

2023

## Investigating The Perceptions Of Science And Engineering University Educators And Students Around Sustainability Integration And The Role Of Digital Tools

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### Recommended Citation

Giannopoulos, G., Kioupi, V., Oti, A., & Vakhitova, T. (2023). Investigating The Perceptions Of Science And Engineering University Educators And Students Around Sustainability Integration And The Role Of Digital Tools. European Society for Engineering Education (SEFI). DOI: 10.21427/STRG-HW66

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# INVESTIGATING THE PERCEPTIONS OF SCIENCE AND ENGINEERING UNIVERSITY EDUCATORS AND STUDENTS AROUND SUSTAINABILITY INTEGRATION AND THE ROLE OF DIGITAL TOOLS (PRACTICE)

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**Conference Key Areas:** *Embedding Sustainability and Ethics in the Curriculum, Engineering Skills and Competences, Lifelong Learning for a more sustainable world*  
**Keywords:** *Sustainability integration, educational software, staff and student surveys, materials education workshop, whole institution approach*

## ABSTRACT

*Last year we presented the first phase of our on-going research project - a collaboration between researchers at UCL and Academic Development team members at Ansys Ltd on sustainable digital transition in education. The results of the first phase were published in proceedings of the 25th International Conference on Interactive Collaborative Learning (ICL2022). We developed a framework to explore how technology companies, with a focus on education, approach sustainability in education through their products and their practices and what makes them impactful, focusing on a specific case of Ansys Granta EduPack.*

The framework was the amalgamation of two previous analyses that explored i) how learning outcomes associated with the UN Sustainable Development Goals could be used to foster ways in which learning for sustainability can be implemented in Higher Education, and ii) how the same learning outcomes translate to concepts of capital used by companies to assess sustainability impact.

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In this part of the study, we present the second phase of our project, the development of two questionnaires for university students and educators based on the framework, described earlier. The questionnaires focus on assessing sustainability awareness and involvement of staff and students of Science and Engineering Departments in sustainability activities, using a Whole Institution Approach.

In this paper we present preliminary data from the piloting of the questionnaires during a materials education workshop for University Educators organised by Ansys Ltd in Cambridge UK. In the third phase of this research project the questionnaires will be shared more widely with staff and students in science and engineering focused faculties internationally.

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# 1 INTRODUCTION

## 1.1 Sustainability as an Institutional dimension for Universities

Sustainability is a crucial institutional dimension for many Universities as students have been shown to select University departments to study based on their engagement with sustainability and recent surveys they have calculated that 88% of all undergraduate students in the UK would like their courses to be directly related to sustainability and the UN SDGs (Students Organising for Sustainability 2022). Impact and value creation at the job environment is also a factor influencing how recent graduates choose a work place and to quote the above mentioned survey:

*“... the majority of students still say the chance to work in an organisation that makes a difference to environmental and/or social issues is something they would consider at the application stage but 77% would accept an annual salary sacrifice of £1000 to work for an organisation that has a good environmental and social record, down from 80% in 2020-21.” (ibid)*

Sustainability is an interdisciplinary topic and many Universities are recognising the need to equip their students with skills for sustainability as they will enter a complex world of unprecedented change in which they will have to make crucial decisions (Lozano-García, Huisingh, and Delgado-Fabián 2009). Universities are embedding sustainability as either a module within specific disciplines, an elective course that students can take as part of their University studies, an interdisciplinary programme of study at postgraduate level usually and less so at undergraduate level or they are trying to reform their curricula so they embed it as content and pedagogy which is the most complex of all (Kioupi and Voulvoulis 2022).

However, for a University to be truly sustainable, it usually has to embed sustainability using what is called the Whole Institution Approach (WIA) as advocated by UNESCO (Wals 2014). This approach talks about engagement with sustainability through all the dimensions of the institution that is through research, teaching and learning, governance and operation as well as community engagement. This is thought to be a systemic approach to integrate sustainability in an institution as it enables a change of culture in the University and requires committed and inspiring leadership, usually of a transformative nature (Tilbury 2011). It starts with integrating sustainability to the vision and mission of the University so it guides its strategy in how the university operates, does research, provides education and relates to internal and external stakeholders. Some steps on how this can be achieved in terms of using the SDGs as a guiding framework have been discussed in the literature and can be useful in helping University stakeholders start a discussion on what this would look like in their University (Kioupi and Voulvoulis 2019).

