

# **Students' development of employability skills through an online international hackathon**

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## **Abstract**

This article explores the skills generated from an online 2-week sustainability hackathon. Participants of the hackathon were students enrolled in one of the universities under the UK-Singapore universities alliance for entrepreneurship and innovation. The hackathon included 80 students from 14 universities in Singapore and the UK. Data was collected from 18 out of 80 participants who took part in the hackathon via a post-hackathon questionnaire. The 22 semi-structured questions included questions on participants' previous work experience, reasons for taking part in the hackathon and what skills and experience they gained from taking part. Qualitative data was analysed using a comparison of descriptive statistics and qualitative data was examined using a thematic analysis approach. The results showed an awareness in enhancement of both personal and professional skills, ranging from teamworking, communication, ideation and critical thinking. Participants also appreciated the interdisciplinary working and connecting with students from different countries and institutions.

## **Keywords:**

hackathon, sustainability, employability, student enterprise, international collaboration

## Introduction

Traditionally, the term 'hackathon' was self-explanatory, a 'hacking marathon' intended for those in the computer programming sector. The goal, to bring professionals together to work collaboratively over a short period of time to solve problems (Briscoe, 2014). Over the years hackathons have grown in popularity and have evolved to provide broader collaboration whilst tackling a plethora of eclectic real-world challenges from health to politics to sustainability (Soltani et al., 2014). Hackathons have typically developed to include mentors offering support with presentations at the end of the event with *winning* teams decided by a judging panel, often being rewarded with prizes or awards (Nolte et al., 2018). Nevertheless, the core premise of the hackathon model has remained the same, to provide a scenario which fosters community building, collaboration, ideation, problem solving and innovation.

Amidst the COVID-19 pandemic, educational landscapes dramatically shifted towards online education. Virtual hackathons, facilitated by advanced digital platforms, emerged as a crucial avenue for students to collaboratively address problems, overcoming geographical constraints (Happonen et al., 2021). This strategic adaptation aligns seamlessly with evolving educational dynamics, addressing the critical need for innovation in student-centred learning.

With increasing pressure within higher education to provide student-centred learning and develop students' 'transitional skills', hackathons are increasingly utilised (Kienzler and Fontanesi, 2017; Porrás et al, 2018). Alongside some of the aforementioned benefits, hackathons have the potential to develop communication skills, exercise creativity, enhance employability and develop teamwork – all of which can be difficult to teach in a traditional classroom setting (Vogler et al., 2018; Uys, 2019). Furthermore, employers are progressively searching for graduates who can work internationally in multicultural teams, highlighting the importance for universities to facilitate

such experiences (Lokkesmoe et al., 2016; Atalar, 2020). Current literature on whether international hackathons can enable such interactions is limited and is one of the focuses of this paper.

There are several factors which can influence the level of student development in a hackathon such as: the engagement from the student (i.e. intrinsic and extrinsic motivation), the relevance of the real-world challenge and the effort of the academic in supporting student development alongside relating the challenge to theoretical concepts (Porrás et al, 2018). If the hackathon is implemented successfully, research by Szymanska et al. (2020, p10) suggests that it can lead to a students' 'creative "reframing" of one's-own self-image and career ambitions' as students see an increase in self-efficacy and exposure to different beliefs and disciplines.

The purpose of this paper is to expand on current literature around creating hackathons and perceived student development in a higher education setting, with a focus on international community building, multicultural awareness and building global citizenship. The paper will also seek to explore whether employability, CV development and student career aspirations are adjusted upon completing an international hackathon. The study focuses on surveying students who participated in the first UK-Singapore Universities Alliance for Entrepreneurship and Innovation (UKSAEI) Sustainability Hackathon in 2021.

## **Methodology**

### **Hackathon structure and delivery**

This Climate and Sustainability Hackathon was led by the UK-Singapore universities alliance for entrepreneurship and innovation (UKSAEI) in advance of COP26, in partnership with the British High Commission Singapore and Science and Innovation Network. Participants of the hackathon were students currently enrolled in one of the universities under the UKSAEI, across all subject disciplines and levels of Undergraduate and Postgraduate study. This

hackathon brought together 80 students from 14 universities in Singapore and the UK (Table 1, overleaf) to pitch their innovative solutions in achieving net-zero emissions by 2050. The hackathon was held remotely via Microsoft Teams over two weeks (18<sup>th</sup>- 28<sup>th</sup> of October 2021). Lead colleagues from Student Enterprise, International office and Innovation across the different Universities were involved in the design, organisation, and delivery of the event. The purpose of this hackathon was to foster student engagement, specifically intermingling of cultures and encourage knowledge exchange amongst students from various UK and Singapore universities.

