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Educational benefits of hackathon: A systematic literature review

Kayode Oyetade*, Vaal University of Technology, Department of Information and Communication Technology, Andries Potgieter Blvd, Vanderbijlpark, 1900, South Africa. https://orcid.org/0000-0003-0516-0639

Tranos Zuva, Vaal University of Technology, Department of Information and Communication Technology, Andries Potgieter Blvd, Vanderbijlpark, 1900, South Africa. https://orcid.org/0000-0001-9579-3899

Anneke Harmse, Vaal University of Technology, Department of Information and Communication Technology, Andries Potgieter Blvd, Vanderbijlpark, 1900, South Africa. https://orcid.org/0000-0003-1135-2573

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Abstract

Hackathons are said to promote a variety of innovative ideas and can be traced back to the idea of problem-solving. There is little research on the use of hackathons in classes to meet course-level learning objectives, despite the emphasis given to its advantages in other human efforts. By conducting a systematic literature review (SLR), this study uses the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement criteria to better understand the advantages of hackathons in education. From an initial search result of 108 research publications obtained from Google scholar and Scopus databases and published between 2015 and 2022, 25 articles were reviewed. The findings point to three important educational advantages of hackathons: improvement of technical and soft skills, learning new things, and successful networking. The study has implications for academics and other interested parties in in adopting hackathons in an academic curriculum. It suggests a need to model and develop instruments to introduce hackathon-based pedagogies to support traditional classrooms.

Keywords: Educational support, hackathon, students, systematic review, teaching pedagogy.

* ADDRESS FOR CORRESPONDENCE: Kayode Oyetade, Vaal University of Technology, Department of Information and Communication Technology, Vanderbijlpark, 1900, South Africa
E-mail address: kayoyetade@gmail.com / Tel.: +278-4651-4453

1. Introduction

Hackathon has become a platform that is frequently used for innovation and intended to promote the use of digital technologies in a wide range of professional contexts, including open data, music, fashion, commercial, and civic reasons (Remshagen et al., 2018). Traced back to ancient Roman beliefs, the Hackathon is associated with the concept of problem-solving (Emesobum & Shchyhelska, 2016). Since the beginning of the new century, hackathons have begun to garner serious interest among large organisations to produce new levels of innovation capabilities (Medina Angarita & Nolte, 2020). Despite the diverse definitions of hackathons, most studies agree that hackathons are events that engage groups of people to produce software in a limited time frame (Gama et al., 2021). Hackathons are events with a certain theme and a set amount of time allotted for participants to work in teams to implement a concept that interests them. (Medina Angarita & Nolte, 2020). But its adoption for educational purposes in recent times has only recently come into research focus (Oyetade et al., 2022; Trainer et al., 2016). The incorporation of hackathons in education can enhance problem-solving, interest, and creativity in students as it engages them in the learning process and retention of new knowledge (Mhlongo & Oyetade, 2017; Mhlongo et al., 2020). Its benefits in teaching and learning are being carefully explored as an approximate project-based-learning (PBL) strategy by allowing students to learn new technical skills while increasing student interest and engagement. This is crucial to ensuring the drive towards innovation (Horton et al., 2018; Mhlongo et al., 2020). Some alternative learning approaches have a theme to steer students toward a particular problem space. However, literature is absent regarding the use of hackathons in-class to support course-level learning objectives (Page et al., 2021; Porras et al., 2019; Rennick et al., 2018). With more higher education institutions (HEIs) realising what Hackathon can offer, an improved and clear guideline on its application in the academic curriculum should be designed. This encourages student participation, nurtures engagement, and promotes teamwork when students interact while learning.

This study aims to review the literature on hackathon applications in education to identify the various aspects of hackathon and inform the hackathon benefits that adds greater value to academic curricula. Against this background, this study reviews recent literature on the use of hackathons in education and synthesizes the knowledge gained to answer the following research questions:

- What research on the usage of hackathons in education is available?
- What advantages do hackathons provide for education?

A comprehensive review is planned in the next section to explain the diverse use of Hackathon in education.

