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The use of extracurricular hackathons to promote and enhance students' academic and employability skills

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ABSTRACT/SUMMARY

This article explores the academic and personal development outcomes from a two-week, University-wide sustainability hackathon conducted online. Data was gathered from 18 out of 23 participants through a post-hackathon questionnaire featuring 24 structured questions. These questions covered various aspects, including participants' prior work experience, motivations for participating in the hackathon, shifts in their attitudes toward sustainability, perspectives on interdisciplinary collaboration, and acquired skills. Quantitative data underwent analysis using, as appropriate, Spearman's correlation and Mann-Whitney tests, while qualitative responses were examined via thematic analysis. The results showed an improved awareness and appreciation of several personal and professional skills, encompassing ideation, product development, leadership, resilience, and teamwork. Additionally, they highlighted an increased appreciation for interdisciplinary collaboration, fostered through interaction with students from diverse academic backgrounds.

Introduction

Since their inception in the technology sector, hackathons, or 'hacking marathons,' have gained popularity in higher education (Warner & Guo, 2017). Originally, hackathons were events where interdisciplinary teams collaborated rapidly to prototype new applications over a 24–48 h period (Uys, 2019). These typically followed the input–process–output (IPO) model, with the 'input' phase involving ideation and team building, the 'process' phase characterised by intense 'hacking' and demonstration of results, and the post-hackathon, or 'output' phase, consisting of developing plans or solutions to a problem (Komssi et al., 2014).

Industries and educational institutions are increasingly embracing hackathons due to the opportunities and benefits they offer (Kienzler &

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Fontanesi, 2017). In higher education, the IPO model has expanded into various subjects and extracurricular disciplines, where participants collaborate to generate new ideas and address real-world challenges in an experiential setting (Iglesias-Sánchez et al., 2019).

As such, hackathons are emerging as potentially effective active learning methods, particularly in problem-based learning (PBL) and creating opportunities for deep, sustained, and meaningful learning that integrates theory and practice (Savery, 2006; Avila-Merino, 2019).

Engagement in hackathon style projects has also been seen to lead to the development of skills highly valued by employers, including communication, problem-solving, and teamwork (Uys, 2019). These skills can be challenging to incorporate into traditional higher education curricula, yet they are crucial for making a positive impact in the workplace and other professional settings (Loveland, 2017; Uys, 2019).

Whilst it is uncertain how much personal development students can achieve during the limited timeframe of hackathons (Porras et al., 2018), personal growth remains a key incentive for student participation, alongside 'the opportunity to meet new people while learning and experimenting' (Komssi et al., 2014). Some authors have even concluded that hackathons may be more effective in developing entrepreneurial self-efficacy than longer courses (Szymanska et al., 2020; Eimler & Straßmann, 2023; Funck, 2023).

In addition to transferable skills, employers also perceive the development of sustainability-orientated skills (such as the ability to analyse interdependencies and to analyse and predict consequences) as important amongst recent graduates (McCarthy & Eagle, 2021). To help develop students' competencies in sustainability, engagement in authentic 'real-world' projects has been seen as a preferred method (Bigg et al., 2018).

The University of Surrey has a well-established history of providing entrepreneurial-style opportunities through its 'Student Enterprise' facility. This includes the organisation of hackathons tailored for students interested in launching businesses and the 'Enactus Programme,' an initiative aimed at empowering student-led social enterprise projects. Despite their merits, these initiatives face limitations in terms of their reach across the University.

To address this challenge plus foster the transfer of essential skills and sustainability awareness, we organised a university-wide sustainability hackathon. Additionally, we conducted a post-event analysis to assess the impact of student participation.

Therefore, this study focuses on how participation influenced students' attitudes and intentions toward sustainability, entrepreneurial activities, their confidence in approaching the labour market, and the extent to which they felt their involvement enhanced specific skills and capabilities. Additionally, the study makes recommendations to inform the development of future hackathons based on the University of Surrey's experiences.

Rationale for approach taken

The format of the sustainability themed hackathon emerged from combining the need to develop students' employability, transferable and sustainability-orientated skills with the University of Surrey's commitment to sustainable development and education.

A 'real-world' project approach was chosen, allowing students the flexibility to select issues aligned with the United Nations' Sustainable Development Goals (SDGs) for resolution. This approach was specifically chosen for its proven effectiveness in cultivating skills related towards sustainability (Bigg et al., 2018).

The hackathon aimed to educate students on the UN's SDGs, raise awareness of global sustainability issues, spark innovation, develop students' critical thinking and business skills, and inspire students to reflect on the roles they could play in developing a sustainable economy. The approach explicitly linked entrepreneurial activities with sustainability and a sustainable economy, in line with the UN SDG 9: Industry Innovation and Infrastructure and UN SDG 8: Decent Work and Economic Growth.

The hackathon also represented an innovative way to deliver opportunities for students that aligned with all five of the University's Education Strategy (Forward Thinking and Doing 2021–24) graduate attributes: Sustainability, Digital capabilities, Employability, Global and Cultural awareness and Resourcefulness and resilience.

