How to Support Newcomers in Scientific Hackathons - An Action Research Study on Expert Mentoring

ALEXANDER NOLTE, University of Tartu, Estonia and Carnegie Mellon University, USA
LINDA BAILEY HAYDEN, NSF Science Gateway Community Institute, USA
JAMES D. HERBSLEB, Carnegie Mellon University, USA

Time-bounded events such as hackathons have become a global phenomenon. Scientific communities in particular show growing interest in organizing them to attract newcomers and develop technical artifacts to expand their code base. Current hackathon approaches presume that participants have sufficient expertise to work on projects on their own. They only provide occasional support by domain experts serving as *mentors* which might not be sufficient for newcomers. Drawing from work on workplace and educational mentoring, we developed and evaluated an approach where each hackathon team is supported by a community member who serves in a *mentor* role that goes beyond providing occasional support. Evaluating this approach, we found that teams who took ownership of their projects, set achievable goals early while building social ties with their mentor and receiving learning-oriented support reported positive perceptions related to their project and an increased interest in the scientific community that organized the hackathon. Our work thus contributes to our understanding of mentoring in hackathons, an area which has not been extensively studied. It also proposes a feasible approach for scientific communities to attract and integrate newcomers which is crucial for their long-term survival.

CCS Concepts: • **Human-centered computing → Empirical studies in collaborative and social computing**.

Additional Key Words and Phrases: Hackathon; Mentoring; Scientific Communities; Learning

ACM Reference Format:
Alexander Nolte, Linda Bailey Hayden, and James D. Herbsleb. 2018. How to Support Newcomers in Scientific Hackathons - An Action Research Study on Expert Mentoring. *J. ACM* 37, 4, Article 111 (August 2018), 23 pages. https://doi.org/10.1145/1122445.1122456

1 INTRODUCTION

Starting as coding competitions in the early 2000s, time-bounded events have since become a global phenomenon [71]. These events are – depending on their focus or context – typically labeled as hackathons[1], data dives, codefests, hack days, code camps, design jams, edit-a-thons or others. They are organized in various domains including corporations [56, 64], higher education [39] and civic engagement [30, 32] with the aim to develop innovative ideas [12, 17], add features to existing software [74], foster learning [27, 52] and tackle civic and environmental issues [6, 7, 59, 83]. In

[1]We will use the term *hackathon* as a substitute for the set of aforementioned events throughout the remainder of this article.

Authors' addresses: Alexander Nolte, alexander.nolte@ut.ee, University of Tartu, Tartu, Estonia, Carnegie Mellon University, Pittsburgh, PA, USA; Linda Bailey Hayden, haydenl@mindspring.com, NSF Science Gateway Community Institute, San Diego, CA, USA; James D. Herbsleb, jim.herbsleb@gmail.com, Carnegie Mellon University, Pittsburgh, PA, USA.

0004-5411/2018/8-ART111 $15.00
https://doi.org/10.1145/1122445.1122456

specialized scientific communities such as e.g. Bioinformatics [75] or Astronomy [55] there is a surging interest to organize hackathons [75] to grow interest and membership [49, 74] and create new or expand existing technical artifacts [73, 75]. The initiative Science Hack Day[2] alone registered more than 100 hackathon events since June 2010 in support of scientific communities worldwide.

During hackathons participants form teams and engage in intense collaboration over a short period of time to complete a project of their interest [56]. Teams typically work on projects that are related to their expertise since they are expected to define and carry out their project with minimal external guidance. This guidance typically comes in the form of domain or technical experts who are invited by hackathon organizers to provide sporadic on-demand project feedback and technical support [8, 69]. Developing artifacts for a scientific community however typically requires specific domain and technical expertise [19] which hackathon participants that are not familiar with the community that organizes an event might not possess. The common approach of providing on-demand support can thus not be expected to be sufficient for this setting.

Our aim is to support scientific communities to conduct hackathons that grow interest in their community and that allow community newcomers to develop technical artifacts that are perceived as useful by the community that organizes the event. Based on this aim we developed an approach where one community member is assigned as a mentor to each team of newcomers for the entire duration of a hackathon. These community members will support their team to develop a project idea, set goals, assess their progress and adapt project goals and execution strategies if necessary. It is important to note that the project idea and the subsequent goals need to be structured so that the team can reasonably reach them during the short duration of a hackathon. Moreover, the aforementioned community member will also support their team to effectively use – potentially domain specific – technologies for their project. We will refer to this support as technical advice during the course of this paper. Our approach is based on existing literature on mentoring outside of the context of hackathons since – despite mentoring being generally perceived to contribute to hackathon success [13, 51, 69] – there is limited insight into how mentors approach their role and how different approaches might relate to the perception of mentors and participants. Our study addresses this gap by answering the following two research questions:

RQ$_1$. *How did mentors support teams of newcomers to a scientific community to set and adapt goals during a hackathon of that community?*

RQ$_2$. *How did mentors provide technical advice to teams of newcomers to a scientific community during a hackathon of that community?*

In addition to gaining insight into how mentors approached their role we also aim to study how the different teams and mentors perceived the project they worked on and what future intentions – if any – participating newcomers have towards the community that organized the hackathon after it has ended. These two aspects are particularly relevant since growing interest in a community and contributing to existing or developing new technical artifacts are among the main reasons for scientific communities to organize a hackathon as discussed before. We thus consequently also aim to answer the following two research questions:

RQ$_3$. *How did mentors and participating newcomers to a scientific community perceive the project they worked on during the hackathon?*

RQ$_4$. *What were future intentions of participating newcomers towards the community that organized the hackathon?*

To answer them, we conducted an action research study [46] of three student groups that worked on projects proposed by three community members during a hackathon of the science

[2]http://sciencehackday.org

gateways community. Science gateways provide *"a community-specific set of tools, applications, and data collections that are integrated together via a portal or a suite of applications, providing access to grid-integrated resources"* [80]. They thus support researchers of different science and engineering communities to access data, tools and equipment related to their domain. Each of the aforementioned community members served as a mentor for one student team. We instructed the mentors before the hackathon, observed all teams during its early and late phases, conducted interviews with students and mentors after the hackathon and administered questionnaires before and after the event.

Our results provide insights into potential future intentions of participating newcomers towards the community that organized the event as well as how different mentors connected with their teams, how they supported them and how teams and mentors perceived their project. Teams who took ownership of their project and set achievable goals early while receiving learning-oriented support by a mentor who connected with their team on a personal level reported positive perceptions related to their mentoring experience. They also reported learning gains, perceived their project outcome to be satisfying, voiced intentions to continue working on their project, continue learning about the technologies they used and expressed an increased interest in the community that organized the event. The contribution of this paper is thus twofold. First, we explored how community members that were assigned as mentors to teams of newcomers supported them during a hackathon of their community, how teams and mentors perceived the project they worked on and which potential future intentions participating newcomers had towards the community that organized the event. Second, based on these findings we developed suggestions for how organizers and mentors of hackathons can support newcomers during a hackathon of a scientific community.

2 HACKATHONS AND MENTORING

The origins of the term *hackathon* can be traced back to competitive coding events during which young developers formed small ad-hoc teams and engaged in short-term intense collaboration on software projects [12]. Since then hackathons have proliferated into various domains including larger corporations [33, 53], small and medium size enterprises [40], start-ups [17, 20], (higher) education [29, 39, 58], civic engagement, [30, 32, 47], (online) communities [4, 18] and others. This extension into different domains has also broadened the focus of events from creating innovative technical solutions that can be turned into products [12, 17] to covering themes such as tackling social [30, 32, 59] and environmental issues [83], supporting informal and collaborative learning [27, 45, 52] and creating new or expanding existing communities [49, 76].

Consequently research on hackathons has also grown in recent years mainly covering aspects related to the event itself such as how to run hackathons in various contexts [49, 56], how hackathon teams self-organize [75], how to attract diverse audiences [25, 34] and how to foster potential hackathon outcomes such as the ones discussed before [32, 40, 53, 71]. The HCI and CSCW communities in particular have seen an increased interest in research on hackathons since such events typically require individuals to collaborate while developing a technical artifact which is of core interest to these communities [15, 28, 74, 75]. Researchers have however also criticized hackathons for their focus on technical solutionism [50] which postulates the assumption that it is possible to understand a problem and develop a suitable technical solution during the short period of an event[3]. Moreover, hackathons are also often perceived to favor individuals that possess specific technical expertise [35] which in turn can be intimidating to individuals who do not possess this expertise or who do not perceive themselves to be proficient. This perception can be amplified by the competitive climate of most hackathons [79].

[3]http://techpresident.com/news/wegov/23146/app-contest-or-not-app-contest

Our work however is different to other studies on hackathons which presume that participants possess sufficient expertise to work on projects on their own [44, 55, 81]. We instead focus on newcomers to a scientific community which do not necessarily possess specific domain or technical expertise to work on a project in the context of that community on their own. In contrast to common hackathon approaches our setting thus requires newcomers to quickly become acquainted with the domain and the technologies used in order to be able to develop artifacts that community members may perceive as useful. We will refer to those artifacts as meaningful artifacts during the course of this paper. Our setting is thus closely related to educational hackathons or coding camps [58] which in turn are related to project-based learning [72] in that they require participants to engage in a *"constructive investigation"* [72]. In other words, participants intentionally work on projects that require them to acquire new skills [57]. It should be noted though that educational hackathons are different from typical project-based learning settings in that they are commonly not explicitly integrated into formal education settings [54, 79].