Apart from greening the campus initiatives which are important for offering a lived experience of sustainability for students and staff and offering engagement opportunities beyond specific roles, Universities have a social role to fulfil which is linked to the research they conduct. This in the times of existential crises we are currently being faced with could be related with providing solutions to challenges related to the SDGs or even ways forward e.g. solutions to climate change, safe water access, sustainable urban environments or even combating inequality and poverty (Lukman and Glavič 2007; Australia/Pacific SDSN 2017). Through the education they

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offer they can empower their students with sustainability competences, which are complex constellations of knowledge, skills, values, attitudes and behaviours that have to do with tackling problems holistically but also with imagining and enabling alternative sustainable futures (Kioupi & Voulvoulis, 2022). With regards to community engagement, Universities are starting to develop hubs, such as living labs, community spaces in which different departments contribute as testbeds for sustainability but also relationships with local communities, organisations and businesses to offer solutions or to co-produce knowledge with citizens and other professionals and come up with innovative ideas e.g. maker spaces (Leal Filho et al. 2019).

One important area of sustainability integration within a University's teaching practice is through the digital transition and technology companies can be useful in linking their educational offering to clear educational outcomes that will benefit the University's transition as well as help students and staff develop digital skills. This paper links our previously published framework for assessing sustainability integration in educational products of technology companies with the views of educators and students on educational outcomes for sustainability through the design and testing of quantitative measures that aim to research views of how Universities are incorporating the WIA in their realities as well as how educational software for sustainability is perceived and utilised.

## **1.2 Background and rationale**

Sustainable digital transition (SDT) is the name we are using to describe the integration of sustainability in the digital economy and it is linked with "greening the economy" efforts as well as with creating enabling policy to allow for innovation related with environmental, economic and social targets (European DIGITAL SME Alliance n.d.). Education is an important part of the economy as it is related with skills essential for the workforce, as well as with innovation and tackling of pressing challenges. So there is also an effort towards the sustainable digital transition of education by the integration of the UN Sustainable Development Goals in education (Kioupi and Voulvoulis 2019, 2020; Sachs et al. 2019).

In the first phase of our case study, we observed that the SDGs were attached to learning objectives that could be used to influence the cognitive, socio-emotional, and behavioural learning of students (UNESCO 2017). Thereby, the SDGs can contribute to sustainability awareness raising among students. However, in their original form the SDGs were too complex to implement in education. We also observed that the products and practices of EdTech providers had an influence on student learning, although it was not initially clear how the products and services related to learning objectives. We developed a framework to explore relationship between the SDGs, learning objectives, EdTech products and practices. To aid our comprehension we focused on the use of Ansys education-focused software. Details of the framework can be read in a previous publication (Vakhitova et al. 2023).

The findings of the framework indicated that EdTech providers use their CSR (and CR) reports to demonstrate their approaches towards sustainability. In these reports sustainability was viewed as different forms of capital (Maack and Davidsdottir 2015), two of which (human and social) aligned well with the learning objectives of courses that link to sustainability and were aligned in the used Ansys products. We then

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identified which of the SDGs were attached to the learning objectives associated with human and social capital using a previously published framework for integrating the SDGs into educational programmes that takes a systemic approach instead of accounting for separate SDGs (Kioupi 2021).

We highlighted that the framework offers a consistent way by which sustainability integration in digital tools/educational software can be assessed using environmental, social and economic capitals (M. Ashby 2015) as well as enabling conditions for the UN SDGs (Kioupi and Voulvoulis 2020) as demonstrated in the case study of Ansys Granta EduPack (Vakhitova et al. 2023; “Ansys Granta EduPack | Software for Materials Education” n.d.). This fills a gap in the existing literature and practice and allows both educational institutions, such as Universities, and EdTech companies a coherent way of providing evidence of the links to sustainability of their programmes and services but also provides a way to link with learning outcomes and quantify the impact on student learning and sustainability competence development.

Usually sustainability integration in education, is representative of a top-down approach, originating from bodies, organisations and businesses outside of the educational institutions in which the changes are to occur, which provide the guidelines to educational institutions to do so. Furthermore, the alignment between the SDGs, learning objectives, EdTech products and practices, is characteristic of an incidental approach towards sustainability whereby raising awareness among students is an additional benefit rather than an intended outcome (Brinkhurst et al. 2011). The incidental nature of the relationship between the SDGs, learning objectives and EdTech implies that further exploration is needed through the validation of our framework.

