paper), and South Africa (1 paper).

4.2 Thematic analysis results

As part of "charting the data" stage, the following data were extracted from the articles: keywords, aim of the study, year, location, research type/methods, research questions/objectives, major outcomes, and recommendations. Next, a thematic content analysis was conducted on the collected data to identify common patterns and themes in the research sample. The authors adopted Braun and Clarke (2006)'s six-phase guide to conduct a thematic review on the collected data. The six-phase guide includes familiarisation with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report (Braun & Clarke, 2006). Nine themes emerged from the thematic analysis of charted data and are provided in Table 3 below. The themes and factors were incorporated in a proposed research framework as shown in (Fig. 4) which forms the basis for the thematic analysis presented in the following subsections (4.2.1 to 4.2.10). The framework is discussed and applied to organise and critically review the findings under each theme. Nonetheless, the framework can be used as basis for future research by enabling researchers to concentrate their efforts and place their contributions in an overall context, thus aiding in building a coherent body of knowledge in this research area.

4.2.1 Motivations

The topics covered under this theme include diverse motives and drivers for integrating sustainability in IS curricula as commonly identified in the research sample. In essence, the motivations stem from the recognition that our planet faces grand environmental challenges and the urgent need for IS students to develop a deep understanding of sustainability concepts. Studies such as (Klimova et al., 2016) reported that sustainability in IS curriculum is anticipated to aid the shift towards a sustainable society by facilitating the efforts of organisations and individuals in minimizing the environmental impact of their ICT footprint. Mishra and Mishra (2020) emphasized the importance of future ICT professionals adopting sustainable and eco-friendly practices in planning and developing solutions within the ICT sector, to ensure a greener and more responsible IS practices.

According to (Klimova et al., 2016; Mishra & Mishra, 2020; Richards et al., 2011), sustainability in IS education holds vital importance as it equips IS graduates with new skills and competencies related to sustainability which are growing in demand in the industry. Given that a primary objective of higher education is to produce job ready graduates, it becomes crucial to address the changes in skills' needs within industries. Hence, by incorporating sustainability into IS courses, students are expected to comprehend the interconnectedness of social, economic, and environmental systems, fostering critical thinking and problem-solving skills necessary for addressing complex sustainability issues (Issa et al., 2014). In addition, (Issa et al., 2014) suggests that sustainability in IS education can encourage students' critical

Table 3 Emergent themes from the reviewed articles

Theme	Definition	Source(s)
1. Motivations	Motives and drivers for integrating sustainability concepts in IS curriculum	(Cai, 2010; Calloway, 2011; Issa et al., 2014; Klimova et al., 2016; Mishra & Mishra, 2020; Turkin & Vykhodets, 2018)
2. Sustainability integration approaches and strategies	Strategies and approaches to implement sustainability related learning materials in IS curriculum.	(Cai, 2010; Calloway, 2011; Issa et al., 2014; Özkan & Mishra, 2015; Penzenstadler & Bauer, 2012; Robila, 2012; Watson et al., 2021)
3. Pedagogy	Pedagogical approaches adopted for teaching sustainability concepts in IS classrooms	(Issa et al., 2014; Oktavia et al., 2022; Özkan & Mishra, 2015; Penzenstadler & Bauer, 2012; Richards et al., 2011; Scott et al., 2012)
4. Classroom educational tools and technologies	Educational tools adopted for teaching sustainability concepts in IS	(Issa et al., 2014; Oktavia et al., 2022; Özkan & Mishra, 2015; Penzenstadler & Bauer, 2012)
5. Emphasised sustainability education topics in IS	Sustainability related topics and concepts emphasised in IS education	(Cai, 2010; Calloway, 2011; Issa et al., 2014; Klimova et al., 2016; Mishra & Mishra, 2020; Özkan & Mishra, 2015; Penzenstadler & Bauer, 2012; Richards et al., 2011; Robila, 2012; Scott et al., 2012; Turkin & Vykhodets, 2018; Watson et al., 2010, 2012)
6. Evaluation of sustainability infused IS courses	Methods and techniques used to assess the effectiveness of sustainability education in IS classrooms	(Cai, 2010; Issa et al., 2014; Robila, 2012; Scott et al., 2012)
7. IS Graduate attributes and skills	Key graduate attributes and skills to be addressed in sustainability infused IS curriculum	(Cai, 2010; Calloway, 2011; Klimova et al., 2016; Penzenstadler & Bauer, 2012; Richards et al., 2011; Scott et al., 2012; Turkin & Vykhodets, 2018; Watson et al., 2010, 2012, 2021)
8. Engaging external stakeholders in sustainability education	Approaches for engaging external stakeholders in sustainability infused IS classrooms	(Klimova et al., 2016; Özkan & Mishra, 2015; Penzenstadler & Bauer, 2012; Watson et al., 2021)
9. Challenges and barriers	Challenges and barriers to integrating sustainability in IS curriculum	(Cai, 2010; Klimova et al., 2016; Özkan & Mishra, 2015; Penzenstadler & Bauer, 2012; Richards et al., 2011; Robila, 2012; Scott et al., 2012; Turkin & Vykhodets, 2018; Watson et al., 2010, 2021)

