Designing an Effective Hackathon via University-Industry Collaboration for Data Science Education

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***Abstract*—Hackathons have been used not only by enterprises for technological innovation and digital transformation, but also in academia for education innovation and programme promotion. This paper presents a hybrid approach for transforming an enterprise's workplace problem into a technology vendor-sponsored hackathon education. A real-life case study of a hackathon for college participants who are prospective students of a university data science programme is demonstrated. The university-industry collaborative approach of the hackathon provides several benefits for its stakeholders, namely promoting the reputation and recognition of the university's data science programme; offering creative and innovative solutions to the enterprise's workplace problems; encouraging the adoption of the technology vendor's platform, and finally, enhancing the teaching and learning experience for the college students and lecturers. This paper provides a structured framework and recommends practical principles and guidelines for designing effective hackathons that can bring about mind-set change and real-world business transformation.**

Keywords—Hackathon Education, Data Science Education, Education Innovation

I. Introduction

Exacerbated by the rise in digital disruption, organisations have been using hackathons as a valuable tool for delivering innovative breakthroughs, accelerating organisational change, and forging a user-centric culture. A hackathon event typically brings enthusiastic individuals from different backgrounds together for creative problem solving [1]. Through active collaboration, ideation, prototyping and experimentation, a hackathon can be effectively implemented to encourage innovation through digital technologies in a wide array of disciplines (i.e., marketing, management, data science), industries (i.e., media, energy, robotics), and a large range of spaces (i.e., open data, academia, practitioner) [2]. Often, hackathons are open to the public (i.e., also known as enriched crowdsourcing) [3], though some can be private events for employees or affiliates of the organiser. Open hackathons are suitable for education and learning, while close hackathons are appropriate for workplace training and problem solving. These fast-paced and highly engaging events can be organised by commercially driven corporations, non-profit foundations, universities, online communities, or small, new start-up companies [4].

Hackathons can vary depending on their purpose and execution [5]. A good hackathon focuses on the customer journey and the customer experience, while considering the front and back-end organisational support functions [6]. The involvement of a cross-functional team helps uncover new perspectives and deep collaboration, while keeping group think at bay. Participants are intentionally challenged to stretch their ingenuity to reimagine, design, and develop a new prototype for the future. Innovative and feasible solutions to wicked workplace problems can be delivered at great speed and agility, a key competitive advantage for driving business value. Although hackathons are mostly viewed as a platform for concept generation [7], a good hackathon should ideally end on a positive note, with an iterative and continuous cycle of refinement that can bring about mindset change and real-world business transformation.

Hackathons have been widely used in education. For example, Gama et al. [8] implemented a hackathon on Internet of Things (IoT) in an undergraduate coursework project, while Cwikel and Simhi [9] presented a hackathon model in social work education. In addition, Mhlongo at el. [10] examined the applicability of hackathons in promoting collaborative learning and computer programming skills for students, Sadovykh [11] developed a hackathon as part of the curriculum of a software engineering programme, while Isli and Norstrom [12] designed a hackathon for students to prepare the future workforce. Although Kuter and Wedrychowicz [13] detailed their experiences with hosting a hackathon event for data science in a college setting, research on this topic is still largely underdeveloped. Moreover, hackathons can be used for university-industry collaborations via the engagement of industry partners in real-world contexts. Hence, in this paper, we present a university-industry collaborative approach to the organisation and implementation of a data science hackathon targeted at college students who are prospective students of the host-university's data science programme.

The paper aims to outline a roadmap for organising and implementing a hackathon using an actual case study. The rest of the article is presented as follows. In Section II, a framework for creating a hackathon is offered. Next, an overview of the hackathon is presented in Section III, followed by a description of the hackathon challenge and structure in Section IV. In addition, relevant findings as well as implications are provided in Section V. Section VI concludes with limitations and future research suggestions.

II. Towards a Hackathon Roadmap

A. Designing a Hackathon Framework

This section presents a detailed exploration of the possible aspects of a hackathon design. Hackathons can be a great place for the larger community and diverse talents to meet, however, to ensure the success of a hackathon, prior planning and preparation work have to be conducted well in advance. Firstly, the strategic objectives of the organiser need to be identified and aligned with the objectives of the hackathon.