Previous literature advocates the use of questionnaires to measure attitudes and behaviours regarding sustainability. Gericke et al. (Gericke et al. 2019) presented their investigation of Sustainability Consciousness - “an individual’s experience and awareness of sustainable development”. To gather individual views the researchers used a questionnaire, which explored three key aspects of consciousness, these being Knowingness “the state of mind in which a person thinks something to be the case” Attitudes & Behavior. All three aspects are similar to our focus on exploring the cognitive, socio-emotional, and behavioral learning of students (UNESCO 2017) which implies that a similar construct would be appropriate for the second phase of our case study.

At present, the first phase of our case study has explored how EdTech providers approach sustainability in education through their products and practices. However, to fully explore what makes EdTech products and practices impactful regarding sustainability, we need to obtain the views of faculty staff and students. These views are representative of bottom-up perspectives (of students) and often overlooked middle-out perspectives (of faculty staff). We will look for alignment between the top-down, middle-out and bottom-up perspectives. In the second phase of our case study, we will deploy a whole-institution approach (WIA) to explore the extent of sustainability awareness and integration among faculty and students, following the below definition of a WIA:

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*A “whole institution approach” means that all aspects of an institution's internal operations and external relationships are reviewed and revised in light of SD/ESD principles... A whole institution approach means that the strategy of the institution, and ultimately its culture, is oriented towards sustainable development.” (UNECE 2008)*

The extent of alignment between the perspectives would be an indication of what makes educational technology products and practices impactful in education. Strong alignment may be indicative of co-ordination and collaboration between faculty, students, and EdTech providers. Weak alignment may suggest that SDT in education is incidental and lacks co-ordination. In both scenarios it may be possible to identify strengths and weaknesses of SDT enabling more coherent strategies to be created and deployed.

## **2 METHODOLOGY**

### **2.1 Design and development of surveys to gauge student and staff experience of sustainability in Universities in the UK**

We are focusing our research on how Universities practice sustainability and we wanted to understand how they embed sustainability through WIA. We are focusing initially in the UK and in departments related with science and engineering but we want to expand to departments with orientation to social studies as well as to those outside the UK. This will allow us to collect data from diverse Universities and map what they are doing but also how students and staff are experiencing these efforts. To start our research and establish a baseline of how sustainability is practised we developed two questionnaires to understand how University educators and students engage with sustainability on and off campus. The questionnaires were built using previously published and validated questionnaires as well as we included some new questions that would allow us to cover as many aspects of the WIA as possible as well as to collect data on how Universities are using educational software related to sustainability (Barth 2011; Gora et al. 2019). The use of technological educational solutions (software) is a promising way to engage students with sustainability and the development of students' digital skills is crucial from an employability point of view.

The questionnaires include four areas of engagement with sustainability: curricular, institutional, research-based and community-based. The questionnaire for University staff also includes a question about the use of educational software. The questionnaires include mostly close-ended questions answered on a Likert scale on a Not at all to A great extend range, including a Don't know answer, yes/no/don't know options or a sliding scale and some open-ended questions to gain more descriptive and qualitative information about the aspects of sustainability they feel are already integrated or they would like to see integrated in the future.

The student questionnaire includes 12 questions and starts by asking if the students are undergraduate or postgraduate what is their University and department at its introductory part. It also asks about courses offered in relation to sustainability as well as any curricular integration of it and seeks to also check for any gaps the students can identify in their curricula. The next section is about the sustainable use of resources and the enhancement of biodiversity as well as the provision of opportunities for the community on and off campus to engage in new connections and solutions building for sustainability. The final part is concerned with the opportunities

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that are specific to students in relation to their engagement with sustainability on and off campus.

The staff survey starts in a similar way and includes 16 questions, it asks about staff professional role in the university, University name and department. Then it goes on to questions about curricular integration of sustainability and identification of gaps as well as sustainable use of resources and community engagement with sustainability. Then it includes a section about opportunities for research related to sustainability for staff and students, professional development offered to staff in relation to sustainability integration and criteria for employment related to sustainability. The final section concerns collaboration with technology companies and the use of educational software in the area of sustainability that they are already engaging with or they would like to in the future and the areas that they would like to address.