thinking regarding the opportunities and risks of using ICT in their studies as well in the workforce in the future.

4.2.2 Sustainability integration approaches

The research sample exhibits a consistent focus on the theme of 'sustainability integration approaches' in IS courses and programs. The thematic analysis shows various approaches and strategies proposed by researchers in this field to facilitate the integration of sustainability in IS education as depicted in Table 4. These diverse integration approaches highlight the complexity and multidimensionality of this topic, emphasizing the need for further empirical research. Collectively, the contributions of the reviewed studies provide a comprehensive understanding of this theme and contribute to the advancement of knowledge in this area.

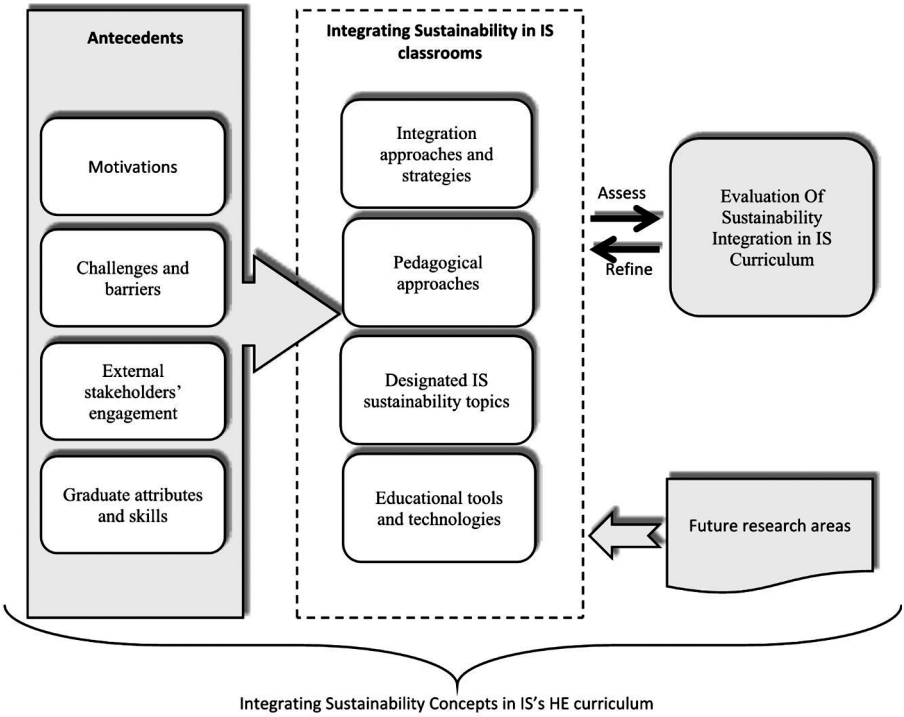

Fig. 4 The proposed research framework

Table 4 Summary of commonly adopted approaches to integrating sustainability in IS courses

