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Hacking Hackathons: Preparing the next generation for the multidisciplinary world of healthcare technology

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A R T I C L E I N F O

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A B S T R A C T

Objective: Machine learning in healthcare, and innovative healthcare technology in general, require complex interactions within multidisciplinary teams. Healthcare hackathons are being increasingly used as a model for cross-disciplinary collaboration and learning. The aim of this study is to explore high school student learning experiences during a healthcare hackathon. By optimizing their learning experiences, we hope to prepare a future workforce that can bridge technical and health fields and work seamlessly across disciplines.
Methods: A qualitative exploratory study utilizing focus group interviews was conducted. Eight high school students from the hackathon were invited to participate in this study through convenience sampling Participating students (n = 8) were allocated into three focus groups. Semi structured interviews were completed, and transcripts evaluated using inductive thematic analysis.
Findings: Through the structured analysis of focus group transcripts three major themes emerged from the data: (1) Collaboration, (2) Transferable knowledge and skills, and (3) Expectations about hackathons. These themes highlight strengths and potential barriers when bringing this multidisciplinary approach to high school students and the healthcare community.
Conclusion: This study found that students were empowered by the interdisciplinary experience during a hackathon and felt that the knowledge and skills gained could be applied in real world settings. However, addressing student expectations of hackathons prior to the event is an area for improvement. These findings have implications for future hackathons and can spur further research into using the hackathon model as an educational experience for learners of all ages.

1. Introduction

The landscape of healthcare technology is becoming increasingly complex. As the promises of “low hanging fruit” have collided with the realities of an ever more entangled and complicated healthcare field, it has become clear that any hope of creating meaningful solutions requires both advanced technical knowledge, as well as a native understanding of daily practice within the healthcare space [1]. This is particularly true in the field of machine learning in healthcare which requires effective cross-disciplinary collaborations between the fields of computer science, data analytics and clinical care.

Hackathons are intense, short, collaborative events focused on

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creating innovative solutions for pressing problems [2]. Over the past few years there has been a growing movement to use hackathons to bring multidisciplinary teams together to generate excitement around collaborative groups, and demonstrate what can be accomplished when the right partners are at the table [3]. While these events have shown some success in the development of prototypes and healthcare technology solutions, one of their underappreciated successes has been as educational tools [4–8].

Hackathons have the potential to be powerful authentic learning experiences that promote content mastery, development of technical and thinking skills, creation of supportive professional and social networks, and that engage and empower individuals and groups to take action [3,4,6]. These are critical objectives of K-12 education reform, and as a result, teachers are starting to explore hackathons as a platform to achieve important student learning and growth [9,10]. Little is known, however, about student learning experiences during hackathons, and how these are impacted by the design and execution of these events [11].

To face the looming challenges that arise with the use of increasingly powerful tools such as machine learning, artificial intelligence, and big data analytics, it is critical that we prepare future leaders to bridge technical and health fields and work seamlessly across disciplines. Here we examine high school student participation in hackathons as mechanism to accomplish these goals.

2. Background

Sana is an organization hosted at the Institute for Medical Engineering and Science at the Massachusetts Institute of Technology (MIT) that is rooted in the aspiration of socially-minded engineers and healthcare professionals to use technology to address the challenges of providing quality health care to underserved populations. Since early 2014 we have been using hackathons and more recently “datathons” [12] to bring together diverse stakeholders around technology-based solutions to critical healthcare problems both in the US and around the world. Like hackathons, datathons function by bringing together diverse multidisciplinary teams, but rather than being focused around a particular health need, datathons are focused on analyzing clinical data to answer research questions using machine learning techniques.

The growing prevalence of hackathons demands some reflection and study to ensure there is a meaningful impact. Unfortunately, research examining the effectiveness and outcomes of hackathons have been somewhat sobering with one report suggesting only 36% of teams formed at hackathon-style events continue to work together after 3 months [8,13,14]. In terms of outcomes, a survey of 12 healthcare hackathons found only 30% of healthcare hackathon projects had made progress after 12 months [15]. Our observations, however, suggest that the true value of these types of hackathons, is not in the generation of projects or start-up companies, but rather in providing immersive educational experiences and in sparking collaboration [11].