The main difference between the aforementioned code camps and our study is that we focus on a setting where each team is supported by one mentor that is assigned to this team during the entire duration of the hackathon. This is different from common hackathon settings where there is typically a team of mentors that provides sporadic on-demand support and feedback to any team in need [13, 41, 51, 69]. Moreover, in our study we focus on the role of the mentor while – despite most researchers acknowledging the importance of a mentor [5, 16] in a hackathon setting – their role has not been extensively studied so far [54, 57, 77]. Our work aims to close this gap.

Since previous work on hackathons provides limited insight into the role of the mentor we had to turn towards literature on mentoring in an organizational and educational context as a basis for our study. Before going into detail, it is important to note that the usage of the term *mentor* in the context of hackathons is different from the common understanding of mentoring at the workplace [43, 48, 70] or in education [31, 36, 65]. In the context of hackathons, the term *mentor* typically refers to a *"professional with work experience and background knowledge who answer questions from hackathon teams and provides guidance"* [62]. The common understanding of mentoring at the workplace or in education in contrast refers to a long term [1] dyadic relationship between a mentor – who *"supports, guides, and counsels a young adult"* [43] – and a protégé. This relationship develops over time [42] with the mentor not only taking the role of a teacher but also serving as a sponsor, protector and friend [38, 61]. This understanding of mentoring is thus broader than the common understanding of mentoring in the context of hackathons. For the approach we propose in this paper we will – similar to Kram [43] – refer to a *mentor* as an individual who supports a single team during the entire duration of a hackathon to scope and execute their project.

It appears reasonable to focus on literature on mentoring at the workplace and in education since mentoring in these contexts is not only perceived to be an effective means of knowledge transfer [36, 70]. It can also improve self-confidence, productivity [36] and satisfaction [23] all of which can be considered important for a team to be effective and efficient during the tight time constraints of a hackathon. To achieve the aforementioned outcomes scholars found that mentoring requires the consideration of career oriented as well as psychological functions [3, 36]. Career oriented functions cover aspects such as mentors sponsoring protégés, coaching them and providing feedback while psychological functions are commonly related to counseling, friendship and serving as a role model [37, 42]. In order to cover both it is thus important for mentors in our setting to not only focus on the team's project but also on their relationship to their team [60].

Considering the short-term nature of hackathons, it is not certain whether hackathon teams will actually benefit from a mentor that is embedded in their team since most studies on mentoring focus on long-term dyadic relationships [1]. There is however evidence for the effectiveness of mentoring in open source projects [76] and online communities [14]. In these settings newcomers are typically mentored by community members who e.g. support on-boarding [24, 26] by helping newcomers to overcome early struggles related to – among others – understanding how a community operates [68]. It thus appears reasonable to assume that assigning a community member to a team of newcomers might be feasible for teams in scientific hackathons as well.

3 EMPIRICAL METHOD

To answer our four main research questions, we conducted an action research study [46] of a scientific hackathon with the hackathon serving as a revelatory case [82] that exposes a phenomenon – a new form of mentoring – that has not been observable before. This approach appears reasonable since we developed a specific intervention to assess how mentors support teams of newcomers to set and adapt goals (**RQ**$_1$), provide technical advice (**RQ**$_2$) and how teams and mentors perceived their project (**RQ**$_3$) and what potential future intentions participating newcomers have towards the community that organized the event (**RQ**$_4$). We will outline the specifics of this intervention in the following (section 3.1). With this study we thus aim to solve a practical problem by developing, evaluating and improving a specific intervention [21].

3.1 Assigning individual team mentors

In order to support scientific communities to conduct hackathons during which community newcomers can work on projects that potentially require specific domain and technical knowledge we developed a specific intervention. This intervention was based on explicitly assigning one community member as a mentor to each hackathon team consisting of newcomers to the community that organized the event. Based on our suggestion the organizers of the hackathon identified community members with multiple years of experience in the field who were willing to serve as a mentor. We intentionally asked the organizers to select mentors that represented different focus areas within their community in order to allow participants to choose from a larger variety of projects. After identifying suitable mentors, we briefed them about the details of how they would engage with the participants prior to and during the hackathon. The mentors first came into contact with the participating newcomers during a webinar which took place one week before the hackathon. During this webinar the mentors were asked to outline their respective project idea(s) and provide general information about their focus area within the community. We intentionally left the remainder of the preparation to the mentors to be able to study their approaches. We did however suggest for them to prepare additional materials such as sample code, documentation and – if necessary – user accounts to minimize potential delay during the hackathon. At the beginning of the hackathon the mentors were asked to present their project idea and focus area again to remind the participants about the different options they could choose from. The participants then were asked to choose a project that they were interested in. To ensure that teams would be comparable in size participants were assigned on a first come first serve basis. The researchers supported the hackathon organizers during this entire process. After the hackathon had begun, they focused on observing the different teams while abstaining from interfering with the procedure of the hackathon.

3.2 Setting and procedure

The hackathon we studied was a 24-hour event which was organized by members of the science gateways community in conjunction with one of their main conferences[4] . The community organized this hackathon to increase student interest by exposing them to projects in this domain and to develop artifacts for the gateways involved (Fig. 1 shows a sample interface).

[4]https://sciencegateways.org/web/wd/hackathon18

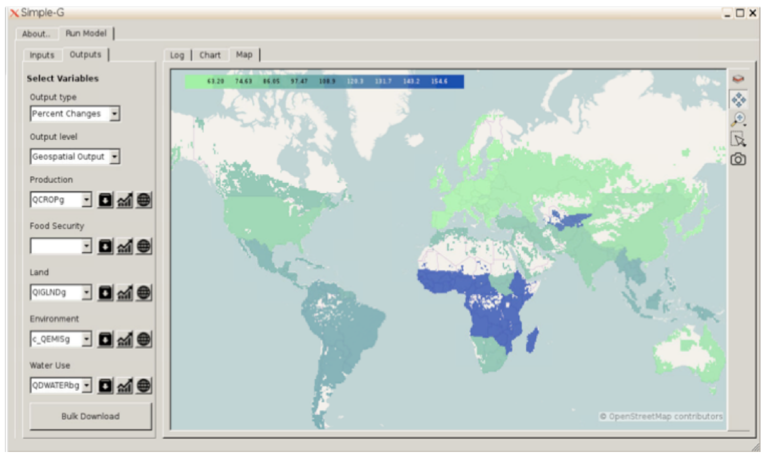

Fig. 1. Sample interface of the GLASS science gateway (https://mygeohub.org/groups/glass)

Preparation for the event started 6 months prior to the hackathon (Fig. 2 provides an overview of the timeline) based on the proposed intervention discussed before (section 3.1). The three identified gateways were located in the context of Biology and Geology (Table 1 for an overview) and the selected mentors (1 female, 2 male) had between three and twelve years of experience as software engineers and / or research scientists working in the context of the gateway they represented. They also had previous experience conducting introductory events for students and professionals.

We recruited eleven students (5 female, 6 male) which formed three teams (3.66 to 1 student to mentor ratio). We recruited them among first time participants of the aforementioned conference and among students of universities that were located close to the conference venue. The students we recruited came from different ethnic backgrounds (Asian, African American, Middle Eastern and Caucasian) and studied different subjects (computer science, mechanical engineering and mathematics) on different levels (sophomore, junior and senior). Before participating in the hackathon students were asked to complete an online registration form which we developed in collaboration with the three mentors (section 3.3 for more details).

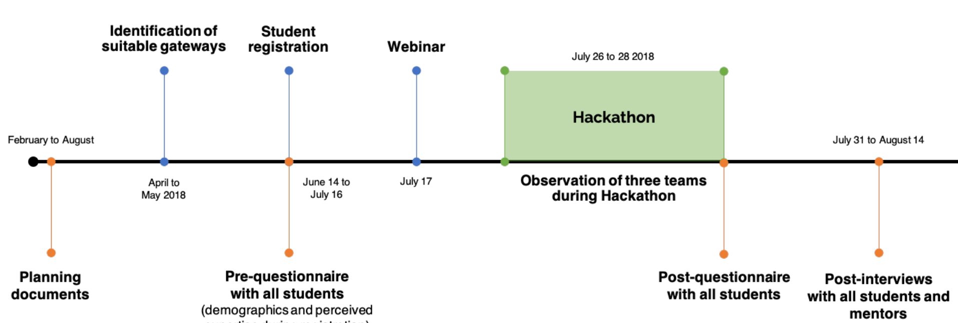

Fig. 2. Preparation activities and data collection points before, during and after the hackathon.

The hackathon started with a short introduction by the organizers. Afterwards the students chose their projects and joined the corresponding mentors who introduced them to the domain and the project that the mentors had envisioned. We intentionally left the way that each mentor engaged with their team open to be able to observe their strategies (**RQ**$_1$ and **RQ**$_2$) and subsequently discuss how mentors and participants perceived their projects (**RQ**$_3$) and how participants aim to engage with the science gateways community in the future (**RQ**$_4$). All teams presented their work at the end of the hackathon. The presentation was streamed live to all interested community members. Teams could win different prizes during the hackathon including a monetary prize for the winning team at the end of the event.