This can help ensure the adequate allocation of time, resources, and funds to support the event. Secondly, working with the respective stakeholders, the purpose and theme for the hackathon should be determined. According to a study by Gartner, hackathon themes can be challenge-based (i.e., solving business issues), mission-based (i.e., social causes or giving back to the community), improvement-based (i.e., enhancing business-units or process), or trail blazing-based (i.e., examining disruptive technology) [14]. On occasions, the intended demographic groups can be delineated depending on the objective of the event.

Thirdly, the operational and logistical decisions pertaining to location (i.e., online, physical), timing, duration, infrastructure (i.e., technology and physical), and contingency plan, if any, need to be determined. Fourthly, the requirements of the hackathon should be explicitly outlined, including the participant eligibility, judging process, evaluation criteria, and categories of awards, which can be either monetary or non-monetary. Once the above-mentioned processes are in place, the agenda and timeline for the hackathon can be finalised, and commitment from guest speakers, subject matter experts, judges, and sponsors can be secured. In addition, accompanying terms and conditions, ethical guidelines as well as relevant code of conduct should be determined.

B. Key Hackathon Skills

Hackathons allow participants to intensively focus on their tasks through writing codes continuously without a break. In general, hackathons comprise four phases: team forming, creative problem solving, coding, and data analysis, and preparation for presentation. Throughout these phases, participants can cultivate the following skills:

1) Teamwork and Collaboration

Team formation is an important part of the hackathon event as it facilitates feelings of team bonding, collaboration, and inclusiveness. Teamwork and collaboration are key to the success of a hackathon. The cross-team and interdisciplinary knowledge and skills can help the team tackle problems from a variety of perspectives, allowing team members to try new things, think outside the box, and foster innovation. In most cases, a strong team can generate collective team identity and increased team effort and encouragement, leading to greater team motivation.

2) Problem Solving and Design Thinking

Problem solving is a crucial skill in a hackathon, as it can bring forth the development of practical and creative solutions. Problem solving entails the process of identifying a problem, developing possible solution paths, and taking the appropriate course of action [15]. Design thinking, an important process of problem solving, can be adopted to increase the success rate of a hackathon challenge, leading to sustained innovation. The stages in design thinking, namely concept development, applied creativity, prototyping, and experimentation, can be applied to hackathons that focus on open innovation and usable innovations.

3) Coding and Data Analytics

Some hackathons provide participants with an excellent opportunity to hone and assess their data science skills. Hackathon platforms can offer a wide variety of emerging digital problems such as image classification, customer prediction, data optimisation, click prediction, and Natural Language Processing (NLP). These days, hackathons are hosted to solve societal challenges around sustainable and green businesses, social impact, healthcare, and data privacy, as well as cybersecurity and data protection. In these events (i.e., machine hack), coding and data analytic skills are essential, especially in the coding round, where participants find themselves coding in Java, Scala, and Python programming languages in a live coding environment where they can code and compile their codes on the go.

4) Effective Communication and Presentation

Hackathons can bring ideas to life, as such, it is critical that these ideas are effectively communicated as part of an impactful presentation or pitch. As hackathon pitches can be typically short, about five to 10 minutes, it is critical that the team select an eloquent communicator who can present comfortably in a natural and witty manner to impress the judges and audience. A good pitch should consist of a well-planned structure that restate the vision and uniqueness of the business value as well as the impact of the proposed prototype.

III. Organising A Education Hackathon

A. Background

The hackathon framework is applied to an actual case study of a data science hackathon hosted by a university in Singapore. The university planned to promote the full-time data science programme with the intention of attracting good quality applications from students in the local polytechnics. An education hackathon is an ideal marketing channel for executing this socially responsible strategy. Through the event, participants can develop their skills by deep diving into specific datasets, problems, or concepts, engage in collaborative teamwork and brainstorming, and develop algorithm and prototypes to solve real-world problems.