Across many of these events, we have seen enthusiastic participation of high school students [11]. Despite their lack of experience, they do not appear to be intimidated working with higher education students and professionals, and they make significant contributions to their teams. By maximizing the learning experience for these students, we hope to provide some of the tools necessary to succeed in the complex and multidisciplinary healthcare technology field.

3. Description of hackathon

To explore high school student learning during a hackathon, the “Hacking Hackathon” event was hosted at the Laboratory for Computational Physiology at MIT in August of 2016. This event was a collaboration of MIT Sana and a group of education experts at the MIT Learning Lab. The event had two main goals: the evaluation and improvement of the hackathon model in spurring global mobile health (‘mHealth’) [11], and the exploration of hackathons as tools for engaging high school participants in design thinking, and science, technology, engineering, and maths (‘STEM’) education. This paper will focus on this second goal since the inclusion of high school students in an international hackathon event, is to our knowledge a novel approach and worthy of directed study.

Two cohorts of participants were invited to participate in this event; the first group was comprised of adult learners who were winners and participants from prior international Sana mHealth hackathons. This included undergraduate and graduate students from Greece, Colombia, Mexico, and Brazil.

The second cohort of participants were high school students. These were selected from two very different environments: 12 students were participants in programs run by Health Resources in Action (HRiA, hria.org), a non-profit advocacy group focused on promoting social change to improve population health in Boston; and 6 students were part of City Links (now Enroot, http://www.enrooteducation.org/), a Cambridge, MA-based organization that supports the assimilation of immigrant students. The age of the students ranged from 15 to 18, with a mode of 18. Most were multilingual. Most of the City Links students had a mother-tongue other than English, and two students had rather limited command of this language.

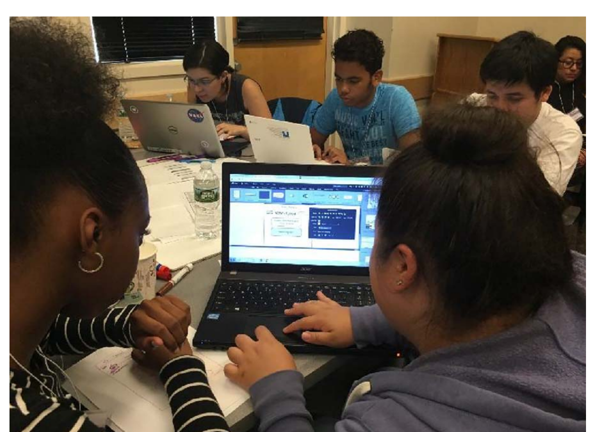
Participating students were purposefully selected to represent a range of demographics. Specifically, we sought to include students with and without an established interest in health care challenges, and those with or without international experience or connections. With few exceptions, the students from HRiA were US-born and had significant experience with health care before the event, while those from Enroot were not US-born and had no previous exposure to health care.

The two-day hackathon included a variety of activities for both cohorts of participants. The groups started the event in split sessions. During this time, the adult participants identified common themes of positive and negative feedback across the varied experiences during their respective hackathons. The result of this session was a consensus document of feedback and suggestions that has been immensely helpful in planning subsequent events.

In parallel, the high school students engaged in a series of short, engaging, kinesthetic activities designed to acclimatize them to their location, practice and encourage their creativity and problem-solving capacity, and model teamwork and team building (Fig. 1).