Team	Gateway focus	Project	Mentor background (code)	Student background (codes)
A	Cryoelectronic microscopy	Image stack viewing app where researchers can mark image areas	Software engineer (MA)	Sophomore to senior computer science and mathematics students (A01 to A04)
B	Geospatial data and tools	Web-based app to collect and analyze social media activity during weather events	Software engineer and research scientist (MB)	Sophomore to junior computer science and mechanical engineering students (B01 to B03)
C	Carbon capture, utilization and storage	Transfer existing desktop app on carbon mapping to the web	Research scientist (MC)	Sophomore to senior computer science and mathematics students (C01 to C04)

Table 1. Overview of gateways, projects, mentors and students

3.3 Data sources

For our study we collected data from different sources including planning documents, interviews, observations and a pre- and post-questionnaires (Fig. 2 shows an overview of the timeline). We will elaborate on how each data point contributes to answering our four main research questions in the following (Table 2 provides an overview). Each team represents one unit of analysis.

Before participating in the hackathon students filled out an online registration form. It included a consent form as well as demographic questions and questions about the potential prior experiences of students related to different programming languages the mentors perceived to be relevant for their projects. To cover their perceived expertise, we asked students for each language to state if they perceived themselves to be able to write parts of a program using that language and about their level of comfort using it. Each question was assessed on a 5-point scale. Asking the same questions in the post-questionnaire and comparing the results contributed to our understanding of the students' perceived experience gains which can potentially be related to the quality of the project they worked on (**RQ**$_3$) and to their potential future interest in the science gateways community (**RQ**$_4$). Students' answers to questions in the registration form also provided information to mentors about the technical background of the students which could help them to tailor their technical support (**RQ**$_2$). We used this simple method to assess the students' technical experience since we did not aim to analyze the results quantitatively. We rather used them as additional information for our qualitative analysis. Moreover, there is evidence that the self-assessment of students related to their programming expertise is not accurate [67] which makes the use of sophisticated measurement scales questionable for quantitative assessment in general.

RQ	Post-interviews (mentors and students)	Observations (mentors and students)	Pre-questionnaire (students)	Post-questionnaire (students)
1	perception about how mentors supported students to set and assess goals	observe how mentors support students to set goals		goal clarity, process satisfaction
2	perception about how mentors provided technical advice	observe how mentors provide technical support	perceived level of technical expertise	process satisfaction
3	perception about the team's project		perceived level of technical expertise	perceived level of technical expertise, process satisfaction, project satisfaction
4	perception about future intentions towards the science gateways community (students)		perceived level of technical expertise	perceived level of technical expertise

Table 2. Contribution of each data point to the four main research questions

To observe students and mentors during the hackathon we assigned one researcher to each team. Each observer stayed with their team during the first six to eight and final six to eight hours of the hackathon. Prior to the hackathon the observers discussed about sensitizing concepts [10] that could serve as a basis for the observation. Since we focused on how mentors supported teams to set and assess goals (**RQ**$_1$) and how they supported them to use specific technologies (**RQ**$_2$) our concepts included *discussion about project content*, *searching for a technical solution*, *asking for technical advice* among others. The research team had prior experience conducting studies on hackathons. We documented the interaction between mentors and students in a free text form focusing on the previously discussed sensitizing concepts. This approach appeared suitable since we mainly focused on the perception of mentors and students as covered by interviews and questionnaires with the observation serving as additional context. We did not observe the teams during the entire duration of the hackathon since we perceived the early and late phases of the hackathon to be particularly important. During the early phases mentors and students can be expected to interact more intensively when they get to know each other, and teams start scoping their projects and start using the required technologies. Afterwards teams can be expected to execute tasks with little to no interaction between mentors and students. Moreover, we expected mentors as well as students to take short breaks during the night to sleep. During the late phases, interaction can be expected to intensify again due to the approaching final deadline.

After the hackathon we administered a second questionnaire. Next to the previously discussed expertise related questions it also included questions related to goal clarity, satisfaction with the process during the hackathon and satisfaction with their project. For these aspects we used scales that were previously tested and validated as part of a larger survey instrument by Filippova et al. [25] who adapted scales by Sawyer [66] (goal clarity) and Reinig [63] (process and outcome satisfaction) for the context of hackathons. Administering this questionnaire, we aimed to gain insights into the perceptions of student teams related to their ability to set goals and assess their progress ($\mathbf{RQ}_1$). Moreover, results from this questionnaire will also contribute to our understanding of how students perceived their progress during the hackathon which can hint towards the support they received during the hackathon ($\mathbf{RQ}_1$ and $\mathbf{RQ}_2$). Finally, the questionnaire also contributed to our understanding of the students' perception of their project ($\mathbf{RQ}_3$).

The main source of information for our study were interviews we conducted with all mentors and students after the hackathon. The student interviews lasted about 17 minutes and the mentor interviews lasted about 23 minutes on average. The aim of the student interviews was to understand their motivations to choose a particular project (e.g. *Why did you decide to work on this particular project?*), their preparation activities (e.g. *How did you – if at all – prepare for the hackathon?*), their work process as a group during the hackathon (e.g. *How did you and your team work together?*), their interaction with their mentor (e.g. *How and under which circumstances did you interact with your respective mentor?*, *How did your mentor provide technical advice?*), their satisfaction with their hackathon project (e.g. *Are you satisfied with the project you created during the hackathon?*) and their mentor (e.g. *How did you perceive the support you received by your mentor?*) and their future intentions related to the science gateways community (e.g. *Are you planning to attend any future community events?*). We asked these questions to study why students chose certain projects, how they perceived their mentor's support to set and asses goals ($\mathbf{RQ}_1$) and how they perceived their mentor's technical advice ($\mathbf{RQ}_2$). Results from the analysis will also provide indication for how teams perceived their project ($\mathbf{RQ}_3$) and their future intentions towards the science gateways community ($\mathbf{RQ}_4$). Complementing the students' perspective, the mentor interviews focused on similar themes including their motivations for proposing a project (e.g. *Why did you propose this particular project? What did you want to achieve coming into the event?*), their preparation activities (e.g. *What did you do to prepare for your role as a mentor during the hackathon?*), their interaction with their team (e.g. *How and under which circumstances did you interact with your team?*, *How did you provide technical advice?*) and their satisfaction with the respective outcomes (e.g. *Are you satisfied with the project the students created?*). The mentor interviews thus complement the students' perspective related to how they supported teams to set goals, assess progress and provide technical advice ($\mathbf{RQ}_1$ and $\mathbf{RQ}_2$). Moreover, they provide insights into how each mentor approached their role and how they perceived the project the students worked on during the hackathon ($\mathbf{RQ}_3$).

Finally, we also analyzed artifacts that the mentors developed to prepare for the hackathon (code artifacts, documentations and tutorials), planning documents between mentors and hackathon organizers and project presentations during the webinar. These serve as additional background information for the previously discussed data sources.

3.4 Analysis procedure

To answer our four main research questions, we started by reconstructing the stories of each team and their mentor from the point when the mentors chose a project area to the end of the hackathon by analyzing interview recordings, questionnaire results, observation notes and planning artifacts. The interviews served as our main data source with questionnaires, planning documents and observation notes complementing the interview recordings and providing additional context.

From the student perspective we focused on their motivations to choose a project, their technical expertise related to the technologies they used, their preparation before and their process during the hackathon including their interaction with their mentor related to setting and assessing project goals ($\mathbf{RQ}_1$) and to the technologies they used ($\mathbf{RQ}_2$). Moreover, we focused on their perception of the project they worked on ($\mathbf{RQ}_3$) and their future intentions towards the science gateways community ($\mathbf{RQ}_4$). We followed a strategy similar to thematic analysis [11] by first familiarizing ourselves with the data before creating and applying initial codes to the interview transcripts based on our research questions (*motivation*, *preparation activities*, *interaction between student and mentor*, *satisfaction with mentoring process*, *satisfaction with project outcome*, *future intentions towards the science gateways community*, etc.). Comparing findings for each team we identified common themes related to the four research questions (*initial goal setting*, *technical support*, *mentoring focus*, etc.). Iterating the procedure, we refined the identified themes, added new ones based on our findings (e.g. *goal alignment*) and created suitable labels for the final report presented here.

Complementing the analysis from the mentors' perspective we analyzed how they identified a project for the students to work on, their preparation activities, how they engaged and interacted with their teams (**RQ**$_1$ and **RQ**$_2$), how they approached their roles and how they perceived the project their teams worked on (**RQ**$_3$). To uncover those aspects, we followed the same procedure as described before using codes such as *motivation*, *perception of student expertise*, *interaction between student and mentor* and *satisfaction with project outcome*.

4 FINDINGS

In this section we will first outline the individual journeys of each team and their mentors (sections 4.1 to 4.3) before discussing differences between teams related to how teams and mentors perceived their collaboration (**RQ**$_1$ and **RQ**$_2$, section 4.4), how they perceived their project and the future intentions of students towards the science gateways community (**RQ**$_3$ and **RQ**$_4$, section 4.5).