The hackathon was initially designed for foundation year students to facilitate a smooth transition to successful university-level studies at levels 4–6. As the planning phase progressed, it became evident that the interest and participation of foundation students were lower than expected. Consequently, the participant intake was expanded to address this issue. This introduced a potentially beneficial dimension to not only offer interdisciplinary learning experiences, but also to build in designed inter-level learning experiences, with students from different year groups learning from each other. This kind of inter-level learning is increasingly seen as valuable in research, education and the job market (Zirger & Privitera, 2009).

Methodology

Hackathon structure and delivery

The project was carried out with 23 participating students and was delivered remotely via Microsoft Teams over two weeks (**Appendix 1**) immediately after the Spring semester examination period (14–25th June 2021). Colleagues from all faculties (Faculty of Arts and Social Sciences, Faculty of Engineering and Physical Sciences and Faculty of Health and Medical Sciences), the Sustainability team, the Surrey Institute of Education, Library and Learning Services and Student Enterprise were involved in the design, organisation, and delivery of the event.

The event was structured as follows: the first three days were delivered as an intense series of sessions on teamworking, presentation of the sustainability 'problem statements' and masterclasses on entrepreneurial and business skills. This was followed by a week of working on the selected problem statement in teams, with set points for facilitation by PhD student mentors including a practice pitch/feedback session with MBA students before the final pitch of the completed business ideas and plans to a panel of judges on the final day. The first day concentrated on icebreaking activities encouraging networking between participants to form teams from differing degree programmes and levels, to encourage interdisciplinary working and learning across levels. This was followed by the presentation of five problem statements relating to various areas of sustainability pitched to the students by three 'clients': one representing the University, another representing a health charity and one representing the UK Environment Agency.

The sustainability problem statements presented to students were as follows:

Statement 1: UN SDG 3: Good Health and Well-being:
Task: Consider ways to increase health screening and decrease stigma around cervical smear testing, and find solutions to increase funding for a health charity.
Statement 2: UN SDG 6: Clean Water and Sanitation:
Task: Find solutions to address major sewage issues in the area, including the formation of fatbergs.
Statement 3: UN SDG 10: Reducing Inequalities:
Task: Develop digital products, tools, and apps to improve racial equality at the university.
Statement 4: UN SDG 11: Sustainable Cities and communities:
Task: Design a solution to ensure that food and compostable items are no longer disposed of in the wrong bins on campus.
Statement 5: UN SDG 12: Responsible Consumption and production:
Task: Design a solution to reduce face mask littering at the University.

In working with local communities, this project employed community-engaged pedagogies (Rubin et al., 2012) and a service-learning approach which fosters a sense of community service aligned to learning goals and to promoting student learning and the common good (Bandy, 2011). Importantly, this experiential learning allows students to be more aware of a wider range of future professional paths. Our partnerships involved academic staff and professional companies and, in doing so, we used a 'living lab' approach (Higgins & Klein, 2011) designed to foster dynamic partnerships between the University and local stakeholders to address real-world sustainability problems. As such, following the presentations by the 'clients', the participant teams selected their preferred issue and were encouraged, throughout the ideation and preparation phase, to collaborate and discuss possible approaches with professionals working in the fields related to their chosen problem.

Over the following two days, the teams attended a range of masterclasses that delivered business training including an introduction to Social Lean Canvas (a tool to develop a business solution contained within a single page), identification of target market and sales channels, how to build a business model (in particular, how to identify possible revenue streams), cost structures, how to use key performance indicators and how to prepare an investor deck for business plan pitches.

Teams were assigned PhD student mentors, with whom they met on days 5 and 10, whilst preparing their sustainable solutions; the teams then pitched online to MBA students in a practice run on day 11, prior to the final pitch to a panel of judges on day 12. The judging panel was made up of three senior members of staff with expertise in entrepreneurship and sustainability in business, and an Associate Dean of Education. The prizes awarded were for the best- and second-best overall solution and pitch, alongside some individual performance prizes for most engaged team player, inspiring leadership, resilience, innovative thinker and, finally, an audience vote for favourite pitch.

Participant recruitment and team population

Participants were recruited following email advertisements, lecturers promoting the project within their classes and promotion on the University's virtual learning environment. Students were asked to complete a Microsoft Forms expression of interest and provide details of their year of study and course and were then selected onto the final project teams. The final composition of participants was as follows: foundation year (13 students), first year of undergraduate studies (3 students), second year of undergraduate studies (2 students), placement year (1 student), masters (2 students) and PhD (2 students), a total of 23 participants.

Students were placed into seven teams of four or five based on their course, such that no more than two people from similar courses were on the same team. This ensured teams had diverse backgrounds of skills and subject experiences and deterred students from forming teams with their friends, which were likely to have come from the same course. A characteristic example of the programme diversity achieved would be a group including students from Nursing, Economics, Chemistry and Sociology.

All students who took part in the hackathon were contacted via email to participate in a post-hackathon questionnaire.

Sampling and data collection

The use of a questionnaire to collect data, including a mix of closed questions and freeform fields post-event from participants and quantitative and qualitative (thematic analysis) thereof received ethical approval by the University of Surrey ethics committee (FHMS 20–21 185 EGA).