**Table 1 Breakdown of students from British and Singaporean Universities**

University	No. of students who took part in the event	No. of students who filled out the questionnaire
Bath <sup>a</sup>	5	1
Coventry <sup>a</sup>	5	2
Cranfield <sup>a</sup>	5	1
Dundee <sup>a</sup>	4	4
Glasgow <sup>a</sup>	11	3
Nottingham <sup>a</sup>	5	1
Strathclyde <sup>a</sup>	5	0
Surrey <sup>a</sup>	4	0
Newcastle <sup>a</sup>	5	0
Nanyang Technological University <sup>b</sup>	10	2
National University of Singapore <sup>b</sup>	2	0
Singapore Institute of Technology <sup>b</sup>	10	3
Singapore Management University <sup>b</sup>	5	0
Singapore University of Technology and Design <sup>b</sup>	4	1
<b>Total</b>	<b>80</b>	<b>18</b>

<sup>a</sup>Universities based in the United Kingdom

<sup>b</sup>Universities based in Singapore

The first three days of the hackathon (18<sup>th</sup> – 20<sup>th</sup> of October) involved students meeting and getting to know their teams (teams were between 5-6 students). Next students took part in sessions on teamworking, this involved them participating in ice-breaking activities to encourage team bonding and cohesion between the mixed subject discipline and level teams. This was followed by the presentation of problem statements by a Professor in Leadership and Enterprise. Teams were asked to choose from the following problem statements and focus on solutions or processes for UK and Singapore organisations to adopt, to mitigate climate change-related issues:

What incentives could be developed by governments and other relevant organisations (e.g. NGO's) to encourage businesses, the public and third sectors to adopt new processes or adapt existing processes to advance the net-zero cause?

OR

How could business and organisational rules and structures, both public and private, be adapted to encourage organisations to be more socially responsible with a particular focus on achieving net-zero?

A series of intense sessions on entrepreneurial, business skills and climate issues were presented to students during this time. This was followed by a week of masterclasses (21<sup>st</sup> – 28<sup>th</sup> of October), from experienced entrepreneurs and successful start-ups. Students used this week to work on ideation, pitch deck creation and participate in 'meet with the experts' sessions. They also had the opportunity to engage in a 'pitch practise' session with an academic mentor. At the end of the week (29<sup>th</sup> of October) the teams delivered a 10-minute final business pitch to a panel of judges, with five minutes for question and answers. The judging panel was made up of the British High Commissioner to Singapore, President of British Chamber of Commerce Singapore and a Senior Vice president of a University in Singapore. The prizes awarded were namely for the 1<sup>st</sup> and 2<sup>nd</sup> best overall solution and

pitch based on the innovation and viability of the business case they presented.

## **Team population**

Students were placed into ten teams of eight based on their course, such that no more than three people from similar courses were on the same team. This ensured teams had diverse backgrounds of skills and experiences and prevented students from forming teams with their friends, which were likely to have come from the same course. A typical team composition might be students from law, economics, chemistry, and electronic engineering.

## **Sampling and data collection**

The use of a post-hackathon questionnaire to collect data (Appendix 1) and freeform comments from the participants and qualitative and thematic analysis thereof received ethical approval by the University of Surrey ethics committee. All participants gave their informed consent to participate in this study and the final composition of students was as follows: first, second, third and fourth year of undergraduate studies: 2, 4, 1 and 5 students respectively and 6 masters students - in total 18 participants (a response rate of 22.5%).

An online semi-structured questionnaire using Qualtrics was used for data collection. The questionnaire comprised of 22 questions exploring previous work experience and entrepreneurial experiences, prior interests in sustainability issues, reasons for participating in the hackathon project, what they most valued about the experience of taking part in the hackathon, perspectives on the experience of working in an international team, experience of working in an interdisciplinary working and the skills students feel they gained from the Hackathon project. The questionnaire used a mix of Likert scale questions, closed and open-ended questions. Utilizing a pragmatist approach (Morgan, 2007; Onwuegbuzie and Leech, 2005), the

study acknowledges the relevance and usefulness of a mixed-methods methodology in addressing specific research questions (Bryman, 2006).

## **Questionnaire analysis**

Quantitative data analysis was conducted, and the qualitative or descriptive analysis followed a thematic analysis approach based on coded responses from which themes emerged (Elliott 2018) and can be seen later in the results section. The quantitative data was analysed using SPSS [Version 28.0.1.0].

## **Results**

### **Recruitment and previous participant experience**

The demographic characteristics for the responding student populations (18/80 participants, 23%) are shown in Table 1. There were 12 UK respondents and 6 Singapore respondents. The majority of survey responders were Masters students (33%). This was followed by Year 4 undergraduate students (28%), Year 2 undergraduate students (22%), Year 1 undergraduate students (11%) and Year 3 undergraduate students (6%).