2. Methods

The PRISMA statement inspired the methodology adopted for this study. The PRISMA reporting guidelines have been promoted as an inclusive source of evidence for decision-making and to encourage transparency and comprehensiveness in reporting systematic reviews methods and results (Welch et al., 2016).

2.1. Search strategy

Due to its accessibility and wide range of educational and hackathon studies, the Scopus and Google Scholar databases were chosen to give comprehensive coverage of the literature by the most eminent authors in the computing field. Although the authors were interested in studies that applied Hackathon specifically to pedagogy and learning, the search terms (Hackathon) AND (learning OR education) were employed to look for relevant content. To find evidence of recent study in the context of hackathons in education, we looked for papers in peer-reviewed scientific publications between 2015 and 2022.

2.2. Eligibility Criteria

Following a search of the database, 108 articles were identified. Duplicate papers were discarded, and the remaining articles were screened for title, abstract, and keywords to remove studies that are irrelevant to the aim of the study. Full-text versions of the remaining articles were assessed for eligibility. The following eligibility criteria were applied as presented in Table 1 to select our final articles to guide the authors in gathering the relevant studies for inclusion in this review.

Table 1.

Eligibility Criteria

Exclusion criteria	Inclusion criteria
Papers not focusing on hackathons in education.	Hackathon literature published between 2015 and 2022. This is because the hackathon studies have only taken root in the past decade and those before 2015 have no defined framework or methodology.
Those papers published in languages other than English.	All review articles with a study design ranging from quantitative to qualitative case studies to mixed-method evaluation was considered.
Hackathon studies that are not explicitly dealing with the focus or contribution of hackathon in education.	Peer-reviewed publications, including book chapters, conceptual studies, and conference proceedings were included in the search result.
Papers on Hackathon that are not peer-reviewed	Studies that define the process and implementation of a hackathon in education were considered.
Papers that did not explain how students or teachers contributed to the hackathon process.	

2.3. Data extraction and analysis

A Microsoft Excel spreadsheet was developed for the final set of the full-text article to enter the studies found through the initial search research result using the above-mentioned search keywords. Once duplicated articles were excluded, the remaining studies were screened for relevance based on their titles and information from the abstracts. Afterwards, the full text of all studies was screened and reviewed to ensure it fulfilled the inclusion and exclusion criteria. Subsequently, the content of these articles was further scrutinised to ascertain that it aligns with the aim of this study. The data extracted covered the authors' names, year of publication, discipline of study, study design/method, demographic characteristics, findings and the geographical location where the hackathon study was constructed to extract relevant information from each of the studies included in this review. Also, the study carefully examined the eligible articles to describe the benefits of hackathons in educations by area of study paying attention to how each author reported it. Finally, the study synthesised all the benefits into three themes and reported the benefits across all the study disciplines.

3. Results

This section presents the study's outcome by presenting the study selection, and study characteristics and, subsequently, the benefits of hackathons in education in detail.

3.1. Study selection

The database search returned 108 articles from Scopus and Google Scholar due to ease of download from Google scholar and the University subscribes to Scopus. The removal of duplicates reduced the research articles to 85. The abstracts and titles were screened, and 24 records were excluded. Full-text articles not focusing on education were discarded after due diligence, leaving the study with 25 eligible studies for final review. Figure 1 shows a map of the review process through phases of literature identification, screening and discarding ineligible literature after titles, abstracts and full-text reviews and selection of included studies to determine those selected for detailed analysis.

3.2. Study characteristics

The remaining 25 eligible studies were read in full to identify and extract diverse benefits of hackathons in education across different disciplines. Table 2 provides a summary of the 25 qualifying research articles in the SLR that offer specific information on the retrieved data. It includes authors' reference, discipline or focus of hackathons research and the benefits of hackathons relevant to this study's focus of research.