Data collection occurred post-student participation in the hackathon, utilising a structured online questionnaire (Axinn & Pearce, 2006). The questionnaire prompted students to reflect on their pre- and post-event perceptions, capturing insights into what they expected the participation to entail and how the overall experience was. The questionnaire (**Appendix 2**) was built following an abductive approach where there was an acknowledgement of both inductive and deductive dynamics in the construction of the research tool (Pearce, 2012). In adopting a pragmatist approach (Morgan, 2007; Onwuegbuzie & Leech, 2005), the study acknowledges the relevance and usefulness of a mixed methods methodology in addressing specific research questions (Bryman, 2006).

All participants gave their informed consent to participate in the study and there were 18 responses to the questionnaire (a response rate of 78.2 %).

Qualtrics was used to design the questionnaire, which comprised of 24 questions exploring: previous student work and entrepreneurial experiences, prior interest in issues of sustainability, reasons for joining the hackathon and their expectations for it (the 'looking back' dimensions); what they learned from the project, what they most valued in the hackathon experience, whether attitudes toward sustainability changed as a consequence of taking part, perspectives on the experience of interdisciplinary working and the skills students felt they took away from the experience (participatory and 'forward looking' dimensions). The research tool used a mix of Likert type questions, closed and open-ended questions.

Questionnaire analysis

Quantitative data was analysed using both descriptive and inferential statistics, whilst qualitative responses were analysed via a thematic analysis approach involving coding of responses to identify themes (Elliott, 2018). These can be seen later in the results section where responses to questions (**See Appendix 2**) are denoted as 'Qnumber' with the sub-question is designated as 'Qnumber_number'.

The quantitative data was analysed using SPSS [Version 28.0.1.0]. Selection of appropriate tests considered the objectives of the study and the four key concepts covered were: sustainability, employability, entrepreneurship and interdisciplinary working. A mix of Spearmans correlation and Mann Whitney tests were run, chosen for their suitability for the data type and depending on whether a test of association or difference was required. Whilst there were cases of Mann Whitney tests used to compare opinions on an ordinal scale between two groups, based on a dichotomous variable, there were also two cases of Likert type items being summed to form a new variable for comparison across two groups.

The first summation related to the level of agreement of these three statements: 'The project has made me realise that connecting with students in different subject areas is important', 'The project made me realise that connecting with people in different subjects enhances my educational experience' and 'I now feel more confident socialising with people from other subjects'. This generated a single score for comparison with 'working with students from other subjects was an initial reason for joining the hackathon'. Due to the small group sizes ($n = 11$ and $n = 6$) and the summation of a small number of ordinal items, a Mann Whitney test was run.

The second summation was to create a total skills variable, utilising the question: 'To what extent do you agree the following skills have been enhanced via participation in this project?' and summing across the following: teamwork, time management, presentation skills, discussion/debating skills, communication skills, and critical thinking skills. Whilst the summation of 6 ordinal 5-point Likert-type items could potentially form an interval variable, given the relatively small groups for comparison ($n = 11$ and $n = 4$), reliable normality testing could not occur, hence the use of a Mann Whitney test.

Results and discussion

It should be noted that, due to the small sample size, inferential statistics should not be taken as conclusive standalone results but

considered in conjunction with qualitative results.

1) **Recruitment and previous participant experience**

The demographic characteristics for the responding student populations (18 of the 23 participants, 78.2 %) are shown in Table 1. Many survey responders were foundation year students (56 %), which is not surprising given the initial focus on recruiting students at this level. This was followed by Year 1 undergraduate students (17 %), Masters students (17 %), Year 3 undergraduate students (6 %) and Placement Year students (6 %).

There were more respondents studying STEM subjects (61 %) than those studying non-STEM subjects (39 %). This could be due to more promotional input from science subject leads, thus highlighting the importance of programme teams' active promotion of extra-curricular events such as the hackathon with their students.

Approximately 39 % 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 (56 %). This larger than expected level of previous experience in entrepreneurial/charitable activity could be due, in part, to the hackathon being promoted through the University's Student Enterprise team, which includes a branch of Enactus, an international organisation who support students in developing entrepreneurial skills and outreach projects.

2) **Sustainability**

Analysis of the participants' freeform responses and quantitative data relating to sustainability can be grouped in three broad categories: prior interest and perceived value in taking part in a sustainability hackathon, impact of participation on UN sustainability goal awareness and broadening of knowledge of the world following hackathon participation.

2.1 Prior interest in sustainability and value of taking part in a sustainability awareness hackathon project

The most selected initial reason for taking part in the hackathon [Q4] was 'interest in sustainability' (83 %, 15 of the 18 respondents). In addition, 92 % (12 of the 13 respondents to [Q7]), identified 'developing their sustainability awareness' and/or 'taking part in a sustainability-focused project' as amongst the 'most valuable aspects' of their participation in the hackathon. This supports the selection of sustainability as a theme for the hackathon project, as it is a concern for many young people and very few studies have addressed engaging students with sustainability in the UK HE context (Saukkonen et al., 2020; de Macedo Guimarães *et al.*, 2021; Haddock et al., 2019).

