On the use of the Lotus Blossom Technique to Foster Collaboration among Students in Software Development

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Abstract. *Collaboration is essential in software development but is often hindered by skill gaps and communication barriers. Techniques like Lotus Blossom provide a structured brainstorming approach to enhance teamwork and ideation. However, its role in fostering collaboration in product discovery remains underexplored. This study examines how undergraduate students applied the Lotus Blossom technique to enhance collaboration. As a methodology, we conducted a 2.5-hour activity where students applied the technique. Researchers assessed its impact using questionnaires. Our findings indicate that Lotus Blossom improved collaboration, helping students structure ideas, coordinate problem-solving, and strengthen teamwork. As a contribution, this study validates the Lotus Blossom technique as an effective method for fostering collaboration in software development education.*

1. Introduction

Collaboration in software teams helps create a structured environment. It supports the progress and success of software development projects at different scales [Lanubile 2006, Chen et al. 2023]. By aligning goals, formulating solutions, and solving complex problems through team interaction, developers improve the quality of the final product [Cheng et al. 2003]. However, teams often face challenges such as skill gaps, communication issues, and a lack of synergy in work approaches [Jiménez et al. 2009]. In this context, techniques like Lotus Blossom, part of the Design Thinking (DT) toolkit, offer a structured way to foster collaboration and support positive outcomes in software development [Parizi et al. 2022].

[Gonsales et al. 2017] highlights that Design Thinking (DT) techniques, such as Lotus Blossom, promote group work by fostering idea exchange, collaboration, and a cooperative spirit—ensuring process cohesion and effective outcomes. These collaborative principles align closely with the 3C Collaboration Model [Fuks et al. 2004, Parizi et al. 2022], and contribute not only to project success but also to the development of soft skills essential for teamwork and creative problem-solving [Majid et al. 2012].

Despite this potential, there is still limited research on how structured DT techniques like Lotus Blossom can be applied to effectively support student collaboration—especially in early stages of software development such as product discovery

[Abich et al. 2024]. Among the many DT tools [Parizi et al. 2022], Lotus Blossom stands out for its structured visual format, clarity in idea generation, and accessibility for first-time users [Gavrilă and Tulbure 2018]. Unlike more complex techniques such as customer journey mapping or stakeholder analysis, it enables students to engage in focused, collaborative ideation within a short session. Its simplicity and low resource demands make it especially suitable for undergraduate classrooms, yet its application remains underexplored in the literature [Pânișoară 2015].

This study investigates how the Lotus Blossom technique fosters collaboration among undergraduate students in a co-creative product discovery course based on Design Thinking (DT) principles. To assess collaborative dynamics, we adopted the 3C Collaboration Model [Fuks et al. 2004], which structures collaboration into three key dimensions: (i) Cooperation, observed through students' willingness to share ideas and help peers during problem-solving; (ii) Communication, assessed by the quality of information exchange and group dialogue; and (iii) Coordination, evaluated by how students organized tasks, assigned roles, and managed their workflow throughout the activity.

We conducted a 2.5-hour session with 21 students, guiding them in applying the Lotus Blossom technique while monitoring their interactions. Collaboration was evaluated using a post-activity questionnaire, aligned with the 3C model. This study aims to answer the following Research Question (RQ): "How does the Lotus Blossom technique contributes to collaboration among students in problem-solving during software development?". The results suggest that the Lotus Blossom technique (i) encourages students to structure and refine ideas collaboratively, (ii) supports coordination in problem-solving, and (iii) helps establish a strong foundation for teamwork and shared decision-making.

Building on these findings, this study contributes by validating the Lotus Blossom technique as an effective tool for enhancing collaboration in educational settings. It also highlights the technique's ability to: (i) promote teamwork among students; (ii) support collaborative problem structuring, thereby improving both ideation and the transition to prototyping; and (iii) strengthen students' soft skills, reinforcing essential collaborative competencies needed in software development and beyond.