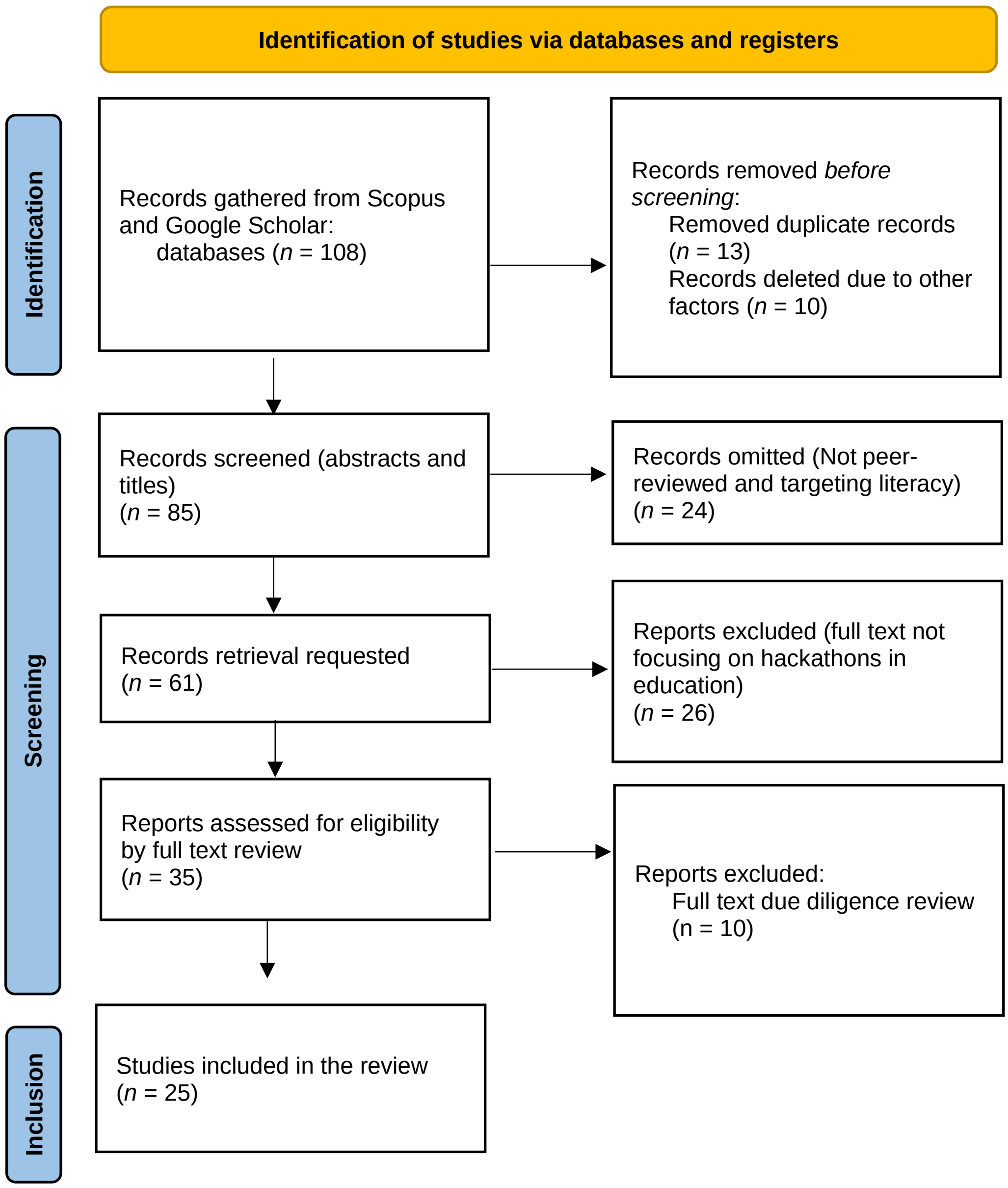

Figure 1.
PRISMA flow Diagram. Adapted from Page et al., (2021)