There were more respondents studying STEM subjects (76%) than those studying non-STEM subjects (24%). This could be due to the hackathon being a climate related project, where students from environmental sciences were more inclined to participate.

Approximately 22% of participants identified as having had prior entrepreneurial experience and more than half of the respondents claimed previous engagement with working with a charity or local business (72%).



**Table 2. Demographic characteristics of student hackathon programme respondents (N=18).**

Variable		Frequency	Percentage (%)
<b>Year of study</b>	Year 1 of undergraduate studies	2	11
	Year 2 of undergraduate studies	4	22
	Year 3 of undergraduate studies	1	6
	Year 4 of undergraduate studies	5	28
	Masters student	6	33
<b>Degree course studied</b>	STEM subject	13	76
	Non-STEM subject	4	24
<b>Previous entrepreneurial experience prior to hackathon participation</b>	Yes	4	22
	No	14	78
<b>Previous experience working with a charity or a local business prior to hackathon participation</b>	Yes	13	72
	No	5	28

## 1) Sustainability

Analysis of the participants' freeform comments and quantitative data related to sustainability revealed three broad categories: prior interest in

sustainability, positive impact of the hackathon in improving sustainability awareness and negative impact of the hackathon in improving sustainability awareness.

### **1.1 Prior interest in sustainability and value in a sustainability awareness hackathon project**

The most selected initial reason for taking part in the Hackathon [Q4] was 'interest in sustainability' (89%, 16 out of 18 respondents). In addition, 89% (16 of the 18 respondents to Q7), identified 'developing their sustainability awareness' and/or 'taking part in a sustainability-focused project' as among the 'most valuable aspects' of their participation in the Hackathon.

### **1.2 Positive and negative impact of the hackathon in improving sustainability awareness**

When asked if participation in the hackathon 'has increased my awareness of sustainability issues' [Q7\_11], 14 of 18 respondents (78%) agreed (eight 'strongly', six 'somewhat'), with two students responding neutrally and two students strongly disagreeing. In addition, when asked if they agreed with the statement 'I am more actively trying to resolve sustainability issues within my daily life' [Q7\_12], 13 of 18 respondents (72%) agreed (seven 'strongly' and six 'somewhat'), with two students answering neutrally and three students somewhat disagreeing.

In general, the participants had different levels of feelings towards the sustainability dimension of the hackathon. Some participants felt that the hackathon was a positive experience for them, as it allowed students to consider the issue of sustainability from other student perspectives.

*"Moreover, realizing the talent and awareness about our environment into fellow students is a relief."*

*"Got to personally hear about ways in which different universities in the UK and in Singapore tackle sustainability"*

For one participant, the level of sustainability expertise within their team seemed to be a worry

*"As the only Sustainability student I had to teach them a lot as there wasn't time for them to teach themselves"*

In another case, one participant believed that the hackathon would provide a negative experience for the students participating in terms of sustainability awareness.

*"What certainly worked well was using "sustainability" as a buzzword and washing any meaning out of it. misleading the participants about individual impacts on the environment being more important than impacts of fossil fuel industry... Do you think it is fair to use businesspeople to judge solutions to the climate crisis? or was this hackathon a performative event done for marketing purposes of universities involved?"*

## **2) Skills, employability and enterprise/entrepreneurialism**

Three broad categories related to employability and enterprise were found upon analysis of participants' freeform responses and quantitative data: perceptions on employability, student enterprise experience and wider skills development.

### **2.1 Perceptions of employability**

When asked if they had any previous experience working in a charity or local business [Q5], thirteen of the 18 respondents indicated that they had.

Eleven out of 18 (61%) of respondents identified that enhancing their CV was one of their reasons for taking part in the hackathon and 44% respondents

wanted to improve their employability skills [Q4]. Following the project, 10 out of 18 (56%) agreed that one of the most valuable aspects of having taken part was 'improving my CV'.

When asked 'Do you think that participation in the Hackathon has made you aware of a wider range of career paths?' [Q18], eight (53%) of 15 students indicated 'yes', with four (27%) opting for 'unsure' and three (20%) for 'no'.

## **2.2 Student enterprise/ entrepreneurial experience**

Nine out of the 18 (50%) respondents indicated that 'to gain experience in entrepreneurial activities' was one of their reasons for taking part in the hackathon [Q4\_4]. When asked if they had any previous entrepreneurial experience before taking part in the hackathon [6], fourteen of the 18 (78%) respondents indicated that they had.