The remainder of this paper is organized as follows: Section 2 introduces the Lotus Blossom technique and the 3C Collaboration Model. Section 3 describes the study's methodology. Section 4 presents the results, while Section 5 discusses their implications. Finally, Section 6 offers concluding remarks and future research directions.

2. Background

2.1. Lotus Blossom

The Lotus Blossom technique is a user-centered method that structures creative thinking and supports systematic, collaborative ideation. As part of the Design Thinking toolkit, it complements other techniques such as brainstorming and empathy mapping [Hanesová et al. 2014, Parizi et al. 2022].

Figure 1 illustrates the structure of the Lotus Blossom. The central idea (I) is placed at the center and is surrounded by eight secondary ideas (A–H). Each of these expands into numbered spaces (1–8) that represent causes, solutions, or refinements of the original concept. The name comes from this layout, which resembles the petals

Figure 1. Lotus Blossom Technique

of a lotus flower [Pérez and Rubio 2020]. Each secondary idea then becomes the center of a new "flower", allowing for a continuous and in-depth exploration of the topic [Pânișoară 2015].

The technique involves a sheet rotation process, where participants iteratively contribute by identifying causes, solutions, or developments related to a central problem. This cyclical brainstorming continues until a satisfactory solution is reached or a set number of ideas is generated [Pérez and Rubio 2020].

Although designed for group collaboration, the Lotus Blossom can also be applied individually, offering flexibility and ease of use. It stimulates creativity, reveals innovative connections, and supports a structured and productive environment—making it well-suited for complex problem-solving and group projects [Gavrilă and Tulbure 2018, Shen et al. 2016].

However, while the technique encourages collaboration, evaluating its effectiveness in collaborative settings requires a broader analytical perspective. The 3C Collaboration Model offers this broader view, enabling a deeper assessment of group dynamics beyond just idea generation.

2.2. 3C Collaboration Model

The 3C model offers a theoretical framework to understand and improve teamwork by examining the dynamic interplay among its core dimensions [Fuks et al. 2004]. It helps identify the key elements that support collaborative work and enables more productive group interactions.

The model organizes collaboration into three main dimensions: (i) Communication involves the exchange of information, feedback, and ideas. It ensures team alignment and helps build a collaborative environment [Berlo 1987, Sousa 2004, Canha 2021]; (ii) Cooperation focuses on the collaborative execution of tasks. It integrates different skills to achieve shared goals, promoting trust, group learning, and innovation [Freitas et al. 2022, Miranda and da Rosa Mangini 2020, Peduzzi et al. 2020]; (iii) Coordination connects communication and cooperation. It supports the management of interdependent tasks by defining roles, aligning efforts, and transforming communication into concrete plans. This ensures structured teamwork and goal achievement [Miranda and da Rosa Mangini 2020, Peduzzi et al. 2020, Antunes 2021].

Our study explores the use of the Lotus Blossom technique in an undergraduate Software Engineering course. It examines how the technique supports collaboration during product discovery activities. Based on the 3C Collaboration Model, we analyze how it promotes team interaction and problem-solving. The next section presents the methodology used to conduct the study and evaluate its collaborative impact.

3. Methodology

This section describes the application of the Lotus Blossom technique in an undergraduate Software Engineering course. The goal was to assess how it fosters collaboration among students involved in product discovery activities.

To guide the investigation, we defined the following Research Question (RQ): ***"How does the Lotus Blossom technique contributes to collaboration among students in problem-solving during software development?"***. From this question, we derived three Sub-Questions (SQs) to explore specific aspects of collaboration, as outlined in the 3C Collaboration Model [Fuks et al. 2004]. These SQs were formulated by mapping the theoretical dimensions of the model to the expected collaborative behaviors observed during the activity. They include SQ1: ***"How does the Lotus Blossom technique facilitate group collaborative dynamics to ensure that all members actively contribute and integrate their ideas during the brainstorming process?"***; SQ2: ***"How does the Lotus Blossom technique help the group structure and conduct the collaborative process, maintaining focus, meeting deadlines, and progressing through the proposed stages?"***; and SQ3: ***"How does the Lotus Blossom technique enhance collaborative dynamics to generate results that clearly define the problem and inspire practical and innovative solutions?"***.