Table 2.
Characteristics of the Included Studies

Authors	**Discipline**	**Findings/benefits of hackathons**
Uys, 2019 Remshagen et al., 2018 Byrne et al., 2018 Nandi & Mandernach, 2016 Mhlongo & Oyetade, 2017 Mtsweni & Abdullah, 2015 Mhlongo et al., 2020 Kolog et al., 2016 Seidametova et al., 2022	CS/IS Education	• Students learnt to work with new technologies such as public SMS services and Google Application Programming Interface (API) preparing them for real-world environment. • The participants used Scratch to create an animation about a given social theme. • Combining the hackathon-like event and a constructivist learning model can be effective in increasing student motivation, confidence and learning of computer • Peer-learning: Students taught themselves how to overcome difficulties and learn new skills. • The collaborative learning experience of students in-creased when they participated in the hackathon event. • Students' interest in computer science is stimulated and maintained through hackathons, it has been discovered. The hackathon model's core components are characterized as collaborations, networking, mentoring, hands-on participation in socially meaningful computing initiatives, and community involvement. • According to the students, the hackathon strategy will aid in the development of their technical and soft abilities in computer programming. • The hacking event gave participants more encouragement to learn by doing. Students work together to solve problems to maximize their creative abilities. • Hackathons can be utilised as pedagogical technology to educate students the knowledge and abilities required to create software projects and programs.
La Place et al., 2017 Porras et al., 2018 Tandon et al., 2017 Porras et al., 2019 Horton et al., 2018 Rennick et al., 2018	Engineering Education	• The hackathon team displayed a desire to learn and overcome challenges as a group. They communicated by sharing and learning to develop solutions within the allotted time. • Students are exposed to new networks and connections, tacit or new skills that surface and receive either new solution or ideas. • Students who participated in the first CSU East Bay Hack Day had a 98% satisfaction rate. They also learnt more about engineering and biology.

		• Learning outcomes include teamwork or collaboration skills, creativity or innovation skills, context-specific skill (for instance Java programming skills), and presentation (or discussion) skills. • Hackathons promote key learning, understanding of success skills that one would expect from PBL course • The hackathon model improved teamwork, understanding the role of analysis in design, and student engagement was part of the desired outcomes of the Hackathon
Lyndon et al., 2018 Wang et al., 2018 Kienzler & Fontanesi, 2017	Health Education	• The diverse discipline of the students during the Hackathon empowered their learning experience and reports they can apply the knowledge and skills gained to re-al-world settings. • The diversity of participants promotes ideas and projects developed to address clinical and complex healthcare challenges. • Hackathons among undergraduates allowed for development of critical thinking, presentation, and on-the spot thinking skills. Also, students worked with different software, created website prototypes, and disseminate their work with postgraduate student support.
Cobham, Jacques, et al., 2017 Cobham, Hargrave, et al., 2017 Avila-Merino, 2019	Business Education	• Team building and bonding • The use of hackathon to teach entrepreneurship is key to boosting student interest in the subject increasing better outcomes for students after they have completed a degree.
Page et al., 2016	Design Education	• Student engagement level was impressive with the quality of ideas/concepts generated over the week.
Paul, 2020	Environmental related improvement	• Earth Hacks demonstrated that technology is a potentially powerful tool that fosters practical, innovative, and implementative solutions to environmental issues.
Calco & Veeck, 2015	Marketing Education	• The students gained important business knowledge and marketing principles. Additionally, it increased the students' interest in the course.

Suominen et al., 2018	Product Development	• Students from different academic backgrounds expressed organised integrated learning. They integrated their knowledge to yield novel products and services.

For further analysis in terms of the levels of education, the 25 studies are categorised into 2: 23 studies (92%) targeting HEI and 2 studies (8%) targeting high schools. This implies a significant growth of research on HEI as most studies focus on hackathons in higher education in the last decade as opposed to hackathon use in high schools, as shown in Figure 2.