B. Key Hackathon Phases

The six distinct phases of the hackathon are summarised in Fig. 1. A typical hackathon usually lasts for 24 to 48 hours [16]. As the target participants are polytechnic students with basic or intermediate programming skills, the duration for the event was planned for 15 days. Adopting a problem-based learning instructional method over an extended period, students will have the opportunity to engage in critical thinking, build and launch the prototypes, and reflect on the critical tasks, which can further enhance their diagnostic and programming skills.

Fig. 1. Six key hackathon phases

Phase 1: Hackathon Preparation

A team of task force was formed to evaluate a range of diversed issues including hackathon theme, venue, timing, duration, marketing and promotion strategy, logistics, human resources allocation, student helper recruitment, registration issues, guest speakers, judges, prizes, sponsors, and contingency plans. To advertise the event, a poster publicising the hackathon was designed and promoted online via social

media platforms as well as through direct mails and flyers physically at the polytechnics. The participants were targeted based on their similarity with the student demographics of existing students. Interested participants were required to register individually or in small teams of two to four members, and the registered teams were encouraged to nominate a supervisor or a mentor, who should ideally be a subject matter expert or lecturer in data science.

Phase 2: Orientation and Training

A total of 36 teams, comprising 99 participants, made up of 86 students and 13 supervisors, registered for the hackathon. The participants were invited for the orientation and training on Day 1. During the day, the hackathon challenge was introduced and a workshop on how to use the *R* based on free commercial platform was delivered by an industrial trainer. In addition, an in-depth tutorial which introduced relevant *R* functions, algorithms, and packages that can be used to derive possible solutions for the challenge was conducted. Online materials and tutorial guides were made available throughout the hackathon. Participants were able to soak in a real-world, training-based atmosphere, which was accompanied by the availability of food and beverage throughout the day.

Phase 3: Solution Implementation

After completing the orientation and training, the participants started problem solving and exploring feasible solutions. They were given the flexibility to use any free programming language software to solve the problem, including *R*, the open-source software they were trained to be used. The participants utilised their design thinking skills to solve the wicked problem. Through design thinking, thought processes pertaining to the solution can be structured systematically, which can help the team decide on what problem is the most critical to focus on. Relevant ideation techniques can be applied in the solution generating phase, for example, brainstorming (both as a group and individually), mind mapping, sketching, storyboarding, prototyping, or taking a creative pause at times, to reflect and reapproach the challenge with renewed perspectives. Some teams were able to test out alternative solutions with the support of their mentors (i.e., polytechnic lecturers). In total, 23 teams successfully completed the challenge and submitted their work on Day 10. Each submission comprises a solution dataset in one compulsory format and one complimentary format, as well as an accompanying technical document that described the solution and its implementation.

Phase 4: Shortlisting

On Days 11 and 12, the faculty technical lead analysed the submitted dataset against the benchmarking programme. Eleven teams managed to meet the basic requirements to generate feasible solutions that addressed the tasked challenge. Seven teams with top benchmarking performance scores were shortlisted and subsequently informed of their eligibility to proceed to the final round on Day 15. During this phase, a panel of three judges from the university and one from the industrial technical trainer were appointed, and the judgement criteria and the weights were confirmed by the panel.

Phase 5: Pitching and Award Ceremony

On receiving the shortlisted notice, the finalist teams have two days to prepare their final presentation. Each shortlisted team had ten minutes to pitch their solution to the panel. For each pitching session, eight minutes were used for the presentation session and two minutes were used for the question-and-answer session.

The final judgement scores were based on the solution performance results in Phase 4, while the presentation scores were rated by the four judges. Three winning teams were awarded the cash prizes sponsored by a local enterprise. In addition, the shortlisted participants were given conditional offers for admission into the data science programme. To evaluate the effectiveness of the hackathon, an online questionnaire link was distributed to the participants and their supervisors. The purpose of the survey is to collect participant feedback for detailed analyses, debrief, and future improvement. The result is discussed in Section IV.

Phase 6: Post-Hackathon and Review

A debrief report was produced to conclude the success of the event. The university reviewed the event performance and the marketing communications team publicise the event in various university-initiated social media platforms.