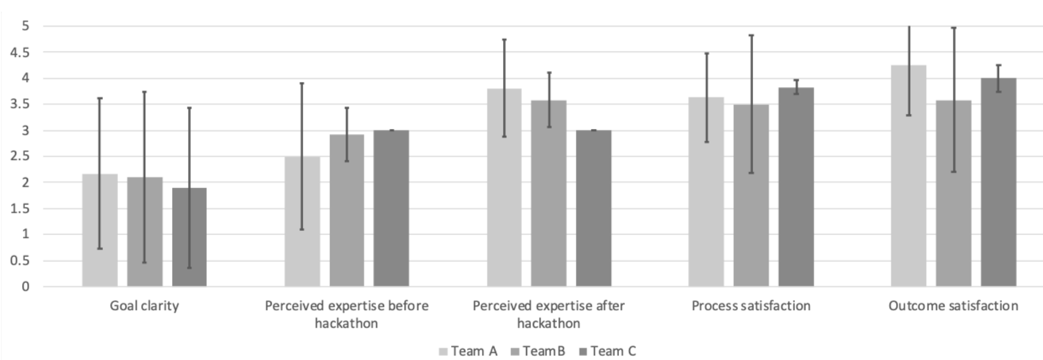

Fig. 3. Questionnaire responses by students after the hackathon. All responses were given on a 5-point scale which were anchored between *strongly disagree (1)* and *strongly agree (5).* The bars indicate the mean (m) and standard deviation (SD) for each team.

4.1 Team A

MA proposed the project because *"the gateway misses an important feature"* (MA) and MA perceived the project to be *"relatively simple"* (MA) and a good learning experience for the students (*"I wanted them to learn"*, MA). During the webinar MA explained the context of the gateway, its general architecture and the envisioned project including required technologies (*"HTML, Javascript and JSON"*, MA). MA prepared for the hackathon by *"collecting images from colleagues"* (MA).

Students mainly chose this project because they wanted to learn a new technology (*"I picked the project that had languages that I had no experiences in"*, A02). They reported prior knowledge using *"a little bit of HTML"* (A02) with all but one student stating that they had no prior experience using the other required technologies (*"never seen JavaScript before"*, A03). At the start of the hackathon MA *"explained the background of the project"* (A03) and told the students that they could *"do it however they liked"* (MA). The students had difficulties understanding the project initially (low goal clarity in Fig. 3, *"confusing at first"*, A03). MA subsequently showed them a *"sample viewer that was kinda similar"* (MA) and suggested to *"break [the project] down"* (A02).

After these initial struggles the team split the project into different tasks (*"we had a list"*, A04) and started working on them individually only coming together to solve problems (*"when one person had a problem we worked together and then went back to our individual work"*, A02). Decisions about the direction of the project were taken as a team with MA supporting if necessary (*"discussed as a team and then with [MA]"*, A04). During this time their lack of previous knowledge related to the technologies they used became visible because they frequently searched for examples and tutorials online (obs.[5]). The team also approached MA multiple times during the hackathon to ask for support on technical issues (obs.). MA supported the team by pointing them towards useful resources (obs.) without giving solutions away (*"s/he would not give us any code but help us"*, A03). MA was generally perceived as *"willing to help"* (A01) because s/he regularly *"came around and asked"* (A04) if s/he could help. MA also engaged with the team on a personal level by *"asking [...] about our lives"* (A02) and telling them about *"her/his experiences when s/he graduated"* (A02).

The team was generally satisfied with their group process (high process satisfaction in Fig. 3) and both team and mentor were satisfied with their collaboration. The students perceived MA as a *"great mentor"* (A02) who *"was really into it which made me into it as well"* (A01) and who helped them to feel *"more comfortable with [technologies]"* (A02). This is reflected by an increase in reported questionnaire scores (perceived expertise before and perceived expertise after in Fig. 3) which indicates that the students felt more comfortable about the technologies they used after the hackathon than they did before. MA stated that s/he was *"very impressed"* (MA) both by the project and the progress the students made (*"they learned a lot"*, MA). Moreover, both mentor and students voiced an interest to continue the project after the hackathon (*"[I would] continue exploring"*, A01) with MA taking steps towards securing its continuation by talking to the principal investigator of the gateway about hiring one of the students *"for an internship"* (MA). The students were satisfied with the outcome (high outcome satisfaction in Fig. 3) and also reported an interest in continuing to expand their knowledge about the technologies they used during the hackathon (*"continue learning those technologies"*, A02). They also voiced an increased interest in the community (*"I am more interested in science gateways now"*, A04).

4.2 Team B

MB proposed this project because it was *"something we definitely need"* (MB) and that s/he perceived to be *"relatively easy"* (MB). During the webinar MB presented the context of the gateway, the purpose of the envisioned project including a detailed project plan and an outline of required technologies (*"Python and Jupyter"*, MB). MB also prepared *"sample code"* (MB) and *"looked into things that were really domain specific"* (MB) prior to the hackathon.

The students mainly selected this project because it allowed them to *"code around Twitter"* (B03) – something they use *"every day"* (B01). All students reported that they were *"familiar with Python"* (B03) but that they used *"Jupyter notebooks [for the] first time"* (B02). At the start of the hackathon MB *"talked about the project goals [and] why we want to do that"* (MB). MB helped them to set up their development environment (obs.), *"showed them the [pre-prepared] sample code"* (MB) and gave them an initial task. MB's aim was for the students to *"dive into the project"* (MB) as quickly as possible (*"there was a lot to cover and I wanted to get through that as quickly as possible"*, MB). The students however struggled to understand the project (low goal clarity in Fig. 3) and the required technologies. This was evident by them frequently turning to MB for help (obs.) who proceeded to

[5]We use "obs." to mark findings that are based on observation notes.

walk them *"through the code"* (MB). MB also *"brainstormed with them"* (MB) which resulted in the team developing the idea to visualize Twitter data thus deviating from the original project focus.

During the remainder of the hackathon the students worked together on the project (obs.) only turning to their mentor to *"make sure we were on the right track"* (B03). MB intentionally let the team work by themselves during the project because s/he wanted them to complete it on their own (*"I was hoping that I would provide a spark and then they would move on from there"*, MB).

The students were mainly satisfied with their group process (high process satisfaction in Fig. 3) despite early struggles and both team and mentor were satisfied with their collaboration. The students reported that MB helped them to *"find a direction"* (B01) and also *"help[ed] with errors"* (B01) when asked. They also reported that they feel *"more comfortable [with technologies] than before"* (B03) which is reflected by the questionnaire scores (perceived expertise before and perceived expertise after in Fig. 3) and MB's perception (*"the students learned"*, MB). The students' opinions about the outcome of the hackathons were mixed (medium score and large standard deviation on outcome satisfaction in Fig. 3). B01 stated that s/he *"achieved more than I thought I would"* (B01) while B03 *"did not achieve what I wanted"* (B03). MB also voiced dissatisfaction with the project outcome because s/he expected the students to reach *"the next stage of conceptualizing the project"* (MB). MB attributed the – from her/his perspective not satisfying – outcome to the students' lack of *"experience in programming"* (MB) stating that s/he generally *"expected a bit more knowledge in Python and so on"* (MB) based on the students' self-reported expertise in the pre-hackathon questionnaire. Despite those difficulties, all students reported that they would like to *"continue working on [the project]"* (B01), *"continue learning"* (B02) and that the hackathon made them *"more interested in science gateways"* (B02). MB also voiced an interest in continuing the project while acknowledging that the *"idea will live on but the code will probably not"* (MB).

4.3 Team C

MC suggested this project because it was on a *"list of things I want to achieve over the next few years"* (MC) and because s/he thought that it would be feasible for *"a 24-hour period"* (MC). During the webinar MC introduced the gateway along with a concrete project idea including a list of tasks and an outline of required technologies (*"Python, Javascript, Django"*, MC). MC also explained that s/he will only be *"available via Skype"* (MC) during the hackathon. MC created a *"tutorial"* (MC), *"a schedule for the whole 24 hours"* (MC) and sample code prior to the hackathon.

The students chose this project for different reasons including working with technologies that they were *"not familiar"* (C01) with, working in an interesting context (*"mapping and CO2"*, C02) and building *"something useful"* (C03). Only one student reported previous experience related to relevant technologies (*"[I am] very comfortable with Python", C02*). At the beginning of the hackathon MC called via Skype and attempted to walk the team through the tutorial s/he had prepared (obs.). MC also provided additional contact information (email and Slack) and told them *"hours that I would be available"* (C01). During the tutorial the students attempted to download and set up the existing desktop application which failed because of *"technology difficulties"* (MC). This led to confusion among the students about the project in general (low goal clarity in Fig, 3, *"I don't think we had a visual about how everything was supposed to look"*, C04) which they did not manage to resolve on their own before the next call with MC around midnight (*"breakthrough after midnight"*, MC) despite their continued efforts to get the desktop application to work (obs.).

After the midnight call the team split up (obs.) started to work *"on different parts"* (C02) of the project with MC helping *"with coding issues"* (C03) during the times s/he was available. Decisions about the direction of the project were taken based on the desktop application (obs.).

The students were generally satisfied with the way they worked together (high process satisfaction in Fig. 3) but they had a *"neutral"* (C01) to negative perception about MC stating that *"help* *[was] lacking"* (C02). Only one student voiced her/his understanding about the situation (*"there is only so much you can do remotely"*, C03). Despite attempting to *"give them a lot of guidance"* (MC) MC perceived their collaboration as similarly problematic because *"I couldn't personally connect with the students"* (MC). This feeling was amplified by MC's perception to *"only communicate with 2 out of 4 students"* (MC) during Skype calls despite other team members being present outside of the view of the camera (obs.). The students were generally satisfied with their project after the hackathon (high outcome satisfaction in Fig. 3). MC however was less satisfied (*"they did not make it as far as I thought"*, MC) suggesting that *"the skill level [of the students]"* (MC) might not have been sufficient for *"the time that we gave them"* (MC). The students did not report any learning gains (perceived expertise before and perceived expertise after in Fig. 3, *"I didn't really pick [technology] up"*, C03) with three out of four students stating that the hackathon had *"no impact on [their] interest"* (C02) and only C01 reporting that s/he will *"continue learning [technologies]"* (C01). Only C03 mentioned s/he would *"continue this project"* (C03). MC also voiced continuation intentions related to the project while acknowledging the necessity to *"rebuild it"* (MC) from scratch.