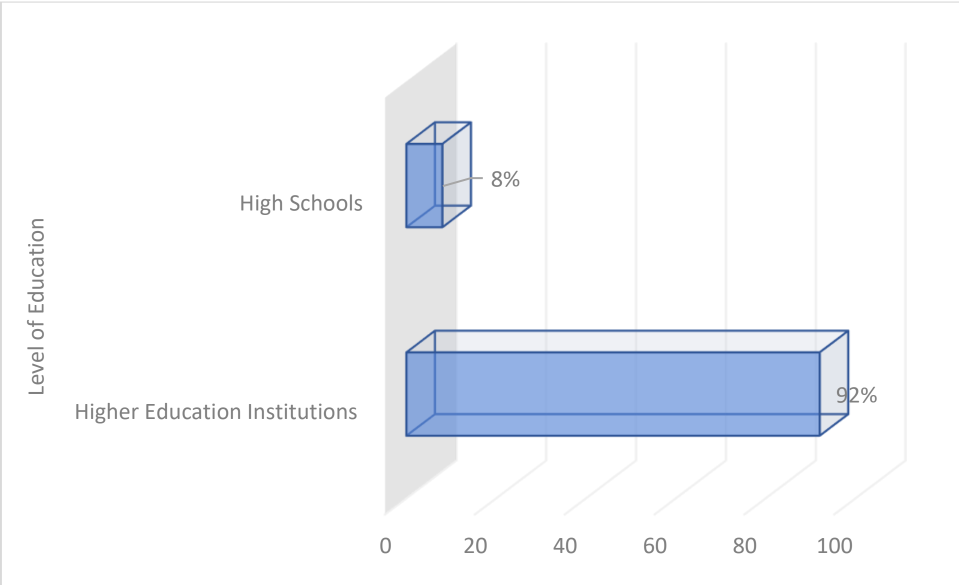

Figure 2.
Summary of Studies in Terms of Students' Level of Education

Of the 25 studies analysed for the research methods employed to gather data, 3 categories emerged: 12 studies (48%) adopted the qualitative method, followed by research that adopted quantitative methods with 7 articles (28%), and a mixed-methods approach with 6 articles (24%), as shown in Figure 3.

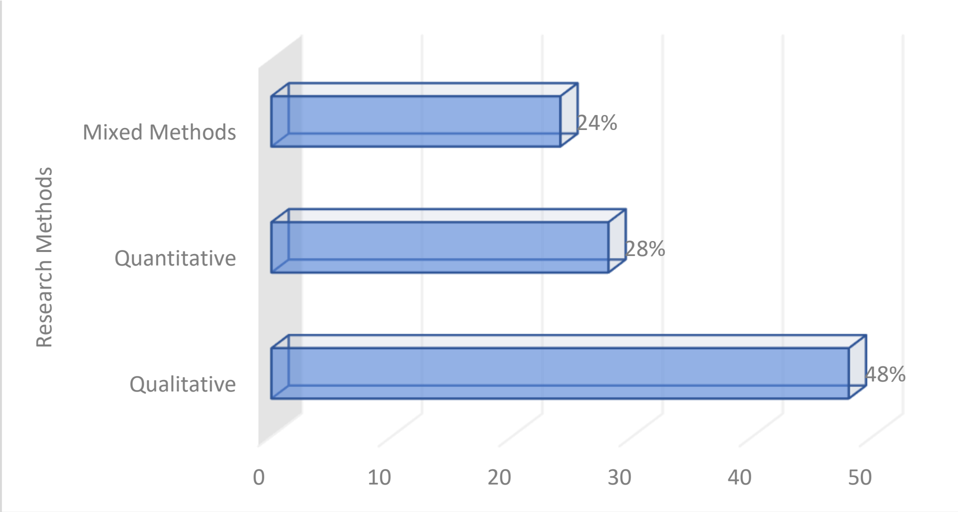

Figure 3.: Summary of Studies In Terms of Research Methods

Concerning the geographical distribution of the authors, it is interesting to note that the papers included in the systematic review were distributed across Europe, Africa, and North America as shown in Figure 4. This implies that the educational benefits of hackathons in education derived from this study are identified from different geographical locations of the world. USA dominated research on hackathon studies in schools with 40%, followed by UK with 20%, 16% each for Finland and South Africa, and Canada and Ukraine coming behind with 4%. This ensures the systematic review covers varieties of cultural contexts across the world.