To increase the questionnaire reliability and validity we asked colleagues from the Department of Physics and Astronomy at UCL to review them and provide comments to us. We also asked a group of 8 Year 3 students from the same department, who were engaging in an open project that links Physics and engineering with sustainability, to check for areas of difficulty and provide feedback. They were shared with colleagues and students at ETH Zurich for their consideration and feedback as a target population outside the UK so the relevance of the questions to audiences outside the UK could be increased. The questionnaires were improved based on the comments, received and finalised for submission for ethics approval by UCL (this process has not been finalised yet). The next step is the dissemination of the questionnaires in UCL, other UK Universities and then abroad, followed by the data collection and analysis. A part of the staff questionnaire was used for collecting responses from participants at the “Teaching Sustainable Development using Ashby’s 5-step method” workshop that took place in Cambridge UK (3/4/23), helping to gain initial insights. It is described in the next part of this paper. The process of developing and validating the surveys is presented in Figure 1.

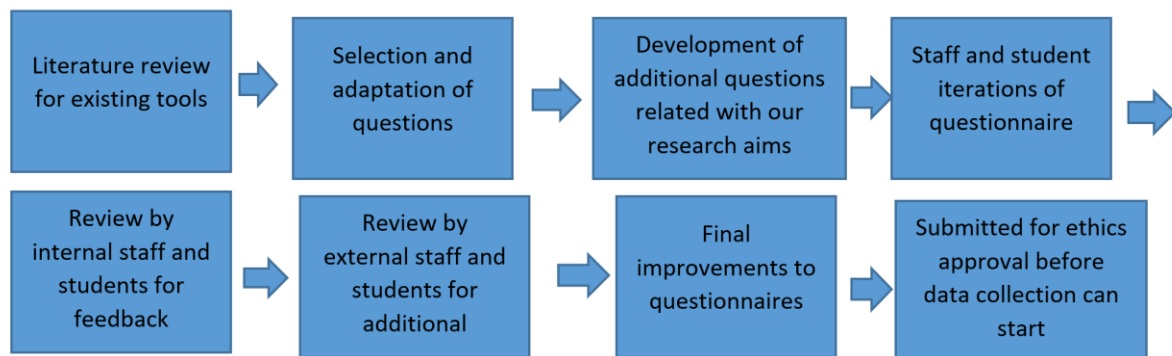


Fig. 1. Flow chart that shows the steps of questionnaire development.

## 2.2 Materials Education Workshop

On the 3d of April, as a part of the International Materials Education Symposium, authors from Ansys Ltd (Academic Development Team) held a workshop, dedicated to Materials and Sustainability, named “Teaching Sustainable Development using Ashby’s 5-step method” ([link to the workshop](#)). The Workshop was based on

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developments in Mike Ashby’s second edition textbook “Materials & Sustainable Development” (M. F. Ashby, 2022). The workshop material (templates and slides)(“Ansys Education Resources – Teaching Materials” n.d.) was used in teaching for several years in various educational establishments, aiming, among others, to support educators from technical educational establishments, embracing the social element of sustainability assessment (“Paper: Social Life-Cycle Assessment and Social Impact Audit Tool | Ansys” n.d.). This workshop has encouraged discussion on sustainability integration in engineering curriculum among participants.

The fourteen participants of the workshop, representing 10 different countries, came from various universities around the world, including Canada, Australia, mainland Europe and from the UK. These were predominantly at a level of teaching staff in engineering/materials field or combining a role in administration of education process at a university. After the workshop participants were asked to fill in a part of the staff questionnaire (6 first questions regarding Sustainability in Curriculum at Departmental Level), we have described in the previous section. The purpose of the survey and the research project was explained, and the anonymity of their responses was guaranteed. All participants agreed to complete and provided their responses to the survey.

### 3 RESULTS AND DISCUSSION

#### 3.1 Materials Education Workshop results

The overall results from piloting the survey at the materials education workshop are presented in Table 1.

*Table 1. Results from the main areas of the survey, distributed at the workshop Materials & Sustainable Development (3/4/23)*

	Questions / Answers	Don't know	Insufficient	Sufficient	None	More than enough	Total responses
1	Sustainability courses		10	4			14
2	Global Warming/Climate Change/Science	1	7	4	2		14
3	Clean Renewable Energy/Critical Materials	1	9	4			14
4	Globalisation & Sustainable Development Goals	1	10	1	2		14
5	Curriculum/ teaching activities*		9	2	1		12

\*2 participants have not responded to question 5

Despite being a relatively small sample, the participants are the people from our target group. These are the individuals, involved in teaching with an interest in sustainability at materials, design and wider engineering faculties around the world. We will further collect data distributing the survey across universities and compare these initial results.