4.4 Relationship between mentors and their teams

In this section we will discuss differences between the teams we studied with respect to how mentors supported them to set and asses project goals (**RQ**$_1$) and how they provided technical advice (**RQ**$_2$). Through the comparison we identified the following six main differences between the three studied teams (Table 3 contains an overview):

(1) **Initial goal setting:** All mentors presented their projects in a similar way during the webinar covering aspects such as the general purpose and background of their gateway, the purpose of the proposed project and the technologies required. At the beginning of the hackathon MA reiterated the background of the project and then let the students decide about its specific direction. MB and MC also reiterated the project background but then proceeded to walk the students through prepared code examples (MB) or a desktop interface that the students should replicate (MC) thus leaving no space for them to develop their own project idea.

(2) **Goal assessment and adaptation:** From the start of the hackathon MA supported the team to develop their own project idea which would match their capabilities. In comparison MB and MC attempted to guide the students towards a level of technical expertise that they perceived necessary to complete the project they had envisioned prior to the hackathon with the students failing to reach this level. MB realized this issue during the hackathon and changed her/his strategy supporting the students to come up with a project idea of their own that would be suitable for their level of technical expertise. MC never changed her/his approach and the students did not reach the state that MC had envisioned.

(3) **Technical support:** Each team required support related to the technologies they used to complete their project. Initially all mentors overestimated the technical proficiency of the students based on pre-questionnaire results. To support students to reach a sufficient level of technical proficiency MB and MC provided tutorials and supplied code fragments. In contrast MA provided hints towards where to find suitable tutorials to solve upcoming problems thus forcing students to find their own solutions.

(4) **Mentoring focus:** MA focused on supporting the students to develop a suitable project idea and a plan on how to approach it while providing occasional support to solve technical problems. MB and MC mainly focused on the technical aspects of their projects with MB altering her/his focus during the hackathon after realizing that the initial approach did not appear to be fruitful.

(5) **Goal alignment between mentor and team:** The goal of all mentors was for the students to develop technical features that could benefit their respective gateways with MA also aiming for the students to learn. They initially assumed that the students would select projects based on their individual expertise related to the technologies that those projects required. The students however mainly selected projects because they wanted to learn about new technologies which led to a considerable disparity between the level of technical expertise expected by the mentors and the actual technical expertise of the students related to the specific technologies the projects required.
(6) **Dynamics between team and mentor:** All mentors attempted to teach students about the technologies required to complete their respective projects. MB and MC however maintained a distance towards their teams thus assuming the role of a traditional hackathon mentor by providing on-demand project feedback and technical support. MC was perceived to be even more distant than MB because of her/his limited online availability. MB and MC moreover showed behavior commonly associated with the role of a stakeholder or product owner by initially (in the case of MB) or continuously (in the case of MC) guiding the students towards completing the project that they had envisioned. MA also provided project feedback and technical support, but s/he also supported the students to develop their own project idea from the start. Moreover, MA connected with them on a personal level by asking them about their life and telling them about her/his experiences as a computer science student thus assuming a role that is closer to the role of a traditional (workplace or educational) mentor.

	Team A	Team B	Team C
initial goal setting	students decided for goals	goals were set by mentor	goals were set by mentor
goal assessment and adaptation	adaptation at the beginning of the hackathon	adaptation during hackathon	no adaptation
technical support	mentor helped team to find tutorials and code fragments	mentor provided tutorials and code fragments	mentor provided tutorials and code fragments
mentoring focus	project idea and project plan	first technical aspects of project then project idea	technical aspects of project
goal alignment	mentor and students focused on learning outcomes	mentor focused on project outcomes, students on learning	mentor focused on project outcomes, students on learning
dynamics between team and mentor	traditional mentor	hackathon mentor and stakeholder / product owner	hackathon mentor with limited availability and stakeholder / product owner

Table 3. Comparison between teams along aspects that are related to $\mathbf{RQ}_1$ and $\mathbf{RQ}_2$.

4.5 Perception of outcomes and future intentions

After identifying these differences, we then turned towards analyzing how teams and their mentors perceived their projects (**RQ**$_3$) and which – if any – future intentions students had towards the science gateways community after the hackathon (**RQ**$_4$). To address these questions, we again compared the different teams focusing on the satisfaction of students and mentors with their projects, their potential future intentions towards their project and potential future intentions of students related to the science gateways community. Since the previous comparison also pointed towards a strong focus of the participating students on learning we also analyzed the students' perception of learning gains and their potential intentions to continue learning about technologies they used (Table 4 provides an overview).

The comparison revealed that the students in team A were satisfied with their mentor and that both mentor and students were satisfied with their project. The students in team A also reported that they perceived to have learned about the technologies they used, mentioned that they would continue working on their respective project and voiced an increased interest in the community. The students in team B were also satisfied with their mentor while the students in team C were not. Moreover, the students in teams B and the mentors of teams B and C were not particularly satisfied with their project while the students in team C reported to be satisfied with the project they worked on. Most students in team B also voiced an interest to continue working on their projects. Only one student in team C and neither MB nor MC voiced similar intentions. Moreover, the students in team B reported learning gains and an increased interest in the community while the students in team C did not. Students of all teams reported that they intend to continue learning about the technologies they used during the hackathon.

	Team A	Team B	Team C
satisfaction with mentor	high	high	neutral to negative
satisfaction with project	high (team and mentor)	low (team and mentor)	high (team), low (mentor)
perceived learning gains	yes	yes	no
project continuation intentions	team and mentor	neither team nor mentor	neither team nor mentor
learning continuation intentions	yes	yes	yes
increased community interest	yes	yes	no

Table 4. Comparison between teams in relation to the perception of teams and their mentors about their project (**RQ**$_3$) and the future intentions of students related to the science gateways community (**RQ**$_4$).

5 DISCUSSION

Reflecting on the previously discussed findings we will discuss in the following how the way different mentors interacted with their teams might have been related to the perception of students about their project and their future intentions towards the community. The aim of this comparison is twofold: (1) to identify means for improving the proposed intervention which is grounded in the traditional understanding of mentoring [43] with one mentor supporting one team throughout the entire duration of a hackathon rather than the common understanding of mentoring in work on hackathons which focuses on on-demand feedback and technical support [13, 41, 51, 69] and (2) to contribute to our understanding of mentoring in the context of hackathons. This aspect has not been extensively studied despite most existing studies acknowledging the importance of mentoring in hackathons [13, 51, 69]. Our work thus expands our current perception of hackathon mentoring in which mentors are typically limited to providing sporadic on-demand project feedback and technical support to any team in need [62].

Comparing our findings on how the different mentors interacted with their teams it appears that the approach of MA was perceived as most positive with MB and MC following as second and third respectively. That MA remained in the **role of a mentor rather than a project stakeholder** in particular appears to have contributed to positive perceptions not only related to the mentoring approach but also related to the satisfaction of mentors and students with their project. This finding is in line with previous work on organizational mentoring [23].

In addition MB and MC taking a more stakeholder-oriented rather than a mentor role might have led to them focusing more on the project they envisioned rather than creating a positive experience for their teams. MA in turn focusing on **student learning rather than project completion** alone could be related to the positive perception team A about their project and their positive future intentions related to the science gateways community. This finding again is in line with previous work in the context of organizational mentoring [42] where coaching has been identified as one of the functions that can relate to positive mentoring outcomes.

The different approaches of each mentor might also have contributed to perceived differences in learning gains between teams A and B and team C. Due to their struggles the students in team C might have perceived their learning gains to be minimal compared to the students in teams A and B. Moreover, MA supporting students to find solutions to technical problems on their own rather than providing solutions might have contributed to a feeling of achievement. This in turn could be related to improving the self-confidence of team A to be able to tackle technical issues on their own. It might thus be advisable for **mentors to support students to seek their own solutions to technical problems rather than providing solutions to them**. This finding is in line with findings in the context of educational mentoring where researchers attributed increased self-confidence to a positive mentoring experience [36].

Moreover our study also provided indication that it might be important for mentors to understand the students' capabilities and support them to set goals that are attainable for them rather than attempting to guide them to reach a level of technical expertise that the mentors perceive to be necessary to complete the project the mentors envisioned. In other words, it might be advisable for mentors to **support students to plan projects that fit their abilities rather than letting them choose projects to learn new technical abilities**. This aspect has been discussed in an educational context by Vygotsky as the *zone of proximal development* [78] referring to tasks learners can carry out with suitable guidance.