Approach	Description	Source(s)
Integration as a new course	Developing a new sustainability course (unit) within the IS programme	(Cai, 2010; Issa et al., 2014; Klimova et al., 2016)
Redesigning existing course(s)	Redesigning an existing course with emphasis on sustainability as a major leaning outcome	(Cai, 2010; Mishra & Mishra, 2020)
Designing independent modules, seminars and/or projects	These educational resources can be plugged into existing courses (shared across courses).	(Cai, 2010; Oktavia et al., 2022; Scott et al., 2012)
Integration early in the degree	Preference for integrating sustainability education in IS in first year/semester and undergraduate degrees.	(Cai, 2010; Penzenstadler & Bauer, 2012)
Centralised design	The sustainability infused course should only be applicable to ICT programs.	(Klimova et al., 2016; Özkan & Mishra, 2015)

4.2.3 Pedagogy

An important theme that emerged from the scoping review was "pedagogical approaches" adopted to effectively teach sustainability in IS courses. The reviewed studies suggest various pedagogy approaches which can be employed by educators and tailored to different learning styles and objectives. Above all, active learning

approaches were found to be the most commonly used methods to actively engage students with sustainability related learning materials. Some studies included specific pedagogical approach such as group-based learning (Penzenstadler & Bauer, 2012) or project-based learning (Oktavia et al., 2022; Scott et al., 2012). Other studies such as (Issa et al., 2014) suggested mixed approaches including traditional methods and collaborative learning approaches. Nonetheless, the review shows an emphasis on classroom's communications and students' collaboration as critical drivers for integrating sustainability in IS classrooms. In addition, problem-solving and experiential learning approaches were suggested as effective methods to foster critical thinking, problem-solving skills, and deeper understanding of sustainability topics (Richards et al., 2011; Scott et al., 2012).

The outcomes from the thematic analysis showed that researchers adopted various techniques and methods to encourage students' communications and collaborations, as well as promoting a deeper understanding of sustainability concepts among IS students. For instance, (Issa et al., 2014) used regular reflections and students' journals to enhance student engagement, motivation, and knowledge retention. Scott et al. (2012) employed mini-deliverables and brainstorming sessions to achieve similar results. Additionally, the review found that researchers followed several classroom techniques to deliver substantiality related learning materials such as using professional workshops, seminars, interactive seminars and lectures, traditional workshops (Robila, 2012). The work of (Scott et al., 2012) presented other techniques such as on-campus pilot projects, while (Richards et al., 2011) suggested learning outside the classroom and community problem solving as effective approaches to achieve the objectives of sustainability integration in IS courses. An interesting take on pedagogical approaches for sustainability integration in IS education emphasized the importance of students' incentives to participate and engage in sustainability related learning activities (Penzenstadler & Bauer, 2012). Nevertheless, other pedagogy approaches such as flipped learning were found to improve students' motivations in IS classrooms (Meyliana et al., 2021).

4.2.4 Classroom educational tools and technologies

The thematic analysis revealed a range of commonly used tools and resources employed to teach sustainability in IS courses. The findings are presented in Table 5 below which shows the tools and resources along with the respective researchers suggesting their use. The integration of these educational tools and technologies in

Table 5 Summary of common educational tools and technologies reported in the reviewed sample

Tool	Source (s)
Interactive presentations	(Özkan & Mishra, 2015; Penzenstadler & Bauer, 2012)
Wikis	(Issa et al., 2014; Penzenstadler & Bauer, 2012)
Online project collaborations	(Oktavia et al., 2022)
Traditional methods e.g., traditional lecture, reports, exams, etc.	(Klimova et al., 2016; Özkan & Mishra, 2015; Robila, 2012)
Reflective journal entries	(Issa et al., 2014)

teaching sustainability in IS courses was reported to have positive outcomes, indicating their potential to enhance the learning experience and support IS students' understanding of sustainability principles. Nonetheless, further research is needed to explore their effectiveness across different IS areas and student populations as well as to investigate the use of other emerging educational technologies such as Artificial Intelligence (AI)-based tools.