After participation, eight of the 18 (44%) respondents agreed that 'developing entrepreneurial skills' was one of the most valuable aspects of having taken part [Q7\_4]. Interestingly, the similarity between before and post participation responses highlight variation. Seven of the nine students who had indicated developing entrepreneurial skills as a reason for taking part confirmed this as among their 'most valuable aspects' of participation. One student who had suggested that developing entrepreneurial skills was not a factor in wanting to take part identified this as among the most valuable aspects of participating, whilst for eight students (44%), the entrepreneurial dimension was not a key factor for participation before or after engaging with the event.

Interestingly, only 6 out of 15 students (47%) indicated that they would consider a future career in entrepreneurial activities [Q19]

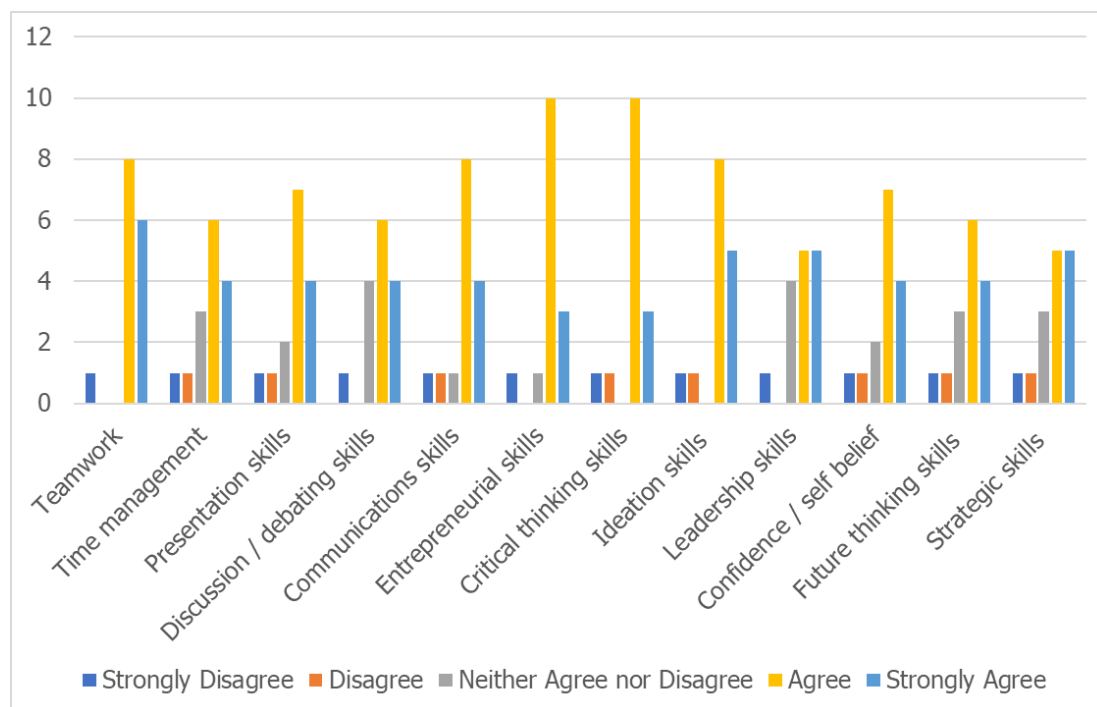
Interestingly, 67% of STEM subject students were considering a future in entrepreneurial activity versus 33% of Non-STEM subject students. This is

perhaps not surprising as more students from STEM based subjects took part in the hackathon (Table 2).

## 2.3 Wider skills

Students were asked several questions to determine whether they had developed a range of transferable skills after taking part in the hackathon. Upon questioning about the improvement in various employability skills, 72% of students agreed that following the hackathon they can 'adjust better to new people, places and situations' [Q8\_4] and 89% 'feel more comfortable talking and discussing my ideas on-line with peers' [Q8\_7].

Several other employability skills that were shown to be enhanced by students (>70% student agreement) included teamworking, communication, entrepreneurial, critical thinking and ideation [Q11] (Figure 1).



**Figure 1. Bar chart showing students' perceptions of skills enhanced as a result of taking part in the hackathon project [Q11].**

Students were asked if there were any other skills that they felt had been enhanced by participating in the project [Q12], responses included 'research into relevant information', 'spotting greenwashing and sustainability baiting' and 'design tips'. Additionally, eleven out of 18 (61%) claimed that learning new skills from students in other subjects was one of the most valuable aspects [Q7\_8].

### **3) Interdisciplinarity**

Two broad categories were revealed upon analysis of participants' freeform responses and quantitative data: the benefits of interdisciplinary working on skill enhancement and benefits & challenges of interdisciplinary working.