Our study also revealed that MA formed a personal connection to her/his team which potentially related to the students' satisfaction with their mentor and their positive future intentions towards the science gateways community. This finding is in line with work in the context of organizational mentoring where scholars discussed the positive effects of a mentor becoming a role model [37, 42]. MA can arguably be perceived as such since s/he discussed with the students about her/his study background and personal journey during the hackathon. In contrast to that our findings revealed that MC being remote could have related to a negative perception of team C about their mentor and a lack of future intentions related to the science gateways community. It thus appears important for mentors to **form a personal connection with students rather than being available remotely only**. This finding stands in contrast to findings of Allen et al. [2] in the context of corporate mentoring and Trainer et al. [76] in the context of e-mentoring who did not report a negative effect of mentor proximity on the mentoring experience. The short duration of the hackathon we studied compared to these settings might however have contributed to this negative experience.

Findings from our study also extend our current perception about who can participate in domain specific hackathons. In a typical hackathon setting, projects are proposed by individuals who are knowledgeable about the project domain and its technical requirements [75] thus limiting the potential audience. Findings from our study suggest that appropriate support can enable newcomers to participate in scientific hackathons, successfully complete projects while growing interest in the community which extends our current perception of the feasibility of hackathons to attract newcomers to specialized communities [49, 74].

Results also confirmed findings in the context of project-based learning which indicated the necessity of qualified mentors to achieve project goals and desired learning outcomes [5, 16]. This necessity might have been amplified in our setting due to the larger heterogeneity of student backgrounds compared to typical project-based learning settings. It became apparent that despite the focus in scientific hackathons being on developing useful artifacts rather than learning outcomes, the participating students mainly required support related to scoping their projects and acquiring the technical expertise necessary to complete them. This is in line with work on project-based learning where supporting students to deal with the complexity of their project is perceived as one of the main challenges [9]. Our study as well as work on project-based learning also provided indications that mentoring can contribute to raising interest in the studied topics [16].

Our findings also contribute to our understanding of mentoring in hackathons in general and educational hackathons in particular [58]. They indicate that positive effects that are generally associated with mentoring can materialize despite mentors and protégés only working together for a relatively short period of time during a hackathon. Our findings are thus in line with similar studies on the effectiveness of mentoring in open source [76] and online communities [14].

Summarizing the previously discussed findings it appears that the primary benefit of the proposed intervention for scientific communities lies in **exposing students to new technologies, creating a positive experience and forming ties rather than creating technical artifacts**. Even the prototype that team A developed which both mentors and students perceived to be satisfying will require future work to be useful for the community. One of the students will in team A will potentially continue working on the prototype which creates a chance to intensify connections to the community and continue the mentor protégé relationship that started during the hackathon.

5.1 Suggestions for organizers of scientific hackathons

All three teams of newcomers we studied managed to complete a project during a scientific hackathon. It thus appears viable for newcomers to participate in a scientific hackathon and to scope and conduct a project if they receive suitable support. Moreover, findings from the comparison between team A and teams B and C suggest that it might be advisable to perceive projects as opportunities to connect to newcomers and support them to learn about technologies that are used within the community rather than as ways to develop crucial technical artifacts. In our study only team A gathered sufficient interest towards their project to get continued but students of both teams A and B voiced future intentions towards the science gateways community. Moreover, all teams voiced their interest to continue learning about the technologies they used during the hackathon. It thus appears reasonable for organizers of scientific hackathons to emphasize the learning aspect of hackathons and focus on their potential to create interest in the community.

Moreover, our study points towards the importance of carefully selecting potential mentors and coaching them prior to the hackathon to remain in the role of a mentor rather than turning towards acting as a stakeholder or product owner. It might even be advisable for organizers to ask mentors to choose projects that are not at the core of their interest or the interest of their community in order make it easier for mentors to stay in their role. Our findings related to teams A and B also indicate that organizers should suggest for mentors to focus on supporting newcomers to develop a project idea that fits their interests and capabilities during the early stages of a hackathon. This includes encouraging them to develop their own idea rather than executing a pre-planned project as in the case of teams B and C. It might thus be advisable for organizers to propose mandatory checkpoints during the early phases of a hackathon which would allow mentors and teams to discuss the teams' project ideas and plans to execute them. This might help teams to develop a viable project idea early thus leaving sufficient time for them to complete it.

Our findings also indicate difficulties related to remote mentoring which did not only appear to hinder students to progress with their project but might also have affected their future interest in the community. To support team progress, it might have been advisable if the remote mentor would be available on demand especially during the early phases of the hackathon. Organizers might also consider having a mentor on site that can support the remote mentor to assess the situation, serve as a connection to the community and provide valuable insight into how the team works. This would allow the remote mentor to adjust her/his approach to the team's interests and capabilities.

5.2 Suggestions for mentors in scientific hackathons

It appeared crucial for teams of newcomers to develop their own project idea which they can reasonably expect to execute during the short duration of a hackathon as early as possible. It might thus be advisable for mentors to get to know their teams and their capabilities early maybe even prior to the hackathon by e.g. engaging them in short tasks and setting team checkpoints during which teams and mentors discuss about the teams' ideas without focusing on technical details straight away. Moreover, it appears advisable for mentors to support students to find their own solutions to technical problems rather than mentors solving them for their team. This was evident in our case through the approach of MA who helped teams to find solutions to technical problems rather than giving them away.

In our case it also appeared important for mentors to connect to teams on a personal level thus serving as a traditional mentor rather than a stakeholder or product owner. The positive reactions of team A to MA's approach point towards this finding. Initially mentors might perceive this as a limitation since one of the main goals for them to serve as a mentor in our case was to create a viable artifact for their community. Our study however provides indication – based on the result of team A – that developing a small but viable artifact might prove to be more sustainable than attempting to help participants create an artifact that is outside of their capabilities. It could also be advisable to ask mentors to propose projects that are not closely related to their current interest or the interest of their community in order to help them to remain in their mentor role.

As discussed in section 5.1 serving as a remote mentor can be challenging. In our case the remote mentor for team C found it particularly difficult to connect with them and to assess their current state. This might have negatively affected the quality of the teams' project as well as their interest in the community. It thus appears advisable to have an additional mentor on site that can provide additional insight into how the team works, serve as a connection to the community and that can provide additional on-demand support.

5.3 Limitations

The goal of our study was to explore how mentors support teams of newcomers to set goals, assess their progress and provide advice during a scientific hackathon. Furthermore, we aimed to study how mentors and students perceived their project and the intentions of students towards the community the hackathon took place in in order to provide suggestions for organizers and mentors of scientific hackathons. It thus appeared reasonable to conduct an action research study

[46]. There are however limitations associated with this particular study design. We developed a specific intervention and studied three teams in a specific domain over a limited period of time that were mentored by three community members with specific backgrounds and goals for the hackathon. Despite making a theoretically founded case selection it is not possible to generalize findings beyond our study context since studying a different setting with different teams, mentors and projects might yield different results. Moreover, the study was conducted by a team of three researchers which poses a threat to validity since different researchers observing different teams might potentially lead to different interpretations. To minimize this threat, we carefully planned the study by discussing among the involved researchers which sensitizing concepts to focus on. The involvement of the participating researchers during the planning phase and their presence during the hackathon itself can also affect the reported findings despite our best efforts to refrain from interfering during the hackathon itself. We also abstained from making causal claims instead providing a rich description of the observed behavior and reported perceptions of mentors and participants based on which we discuss differences in how mentors interacted with their teams, how teams and mentors perceived their project and which – if any – future intentions students had towards the scientific community that organized the hackathon. We hope to see more research on the aspect of mentoring in hackathons in the future to complement our findings.

It is also important to note that the proposed approach requires an individual mentor for each hackathon team which might limit scale ability. It might be not necessary to assign an individual mentor to each team if a sufficient number of participants are familiar with the domain and can serve as team leaders. The proposed approach is also not meant to replace existing hackathon *mentoring* approaches. It should rather be perceived as an option for scientific and other specialized communities to facilitate the participation of newcomers during hackathons of their community.

6 CONCLUSION AND FUTURE PLANS

We are currently in the process of developing the second cycle of the presented action research study which will take place within the same community. Using the aspects outlined in the discussion as a basis we developed guiding materials for organizers and mentors (sections 5.1 and 5.2) that will we use during the planning phase of the hackathon. Changes to the format include checkpoints for teams to get early feedback, suggestions for mentors to abstain from assuming a stakeholder role, connect to students and focus on students' learning gains rather than the completion of a pre-envisioned project. The data collection procedure and instruments used will remain largely the same with a stronger focus on the mentors since most suggestions we developed are targeted at them. We will also alter the focus of the data collection to assess the impact of the aforementioned interventions and include an additional data collection point three to six months after the hackathon to identify potential long-term effects related to the projects that were developed during the hackathon. Moreover, to better cover the community engagement aspect of the studied hackathon we will add a corresponding scale to the questionnaire. The proposed scale has been successfully been used in the context of online communities [22] to assess individual commitment to and identification with a community.

In this paper we presented findings from an action research study on assigning community members as mentors to teams of newcomers during a scientific hackathon. Our findings provided tentative insights into the interaction between mentors and teams and their perception of their hackathon project and their future intentions towards the community that organized the hackathon. Our work not only addresses an important shortcoming in scientific literature on hackathons by studying mentoring in a specific hackathon event. Our findings can also support scientific communities to use hackathons as a means to attract newcomers which is crucial for their survival.

ACKNOWLEDGMENTS

The authors gratefully acknowledge support by the Alfred P. Sloan foundation, Science Gateways Community Institute Workforce Development (funded by the National Science Foundation under award number ACI-1547611) and Elizabeth City State University. We would also like to thank Je'aime Powell, Ei Pa Pa Pe-Than, Amy Cannon, Kathy Traxler, the hackathons mentors and participants and the anonymous reviewers.