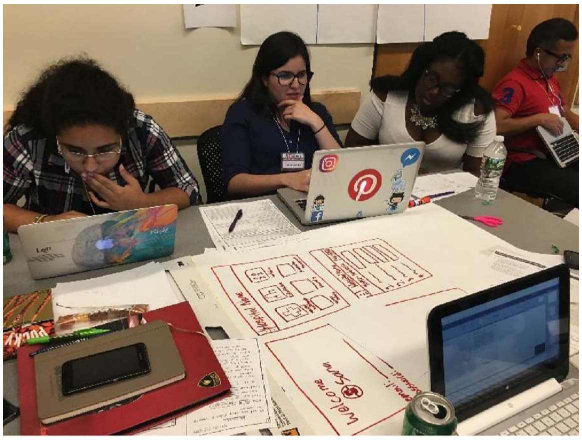
At the end of the morning of split activities, the two groups were introduced to each other through an ice-breaking activity, after which they formed mixed groups that would serve as the hackathon teams for the remainder of the event. Each of the teams were comprised of members of different nationalities, age, and educational experiences.

Teams then received a short briefing on the core challenge of the



High school student participants

Fig. 1. High school student participants.



High school students and adult learner participants

Fig. 2. High school students and adult learner participants.

hackthon: to create an effective user interface for a surgical capacity inventory mobile application being deployed in sub-Saharan Africa by MIT Sana and the Program for Global Surgery and Social Change at Harvard Medical School. This project was chosen as a relevant and urgent example of what mobile health initiatives are aspiring to accomplish, that was also likely to be accessible and engaging to all participants, even those with limited or no coding experience, by focusing on UX and design, and not software development.

To help teams prepare to tackle the hackathon challenge, they spent the first day exploring relevant concepts and building skills, including UX design, UI heuristics analysis and prototyping, through collaborative, hands-on activities. (Fig. 2)

During the second day, teams developed a digital prototype for their solution to the hackathon challenge using wireframing software. At the end of this session, teams presented their solution prototypes and recommendations to an audience of fellow participants, mentors, and members of the MIT Sana and Program for Global Surgery and Social Change.

4. Methods

4.1. Procedures and data collection

Ethics approval was granted by the MIT Institutional Review Board. This study was an exploratory qualitative study which utilized focus group interviews. Data were collected through a semi-structured interview process in which the researcher had a set of eight guiding questions (see Appendix A), but questions evolved as the focus group proceeded

Eight of the High school student participants in the hackathon were invited to participate in this study through convenience sampling. The invited students all agreed to participate, and were allocated into three focus groups. The three focus groups were conducted at the hackathon venue during the final day of the event.

Focus groups were facilitated by a research assistant. Informed consent was obtained from all participants who volunteered to participate. The objectives of the focus group were explained to the participants at the beginning of each focus group. Core activities during the focus group were reflection and the sharing of ideas and experiences at the hackathon. All focus group discussions were audiotaped and transcribed verbatim for analysis.

4.2. Interpretation of data

The primary source of data was the focus group transcripts which were analyzed in qualitative research software (NVivo). To analyze the data, a phenomenological approach was adopted to understand participants experiences of the hackathon from their own perspectives [16]. As part of this approach, inductive thematic analysis of focus group transcripts was conducted by two co-authors (ML and MC). Both authors completed their PhD research focused in education, and have previously conducted qualitative research [17,18]. Firstly, each line of the transcripts was read and coded, and then the codes were collated into potential themes. To ensure reliability of the coding system, two study authors (ML and MC) independently coded the data. Both coders compared their individual codes and themes and resolved discrepancies by reaching consensus. This iterative process aimed to achieve a high level of trustworthiness in the development of the emerging themes. A final summative check between coders was performed to verify the trustworthiness and reliability of the themes.

4.3. Findings

Participants discussed their perspectives about their hackathon experience. Three major themes emerged from the data: (1) Collaboration, (2) Transferable knowledge and skills, and (3) Expectations about hackathons. These themes highlight strengths and potential barriers when bringing this multidisciplinary approach to high school students and the healthcare community.