These sub-questions guided the analysis of the technique's impact on collaborative behavior. SQ1 focused on group dynamics and participation, SQ2 examined the structure and flow of collaboration, and SQ3 assessed the quality and clarity of the outcomes produced during the collaborative process.

We conducted the study with 21 undergraduate students enrolled in a project-based software development course. All participants signed an Informed Consent Form before the activity, following ethical research guidelines and confirming their awareness of data confidentiality, rights, and voluntary participation. Most students had prior knowledge of Design Thinking and experience with collaborative techniques and tools, as these topics were part of the course curriculum. To ensure methodological rigor, the research design and instruments were reviewed by one of the authors—a Software Engineering researcher with experience in empirical studies and collaborative learning environments.

We implemented the Lotus Blossom technique during a 2.5-hour session, corresponding to the regular class duration on the day of the activity. To support ideation, we used white sheets, colorful post-its, and pens, allowing for both individual and group contributions. We collected feedback by using a Google Forms[1] questionnaire[2], designed to capture participants' perceptions of the activity.

[1] `forms.google.com`

[2] `https://doi.org/10.5281/zenodo.15271304`

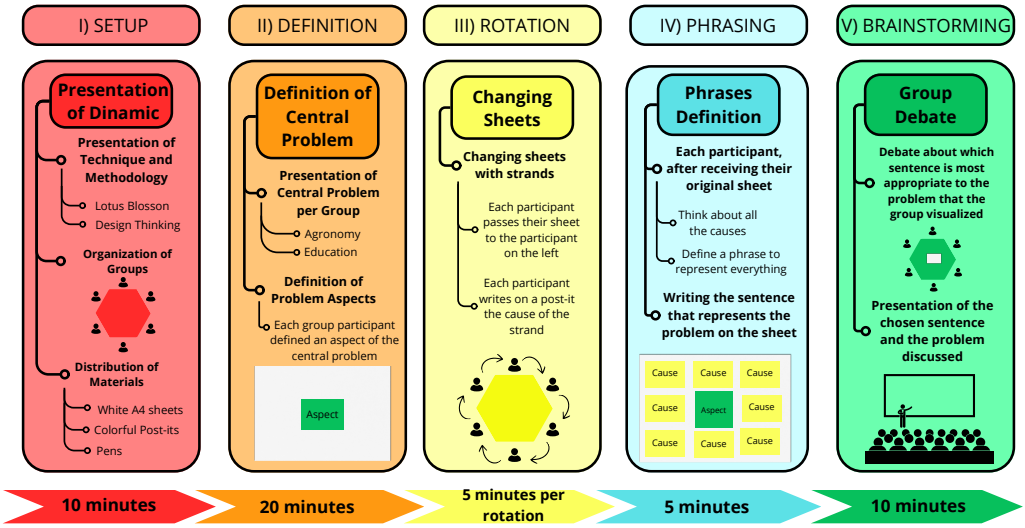

Figure 2. Methodology Diagram

3.1. Design and Execution

Figure 2 presents an overview of the activity. We organized it into five sequential steps designed to guide students through the application of the Lotus Blossom technique. These steps are: I) Setup, II) Definition, III) Rotation, IV) Phrasing, and V) Brainstorming.

We planned each phase to progressively foster collaboration, from introducing the method to generating and refining ideas through structured group interaction.

I) Setup

We began by introducing the Lotus Blossom technique, explaining its role within the Design Thinking approach, which served as the central methodology of the course. This brief, 10-minute introduction outlined the technique's purpose, structure, and how it supports collaborative problem-solving.