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The key conclusions suggest there is still a gap in the inclusion of sustainability in the curriculum in most of these universities, specifically there is an insufficient number of courses focusing on sustainability offered at higher education establishments. The most disregarded is the topic of Globalisation and Sustainable Development Goals, as well as Climate Change and its Science, showing that crucial international policy developments such as the Paris agreement and the UN SDGs are being left out.

Some of the discussions have focused on the need for a greater collaboration among scientists and engineers and academics from arts/humanities areas to address all the complexities, sustainability offers. Suggested ways forward linked with the methodology taught during the workshop has to do with the framework/templates provided for the 5-step methodology and had an overwhelming success. This methodology helps to tackle complexity by providing a clear step to include problem statement, identification of stakeholders' concerns, a step, focusing on factual information regarding the former, and sustainability assessment and reflection parts. At the workshop, several participants mentioned that sustainability-focused new courses are being set-up at their respective departments and the topic is addressed at the top level at universities, including setting-up responsible personnel/new responsibility areas.

Specific comments from a staff member of a mechanical engineering faculty suggested the need to have a more specific course focusing on sustainable development, apart from existing specialised e.g. "ocean engineering", "green materials". Among the essential courses not being taught, were suggested: "Lifecycle Analysis", "Materials Selection", "Critical materials", "Project management", "Science Communication in Engineering", "Materials Engineering", "Materials Science & Technology", "Sustainability & Social Impact", "Waste Management", and a need for more "Arts/Humanities – related subjects".

### **3.2 Discussion**

The preliminary findings from piloting our survey in the workshop advocate for the need to establish the baseline of what is practiced in Universities at the curricular level, but also mandate the need to see sustainability as a WIA. As evident, Universities are trying to develop new courses to tackle sustainability but sometimes these are highly specialised and they do not help students understand the bigger picture of what sustainable development is and develop general sustainability competences. This coupled with the lack of SDGs and climate change education show that crucial areas of tackling sustainability challenges are missing from curricula. However, educators in the workshop showed that when an educational software is combined with a methodology that can help them assess sustainability can be an important way of enhancing learning outcomes for students. In other words the pedagogy and specially designed educational material that accompanies the software are of utmost importance. Still the educators shared generic views such as that sustainability is a priority of their institutions and the University is hiring personnel and developing committees or other strategies to tackle it, and here our survey can clarify the areas that University is aiming to focus on regarding sustainability and help University educators and staff clarify the benefits of a WIA into their sustainability integration.

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In this study we have established the need for the student and staff survey in alignment with our published framework as it will provide the data needed to understand how Universities are integrating sustainability and suggest ways forward. The findings of the questionnaires will be triangulated against the results of the previous framework in a new study. The aim is to evaluate the current state of sustainability integration at science and engineering focused universities/faculties, offering ways to address any gaps and to offer recommendations for technology companies to promote sustainability through their education offerings. The alignment of perspectives among staff, students, technology companies' contribution to sustainability, and our framework will be checked after final data analysis and ultimately will suggest practical steps to address sustainability awareness, educational and WIA implementation gaps.

#### **4 SUMMARY AND ACKNOWLEDGMENTS**

This paper describes the second stage of the research project, focusing on the two questionnaires for university students and educators based on the framework, which brings together UN Sustainable Development Goals and Learning Outcomes in Higher Education (published elsewhere, e.g. Vakhitova et al. 2023).

The questionnaires focus on assessing sustainability awareness and involvement of staff and students of Science and Engineering Departments in sustainability activities, using a Whole Institution Approach. The preliminary results were collected, using a part of the questionnaire for educators, and described in this manuscript. Among the main findings is that implementation of sustainability into the curriculum to tackle global sustainability challenges needs to be further improved, and this is the main goal of the third part of our effort.

We would like to thank the participants of the workshop in Cambridge (UK) for contributing to this project.

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## Response to Reviewers

Dear Organizers of 51st Annual Conference of the European Society for Engineering Education,

I hope you are well.

We would like to thank you for the acceptance of our work for presentation at the SEFI 2023 Conference.

We have submitted the final version of our manuscript addressing the comments of the reviewers.

More specifically, please see below our responses to the reviewers:

Reviewer 2: Additional information regarding the summary of our work was added in the Summary and Acknowledgement section, as suggested by the reviewer.

Reviewer 1: The reviewer is wondering “How does it possible to use these questionnaires without receiving their ethical approval?” referring to the dissemination of the questionnaire during our workshop.