4.2.5 IS sustainability topics

Another theme that was recurrent throughout the majority of reviewed papers was "IS sustainability topics." The studies identified several sustainability related topics that were considered as essential for inclusion in IS classroom teaching. These topics encompass a range of subjects and aim to enhance students' knowledge, and overall educational experience regarding sustainability and IS. The following Table 6 provides a summary of these topics as commonly reported in the research sample. By incorporating these topics into IS classroom instruction, educators can help foster comprehensive learning experiences that address the complex nature of sustainability integration in IS courses.

4.2.6 Assessing the effectiveness of the implement sustainability course

This theme includes studies that adopted some type of evaluation methods to assess sustainability infused classroom teaching. It is noted that all the reviewed studies

Table 6 Summary of commonly reported sustainability defiant in IS topics

Topic	Sub-topics	Source (s)
Green IS	• Theoretical frameworks of Green IS • Sustainability in the systems analysis and design core processes • Impacts of ISs on economic viability, social responsibility, environment, and other ecologic aspects. • Contributing the information component of engineering solutions and solving the problems of Software Engineering • Big data and Server virtualization	(Issa et al., 2014; Mishra & Mishra, 2020; Richards et al., 2011; Robila, 2012; Watson et al., 2010, 2012)
Green IT	• Green computing • Using ISs and Technology to achieve UN's SDGs • Sustainability Oriented Human Computer Interaction	(Klimova et al., 2016; Mishra & Mishra, 2020; Özkan & Mishra, 2015; Watson et al., 2012)
Impacts of ICT on the environment	• Waste disposal • Recycling and clean production • Impacts of data centres on the environment • Greenwashing • Computing impact carbon footprint • Energy efficiency	(Calloway, 2011; Issa et al., 2014; Penzenstadler & Bauer, 2012; Richards et al., 2011; Scott et al., 2012)
Ethics and sustainability	• IT ethics • Social responsibility	(Özkan & Mishra, 2015; Penzenstadler & Bauer, 2012; Watson et al., 2010, 2021)

which involved an action research approach incorporated a method to assess and evaluate the overall learning objectives of the course. Table 7 below shows common reported methods for evaluating sustainability and IS courses as found in the reviewed papers. Course evaluation provides valuable insights into the overall impact and success of the teaching approach, enabling educators to make informed decisions for future improvements. By utilizing a systematic evaluation approach, educators can gather valuable feedback to identifying areas of improvement, measuring the overall learning outcomes achieved by students and ensure continuous improvement in their T&L activities. In addition, it enables continuous improvements and refinements of the instructional design of sustainability and IS courses.

4.2.7 Graduate attributes and skills

The topics covered under this theme include major graduates' skills and attributes that were recognised as valuable outcomes of sustainability and IS courses in the research sample. These skills and attributes are proposed to better meet the needs of IS students and industry, and as such it is important to integrate them into the IS curriculum. One important skill is "competency in designing environmentally sustainable organisational practices" as suggested by (Watson et al., 2010, p. 32). IS Graduates need to develop the skill and ability needed to develop strategies which monitor and, ideally, align the organisation's practices with its sustainability development goals (Watson et al., 2010). This skill entails an adequate understanding of the environmental impact of ISs and the importance of co-designing and co-managing these systems to achieve higher levels of energy efficiency and utilization (Cai, 2010; Watson et al., 2012). Turkin and Vykhodets (2018) suggests that IS graduates should be trained to be able to determine the goal and strategy of sustainable software development in accordance with organisations' policies in the field of SD. Ultimately, IS graduates should be able to demonstrate an adequate understanding of the complex issues related to global information and communications technologies, sustainability and the Millennium Development Goals (MDGs) (Calloway, 2011; Watson et al., 2021). In addition, the research sample outlined soft skills, technical, business, and green skills as essential graduate skills to consider in sustainability infused IS course (Klimova et al., 2016; Richards et al., 2011). Hence, IS graduates will be able to contribute to creating more environmentally conscious and resource-efficient organisations as well as supporting the organisations efforts to achieve their sustainability development goals.