REFERENCES

[1] Tammy D Allen. 2003. Mentoring others: A dispositional and motivational approach. *Journal of Vocational Behavior* 62, 1 (2003), 134–154.

[2] Tammy D Allen, Lillian T Eby, and Elizabeth Lentz. 2006. Mentorship behaviors and mentorship quality associated with formal mentoring programs: closing the gap between research and practice. *Journal of Applied Psychology* 91, 3 (2006), 567.

[3] Tammy D Allen, Lillian T Eby, Mark L Poteet, Elizabeth Lentz, and Lizzette Lima. 2004. Career benefits associated with mentoring for protégés: A meta-analysis. *Journal of applied psychology* 89, 1 (2004), 127.

[4] Pantelis Angelidis, Leslie Berman, Maria de la Luz Casas-Perez, Leo Anthony Celi, George E Dafoulas, Alon Dagan, Braiam Escobar, Diego M Lopez, Julieta Noguez, Juan Sebastian Osorio-Valencia, et al. 2016. The hackathon model to spur innovation around global mHealth. *Journal of medical engineering & technology* 40, 7-8 (2016), 392–399.

[5] Craig Anslow, John Brosz, Frank Maurer, and Mike Boyes. 2016. Datathons: an experience report of data hackathons for data science education. In *Proceedings of the 47th ACM Technical Symposium on Computing Science Education*. ACM, 615–620.

[6] Bastiaan Baccarne, Peter Mechant, Dimitri Schuurma, Lieven De Marez, and Pieter Colpaert. 2014. Urban socio-technical innovations with and by citizens. *Interdisciplinary Studies Journal* 3, 4 (2014), 143.

[7] Eric Berger. 2017. Karachi Hackathon Takes on Emergency Medicine Challenges: Solutions Pitched for Resource-Poor Environments. *Annals of Emergency Medicine* 69, 3 (2017), A17–A20.

[8] Nataly Birbeck, Shaun Lawson, Kellie Morrissey, Tim Rapley, and Patrick Olivier. 2017. Self Harmony: rethinking hackathons to design and critique digital technologies for those affected by self-harm. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, 146–157.

[9] Phyllis C Blumenfeld, Elliot Soloway, Ronald W Marx, Joseph S Krajcik, Mark Guzdial, and Annemarie Palincsar. 1991. Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational psychologist* 26, 3-4 (1991), 369–398.

[10] Glenn A Bowen. 2006. Grounded theory and sensitizing concepts. *International journal of qualitative methods* 5, 3 (2006), 12–23.

[11] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative research in psychology* 3, 2 (2006), 77–101.

[12] Gerard Briscoe. 2014. Digital innovation: The hackathon phenomenon. (2014).

[13] Jake Rowan Byrne, Katriona O'Sullivan, and Kevin Sullivan. 2017. An IoT and Wearable Technology Hackathon for Promoting Careers in Computer Science. *IEEE Transactions on Education* 60, 1 (2017), 50–58.

[14] Julie Campbell, Cecilia Aragon, Katie Davis, Sarah Evans, Abigail Evans, and David Randall. 2016. Thousands of positive reviews: Distributed mentoring in online fan communities. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing*. ACM, 691–704.

[15] Joohee Choi and Yla Tausczik. 2017. Characteristics of collaboration in the emerging practice of open data analysis. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing*. ACM, 835–846.

[16] Irene-Angelica Chounta, Sven Manske, and H Ulrich Hoppe. 2017. " From Making to Learning" : introducing Dev Camps as an educational paradigm for Re-inventing Problem-based Learning. *International Journal of Educational Technology in Higher Education* 14, 1 (2017), 21.

[17] David Cobham, Bruce Hargrave, Kevin Jacques, Carl Gowan, Jack Laurel, Scott Ringham, et al. 2017. From hackathon to student enterprise: an evaluation of creating successful and sustainable student entrepreneurial activity initiated by a university hackathon. In *9th annual International Conference on Education and New Learning Technologies*. EDULEARN.

[18] R Cameron Craddock, Daniel S Margulies, Pierre Bellec, B Nolan Nichols, Sarael Alcauter, Fernando A Barrios, Yves Burnod, Christopher J Cannistraci, Julien Cohen-Adad, Benjamin De Leener, et al. 2016. Brainhack: a collaborative workshop for the open neuroscience community. *GigaScience* 5, 1 (2016), 16.

[19] Kevin Crowston, Qing Li, Kangning Wei, U Yeliz Eseryel, and James Howison. 2007. Self-organization of teams for free/libre open source software development. *Information and software technology* 49, 6 (2007), 564–575.

[20] Marthe Dehli. 2016. *Hackathons as a ground for creating start-ups: Evidence from THE Port 2014*. Ph.D. Dissertation. CERN.

[21] Martyn Denscombe. 2014. *The good research guide: for small-scale social research projects*. McGraw-Hill Education (UK).

[22] Naomi Ellemers, Paulien Kortekaas, and Jaap W Ouwerkerk. 1999. Self-categorisation, commitment to the group and group self-esteem as related but distinct aspects of social identity. *European journal of social psychology* 29, 2-3 (1999), 371–389.

[23] Ellen A Fagenson. 1989. The mentor advantage: Perceived career/job experiences of protégés versus non-protégés. *Journal of organizational behavior* 10, 4 (1989), 309–320.

[24] Fabian Fagerholm, Alejandro S Guinea, Jürgen Münch, and Jay Borenstein. 2014. The role of mentoring and project characteristics for onboarding in open source software projects. In *Proceedings of the 8th ACM/IEEE international symposium on empirical software engineering and measurement*. ACM, 55.

[25] Anna Filippova, Erik Trainer, and James D Herbsleb. 2017. From diversity by numbers to diversity as process: supporting inclusiveness in software development teams with brainstorming. In *Proceedings of the 39th International Conference on Software Engineering*. IEEE Press, 152–163.

[26] Denae Ford, Kristina Lustig, Jeremy Banks, and Chris Parnin. 2018. We Don't Do That Here: How Collaborative Editing with Mentors Improves Engagement in Social Q&A Communities. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, 608.

[27] Allan Fowler. 2016. Informal stem learning in game jams, hackathons and game creation events. In *Proceedings of the International Conference on Game Jams, Hackathons, and Game Creation Events*. ACM, 38–41.

[28] Sarah Fox, Rachel Rose Ulgado, and Daniela Rosner. 2015. Hacking culture, not devices: Access and recognition in feminist hackerspaces. In *Proceedings of the 18th ACM conference on Computer supported cooperative work & social computing*. ACM, 56–68.

[29] Kiev Gama, Breno Alencar, Filipe Calegario, André Neves, and Pedro Alessio. 2018. A Hackathon Methodology for Undergraduate Course Projects. In *2018 IEEE Frontiers in Education Conference (FIE)*. IEEE, 1–9.

[30] Sarah Hartmann, Agnes Mainka, and Wolfgang G Stock. 2018. Innovation Contests: How to Engage Citizens in Solving Urban Problems? In *Enhancing Knowledge Discovery and Innovation in the Digital Era*. IGI Global, 254–273.

[31] Ann M Heirdsfield, Sue Walker, Kerryann Walsh, and Lynn Wilss. 2008. Peer mentoring for first-year teacher education students: The mentors' experience. *Mentoring & Tutoring: Partnership in Learning* 16, 2 (2008), 109–124.

[32] Scott Henderson. 2015. Getting the most out of hackathons for social good. *Volunteer Engagement 2.0: Ideas and insights changing the world* (2015), 182–194.

[33] Chinh Hoang, John Liu, Zubaid Bokhari, and Allen Chan. 2016. IBM 2016 community hackathon. In *Proceedings of the 26th Annual International Conference on Computer Science and Software Engineering*. 331–332.

[34] Alexis Hope, Catherine D'Ignazio, Josephine Hoy, Rebecca Michelson, Jennifer Roberts, Kate Krontiris, and Ethan Zuckerman. 2019. Hackathons as Participatory Design: Iterating Feminist Utopias. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. ACM, 61.

[35] Lilly Irani. 2015. Hackathons and the making of entrepreneurial citizenship. *Science, Technology, & Human Values* 40, 5 (2015), 799–824.

[36] W Brad Johnson. 2002. The intentional mentor: Strategies and guidelines for the practice of mentoring. *Professional psychology: Research and practice* 33, 1 (2002), 88.

[37] Jenni Jones. 2013. Factors influencing mentees' and mentors' learning throughout formal mentoring relationships. *Human Resource Development International* 16, 4 (2013), 390–408.

[38] Marion Jones. 2001. Mentors' perceptions of their roles in school-based teacher training in England and Germany. *Journal of Education for Teaching* 27, 1 (2001), 75–94.

[39] Hanna Kienzler and Carolyn Fontanesi. 2017. Learning through inquiry: A global health hackathon. *Teaching in Higher Education* 22, 2 (2017), 129–142.

[40] Marko Komssi, Danielle Pichlis, Mikko Raatikainen, Klas Kindström, and Janne Järvinen. 2015. What are Hackathons for? *IEEE Software* 32, 5 (2015), 60–67.

[41] Brittany Ann Kos. 2016. The Unique Hackathon Experience. (2016).