To encourage interaction, we arranged the classroom using round tables, creating a layout that supported face-to-face collaboration. Students were then divided into five groups, organized according to their project topics. Three groups focused on agriculture-related issues, seated at two tables, while the remaining two groups worked on education-related challenges, each at a separate table. This configuration promoted collaboration both within and across groups.

Each group included between 5 and 15 students, all working on either the Education or Agriculture topic. We provided materials including white A4 sheets, colorful post-its, and pens to support both individual and group-based ideation and note-taking.

II) Definition

We pre-selected Education and Agriculture as the study's main topics, based on their relevance to the students' local and academic context. These topics were introduced during the definition stage, where each group evaluated both options and chose one as their focus for applying the Lotus Blossom technique. This 20-minute step was designed to stimulate critical and creative thinking.

After the topic selection, we facilitated guided discussions, prompting students to reflect on key questions related to their chosen area. Each group member then identified one specific issue within the selected topic and wrote it on a post-it. These issues addressed various relevant aspects and were placed at the center of an A4 sheet, forming the starting point for the next stage of the technique.

III) Rotation

In this step, participants exchanged sheets to collaboratively explore problems and their possible causes within their assigned themes. Groups working on the same topic—Education or Agriculture—collaborated with one another during this phase.

Each participant began by writing a central problem or key issue in the center of an A4 sheet. The rotation process then followed three main steps: (1) Each participant received a new sheet, reviewed the problem written by a peer, and identified a cause related to that problem, which they added to the sheet; (2) The sheet was then passed to the next participant, who repeated the process; (3) This cycle continued until each sheet returned to its original author. As a result, each group collaboratively produced a set of issues and an associated mapping of causes, fostering a structured, reflective, and interactive ideation process.

IV) Phrasing

Each participant received a sheet containing post-its filled out by their group members, listing causes related to the central problem. They had 5 minutes to review and reflect on these contributions for inspiration.

Based on this analysis, each participant then formulated a structured sentence that clearly and objectively described the refined issue. This final phrasing served as the foundation for the next step, providing a well-defined problem statement to guide the subsequent phase of ideation.

V) Brainstorming

Each group engaged in an in-depth discussion, analyzing different perspectives, raising hypotheses, and exploring the causes and implications of their identified problem. These discussions encouraged critical thinking and collaboration within the group.

Afterward, findings were shared across groups to foster idea exchange and broaden the collective perspective. Finally, each group presented its structured problem statement, consolidating insights and contributing to a deeper, shared understanding of the overall theme.

3.2. Data Collection and Analysis

We collected data immediately after the activity to assess the application of the Lotus Blossom technique. Participants gave their voluntary consent by signing an informed consent form, which explained the study's objectives, guaranteed data confidentiality, and clarified their right to withdraw at any time. After the session, they completed an 11-question questionnaire (see Table 1).

For the analysis, we applied Krippendorff's content analysis method, which allowed us to categorize participants' responses [Krippendorff and Bock 2009]. Answers were organized using a five-point Likert scale, ranging from Strongly Agree to Strongly

Table 1. Evaluation Questions for Group Dynamics

#	Questions
SQ1:	**How does the Lotus Blossom technique facilitate group collaborative dynamics to ensure that all members actively contribute and integrate their ideas during the brainstorming process?**
Q1	Did the Lotus Blossom technique help all group members express their ideas clearly and objectively?
Q2	Did the technique encourage open discussion and respect for all ideas and suggestions?
Q3	Did all participants actively contribute their ideas throughout the brainstorming process?
Q4	Did the technique facilitate the integration of each member's contributions into the group's discussions?
Q5	Did participants remain engaged and committed to the group's success while using the technique?
SQ2:	**How does the Lotus Blossom technique help the group structure and conduct the collaborative process, maintaining focus, meeting deadlines, and progressing through the proposed stages?**
Q6	Did the group follow the structured process of the Lotus Blossom technique and meet deadlines?
Q7	Was the rotation of sheets well-organized and effectively managed?
Q8	Did the technique help the group maintain focus throughout the brainstorming stages?
SQ3:	**How does the Lotus Blossom technique enhance collaborative dynamics to generate results that clearly define the problem and inspire practical and innovative solutions?**
Q9	Did the Lotus Blossom technique help the group formulate a final statement that clearly represents the problem?
Q10	Did the final statement, structured through the technique, inspire practical and innovative solutions?
Q11	Did the technique encourage the group to explore and consider different causes of the problem?
Q12:	**What suggestions would you give about the activity?**