4.3.1. Theme one: collaboration – high school students were provided opportunities to interact with professionals from different fields

One purpose of a hackathon is to bring together diverse groups of people into functional teams. Participants in this study discussed collaborative moments being cross-generational, cross- cultural, and cross-disciplinary. For example, one high student discussed working with professionals: “It was really nice to be able to work with professionals, and also be treated as one, rather than just a high school student.” Some high school students were surprised at how the different professionals worked together. One stated, “I think it's a great opportunity to work with smart people. I never think that we can work with engineers and doctors together.” Another participant added, “It was us working like grown-ups. It was actually really exciting to work with people who was valuing what you're saying as an equal…”

Throughout these cross-generational collaborative moments, participants discussed that they were able to gain confidence. One participant shared, “I'm in a room full of professionals […] and so I expected it to be way more intimidating, but then the tasks that we were getting were sort of new to everybody in the group, so we all got a chance to get to know each other and collaborate…” These high school students benefitted from working with professionals because they were recognized as equals.

Other participants talked about the importance of working with professionals from different cultures and how this was a positive experience. One participant explained, “Different cultures have different ways to think sometimes. So, putting all that together into a project that we all work together was really nice.” Overall, the high school students felt empowered and enjoyed collaborating with others during the hackathon.

4.3.2. Theme two: transferableKnowledge and skills – high school students could develop new skills and knowledge that could be applied beyond the hackathon

Another purpose for this hackathon was to give high school students the opportunity to learn new knowledge and skills, and see how they could be applied to real world situations. First, students discussed their experiences with process design. One explained, “I really think it's useful to learn this kind of process to design [apps]. I found it very difficult to design something that I wasn't truly knowledgeable about. Like, designing an app for use in hospitals, there are a lot of problems that I would have to consider that I wouldn't ordinarily have to consider.” He added: “using the process that we were taught […], really helped me to understand the tasks that I needed to go through, and what [to] think about at each step in the planning process." The design process helped another student to think about creating products for others, for example, "Anything I've ever had to create or design I've done to fit my standards […] it's a new challenge to figure out how to design something that appeals to the masses." Creating an app about a topic that was unfamiliar to the high school students allowed students to strengthen their design skills.

By attending the hackathon, the high school students recognized learning new skills that could be applied to real world problems. For example, one stated, "I feel like the knowledge I learned now can be applied to any field." Having the opportunity to build something for real world application was rewarding for them. One participant described, "I think that in terms of learning experience, it was great⋯I felt like seeing how [experts made apps] in the real world, to me was the most important part of going [to] this."

4.3.3. Theme three: hackathon expectations: high school students had preconceived perceptions and expectations of hackathons

To understand whether student expectations aligned with the organizers, we had them discuss their expectations of the hackathon. Most of the students did not think they would be learning about design although they enjoyed the process. The students thought it would be a lot more about coding. One student explained, "Judging by the name of the hackathon, I would have thought it would have been a lot more computer-based… it was misleading." Another stated, "I honestly expected that we would do much more coding, and we would actually get into the nitty-gritty of computer science. But, I was really surprised that the hackathon was mainly about planning for the app before coding it." Although students were happy with their overall experience, their expectations for the event were not always met.

5. Discussion

The landscape of digital health and health data analytics is rapidly changing. As the tools of machine learning become more powerful and the domains they are applied are increasingly complex, the need for strong multidisciplinary collaboration across this field becomes even more pressing. Current educational frameworks do not adequately train students in the skills needed to thrive in these environments. In this report, we examined the learning experiences of high school students during a health hackathon event in order to investigate this educational platform for preparing the next generation of technologists.

Through structured analysis of focus group transcripts, we identified three key themes regarding the experience of the high school students: (1) Collaboration, (2) Transferable knowledge and skills, and (3) Expectations about hackathons. The responses under the first two themes (Collaboration, and Transferable knowledge and skills) reflected accomplishment of the goals for the event. Based on the feedback of the students, it seems that the event was successful in emphasizing the importance of collaboration across areas of expertise as well as across age groups and cultural background. Students felt empowered and enjoyed collaborating with diverse teammates. Additionally, students reported that the skills they learned during the event were perceived as transferable to other fields outside of healthcare. While this was not an explicit aim of the event, it is certainly a valuable outcome given the interdisciplinary nature of many other fields.