Of the 15 participants identifying a prior interest in sustainability as a reason for participation, nine selected both 'developing their sustainability awareness' or 'taking part in a sustainability-focused project' to be one of the most valuable aspects of participation, five selected one or the other and one selected neither.

Differences in response about the value of participation in the hackathon on their awareness of sustainability could be explained by some of the students feeling that they had good sustainability awareness already (or at least better than some of their peers) and, thus, how this was a less valuable aspect for them. It must not be assumed that just because 'taking part' and 'developing awareness' did not make all respondents' 'most valuable' listings that this necessarily means these were not valued. In retrospect, perhaps we should also have provided an opportunity for participants to rate the value of each aspect.

2.2 Positive impact of the hackathon in terms of reinforcement of UN Sustainable Development Goals (SDG) awareness and personal lifestyle change

When asked if participation in the hackathon 'has increased my awareness of the UN Sustainable Development Goals (SDGs)' [Q8_13], 14 of 17 respondents (82 %) agreed (six 'strongly', eight 'somewhat'), with three students responding neutrally. In addition, when asked if they agreed with the statement 'I am more actively trying to resolve sustainability issues within my daily life' [Q8_14], 15 of 17 respondents (88 %) agreed (seven 'strongly' and eight 'somewhat'), with one student answering neutrally and one student 'somewhat' disagreeing.

To test if there was a relationship between an 'increased awareness of sustainability issues' and the 'likelihood of resolving sustainability issues in their daily lives', a Spearman's rank correlation coefficient test was carried out which demonstrated a weak correlation between the two, that was not significant ($r^2 = 0.395$, $p = 0.116$). A weak correlation was expected, as many students may believe that they are already living a sustainable lifestyle (as evidenced by their initial interest of taking part in the hackathon).

In addition, some of the problem statements covered by the students (such as cervical cancer screening) may not have been as easily identifiable as SDGs, as previous studies have shown that while university students are aware of the SDGs, very few of them have a good knowledge about these. Moreover, studies indicate that students perceive sustainability as mostly an environmental matter, with lesser consideration being given to social and economic factors (Smaniotto *et al.*, 2020; University of Melbourne, 2020).

2.3 Participation in the hackathon 'broadened my horizons and knowledge of the world' / 'changed my perspectives about the world'

The question as to whether the hackathon helped participants to broaden their horizons/knowledge about the world [Q8_12] elicited relatively strong positive responses, with 16 of 17 (94.1 %) respondents indicating that they either strongly or somewhat agreed that it had, and only one respondent adopting a neutral position. That said, there was a ratio of 3:1 in favour of 'somewhat' over 'strongly' amongst the positive respondents.

Naturally, this question does not necessarily relate fully with increased awareness of the importance of sustainability; for example, it could be interpreted more widely, perhaps from the perspective of learning from students studying other subjects and enjoying cross-disciplinary working. This stated, it is reasonable to assume that most, if not all students, were thinking about sustainability when deciding on their response, given that the similar Likert statement, 'The hackathon has changed my perspectives about the world' [Q11_1], invited students to elaborate on their response with freeform responses [Q12] and that, of the 11 responses, nine made explicit sustainability connections (the other two being too opaque to determine with certainty). For example: "I

Table 1
Demographic characteristics of student hackathon programme respondents ($N = 18$).

Variable		Frequency	Percentage (%)
Year of study	Level 3 (Foundation Year)	10	56
	Level 4 (Year 1 of undergraduate studies)	3	17
	Level 6 (Year 3 of undergraduate studies)	1	6
	Level 7 (Masters)	3	17
	Placement Year student	1	6
Degree course studied	STEM subject	11	61
	Non-STEM subject	7	39
Previous entrepreneurial experience prior to hackathon participation	Yes	7	39
	No	11	61
Previous experience working with a charity or a local business prior to hackathon participation	Yes	10	56
	No	8	44

am more conscious about my contribution towards sustainable matters and I am more inclined to share my knowledge with others", "It made me realise how much we need to do to protect our planet" and "It reminded me of the importance of sustainability, which is something that can easily slip out of someone's head if they are not constantly thinking or reminded about it".

3) **Skills, employability and enterprise/entrepreneurialism**

Analysis of quantitative data and the thematic analysis of freeform responses related to employability, enterprise and entrepreneurialism revealed three broad categories: perceptions on employability, student enterprise experience and wider skills development.

3.1 Perceptions on employability

Five out of the 18 (28 %) respondents identified improving their employability skills as one of their reasons for taking part in the hackathon [Q4] but, following the project, 11 out of the 18 (61 %) agreed that one of the most valuable aspects of having taken part was 'improving my CV' [Q7]. This is interesting in the context of the increased focus on employability within higher education globally (Cheng et al., 2022; Govender & Taylor, 2015).