Disagree [Joshi et al. 2015]. We then classified the data according to the Research Questions (RQs) and visualized the results using graphs to support clarity and comparison. The complete dataset is available on Zenodo[3].

4. Results

This section presents the results of the application of the Lotus Blossom technique in a classroom setting. The activity supported students in collaboratively structuring problems and generating ideas within the predefined domains of education and agriculture.

As illustrated in Figure 3, participants applied the technique to address real-world challenges. For example, one group focused on land leasing, developing a structured framework to analyze this issue. Other groups tackled topics such as economic management, the use of Personal Protective Equipment (PPE), and inefficiencies in agricultural processes. In the education domain, discussions centered around organizational and communication barriers, with groups exploring issues such as the integration of new technologies by teachers, disorganized class schedules, and lack of accessibility in schools.

Following the activity, we collected data to assess students' perceptions of the technique. The results are based on responses to the questionnaire presented in Table 1. Figure 4 shows a summary of the responses. Based on this data, we organized the analysis according to the 3 sub-questions derived from the research question (SQ1 to SQ3).

SQ1 explores how the Lotus Blossom technique supports group dynamics by fostering active participation and the integration of ideas. The results indicate a strongly positive perception among participants. Across the five questions related to SQ1 (Table 1,

[3]https://doi.org/10.5281/zenodo.15271304

Figure 3. Examples of Problems Structured with the Lotus Blossom Technique

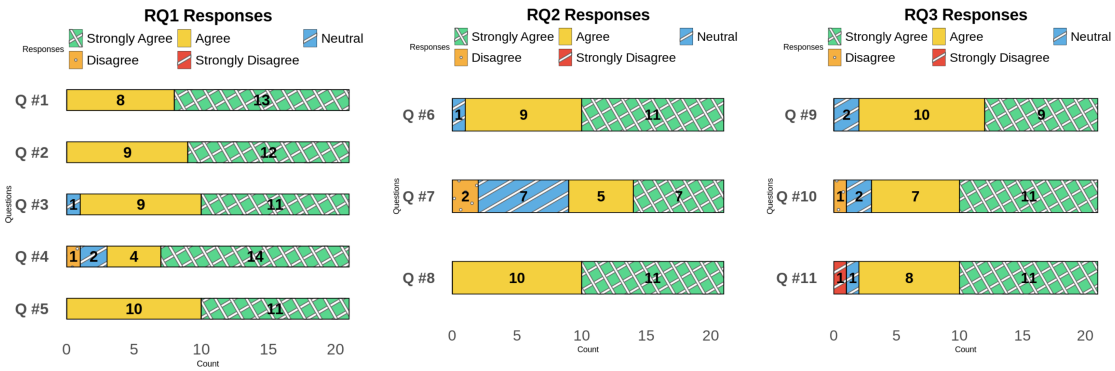

Figure 4. Results Obtained for RQs

Q1–Q5), responses were predominantly in the "Agree" and "Strongly Agree" categories, suggesting that students found the technique effective in promoting clear communication, active engagement, and mutual respect during the brainstorming process.