Simultaneously, the winning teams also reported the event and showcased their awards on the various social media channels adopted by their polytechnics. In doing so, they were able to promote their data science diploma programmes as well as its potential pathway to a university education in data science. The success of the current hackathon event can be used as a learning case for organising and implementing similar hackathons centered around other themes such as sustainability, health, well-being, and financial technology and literacy, on an annual basis.

IV. The Hackathon Challenge

The idea of a hackathon challenge surfaced during a problem solving meeting between the data science team of a local enterprise and the data science faculty of a university in Singapore. To allow for open innovation and co-creation, both parties reached an agreement to host a Hackathon, as such an event could involve a broader group of people in solving the business problem, allowing the enterprise to gain access to different creative and innovative approaches to business transformation. The faculty lead helped to transform the enterprise's workplace problem into a hackathon format suitable for the level of the target audience [17]. The details of the hackathon challenge are outlined below.

A. The Wicked Business Problem

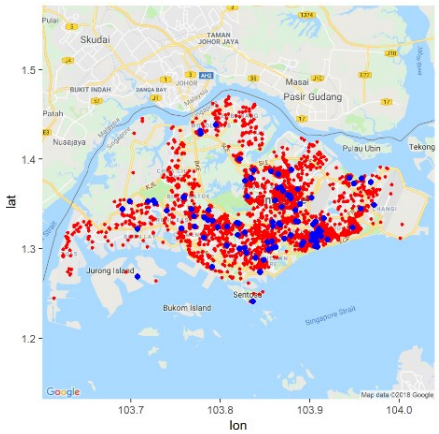

Fig. 2. Visualisation of the locations of riders and delivery orders

A company in the food delivery services industry would like to streamline and improve their order taking and delivery process. The company is contemplating the design and development of an automated tracking system that can optimise the order taking assignments and route the respective order information to their delivery riders. The aim of the hackathon is to design a system that can effectively support the company's operational processes. The two datasets related to the locations of the riders and the order to be delivered are provided in the visualised map in Fig. 2.

The hackathon challenge is to develop an Artificial Intelligent (AI) system that can provide a feasible solution for the company. Specifically, the following challenges need to be addressed:

1. How many orders will be assigned to each rider?
2. Which orders should be assigned to which rider?
3. Which are the most optimised routes for the riders to fulfil the orders?
4. What is the percentage of customer orders delivered on time (i.e., within an hour, as per the service promise of food delivery company)?

B. *Submission Requirements*

TABLE I. A SNAPSHOT OF SOME RIDERS' SOLUTIONS

RiderID	OrderSetID
5006	859,861,1118
5045	961,960,894,882,883,1112,886,895
	……
5089	2534,2533,2532

The participating teams were tasked to develop an application that can generate a solution dataset in csv format and optionally in *R* format, as detailed in an example of the schema in Table I to indicate the order taking assignments and route the respective order information to their delivery riders. Fig. 3 depicts an example of an order taking assignment and the best route solution for a particular rider. The participants were recommended to apply the map visualisation function to deliver a compelling presentation of the proposed solution.

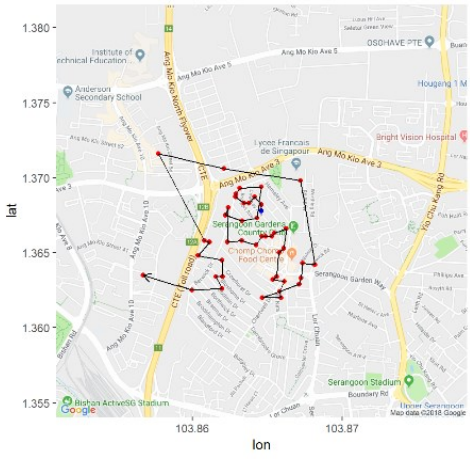

Fig. 3. An example of delivery orders assignment and best route solution for a rider

C. *Participant Performance*

The judgement criteria were based on solution performance and presentation scores with equal weights such that each score can be rescaled to a range between 0 and 50. For the performance score, a coding programme developed by the faculty technical lead was used to score the solution datasets submitted. The score function included total travel time of riders, total waiting time of customers, total penalty score for any cases of late delivery orders, and missing orders.