This increased focus is often contextualised within wider changes in the global political economy, such as the financial crisis of 2008 or the Covid-19 pandemic (Arora, 2015; Buheji & Buheji, 2020). In the UK, increasing marketisation of higher education and the introduction of higher student fees has highlighted the focus on employability even further (Pemberton *et al.*, 2013; Wilton, 2014; Blackmore et al., 2015). In fact, some suggest employability is what students are paying for within such a marketized system (Jameson *et al.*, 2012; Jackson, 2014). One consequence this raises is the skills, attributes and capabilities that a student should be able to evidence, and to what extent they relate to successful participation in the variety of opportunities higher education can offer, such as hackathons (Smith & Worsfold, 2014; Hill *et al.*, 2016). Overall, employability outcomes are important motivators for students and something they expect will be developed during university (QAA, 2016).

When asked 'Do you think that participation … has made you aware of a wider range of career paths?' [Q20], eight (50 %) of 16 students indicated 'yes', with six (38 %) opting for 'unsure' and two (13 %) for 'no'. There did not appear to be a difference in this perception depending on previous experience of working at a local charity/business, or not, post hackathon, as roughly equal numbers responded positively to this question from those with or without previous experience [Q20].

To determine whether students' subject discipline influenced this career awareness, a comparison between those on STEM subject programmes and those taking non-STEM subjects was undertaken. There was, however, no statistically significant difference between their responses (Mann Whitney *U test,* $p = 0.803$). This perhaps goes against perceptions that STEM students have a higher level of career awareness and therefore more positive career outcomes (Xu, 2013).

3.2 Student enterprise/entrepreneurial

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] and 11 students (61 %) in total asserted that this and/or 'improving employability skills' was a reason for participation [Q4_3 & Q4_4]. Asked if they had any previous entrepreneurial experience before taking part in the hackathon [Q6], seven of the 18 respondents indicated that they had. Only two of these seven, however, were amongst the nine students outlining developing entrepreneurial skills as a reason for participating, such that seven students indicating this as a reason had no prior experience.

Following participation, eight out of the 18 (44 %) respondents identified 'developing entrepreneurial skills' as one of the most valuable aspects of having taken part [Q7_4]. However, this similarity of before and after responses masks some variation in individual responses across the questions. Five of the nine students who had indicated developing entrepreneurial skills as a reason for taking part confirmed this as amongst their 'most valuable aspects' of participation, while a further three students who had suggested that developing entrepreneurial skills was not a factor in wanting to take part identified this as amongst the most valuable aspects of participating; for six students (33 %), the entrepreneurial dimension was not a key factor for participation before or after engaging with the event.

Of the 16 responses, 13 (81 %) [Q15_6] were positive about their entrepreneurial skills development after having participated in the hackathon. There was, however, no link between those that had, or had not, indicated an initial interest in entrepreneurial skills for taking part in the hackathon with their perception as to whether their entrepreneurial skills had been developed (Mann Whitney-U test, $p = 0.733$).

Interestingly, only seven out of 15 students (47 %) indicated that they would consider a future career in entrepreneurial activities [Q21] (Fig. 1). No significant difference was observed between those who took part in the hackathon to gain experience in entrepreneurial activities and those who would consider a future related to enterprise [Q4_4 and Q21] (Mann Whitney-U test, $p = 0.254$).

Notably, 75 % of non-STEM subject students reported to be considering a future in entrepreneurial activity, versus 36 % of STEM subject students. This is perhaps not surprising, as the non-STEM subjects included courses such as Business and Economics.

It should also be noted that 87 % of students indicated an interest in taking part in other employability extra-curricular events in future, following participation [Q22].

3.3 Wider skills development

Students were asked in various ways about the extent to which they felt they had enhanced skills more generally, in relation to employability, learning enhancement and life generally.

When asked about improvement in their general employability skills, 88 % of students agreed that, following the hackathon, they felt they could 'adjust better to new people, places and situations' [Q8_3], whilst 82 % indicated 'feel[ing] more comfortable talking and discussing my ideas on-line with peers' [Q8_5] and 94 % believing that the hackathon 'broadened their horizons and knowledge about the world' [Q8_12].

This finding was also supported when asking about the enhancement of students' transferable employability skills such as their teamworking, time management, presentation, discussion/ debating skills, communication and critical thinking skills (Fig. 2) [Q15]. This enhancement was not, however, statistically associated with the students' pre-hackathon perception of the reasons for taking part in this project [Q4_3 and Q15] (Mann Whitney-U test, $p = 0.892$).

More specifically, when asked whether their reason for taking part was to improve discussion/debating skills, only six out of 16 (38 %) students selected this option [Q4_5]. By contrast, 88 % of students agreed/strongly agreed [Q15_4] that their 'discussion/debating skills have been improved by taking part'.. Nevertheless, the Mann Whitney test did not show statistical significance when comparing the opinions on this question between those who took part in the hackathon to

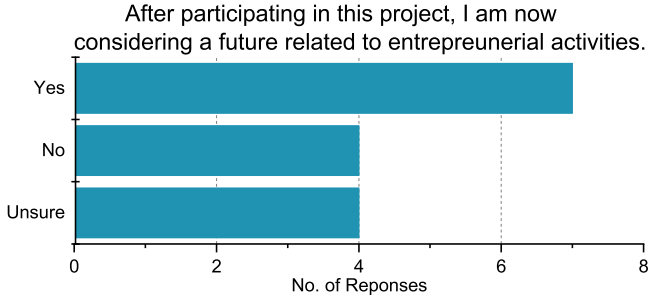

Fig. 1. Bar chart showing agreement that upon completion of the project, students are now considering a future relating to entrepreneurial activities [Q21].