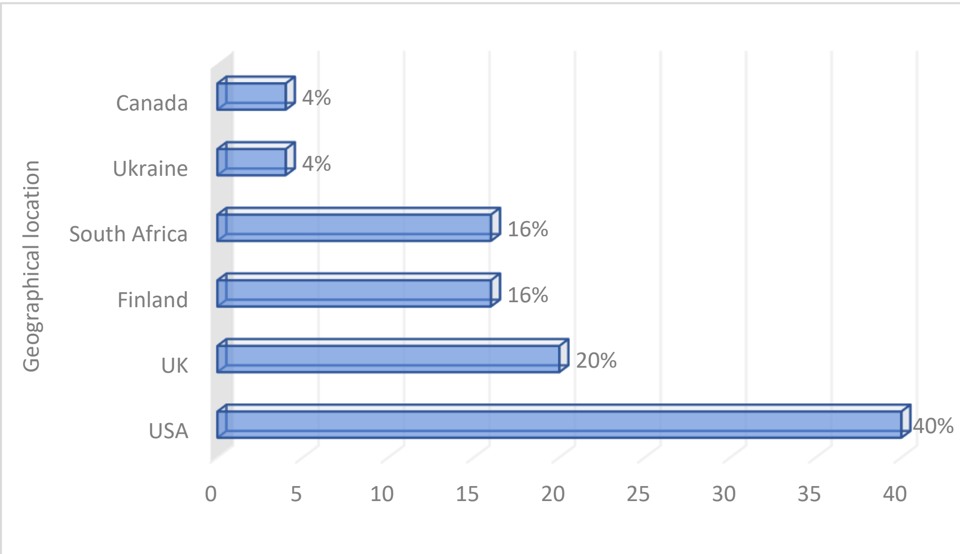

Figure 4. Summary of Studies In Terms Of Location.

In terms of the study disciplines in which the hackathon studies were carried out, the 24 articles are categorised into 8 educational disciplines, and we found the benefits to be more skewed towards Computer Science and Engineering.

Table 3.

Content Analysis on Reviewed Literature

Authors	Research methods	Demographic characteristics	Country
Uys 2019	Qualitative	HEI	South Africa
Remshagen et al., 2018	Qualitative	High School Students	USA
Byrne et al., 2018	Quantitative	HEI	UK
Nandi & Mandernach, 2016	Mixed method	HEI	USA
Mhlongo & Oyetade, 2017	Quantitative	HEI	South Africa
Mtsweni & Abdullah, 2015	Qualitative	HEI	South Africa
Mhlongo et al., 2020	Quantitative	HEI	South Africa
Kolog et al., 2016	Mixed method	HEI	Finland
La Place et al., 2017	Mixed method	HEI	USA
Porras et al., 2018	Qualitative	HEI	Finland
Tandon et al., 2017	Quantitative	HEI	USA
Porras et al., 2019	Qualitative	HEI	Finland
Horton et al., 2018	Qualitative	HEI	USA
Rennick et al., 2018	Mixed method	HEI	Canada
Lyndon et al., 2018	Qualitative	High School Students	USA
Wang et al., 2018	Quantitative	HEI	USA
Kienzler & Fontanesi, 2017	Quantitative	HEI	USA
Cobham, Jacques, et al., 2017	Mixed method	HEI	UK
Cobham, Hargrave, et al., 2017	Mixed method	HEI	UK
Avila-Merino, 2019	Qualitative	HEI	UK
Page et al., 2016	Qualitative	HEI	UK
Paul, 2020	Qualitative	HEI	USA
Seidemota et al., 2022	Qualitative	HEI	Ukraine
Calco & Veeck, 2015	Quantitative	HEI	USA
Suominen et al., 2018	Qualitative	HEI	Finland

UK = United Kingdom, USA = United State of America.

3.3. Insights obtained from this reviews as to the benefits of hackathons in education

The study has sought to identify the educational benefits of hackathons in education. The thematic analysis of the benefits from this review is coded into the three themes: the development of technical and soft skills, learning new things, and effective collaboration. A detailed explanation is presented below.