#### **3.1 pre/post conceptions of the benefits of interdisciplinary working on gaining new skills.**

Twelve out of the 18 responses (67%) identified that that working with students from other subjects was a reason for taking part [Q4\_6] in the hackathon. Post-hackathon, eleven out of 18 respondents (61%) of participants found that learning skills from students from other subjects was one of the most valuable aspects of taking part in the project [Q7\_8]. In addition, nine (50%) confirmed that networking with students and faculty members from other subject disciplines was valuable [Q7\_10].

When students were asked about whether taking part in the hackathon was beneficial in 'connecting with students in different subject areas', fifteen out of 18 respondents (83%) either 'strongly agreed' or 'somewhat agreed' [Q8\_1].

#### **3.2 Benefits and challenges of interdisciplinary working**

Students were asked to comment on the benefits and challenges of interdisciplinary working within the hackathon project [Q9 and Q10]. One common theme amongst student answers in relation to the benefits of interdisciplinary working was the sharing of 'skills' and collaborating with different 'backgrounds'. Another interesting aspect that was noted in three students was the ability to meet and hear ideas from students from other countries. Specific comments from students relating to benefits included the hackathon being able to bring 'cohesion' and was 'fun'. One student enjoyed the collaborative element and noted that: *"Watching our ideas merge and change with each other was incredible."*

Finally, students were asked about the challenges of the interdisciplinary working of the project. Challenges in language and communication between Singapore and the United Kingdom was reported in two students. Two students claimed that the 'online' platforms were a challenge, and this could perhaps be a reason for the difficulties in communication. A further five students reported that time differences were a difficulty and two students noted that personal commitments such as 'school/ exams' interfered with student commitment.

Although three students highlighted that differences in opinions were a challenge, two students found the diversity in subject specialism a difficulty. One student stated:

*"When selecting an idea, we struggled with explaining a very socio-ecological approach to people who have background in bioengineering or business."*

Some students were also able to identify that the differences in interpretation of a task were a hindrance, where one student noted:

*"We all were leaning towards something we had more knowledge of (either from academic sources or past*

*experience).*”

## **4) Global and cultural awareness**

Analysis of the participants’ freeform responses and quantitative data related to global and cultural awareness revealed two broad categories: Post-conceptions of the hackathon on enhancing global and cultural awareness and future in international study or work.

### **4.1 Post-conceptions of the hackathon on enhancing global and cultural awareness**

Following participation, thirteen out of the 18 (72%) respondents identified ‘Developing my global and cultural awareness’ as a valuable aspect of having taken part in the hackathon [Q7\_13], while ten (56%) stated that ‘Learning about the experiences of students in other countries’ was valuable [Q7\_14]. Additionally, nine out of 18 (50%) claimed that networking with students and faculty members from other educational institutions was one of the most valuable aspects [Q7\_15].

When asked whether taking part in the hackathon benefitted their views on connection with other people from different countries in relation to their educational development, thirteen out of 18 (72%) respondents either ‘strongly agreed’ or ‘somewhat agreed’ [Q8\_2]. The impact of the hackathon on benefitting connectivity was further supported by fifteen out of 18 (83%) respondents who ‘agreed’ or ‘strongly agreed’ with the statement that ‘Connecting with students in different countries will help me feel part of a global community’ [Q8\_3].

The question as to whether the hackathon helped participants gain confidence in socialising with people from other cultures [Q8\_6] elicited relatively strong positive responses, with fifteen of 18 (83%) respondents indicating that they



either strongly or somewhat agreed. In addition, fifteen out of 18 (83%) of students were in agreement that the hackathon helped broaden their horizons and knowledge about the world [Q8\_10].

## **4.2 Future in international study or work**

When asked whether students would study 'abroad as part of my degree' [Q16], two (25%) of 8 students indicated 'yes', with two (25%) opting for 'unsure' and four (50%) for 'not applicable' as they were in the final year of their studies. When students were asked for their specific reason for wanting to 'study abroad' [Q17], responses included: to understand how different people think, further my knowledge, enjoyment and to study a course not present in my home country.

Interestingly, only seven out of 15 students (47%) indicated that they would consider a future career that would allow them to travel internationally. A further seven (47%) of students had already considered a future career that would allow them to travel internationally prior to participating in the hackathon project and one (7%) of the students was unsure [Q20].

## **5) Obstacles and strengths of the hackathon**

When asked if there were any 'obstacles in participating in the hackathon' [Q13], some of the comments given by students, mirrored the answers they had previously provided [Q9 and Q10]. Five students recognised that team commitment to the project was an issue. Given the hackathon taking place across two continents online, four students identified that 'timezones' were an obstacle. Three students identified that 'University commitments' outside of the hackathon hindered their progress. A further two comments, were related to personal commitments and lack of sustainability expertise within the judging panel.