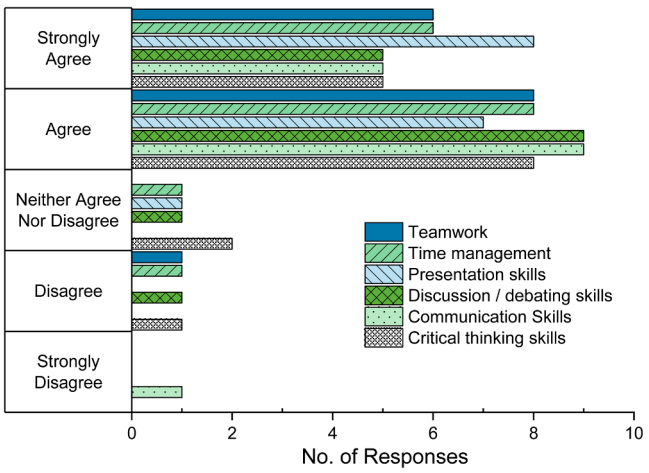

Fig. 2. Bar chart showing students' perceptions of skills enhanced as a result of taking part in the hackathon project [Q15]. Blue, clear: teamwork; green, forward slash: time management; light blue, backslash: presentation skills; dark green, crosshatch: discussion / debating skills; light green, dots: communication skills; white, small crosshatch: critical thinking skills. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

improve discussion/debating and those who did not ($p = 0.808$).

When asked if there were any other skills that students felt had been enhanced through participating in the project [Q16], responses included planning and organising, leadership, people management, project management, research and evaluation, creativity, patience and resilience. Additionally, five out of 18 (28 %) participants claimed that learning to use new online platforms and technologies was one of the most valuable aspects [Q7_9].

4) **Interdisciplinarity**

Analysis of participants' freeform responses and quantitative data related to interdisciplinarity, reveals three broad categories: the benefits of interdisciplinary working on skills enhancement, connection with others and the world, and benefits and challenges of interdisciplinary working.

4.1 Pre-/post-perceptions of the benefits of interdisciplinary working on gaining new skills

Six out of the 18 total respondents (33 %) indicated that working with students from other subjects was a reason for taking part [Q4_6] and, following participation, 9 out of 18 respondents (50 %) suggested that one of the most valuable aspects of taking part was learning new skills from students in other subjects [Q7_ 8]. 8 students (44 %) stated that networking with peers and faculty members from other subject disciplines was valuable [Q7_10]. This equated to a total 11 of the 18 respondents (61 %) seeing value in at least one of these aspects.

This relatively low impact, or perceived importance, of working with others in the acquisition of skills as a result of participation (in comparison to the figures for the importance of sustainability of 83 %) was mirrored in the freeform responses. In response to 'What in your own words were the benefits of working in an interdisciplinary team' [Q13], only three out of the 14 freeform comments alluded to the acquisition of new skills as beneficial.

4.2 Connecting with others and the world

When asked whether taking part in the hackathon benefitted their views on connectivity and sharing of viewpoints with other people, 16 out of 17 respondents either 'strongly agreed' or 'somewhat agreed' with one of 3 questions related to connecting with other students [Q8_1, Q8_2 or Q8_4] (with 16, 16 and 14 out of 17 respondents agreeing, respectively).

A summed score of Question 8_1, 8_2 and 8_4 was created, which represented the impact of the hackathon on skills relating to connecting and socialising with students from other subjects. This was statistically significant when tested against Question 4_6 (which asked if the initial reason for taking part was… 'to work with other students') using a Mann Whitney *U test* ($p = 0.023$, effect size = 1.29, power = 64 %).

This was supported by 15 out of 17 respondents who 'agreed' or 'strongly agreed' with the statement that 'the project has made me realise that connecting with students from a range of subjects will help me view the world differently)' (Fig. 3[Q9]).

When invited to explain their responses as freeform comments [Q10] to the statement included in Q9, 10 students responded with comments, eight of which were positive and two of which were neutral. Four perspectives emerged from these freeform responses (Table 2).

Of the two comments that were more neutral, one indicated that 'had the event taken place in person', they would have experienced this to a greater degree. Studies comparing virtual versus in-person hackathons have highlighted the challenges associated with virtual hackathons, such as: communication issues, difficulty in grasping the common view, decreased social interactions with other teams, a decrease in casual and easy access to mentors and a decrease in networking with other participants (Suominen *et al.*, 2021; Mendes *et al.*, 2022).

4.3 Benefits and challenges of interdisciplinary working

Questions 13 and 14 invited students to leave freeform comments on the benefits [Q13] and challenges [Q14] of working in an interdisciplinary team in the hackathon project.