We are very well aware of the ethics requirements to publish research in education and we thank the reviewer for being diligent. As it is written in the paper “we present preliminary data from the piloting of the questionnaires during a materials education workshop for University Educators organised by Ansys Ltd in Cambridge UK” for feedback before we use them widely. In the third phase of this research project, the questionnaires will be shared more widely with staff and students in science and engineering-focused faculties internationally and they are currently submitted to the ethics committee of UCL for ethical approval. For the piloting and usage of the questionnaires in the workshop, the written consent of the participants was collected prior to the workshop and the participants were able to discuss their thoughts with us. We were able to finalise our questionnaires based on this interaction.

We also noticed that Language, Coherence and Cohesiveness for our paper are given 0/10 and we are really concerned about the effort the reviewer put to review our manuscript and why they gave us this mark as this means it was unintelligible and we would like to understand why the reviewer thought that.

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In the presentation of the theoretical background, the authors claimed that they have used an existing conceptual framework published previously but did not talk about how exactly this framework was used during the development process.

We have published another paper that describes the development of the framework which included a combination of systemic framework grouping the SDGs into educational outcomes as well as the five capitals theory by Ashby (human, manufacturing, social, economic and environmental) so that the framework makes sense for EdTech companies and it is novel in that respect, as before CSR reports focused only on environmental, economic and sometimes social capitals without links to sustainability and educational outcomes.

It is confusing that “the questionnaires were built using previously published and validated questionnaires as well as we included some new questions”. It would be good to better clarify what are the benefits of the present work.

We did a literature review as mentioned in our methods to understand what surveys exist on sustainability education and select questions that have been validated in previous studies, however as we are taking a Whole Institution Approach we complemented the existing questions with others that can enable us to highlight other dimensions of sustainability in Higher Education that we thought were covered in these questionnaires. We also asked students and staff from UCL and ETH to review the surveys so we can have at least some face validity in terms of what we are asking. The next validation will come after the distribution of the questionnaires more widely, when ethics approval will have been granted.

In the second part, the authors present the results of a quantitative questionnaire completed by only 14 participants. This sample is so small that I have serious concerns about the validity and reliability of these results. In addition, the only information that we can have of workshop participants that they are at the level of teaching staff coming “from various universities around the world” that seems to be too vague to know about their context. I would encourage the authors to collect supplementary data.

We had people from University of Birmingham (UK), Institut Universitaire de Technologie (IUT) Lyon1 (France), University of Victoria (Canada), Monash University (Australia), Chalmers University of Technology (Sweden), Northeastern University (USA), Riga Technical University (Latvia), Technological University of the Shannon: Midlands Midwest – TUS (Ireland), University of Bristol (UK), Tallinn University of Technology (Estonia), Hochschule Bonn-Rhein-Sieg (Germany), Falmouth University (UK) and others. These are representatives from 10 different countries, working at European USA and Australian Universities.

As we mentioned above this was a pilot phase of the questionnaire and it was for feedback purposes, when we conduct the large-scale dissemination we will validated out results. We think that the reviewer has misunderstood the aim of our study, which is currently in phase two-piloting.

The discussion part is quite short and talking in a general way (not comparing the results of present study with previous studies mentioned in the theoretical background chapter).

This is accurate but since this was a pilot phase for feedback and proof of concept we think we could not compare with large scale studies for the reasons the reviewer has identified above and that would be a very strong limitation as well as extrapolation without clear meaning.

There is no conclusion and I am quite dubitative about the lesson learned from this study. It would be useful to add a conclusion and talk about it.

Thank you we have added the conclusion now.

The paper have several spelling (e.g.: “EdTech” written “Edtech” or “edteEh”) and grammar mistakes (e.g.: “a group of 8 Year 3 students from the same department”). Several long sentences make the reading quite difficult (e.g.: 1.1. “Apart from greening...” an eight lines sentence). I would suggest reviewing the text for correcting these mistakes and making it more readable.

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We have amended the above typos.

Summary information was added as suggested also by reviewer 2 and minor grammar and structure issues were addressed.

The novelty and main aim of our work is based on the development of a tool to evaluate the current state of sustainability implementation in teaching and digital learning methodologies, while the main findings of our piloting of questionnaires are presented in the discussion section. This is a research project in progress and will be followed by other phases as mentioned in the paper, however, we feel that it will generate interest for the audience of SEFI 2023 as well as discussions on how sustainability can be integrated in HE.

We would like to thank the reviewers for their comments and the organisers for their support.

Please let us know if anything else is needed.

Best wishes,

George