The third theme identified (Expectations about hackathons) is seen as an opportunity for growth. We were interested to find that many of the students who participated in the event came with expectations that did not align with the event curriculum. Students were looking forward to a more technical, "coding"-based activity, and some felt misled when the event focused more on design thinking. Organizers of future events would likely benefit from better pre-hackathon communications so that attendees would have accurate expectation of the event.

5.1. Context within educational theory

The knowledge and skills developed by students at the hackathon can be explained by the theory of constructivism. This theory states that people "learn through doing", that is, construct knowledge developed out of experiences [19]. Inquiry based learning is a concept that falls under this theory, where learning occurs through the process of achieving an outcome [20]. During hackathons, participants actively learn and acquire knowledge through problem solving within a team-based setting with the aim of identifying solutions. Through this collaborative process, participants engage in discussion and are able to build on existing knowledge together. Additionally, participants acquire specific knowledge from other members within the group, in ways which would have been more difficult and time-consuming to achieve alone [21]. In this hackathon experience, high school students responded positively to being situated in the community of professionals, and began to identify themselves as part of that community [22].

5.2. Limitations of the research and future directions

Despite the promising results, there are limitations to this research. First, the focus groups were conducted among a small group of eight high school students at a single hackathon. It is important to be mindful of the small research sample in this study. To increase transferability, further research should be undertaken with a larger cohort to gain wider perspectives from hackathon participants.

Second, there was no longitudinal follow up performed. As we were not able to observe the students after the two-day event, we do not know whether the knowledge and skills reported by study participants were in fact applied in real world settings. A longitudinal study would be able to determine these outcomes, and is therefore recommended for future research.

Finally, as this is one of the first studies undertaken to explore the effects of hackathons on high school student learning, we used only qualitative methods to address our research question. Future investigations should use a multi-methods research approach encompassing both qualitative and quantitative study designs to triangulate findings and to expand the evidence base. By using this approach, the validity and credibility of hackathon research can also be increased.

6. Conclusions

The next generation of innovators in health will need to be highly skilled, not only in technical ability, but also in design thinking and capacity for interdisciplinary teamwork. Through structured interviews with high school participants of a health design hackathon, we investigated a method for teaching these skills to young students. We found that students appreciated and felt empowered by the interdisciplinary experience and felt that the skills they had gained had broad utility. We also identified setting expectations as an area for future improvement and focus. While this study was limited to qualitative data from a small cohort, we hope that these findings will stimulate more research into the hackathon model as an educational experience for learners of all ages. With the pace of the application of machine learning to medicine, we are living in an incredibly exciting time in transforming healthcare – we must ensure that the next generation of innovators are prepared to become leaders in this multidisciplinary field.

Author contributions

MP Lyndon, MP Cassidy – *contributed to the acquisition of data, analysis and interpretation of data; drafting the article, revising the article crticially, gave final approval of the version to be submitted*

L Hendrik, YJ Kim, A Celi, A Dagan – *contributed to conception and design, acquisition of data, interpretation of data, drafting the article,* *revising the article critically, gave final approval of the version to be submitted.*

N Gomez, N Baum, L Bulgarelli, KE Paik- *contributed to conception and design, acquisition of data, drafting the article, gave final approval of the version to be submitted.*

Conflict of interest

None.

Appendix A. Semi structured interview questionnaire

1. Tell me about yourself. What is your grade? What subjects do you like?
2. How did you hear about this hackathon?
3. What is the value of an event like this for you personally? What draws you here?
4. How would you describe your learning style? How do you tend to learn best?
5. What did you hope to learn during this event?
6. Have your expectations been met?
7. Were there any insights that struck you that have surprised you?
8. Out of all the activities, which did you find the most fun? the most enriching?

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