The majority of comments given by students in response to question 13 mirrored the answers they had previously provided in question 10, where they provided freeform comments expressing how connecting with students from various subjects would broaden their perspective on the world. This was particularly so in two areas: for example, five responses highlighted 'ideas generation' as a benefit and seven emphasised the 'Benefits of multiple perspectives/developing new knowledge'. One student commented that "It helped bring out my leadership and teamwork skills and took me out of my comfort zone".

Finally, students were asked 'What were the challenges of working in an interdisciplinary team in the hackathon project?' [Q14] and, from a total of 12 responses, three 'challenge themes' emerged (Table 3).

Challenges of time were highlighted in three instances (all three of which are included above). Interestingly, three students responded that there were no challenges, while one additional respondent suggested "There weren't really any challenges, if anything the challenges were faced together to do with the project". It is worth noting that these responses came from four different student teams, rather than being a sentiment more prevalent in winning teams.

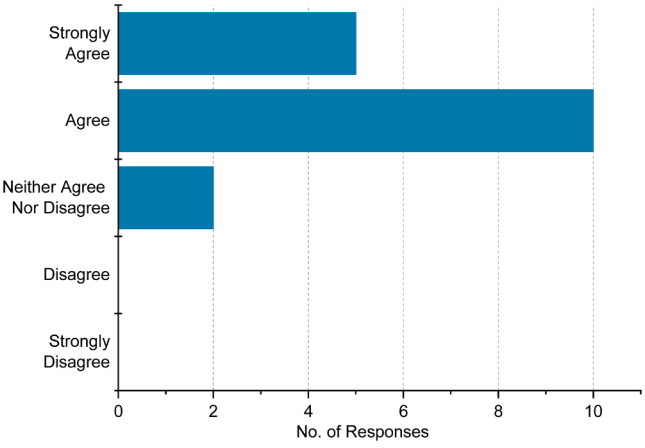

Fig. 3. Bar chart showing agreement that the project made the students realise that connecting with other students from a range of subjects would help them view the world differently.

Table 2
Freeform comments in Question 10 of students explaining their answers to Question 9.

Perspective	Freeform comments
Ideas generation and innovation	"A wide variety of backgrounds leads to a wide variety of ideas" "[it] has taught me that each person has their own different skill set and when used together you can create a great idea/product" "[it] can help bring in new ideas to a team [and] encouraged me to think of more innovative solutions that use my degree background as well"
Benefits of multiple perspectives/ developing new knowledge	"[it allowed us to] share our different skills and experiences that we have learnt from [our] courses" "[it] has taught me that each person has their own different skill set and when used together you can create a great idea/product"
Exploiting varied skills and experiences for mutual benefit	"Being amongst people with different discipline knowledge helped to broaden yet also refine our perspectives in the best possible ways" "When you see the world your own way with no input from others, you [are] guaranteed to misinterpret, overlook or miss something"
Increasing cultural/global awareness	"Everyone has a different background and culture to share and educate others about"

Table 3
Freeform comments of students' challenges when working in an interdisciplinary team in the hackathon project (Q14).

Perspective	Freeform comments
Team members agreeing the way forward/communication difficulties	"Sometimes agreeing on the best way to approach a problem'' "Managing team member's different opinions and mitigating with accurate solutions" "It required a lot more time for all members to get on the same page as there was a lack of knowledge on some subject matters" "Misunderstanding miscommunication"
Addressing areas of lack of knowledge	"People pushing their knowledge more" "Lack of knowledge on some subject matters"
Balancing learning and working commitments and time challenges	"Finding time to discuss our project as we had some students who were working etc." "Task management and time management as [a] few were not in the country."

In summary, looking across the questions addressing interdisciplinary working, we can see that this had multiple benefits for hackathon participants, helping them to broaden their views and develop their skills and the quality of their solutions. While challenges were present, these did not take away from the perceived benefits of working in a multidisciplinary team.

5) Obstacles and strengths of hackathon participation

When asked if there were any 'obstacles in participating in the hackathon', three students said there were none, whilst three identified that 'personal commitments' outside of the hackathon interfered with their full commitment to the project. Given the online nature of the hackathon, one student who was participating from abroad identified that 'time zones' were an obstacle. A further two comments were related to interpersonal skills, where 'stress' and 'lack of communication' was identified [Q17].

Four students acknowledged the support provided by staff and mentors when expressing their views on the advantages and benefits of the hackathon project. An additional four students found the 'teamworking' aspect beneficial. One student noted that the organisation of the event worked well and another thought the theme of the hackathon was beneficial for 'gaining more knowledge on ways to help the local communities' [Q18].

Students also suggested possible improvements for the project. This included a larger 'prize' fund, running future events in-person, having group members that were 'present' for the whole duration of the hackathon and more sessions to enhance knowledge about 'economy'. Whilst 94 % of students believed that the online delivery worked well [Q8_7], having compulsory in person-sessions could promote student engagement and guarantee attendance.

Of the participants, 100 % suggested they would recommend other students taking part in future hackathons [Q23]. Upon analysis of the reasons why students would recommend the event, responses were related to: 'novelty', 'fun', 'CV enhancement', 'skill development' and the opportunity to 'meet new people'.