3.3.1. Development of technical and soft skills

A notable theme from this literature review is that hackathon in education lead to technical and soft skills development when students participate. These skills include creativity, teamwork, project management skills, critical thinking, working under pressure, improving confidence, and bug-fixing. Others involve working with different software, punctuality, responsibility, problem-solving, on-the-spot thinking, prioritisation, and presentation skills, creating prototypes for websites and tools which is a precious activity that prepares them for the demands of the working environment (Byrne et al., 2018; Calco & Veeck, 2015; Kienzler & Fontanesi, 2017; Kolog et al., 2016; Nandi & Mandernach, 2016; Nolte et al., 2018; Olson et al., 2017; Porras et al., 2019; Uys, 2019). As indicated by the sense of fulfilment felt by participants in the hackathon, these skills developed during the event were viewed as transferable to other fields, which is seen as a potential for advancement while keeping a fun, energetic, and engaging experience. (Byrne et al., 2018; Calco & Veeck, 2015; Kienzler & Fontanesi, 2017; Kolog et al., 2016; Lyndon et al., 2018; Nandi & Mandernach, 2016; Olson et al., 2017; Uys, 2019). Seidametova et al. (2022) report that participation in educational hackathons allow for the creation of a shared concept of software development which also coincides with the learning of new skills and the development of new competencies.

3.3.2. Learning novel things

Novel learning is an outcome of the Hackathon reported in this review. This exposes participants to new experiences irrespective of the goal and format of the Hackathon, which is helpful in solving academic and social pressing issues affecting their communities (Calco & Veeck, 2015; Horton et al., 2018; Kolog et al., 2016; Lyndon et al., 2018; Mtsweni & Abdullah, 2015; Nandi & Mandernach, 2016; Remshagen et al., 2018; Uys, 2019). For instance, students reported they learned about working with tools and new technologies using Google APIs and public SMS services (Uys, 2019). Calco and Veeck (2015) describe the notion of a hackathon project, which exposes students to a highly engaging learning style where they apply principles they have studied in different subjects while gaining experience working in a team context. Finally, students grasp concepts easily, quickly teach and learn from their peers to produce a working product that enhances their technical skills due to the time-based nature of Hackathon (Nandi & Mandernach, 2016; Remshagen et al., 2018). Seidametova et al. (2022) also report that participants acquire public speaking and other new skills as they engage and solve standard and non-standard tasks leading to a positive learning outcome.

3.3.3. Effective collaboration and networking

Another theme identified by this study for hackathon in education is effective collaboration and networking as a benefit of Hackathon. Team members were united in the view that the Hackathon could get participants enthused into developing digital solutions, potentially inspiring them to produce great work as well as an alternative to networking where new connections are formed (Alkema et al., 2017; Cobham, Hargrave, et al., 2017; Cobham, Jacques, et al., 2017; La Place et al., 2017; Nandi & Mandernach, 2016; Olson et al., 2017; Saravi et al., 2018). The hackathon experience reported by Kolog et al. (2016) reports that collaboration among hackathon participants inspired motivation and confidence to think of creative ideas to solve. Also, participants reported being empowered by collaboration which strengthened their network beyond the scope of Hackathon to form business ventures and where substantial connections are formed across different expertise and fields (Cobham, Hargrave, et al., 2017; Cobham, Jacques, et al., 2017; Olson et al., 2017). Similarly, Alkema et al. (2017) describe how the FNB Codefest is a platform for teamwork and motivation that produces elements of technical excellence and quality Agile practices. Saravi et al. (2018) reported that the Hackathon has proven to be a successful method of achieving quick and shared understanding between teams and stakeholders during concept design phase of a project.

4. Discussion

Our results from the Scopus and Google Scholar databases enable us to enhance the benefits of Hackathon in education. The systematic review of studies identified three benefits to hackathon participants by providing strong support for the development of technical and soft skills, learning new things, and effective collaboration and networking. The above-mentioned findings support the idea of Porras et al. (2019) who found diverse potentials of using hackathon events in education and in the curriculum. Hence, developing and introducing hackathon-based pedagogies to support traditional classrooms.

Concerning the research methodology, the results show that the qualitative research methods were used in almost half of the reviewed studies. This is followed by quantitative and mixed methods research. This research used a variety of data collection techniques, including questionnaires, interviews, and observations. The research of Porras et al. (2019) which sought to uncover potential strategies for planning and executing the hackathon in computer science and software engineering, is supported by these findings. Furthermore, the study found that the case study design was the mostly used form of qualitative approach indicating its effectiveness in for adopting educational hackathon thereby improve and give more meaningful interpretations in educational hackathon implementation in curricula.