With reference to the advantages of the event [Q14], three students noted that the information provided throughout the sessions was helpful. An additional two students found the 'ice breaker' activities were beneficial. One student noted the benefits of the organisation and cross-disciplinary nature of the hackathon.

Possibilities for the improvement of the project was presented by some students. This included making sure compulsory 'attendance' for the hackathon event, a 'shorter' hackathon duration (2 weeks felt lengthy), increased 'mentoring' support and improved organisation. Interestingly thirteen out of 18 (72%) of participants believed that online delivery worked well [Q8\_9], however, compulsory in person sessions could prevent lack of commitment. Of the participants, thirteen out of fifteen (87%) would recommend other students to take part in another hackathon, whilst two out of fifteen (13%) were unsure [Q22].

## **Discussion**

Hackathons are innovative events used in higher education due to the opportunities they generate for students. This is the first study to show the impact of an international sustainability hackathons on enhancing employability related skills. The study showed that this hackathon was a positive experience for many of the students taking part, where they increased awareness of sustainability issues. Results showed an awareness in the enhancement of both personal and professional skills, ranging from teamworking, communication, ideation and critical thinking. Participants also appreciated the interdisciplinary working and connecting with students from different countries and institutions.

Within our hackathon many students had pre-existing interests in sustainability and were interested in taking part to improve their sustainability awareness. Evidence in the literature has supported the effects that

hackathons have on promoting positive behaviours. For example, Wilson et al., (2019) showed that participation in a university-wide civic hackathon improved students' attitudes and beliefs towards social problems such as homelessness. Additionally, the authors of a hospitality industry-based sustainability hackathon noted that the hackathon encouraged development of universal values linked to 'global citizenship' and promoted participants to reflect on their individual responsibilities (Phi and Waldesten, 2021). Furthermore, the results of a post-participation questionnaire about a sustainability hackathon at a British University (Surendran et al., 2023) saw an 88% agreement in students trying to actively resolve sustainability issues within their daily lives after taking part in a hackathon which is in line with the findings from this current study. Sustainability-based hackathons may encourage participants to take actions towards sustainability problems and 'learn by doing', rather than simply gaining knowledge.

There is a general understanding and acknowledgement amongst academics that developing student employability and producing employable students is of high importance in higher education (Peeters, et al., 2019; Römgens et al., 2020). With that being said, the results of the survey stated that only 44% respondents wanted to improve their employability skills, with 66% of respondents focusing on their enhancing their CVs. This could be due to participants originally signing up to the hackathon to gain sustainability awareness, instead of seeing it as an opportunity to enhance employability skills. Research by Jackson and Tomlinson (2020), states that students have internalised the importance of the need to be more proactive in their career planning. Hence our hackathon event could have done more to promote the potential benefits on offer in relation to employability. This may have helped us attract a wider audience and thus more participants.

The extant literature on interdisciplinary work covers an array of benefits it offers to students, ranging from enhanced employability to critical thinking and cognitive development (Shearer, 2007; Lyall et al., 2015; Seow, 2019; Ahmad, 2020). It was, therefore, encouraging to find that 61% of participants

in our investigation found that learning skills from students studying other subjects was one of the most valuable aspects of taking part in the project. This mirrors the findings from a UK university-wide sustainability hackathon, where 50% of respondents saw learning new skills from other students studying other subject disciplines as the most valuable aspect of taking part in a hackathon (Surendran et al., 2023). Hence, offering students the chance to collaborate across institutions, discipline areas and countries was perceived as a real benefit of the hackathon, and hence the hackathon team carefully curated mixed participant groups to maximise interdisciplinary (Kelly et al., 2020).

One of the main objectives of the UKSAEI partnership was to strengthen ties between Singapore and UK. Hence, the starting point for collaboration was the development of a hackathon for students to work together on tackling climate related issues. The COVID-19 pandemic prevented a physical student exchange, however digital platforms allowed students to undertake international mobility from the comfort of their home. The benefit of a cross-cultural hackathon allows for students to prepare for the future of diverse workplaces (Sernbo et al., 2023) where societal cohesion is fostered and social exclusion minimised (Larsen et al., 2011). The students in our hackathon were able to gain new insights and experiences which are reinforced as previously shown in another student online exchange where students enhanced their global citizenship knowledge (Larsen et al., 2011). Another advantage of a global project is that students can observe key similarities and differences between the way each country addresses issues, and reform their knowledge according to this new information (Mizrahi et al., 2017). Turner et al., (2016) also stated that virtual exchanges would allow students to explore new methods of communication and engagement, which is seen in our study where students realised difficulties in interpreting a task. Furthermore, it should be noted that participants taking part in hackathons could be a subset of students already interested in international collaboration

(Sernbo et al., 2023), which is unsurprising because a large proportion of students in this study were further interested in working abroad.