Table 7 Summary of commonly reported methods for evaluating sustainability infused IS classrooms

Method	Source(s)
Exit surveys	(Cai, 2010; Robila, 2012)
Traditional assessment items	(Issa et al., 2014; Mishra & Mishra, 2020; Oktavia et al., 2022; Scott et al., 2012)
In class Q&A	(Özkan & Mishra, 2015)
students' self-evaluation	(Robila, 2012)

4.2.8 Engaging external stakeholders in IS and sustainability education

The review found a common reported theme relating to engaging external stakeholders in sustainability and IS education. Given the complex and interdisciplinary nature of sustainability concepts and initiatives, the reviewed papers suggested that "external engagement" can play a pivotal role in fostering a multidisciplinary approach towards sustainability and IS and address its complex challenges (Klimova et al., 2016). Accordingly, external engagement enables a more comprehensive understanding of contemporary sustainability issues and solutions, thus enriching the knowledge and expertise of students.

Penzenstadler and Bauer (2012) suggested that external engagement can be achieved by inviting researchers from other disciplines and industry to give input during IS lectures and seminars. Watson et al. (2021) emphasised the importance of collaborating with external bodies to build awareness of sustainability challenges and acquire the necessary capacities to tackle them. These external bodies are not limited to researchers from other disciplines but also include "businesses and business groups, government and semi-governmental organisations and groups, Societal organisations, and groups for social inclusion" as well as professional bodies and philanthropic organisations (Watson et al., 2021, p. 483).

Özkan and Mishra (2015) proposed field visits to ICT organisations and/or data centres as an effective strategy to engage students firsthand with organisations that have implemented valuable practices within the context of sustainability and IS. In addition, Klimova et al. (2016) suggested involving companies in IS programs to provide students with practical knowledge about ecological aspects.

4.2.9 Challenges and barriers

The factors and topics related to the "Challenges and barriers" theme appeared to be diverse and expanding due to the complex nature of this topic, and due to more research surfacing in this area. The following Table 8 provides a summary of common challenges and barries identified in the thematic analysis.

4.2.10 Summary of findings and future research directions

The ongoing study of incorporating sustainability concepts in IS courses is critical for the development of optimal and effective integration frameworks and guides which are currently lacking in the literature. Hence, the first natural direction for future research includes the need for more empirical research to extend the current body of knowledge in this area. More empirical research projects are needed to examine the identified themes in this paper as well as introducing new factors and drivers in the context of sustainability and IS education which could ultimately be incorporated in future integration guides and frameworks. Nonetheless, several critical future research areas emerged from the thematic analysis. The developed research framework shown in (Fig. 4) depicts these areas in a document shape and arrow to indicate that much research remains to be done that could contribute to refine and identify more factors and strategies that relate to successful integration of sustain-

Table 8 Summary of commonly reported challenges and barriers of sustainability education in IS

Factor	Description
Lack of interest	Educators and students may not be convinced of the relevance of sustainability in IS courses.
Resistance to change	Educators can show resistance to change in their T&L approach to accommodate sustainability education.
Staff training	Training educators can be challenging due several factors such as complex nature of sustainability education.
Lack of tradition	The need for a shift towards the new sustainable model in IS education
Lack of priority	Integrating sustainability in IS may not be a top priority in the curriculum.
Lack of educational resources	Lack of educational resources including cases and textbook chapters dedicated to sustainability education in IS.
Isolated approaches to integrate sustainability in IS Curriculum	Lack of established integration standards and approaches.
Complexities in sustainability education	IS and sustainability courses may need to be specific to cultures, languages, and educational levels across countries as well as in regions within the same countries. In addition, systems' complexity requires multi-disciplinary knowledge in their design and analysis.
Lack of awareness	Educators and students may not be aware of the future role graduates can play in this area as well as the sustainability skills in-demand in the industry.
Lack of educational standards	Lack of sustainable IS industry requirements, best practices of sustainability education and standards of green computing technologies.
Differences between industry expectations and graduates' abilities	The issue of aligning green ICT graduate attributes with industry expectations and in-demand skills.

ability concepts in IS courses. The discussion below lays out some of the major and immediately accessible avenues for future research in this area.