[42] Kathy E Kram. 1983. Phases of the mentor relationship. *Academy of Management journal* 26, 4 (1983), 608–625.

[43] Kathy E Kram. 1985. *Mentoring at work: Developmental relationships in organizational life*. University Press of America.

[44] Hilmar Lapp, Sendu Bala, James P Balhoff, Amy Bouck, Naohisa Goto, Mark Holder, Richard Holland, Alisha Holloway, Toshiaki Katayama, Paul O Lewis, et al. 2007. The 2006 NESCent phyloinformatics hackathon: a field report.

[45] Miguel Lara and Kate Lockwood. 2016. Hackathons as community-based learning: a case study. *TechTrends* 60, 5 (2016), 486–495.

[46] Kurt Lewin. 1946. Action research and minority problems. *Journal of social issues* 2, 4 (1946), 34–46.

[47] Thomas James Lodato and Carl DiSalvo. 2016. Issue-oriented hackathons as material participation. *New Media & Society* 18, 4 (2016), 539–557.

[48] Carol A McKeen and Ronald J Burke. 1989. Mentor relationships in organisations: Issues, strategies and prospects for women. *Journal of Management Development* 8, 6 (1989), 33–42.

[49] Steffen Möller, Enis Afgan, Michael Banck, Raoul JP Bonnal, Timothy Booth, John Chilton, Peter JA Cock, Markus Gumbel, Nomi Harris, Richard Holland, et al. 2014. Community-driven development for computational biology at Sprints, Hackathons and Codefests. *BMC bioinformatics* 15, 14 (2014), S7.

[50] Evgeny Morozov. 2013. *To save everything, click here: The folly of technological solutionism.* Public Affairs.

[51] Jabu Mtsweni and Hanifa Abdullah. 2015. Stimulating and maintaining students' interest in Computer Science using the hackathon model. *The Independent Journal of Teaching and Learning* 10, 1 (2015), 85–97.

[52] Arnab Nandi and Meris Mandernach. 2016. Hackathons as an informal learning platform. In *Proceedings of the 47th ACM Technical Symposium on Computing Science Education.* ACM, 346–351.

[53] Alexander Nolte, Ei Pa Pa Pe-Than, Anna Filippova, Christian Bird, and Herbsleb James D. Scallen, Steve. 2018. You Hacked and Now What? - Exploring Outcomes of a Corporate Hackathon. *Proceedings of the ACM on Human-Computer Interaction* 2, CSCW (2018), 129:1–129:23.

[54] Finlay Page, Sylvester Sweeney, Fraser Bruce, Seaton Baxter, et al. 2016. The use of the "hackathon" in design education: an opportunitstic exploration.. In *DS 83: Proceedings of the 18th International Conference on Engineering and Product Design Education (E&PDE16), Design Education: Collaboration and Cross-Disciplinarity, Aalborg, Denmark, 8th-9th September 2016.* 246–251.

[55] Ei Pa Pa Pe-Than and James D Herbsleb. 2019. Understanding Hackathons for Science: Collaboration, Affordances, and Outcomes. In *International Conference on Information.* Springer, 27–37.

[56] Ei Pa Pa Pe-Than, Alexander Nolte, Anna Filippova, Christian Bird, Steve Scallen, and James D Herbsleb. 2019. Designing Corporate Hackathons With a Purpose: The Future of Software Development. *IEEE Software* 36, 1 (2019), 15–22.

[57] J Porras, K Heikkinen, and J Ikonen. 2007. Code camp: a setting for collaborative learning of programming. *Advanced Technology for Learning* 4, 1 (2007), 43–52.

[58] Jari Porras, Antti Knutas, Jouni Ikonen, Ari Happonen, Jayden Khakurel, and Antti Herala. 2019. Code camps and hackathons in education-literature review and lessons learned. In *Proceedings of the 52nd Hawaii International Conference on System Sciences.*

[59] Emily Porter, Chris Bopp, Elizabeth Gerber, and Amy Voida. 2017. Reappropriating Hackathons: The Production Work of the CHI4Good Day of Service. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems.* ACM, 810–814.

[60] Belle Rose Ragins, John L Cotton, and Janice S Miller. 2000. Marginal mentoring: The effects of type of mentor, quality of relationship, and program design on work and career attitudes. *Academy of management journal* 43, 6 (2000), 1177–1194.

[61] Belle Rose Ragins and Dean B McFarlin. 1990. Perceptions of mentor roles in cross-gender mentoring relationships. *Journal of Vocational Behavior* 37, 3 (1990), 321–339.

[62] John W Ramatowski, Christopher Xiang Lee, Aikaterini Mantzavino, João Ribas, Winter Guerra, Nicholas D Preston, Eva Schernhammer, Lawrence C Madoff, and Britta Lassmann. 2017. Planning an innovation marathon at an infectious disease conference with results from the International Meeting on Emerging Diseases and Surveillance 2016 Hackathon. *International Journal of Infectious Diseases* 65 (2017), 93–97.

[63] Bruce A Reinig. 2003. Toward an Understanding of Satisfaction with the Process and Outcomes of Teamwork. *Journal of Management Information Systems* 19, 4 (2003), 65–83.

[64] Bard Rosell, Shiven Kumar, and John Shepherd. 2014. Unleashing innovation through internal hackathons. In *Innovations in Technology Conference (InnoTek), 2014 IEEE.* IEEE, 1–8.

[65] Melody L Russell and Jared A Russell. 2011. Mentoring Relationships: Cooperating Teachers' Perspectives on Mentoring Student Interns. *Professional Educator* 35, 1 (2011), n1.

[66] John E Sawyer. 1992. Goal and process clarity: Specification of multiple constructs of role ambiguity and a structural equation model of their antecedents and consequences. *Journal of Applied Psychology* 77, 2 (1992), 130.

[67] Janet Siegmund, Christian Kästner, Jörg Liebig, Sven Apel, and Stefan Hanenberg. 2014. Measuring and modeling programming experience. *Empirical Software Engineering* 19, 5 (2014), 1299–1334.

[68] Susan Elliott Sim and Richard C Holt. 1998. The ramp-up problem in software projects: A case study of how software immigrants naturalize. In *icse.* IEEE, 361.

[69] Porya Mohajer Soltani, Kalevi Pessi, Karin Ahlin, and Ida Wernered. 2014. Hackathon: A method for digital innovative success: A comparative descriptive study. In *Proceedings of the 8th European Conference on IS Management and Evaluation.* 367–373.

[70] Walter Swap, Dorothy Leonard, Mimi Shields, and Lisa Abrams. 2001. Using mentoring and storytelling to transfer knowledge in the workplace. *Journal of management information systems* 18, 1 (2001), 95–114.

[71] Nick Taylor and Loraine Clarke. 2018. Everybody's Hacking: Participation and the Mainstreaming of Hackathons. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, 172.

[72] John W Thomas. 2000. A review of research on project-based learning. (2000).

[73] Andrea K Thomer, Michael B Twidale, Jinlong Guo, and Matthew J Yoder. 2016. Co-designing scientific software: Hackathons for participatory interface design. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*. ACM, 3219–3226.

[74] Erik H Trainer, Chalalai Chaihirunkarn, Arun Kalyanasundaram, and James D Herbsleb. 2014. Community code engagements: summer of code & hackathons for community building in scientific software. In *Proceedings of the 18th International Conference on Supporting Group Work*. ACM, 111–121.

[75] Erik H Trainer, Arun Kalyanasundaram, Chalalai Chaihirunkarn, and James D Herbsleb. 2016. How to hackathon: Socio-technical tradeoffs in brief, intensive collocation. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing*. ACM, 1118–1130.

[76] Erik H Trainer, Arun Kalyanasundaram, and James D Herbsleb. 2017. e-mentoring for software engineering: a socio-technical perspective. In *Software Engineering: Software Engineering Education and Training Track (ICSE-SEET), 2017 IEEE/ACM 39th International Conference on*. IEEE, 107–116.

[77] Walter F Uys. 2019. Hackathons as a Formal Teaching Approach in Information Systems Capstone Courses. In *Annual Conference of the Southern African Computer Lecturers' Association*. Springer, 79–95.

[78] Lev Vygotsky. 1978. Interaction between learning and development. *Readings on the development of children* 23, 3 (1978), 34–41.

[79] Jeremy Warner and Philip J Guo. 2017. Hack. edu: Examining how college hackathons are perceived by student attendees and non-attendees. In *Proceedings of the 2017 ACM Conference on International Computing Education Research*. 254–262.

[80] Nancy Wilkins-Diehr. 2007. Special issue: science gateways-common community interfaces to grid resources. *Concurrency and Computation: Practice and Experience* 19, 6 (2007), 743–749.

[81] Jane Wyngaard, Heather Lynch, Jaroslaw Nabrzyski, Allen Pope, and Shantenu Jha. 2017. Hacking at the divide between polar science and HPC: using hackathons as training tools. In *2017 IEEE International Parallel and Distributed Processing Symposium Workshops (IPDPSW)*. IEEE, 352–359.

[82] Robert K Yin. 2017. *Case study research and applications: Design and methods*. Sage publications.

[83] Jorge Luis Zapico Lamela, Daniel Pargman, Hannes Ebner, and Elina Eriksson. 2013. Hacking sustainability: Broadening participation through green hackathons. In *Fourth International Symposium on End-User Development. June 10-13, 2013, IT University of Copenhagen, Denmark*.