There were some limitations to this study. The study was a one-one, off online event, with a relatively small sample size of students who took part in the post-event questionnaire. The qualitative methodology used within this research was designed to provide descriptions of the hackathon experience of individual participants. It should be noted that all experiences may differ from the entire population of hackathon participants and thus are subjective accounts. It should also be noted that any verbalisation from a participant represents an opinion given at a moment in time and could potentially change with time. Another limitation to the study was that our sampling was not a random representation of all hackathon participants. The study utilised a purposeful method of sampling, thus those willing to fill the survey may have done so as they may have had particularly strong or negative views regarding the hackathon experience. It must be noted that the results of this study may be used as a platform for additional investigations into the use of hackathons into improving student skills. Although we had no mention of the effect of COVID-19 on student satisfaction; the COVID-19 lockdowns may have played a role in enhancing feelings of solidarity between team-mates whilst collaborating online, which could have led to greater feelings of satisfaction in responses.

There are several reflections and future directions to consider. The first would be to host the hackathon in-person to improve student engagement and attendance. Whilst there are benefits to online provision, the team felt they would see more engagement and commitment from students in-person. From this position, attendance could have been enforced as compulsory in order to build and strengthen team dynamics (Gillett-Swan, 2017). As a result of this feedback, future hackathons will be held in person.

The second reflection is around the marketing of the event. The hackathon team focused their promotions primarily on the sustainability aspect of the

event. Based on student feedback and wider reading, the hackathon team believe the marketing should have also focused on selling the employability and CV building opportunities to capture a wider audience. The third reflection is focused on supporting the participants post-hackathon. As students develop unique and creative ideas to tackle real-world problems, there is an opportunity to take these ideas further and support their development and implementation. This would help build a portfolio of impact from the hackathon and facilitate further development of the skills and employability of students.

Regarding future research, there is the opportunity to produce pre and post questionnaires to better understand student perceptions and so facilitate their potential development. There is also a question of whether the students fully appreciate and understand their development from the hackathon so close to its completion. Therefore, a future direction would be to conduct a longitudinal study to further examine student changing perceptions and the implementation of their hackathon knowledge and skills (Billett, 2009).

In summary, our study, for the first time, suggests that international sustainability hackathons promote the benefits of international collaboration across different subjects. It was also evident that our students were able to develop key transferable and employability skills, such as internationalisation, teamworking and communication skills. In addition to this, partaking in international hackathons is beneficial for university staff and students, as it promotes collaborative working and sharing best practise across institutions. By working together and raising awareness through international hackathons we can continue the global discussion on how to tackle climate change.

## **Declaration of interest statement**

**Disclosure statement:** All materials in the article represent the authors own work and anything cited or paraphrased within the text is included in the

reference list. The work has not been previously published nor is it being considered for publication elsewhere.

**Conflicting interests:** All other authors declare that there is no conflict of interest associated with their contribution to this manuscript.

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## Appendix:

### Appendix 1: Post-hackathon Questionnaire

Q1	<p>Your University (please tick one option from the following list):</p> <ol style="list-style-type: none"><li>1. University of Bath</li><li>2. Coventry University</li><li>3. Cranfield University</li><li>4. University of Dundee</li><li>5. University of Edinburgh</li><li>6. University of Glasgow</li><li>7. Kings College London</li><li>8. University of Manchester</li><li>9. Nanyang Technological University</li><li>10. National University of Singapore</li><li>11. Newcastle University</li><li>12. Singapore Institute of Technology</li><li>13. Singapore Management University</li><li>14. Singapore University of Technology and Design</li><li>15. University of Nottingham</li><li>16. University of Strathclyde</li><li>17. University of Surrey</li></ol>
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Q2	Your degree course _____
Q3	Year of study when undertaking the Hackathon project <ol style="list-style-type: none"><li>1. Foundation year</li><li>2. Year 1 of undergraduate studies</li><li>3. Year 2 of undergraduate studies</li><li>4. Year 3 of undergraduate studies</li><li>5. Year 4 of undergraduate studies</li><li>6. Masters student</li><li>7. PhD student</li><li>8. Other (Please specify) _____</li></ol>
Q4	What were your initial reasons for taking part in the Hackathon project? (tick all that apply)? * <ol style="list-style-type: none"><li>1. Interest in sustainability</li><li>2. To enhance my CV</li><li>3. To improve my employability skills</li><li>4. To gain experience in entrepreneurial activities</li><li>5. To improve my discussion/debating skills</li><li>6. To work with other students from other subjects</li><li>7. Other (Please specify) _____</li></ol>
Q5	Have you previously worked with a charity or a local business?