Although the majority of reviewed studies incorporated some type of assessment and evaluation methods to determine the impact of sustainability and IS courses in classroom settings, assessing the long-term effect of such courses on students' interests, behaviours and future industry practices and decisions remains vague and extremely challenging task (Penzenstadler & Bauer, 2012). Hence, more studies are needed to investigate the long-term impact of sustainability education in IS courses as well as the development of practical comprehensive methods to assess the impacts of these courses. This approach, among others, involves the inclusion of sustainability issues in the ICT curricula that also provides significant opportunities for HEIs to impact longer-term sustainability in society. By addressing this topic, future studies can contribute valuable insights and innovative approaches to tackle the complex challenges associated with this topic. Nonetheless, future research can pave the way for transformative advancements, and driving effective adoption of sustainability concepts in IS education.

A major challenge to the integration of sustainability in IS courses as identified in the thematic analysis was the resistance to change by stakeholders in the HE sector (Scott et al., 2012). This major challenge calls for further rigorous investigation in future research. Future studies can help in gaining deeper insights into this challenge and its associated factors, thus shedding light on novel solutions, and informing evidence-based decision-making in IS education. Furthermore, understanding the fac-

tors contributing to resistance to change in IS educational environments is essential for keeping pace with the changing needs of HE stakeholders and fostering positive sustainability integration impacts.

In addition, future work should be aimed at developing a comprehensive roadmap for identifying core skills, knowledge and competencies in the context of sustainability education in IS (Watson et al., 2021). The thematic analysis identified a critical gap in the current literature regrading a unified skill set and competencies of IS graduates on sustainability concepts. Future research in this area can establish a comprehensive integration process of sustainability education in IS, fostering cross institutional collaborations, and unlocking new opportunities for effective integration approaches. In addition, future research can examine sustainability education in IS from a top-down approach e.g., implementing changes at the policy level, etc.

The reviewed studies did not indicate the existence of majors or minors in sustainability in IS programs (Watson et al., 2021). Perhaps future researchers can examine the possibilities of designing and developing majors or minors in IS programs which incorporates sustainability as a core component in its design. These newly design majors will enable a comprehensive coverage of sustainability concepts and practices in IS and could be the basis for future empirical studies. Nonetheless, these majors may help in addressing a gap in the current literature which is the lack of connection between IS course offerings and the UN's SDGs (Watson et al., 2021). Hence, more research projects are necessary to investigate effective strategies and techniques to address the UN's SDG through IS courses. In addition, there is a need for more studies that investigates the development of holistic approaches towards sustainable HEIs, which can support an effective implementation of the SDGs (Angelaki et al., 2023).

While the thematic analysis revealed various themes and mixed researchers' perspectives on sustainability infused IS education, it can be argued that the integration of these themes is crucial in order to achieve a holistic understanding of sustainability education in IS. The proposed research framework (Fig. 4) includes the nine overarching themes along with the future research areas that emerged from the analysis. Each of these themes covers several subthemes and factors that should be examined to establish an adequate understanding of the current research works on sustainability education and IS. The research framework has the potential to be the basis for further conceptualization in this area and fostering discussions among researchers in the IS discipline as well as researchers from other disciplines.

5 Conclusion

The current landscape of "sustainability education in IS" research includes diverse perspectives and themes with more research are yet to surface. Although it is becoming evident that integrating sustainability concepts in IS education is a great opportunity for IS curriculum developments, there is a concern that educators may not have a comprehensive understanding of how to effectively translate sustainability education in IS into practice. The scoping review found the literature to be lacking an established integration framework of sustainability in IS curriculum, hence previous

research has been limited to self-reported isolated studies. Following a rigorous thematic analysis, several key themes have emerged, shedding light on key factors and drivers impacting sustainability education in IS classrooms. These themes are presented in the proposed research framework (Fig. 4) which provides valuable insights on this topic and can be the basis for future research in this area. The proposed framework can be used by IS researchers as a guide for studying sustainability education in IS and to develop effective integration strategies and approaches to promote positive impacts of integrating sustainability in IS courses. Furthermore, educators can use this framework to examine factors and drivers that can aid the shift towards sustainability education in IS education.

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Declarations

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