The presentation score was based on the average score assigned by the four judges, comprising three judges from the university and one from the industrial technical trainer. The judging rubric for the presentation consists of four items ranked on seven points Likert scale based on technical knowledge (23%), technical feasibility (23%), novelty (27%), and readability (27%). The weights were derived in consultation with inputs from the judges two days before the presentation event.

The performance of the top seven teams is shown in Table II. It can be observed that the Top three teams have scores that are well distinguished from the rest of the teams. Teams D and E have closely similar scores. Although Team E provided a better solution performance than Team D, Team D won due to its higher presentation score.

TABLE II. PERFORMANCE OF PARTICIPANT TEAMS

Team	Performance (Max. 50)	Presentation (Max. 50)	Total (100)
D	37.8	43.8	81.6
E	41.7	36.4	78.1
F	31.2	34.0	65.2
C	18.9	30.6	49.5
D	20.8	28.6	49.4
B	19.6	29.8	49.3
A	15.7	25.1	40.9

V. DISCUSSION AND IMPLICATIONS

At the end of the presentation session, all the participants, including students and teachers, were asked to complete an online questionnaire that was operationalised to collect insights about the execution and outcomes of the hackathon event. There was a total of 23 participants from seven shortlisted teams, and each team indicated that they had a mentor. A total of 13 responses were collected: ten from students and three from teachers. The response rates for students and teachers were 43% and 48% respectively. Tables III-VIII show the percentage of the average scores for each item. For Tables III-VI, the items in the survey were measured on a five-point Likert Scale, with 1 referring to "Strong disagree" and 5 referring to "Strongly agree". The participants were asked yes or no questions in Table VII while the student participants were asked to choose at least one motivation(s) for their participation in Tables VIII. The survey consists of six main categories, and the results are presented below.

A. *Learning Experiences*

The learning experiences associated with the hackathon are summarised according to the two groups, students and teachers, as seen in Table III. Majority of the students and teachers agreed or strongly agreed that the hackathon is beneficial to their learning. Most of the respondents agreed or

strongly agreed that the hackathon provided them with the opportunity to learn something new and interesting. Further, most of the respondents found the hackathon business problem practical and felt that the hackathon improved their teamwork skills and feelings of friendship. Finally, most of the respondents agreed or strongly agreed that they learned from each other, and the hackathon encouraged independent learning, improved their problem solving skills, and allowed them to practise innovative thinking.

TABLE III. EXPERIENCES OF TEACHING AND LEARNING

	Students*	Teachers*
I have learned something new and interesting from this Hackathon.	90.00	93.33
The Hackathon is a good opportunity for me to improve my teamwork skills and friendship.	92.00	93.33
I have learned from other members in my team.	84.00	93.33
The Hackathon is a good exercise to encourage my independent learning.	96.00	93.33
The Hackathon is a good exercise to improve my problem solving skills.	94.00	93.33
The Hackathon business problem is practical.	84.00	93.33
The Hackathon is a good exercise to practise innovative thinking.	90.00	93.33
Overall, I think this Hackathon is beneficial to my learning.	88.00	93.33

* Score mean in %

B. *Student-Teacher Relationship*

The results for student-teacher relationship are summarised in Table IV. Both students and teachers agreed or strongly agreed that the hackathon enhanced their relationship. The students felt that their mentors provided them with good support and coaching, while the teachers enjoyed supervising their students throughout the hackathon.

TABLE IV. STUDENT-TEACHER RELATIONSHIP

	Students*	Teachers*
I am a student. My supervisor has provided good support to my team and my team has learned something from him/her.	93.33	-
I am a supervisor. I am interested to have fun with my students at this Hackathon.	-	93.33
Overall, this Hackathon has enhanced my student-teacher relationship.	88.57	93.33

* Score mean in %

C. *Hackathon Tutorial and Orientation*

The results for the hackathon tutorial and and Orientation are presented in Table V. Most of students and all the teachers agreed or strongly agreed that they were happy with the hackathon tutorial guide provided. The respondents reported that the explanation of the hackathon challenge was clear, while the sections in the tutorial guide and the online materials of the tutorial guide were useful.