	<ul style="list-style-type: none"> <li>• Yes</li> <li>• No</li> </ul>
Q6	<p>Did you have any previous entrepreneurial experience before taking part in the Hackathon?</p> <ul style="list-style-type: none"> <li>• Yes</li> <li>• No</li> </ul>
Q7	<p>What were the most valuable aspects of participating in the Hackathon project (tick all that apply)? *</p> <ol style="list-style-type: none"> <li>1. Developing my academic knowledge of a new subject</li> <li>2. Developing my sustainability awareness</li> <li>3. Taking part in a sustainability-focused project</li> <li>4. Developing entrepreneurial skills</li> <li>5. Winning prizes</li> <li>6. Improving my CV</li> <li>7. Joining a new online virtual community</li> <li>8. Learning new skills from students in other subjects</li> <li>9. Learning to use new online platforms and technologies</li> <li>10. Networking with students and faculty members from other subject disciplines</li> <li>11. Not being formally assessed</li> <li>12. Other (Please specify) _____</li> <li>13. Developing my global and cultural awareness</li> <li>14. Learning about the experiences of students in other countries</li> </ol>

15. Networking with students and faculty members from other educational institutions						
Q8	Following your participation in this project, to what extent do you agree with the following statements? *					
		Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
	1.The project has made me realise that connecting with students in different subject areas is important.					
	2.The project has made me realise that connecting with people in different countries is important for my educational development					
	3.Connecting with students in different countries will help me feel part of a global community					

	4.I believe I now can adjust better to new people, places, and situations.							
	5.I believe that it is important to take the time to learn about global issues							
	6.I feel confident socialising with people from other cultures.							
	7.I feel comfortable talking about and discussing my ideas online with peers							
	8.I feel that my university has developed my use of online technologies							
	9.I believe that online delivery of the Hackathon worked well							



	10.The Hackathon has broadened my horizons and knowledge about the world						
	11.Participation in the Hackathon has increased my awareness of sustainability issues						
	12.I am now more actively trying to resolve sustainability issues within my daily life.						
Q9	What were the main benefits of working in an interdisciplinary team in the Hackathon project? (Please type your response below)						
Q10	What were the main challenges of working in an interdisciplinary team in the Hackathon project? (Please type your response below)						
Q11	To what extent do you agree that the following skills have been enhanced via participation in this project?						
		Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	

	1.Teamwork					
	2.Time management					
	3.Presentation skills					
	4.Discussion / debating skills					
	5.Communications skills					
	6.Entrepreneurial skills					
	7.Critical thinking skills					
	8.Ideation skills (i.e., coming up with new ideas)					
	9.Leadership skills					
	10.Confidence / self-belief					
	11. Future thinking skills (assessing the consequences of actions)					
	12. Strategic skills (i.e., develop and implement innovative actions that					

	further sustainable development)						
Q12	Were there any other skills that have been enhanced via participation in this project? If yes, please write the answer below: _____						
Q13	Were there any obstacles with participating in the Hackathon project? If yes, what were these? _____						
Q14	In your view what worked well with the Hackathon project? (Please type your response below) _____						
Q15	In your view what could be improved with the Hackathon project? (Please type your response below) _____						
Q16	After completing the Hackathon, I am considering studying abroad as part of my degree. *						
Q17	If you answered yes to the previous question, what is your primary reason for wanting to study abroad? (Please type your response below) _____						
Q18	Do you think that participation in the Hackathon has made you aware of a wider range of career paths? <ul style="list-style-type: none"> <li>• Yes</li> <li>• No</li> <li>• Unsure</li> </ul>						
Q19	After participating in this project, I am now considering a future related to entrepreneurial activities.						

	<ul style="list-style-type: none"><li>• Yes</li><li>• No</li><li>• I had already considered a future related to entrepreneurial activities prior to participating in the Hackathon project.</li><li>• Unsure</li></ul>
Q20	After completing this Hackathon, I am considering a career that would allow me to travel internationally. * <ul style="list-style-type: none"><li>• Yes</li><li>• No</li><li>• I had already considered a future career that would allow me to travel internationally prior to participating in the Hackathon project.</li><li>• Unsure</li></ul>
Q21	Do you believe that participating in the Hackathon has enhanced your CV? * <ul style="list-style-type: none"><li>• Yes</li><li>• No</li><li>• Unsure</li></ul>
Q22	Would you recommend other students to participate in a Hackathon? <ul style="list-style-type: none"><li>• Yes</li><li>• No</li><li>• Unsure</li></ul>