Regarding authors' geographical distribution, major research on educational hackathons was undertaken in the USA. This explains why academics from developed countries are passionate about developing digital solutions for educational planning to leverage the power of technology such as computer science, geospatial, big data, and other types of technology to offer new solutions in the way education departments cater to the specific needs of the communities they serve. This will enhance teaching, improve learning, and increase information accessibility. To see how the advantages apply in this environment, more studies on educational hackathons should be undertaken in the Asian and African context.

Our review adds that learning new things is an outcome of hackathons in education. This shows that hackathons can help students deal with other social and environmental issues outside their academic pursuits (Calco & Veeck, 2015; Horton et al., 2018; Remshagen et al., 2018). This agrees with the research findings of Affia et al. (2022) where the hackathon intervention encouraged learning-by-doing amongst students . The students also indicated that they actively engaged and participated with delight in the course. Moreover, our review indicates effective collaboration and networking as a benefit of hackathon. Many students form new bonds and report that they will go ahead to start-up companies as an aftermath of the ideas generated during the hackathon session (Cobham, Hargrave, et al., 2017; Olson et al., 2017). This supports the findings of Affia et al. (2022) where students benefited from hackathon interventions which support teamwork and collaboration. One possible reason for this may be that students found it easy to interact with themselves without the barriers of the teacher-centered approach to knowledge construction. The review shows that the insights obtained from students about the development of technical and soft skills can be implemented into the design of the curriculum as this will prepare the students for the skills needed in the workplace when they graduate from school (Byrne et al., 2018; Calco & Veeck, 2015; Kienzler & Fontanesi, 2017). Moreover, this benefit is one potential outcome of hackathons in education.

This study has added to the body of literature by providing a platform for future research through its systematic analysis of hackathon studies in education published from 2015 to 2022. Also, the current SLR is conducted to review the students' level of education, discipline, research methodology, geographical distribution of the authors, and the benefits of hackathons. The hackathon phenomena needs to be further investigated in light of other developing countries.

The current investigation on one hand identified the benefits of hackathon per the discipline of the research study carried out and on the other discussed the benefits of hackathon across all disciplines. Also, the current investigation focuses on teaching and learning and how education is brought down to students' levels so that knowledge is increased and learning in schools becomes exciting, especially for courses that are perceived as challenging, like engineering and computer programming courses.. As a result of this review's findings that hackathons have potential benefits for education, it is necessary to model and develop tools for introducing hackathon-based pedagogies to support classrooms that allow students and teachers to interact (Horton et al., 2018; Rennick et al., 2018).

5. Limitations

The review identified some gaps regarding educational hackathons, as most studies involve organisations in single domains or events, with fewer empirical studies. We support more research on empirical findings focusing on specific academic fields or areas of study. The study's findings are restricted to the search keywords which exclude several studies even though the study complied with the reporting PRISMA criteria by Page et al. (2021). It's possible that earlier hackathon studies that were published before 2015 offered helpful information about hackathon use. Future research will consider and include publications over a longer period of time. There is a possibility that prior hackathon studies published before 2015 may have provided relevant insights into hackathon use. There is a need to get research articles from South America and Asia to get a complete review of the benefits of Hackathons in education from all nations in the world.

6. Conclusion

This study reports findings from a SLR of 25 papers with emphasis on educational hackathons in an academic environment. The goal of the study was to comprehend the benefits of hackathons in education. Our findings show research on the educational benefits of hackathons are gaining attention in HEIs. Events like hackathons should be promoted in high schools and filtered to teen levels to expose them to the idea of collaboration and networking at a very early age. This is important as the skills needed to excel in the workplace is formed consciously or subconsciously. Hackathon events should be encouraged in high schools (Nandi & Mandernach, 2016; Remshagen et al., 2018). The educational benefits of hackathons point to helpful suggestions for the hackathon format's future implementation

7. Recommendation

This paper provides a thorough evaluation of the literature on the benefits of hackathons in education. This strategy led to the identification of three themes: 1) development of technical and soft skills, 2) learning new things, and 3) effective collaboration. This systematic literature review is special because it will provide effective literature review to novice researchers and provide stakeholders with insights into the development of a framework for hackathon implementation in the academic curriculum.

Future research must include developing a framework for incorporating hackathons into academic curriculum.

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