TABLE V. HACKATHON TUTORAL AND ORIENTATION

	Students*	Teachers*
The explanation of the hackathon problem is clear in the orientation.	84.00	93.33
The sections in the tutorial orientation are useful.	78.00	93.33
The online materials of the tutorial guide are useful.	80.00	93.33
Overall, I am happy with the hackathon tutorial orientation.	78.00	93.33

* Score mean in %

D. *Industrial Training*

The university invited an industrial trainer to conduct the training workshop using the R Programming Language on its free commercial platform. As presented in Table VI, most of the students and teachers felt that the workshop was informative, and some of them used the platform recommended by the industrial trainer to code *R*. If the industrial trainer did not capitalise on the volunteer opportunity to promote their platform, less users would have been exposed to its free commercial platform, and these users would not have used the platform for coding. In general, the students felt that they have learned something new and practical to a real-world industrial setting.

TABLE VI. EXPERIENCES OF TEACHING AND LEARNING

	Students*	Teachers*
The training workshop is informative.	78.00	86.67
Our team has used the platform provider recommended by the industrial trainer.	64.00	33.33

* Score mean in %

E. *Promotion of Programme*

As displayed in Table VII, majority of the students indicated that they would apply to the data sciences undergraduate programme offered by the university, whilst all the teachers encouraged their students to apply to the programme. Should the university offer hackathon-related courses in the near future, most of the students and all the teachers indicated that they would take up these courses. Overall, the hackathon delivered positive outcomes that can facilitate the promotion of the university's undergraduate degree programmes in data science.

TABLE VII. EXPERIENCES OF TEACHING AND LEARNING

	Students*	Teachers*
I will apply (I am a student) or encourage my students (I am a teacher) to apply to your data science degree programme.	78	100
I want to learn to solve various aspects of this Hackathon if your university offers related courses.	90	100

* Score mean in %

F. *Motivations*

The final question elicited students' motivation(s) for participating in the hackathon. Students were asked to choose

at least one item among six possible options. The findings are shown in Table VIII. All the respondents agreed that they could improve their learning through the hackathon, while most respondents agreed that the prize money and peer influence were the essential motivational factors. Moreover, most respondents noted that they joined the hackathon as they were interested to study at the host institution. Finally, half of the respondents stated that their supervisor's encouragement and their intention to apply to other institutions drive them to participate in the hackathon, as they could document this learning journey in their future university admissions application.

TABLE VIII. MOTIVATIONS FOR PARTICIPATING IN A HACKATHON

Motivations	Students*
Improve my learning	100
Prize money	80
Peer influence	80
Intention to study at the host institution	70
Supervisor encouragement	50
Intention to apply to other institutions	50

* Score mean in %

G. *Limitations and Future Research*

A single questionnaire was distributed to only shortlisted participants during the final pitching day of hackathon. Due to the low response rate from non-shortlisted participants after closing day, further statistical analyses cannot be applied. Future research could consider replicating this study in a larger sample, across different disciplines and industries, and extending the effects of a hackathon beyond the constructs examined in this study.

VI. CONCLUSION

This paper provides a structured framework and recommends practical principles and guidelines for designing effective hackathons. A real-life case study of designing and implementing a hackathon is demonstrated. The university-industry collaborative approach of the hackathon provides several benefits for its stakeholders. Firstly, as the organiser of the hackathon, awareness of the university's reputation and academic programmes can be promoted. Secondly, participation in the hackathon can enhance the teaching and learning experience for both the polytechnic students and their lecturers, leading to stronger student-teacher relationships. Thirdly, the industrial training partner can use the hackathon event to promote their free commercial platform to a wider and younger audience, thereby increasing the adoption rate of their platform. Finally, the local enterprise, through sponsoring the event, can engage in social responsibility while generating creativity, innovation, and inspiration to bring about mindset change and real-world business transformation. The findings of this research can be used as a practical starting point for universities that are keen in designing an effective hackathon for promoting data science education in collaboration with industry partners.

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