Final reflections of the hackathon event and conclusions

Overall, the hackathon was a fun and novel experience for most of our students, many of whom had no previous entrepreneurial experience. The success of the event was reinforced by all respondents indicating that they would recommend the event to their peers.

Uptake by foundation year students was lower than anticipated in the first instance and therefore applications were opened to other year groups and levels of study. This had the benefit of increasing the diversity and range of skill sets of participants, and no doubt made for better quality of proposed solutions.

In the future, we will ensure all levels of study are invited to participate from the outset and will encourage a larger number of participants in total, by increasing the profile of the hackathon through University channels and by engaging a corporate sponsor to add gravitas (Lee *et al.*, 2012; Pappu & Cornwell, 2014). Psychosocial theories relating to identity development offer insights into how students evolve both during their university years and in their broader life journey. When students of various academic levels, ranging from Foundation Year (usually around 18–19 years old) to those pursuing a Ph.D., engage with each other, it is seen to create opportunities for the exchange of experiences and knowledge amongst peers; this exchange has the potential to enhance overall development and broaden learning and understanding (Long, 2012). Therefore, by capturing a wider audience for our Hackathon in future, we have the opportunity to create the conditions for additional knowledge exchange and development between the participants.

The range of ventures and campaigns ideated and proposed by student teams was broad and there was an impressive standard of presentation by the student teams on the day, given their limited time for consolidation and preparation. Indeed, we found anecdotally that students struggled to take in all the information that was presented through workshops and from industry experts, with only three short days of instructor led sessions to absorb information on a range of SDGs and problem statement topics.

We would aim to consolidate topics in any future hackathon, with only one or two related SDGs tackled and with problem statements more closely linked to one another so that there was less topic-specific content to cover. By doing this, more time could also be spent on instilling the business fundamentals and consolidating the students' understanding of the topics presented. In addition, we would ensure greater background expertise on sustainability, in the judging panel for future hackathons.

There were personal and professional skills which were demonstrated by participating students throughout the hackathon, ranging from ideation to product development to public speaking and teamwork. Students specifically reported a positive increase in their teamwork, time management, presentation, discussion/debating, communication and critical thinking skills. These are key employability factors, so a real strength of the hackathon was enabling students to develop in these

areas; we should therefore make this explicit as a benefit for future hackathon participation. Increasingly, there is a need for Higher Education providers to target and develop student employability and build competences (Suleman, 2018). In an ever changing and developing world, a challenge for providers is to prepare students for jobs that do not yet exist, or to use technology that has not yet been invented (Römgens *et al.*, 2020). By employing a hackathon as part of the wider curriculum, these challenges can be combatted for students who seek to hone their higher level skills.

The most significant benefit reported by students was an appreciation of connectivity through sharing of viewpoints with others across different subjects. This attests to the value of the opportunity, since no participants had highlighted this as a reason for taking part. This correlates with pedagogic research on collaborative learning where it is reported that people often learn better through social interaction and a networked environment (Lave & Wenger, 1991; Wenger et al., 2002; Gannon, 2018).

The online nature of the event, due to pandemic constraints, made some of the team building exercises challenging, which may have affected team cohesion and accountability. From the initial 28 students participating, we saw dropouts throughout the first week and were less able to monitor attendance at the online workshops than we would have been able to with in-person workshops due to the ability attendees had to drop out of online meetings or to appear present without engaging. Future activities of this nature would be held in person if possible, to help build stronger teams whose members are committed to the entire programme, thus improving relations and reducing any sense of injustice or unbalanced workload in the teams.

The post-event progression of ideas and ventures was hindered by insufficient resources. Going forward, we will allocate more staff time and resources, including seed funding alongside winners' prizes. A similar hackathon event held at the University of Lincoln (UK) also highlights the importance and benefits of allocating additional resources when supporting students throughout the event (Cobham et al., 2017).

Conclusion

The hackathon demonstrated its potential as an experiential learning tool, positively impacting participants' employability, entrepreneurial skills and appreciation of the benefits of interdisciplinary collaboration. Additionally, the study underscores the importance of designing hackathons that accommodate diverse subject experiences and interests, ensuring maximum engagement and impact. As institutions seek innovative ways to integrate sustainability education, the hackathon model presents a promising avenue for holistic, hands-on learning experiences.

Consent for publication

Not applicable.

Availability of data and material

Anonymised data from this project will be available upon request.

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CRediT authorship contribution statement

Shelini Surendran: Conceptualization, Data curation, Formal analysis, Project administration, Writing – original draft, Writing – review & editing. **Katrina Mack:** Project administration, Writing – original draft, Writing – review & editing. **Nathaniel M. Bingham:** Writing – original draft, Writing – review & editing. **Nick Edwards:** Writing – original draft, Writing – review & editing. **Joseph Frost-Schenk:** Data curation, Writing – original draft, Writing – review & editing. **Nayiri Keshishi:** Writing – original draft, Writing – review & editing. **Frederico Matos:** Conceptualization, Writing – original draft. **Julia Moldoveanu:** Writing – original draft, Writing – review & editing. **Robert Walsha:** Writing – original draft, Writing – review & editing. **Kikki Bodman-Smith:** Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

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

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Supplementary materials

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