Participants reported feeling encouraged to express their ideas clearly and objectively (Q1: *8 Agree, 13 Strongly Agree*) and to engage in open and respectful discussions (Q2: *9 Agree, 12 Strongly Agree*). A high level of active contribution was also reported (Q3: *9 Agree, 11 Strongly Agree*). Regarding the integration of individual contributions, most students viewed this positively (Q4: *4 Agree, 14 Strongly Agree*), although 2 were Neutral and 1 Disagreed, indicating some variation in experience. Finally, all participants demonstrated a strong sense of commitment to the group's success (Q5: *10 Agree, 11 Strongly Agree*), reinforcing the collaborative value of the technique.

SQ2 examines how the Lotus Blossom technique contributes to the structure and execution of the collaborative process, focusing on participants' ability to maintain focus, follow deadlines, and complete the defined stages. The overall responses suggest that the technique supported an organized and goal-oriented workflow. Participants reported understanding and following the stages and timeline of the activity (Q6: *9 Agree, 11 Strongly Agree, 1 Neutral*).

However, perceptions about the organization of the sheet rotation process were

more mixed (Q7: *5 Agree, 7 Strongly Agree, 7 Neutral, 2 Disagree*), indicating that some participants faced challenges during this step. Despite that, all students confirmed that they remained focused throughout the activity (Q8: *10 Agree, 11 Strongly Agree*), highlighting the technique's effectiveness in maintaining engagement and process continuity.

SQ3 explores how the Lotus Blossom enhances collaborative dynamics to produce outcomes that clearly define the problem and inspire practical and innovative solutions. Overall, the responses suggest that the technique supported both structured problem formulation and creative exploration, which are essential in product discovery.

Participants reported that the final statement accurately reflected the problem discussed (Q9: *10 Agree, 9 Strongly Agree, 2 Neutral*). They also perceived the statement as capable of inspiring practical and innovative solutions (Q10: *7 Agree, 11 Strongly Agree, 3 Neutral*). In addition, the technique encouraged the exploration of various causes related to the central issue (Q11: *8 Agree, 11 Strongly Agree, 1 Disagree, 3 Neutral*), reinforcing its value in promoting deeper analysis. Despite some neutral or divergent responses, the overall results indicate that the technique effectively supported both analytical depth and creative thinking in a collaborative context.

In addition to the structured outcomes discussed in SQ1, SQ2 and SQ3, participants also shared feedback on the overall execution of the activity (Table 1–Q12). They suggested improvements in time management, expressing concerns about how the allocated time was organized. As this was their first experience with the Lotus Blossom technique, some inefficiencies in the rotation process were anticipated. Despite these challenges, the technique proved effective—particularly in smaller groups, where coordination was easier to manage. Furthermore, many students had prior experience with other Design Thinking techniques from the course, which likely supported their engagement and understanding throughout the activity.

In summary, the results demonstrate that the Lotus Blossom technique effectively supported key aspects of collaboration among undergraduate students engaged in product discovery activities. SQ1 indicated that the technique fostered clear communication, active participation, and the integration of ideas within group dynamics. SQ2 revealed that it contributed to a structured and focused process, although some participants reported challenges with the organization of the sheet rotation. SQ3 highlighted the technique's ability to guide students in clearly defining problems and encouraging practical solutions.

While participants expressed overall satisfaction with the activity, they also suggested improvements in time management, particularly during the rotation phase. Despite this, the technique proved effective—especially in smaller groups, where coordination was easier. Students' prior experience with DT methods likely contributed to their engagement and understanding throughout the activity. Most participants were already familiar with DT, which may have facilitated their use of the technique. However, even those with less experience were able to follow the steps and contribute meaningfully. Questionnaire responses reflected that students found the technique enjoyable and engaging.

The fact that groups worked on different focus areas—education and agriculture—did not appear to affect the quantity or complexity of ideas produced. While the themes varied, all groups demonstrated similar levels of creativity and collaborative engagement. These findings support the Lotus Blossom as a practical tool for enhancing

collaboration, critical thinking, and soft skills in software engineering education.

5. Discussion

The application of the Lotus Blossom technique demonstrated its potential to promote collaboration in problem identification and resolution. Although students faced challenges related to time management and the rotation process, these were expected given it was their first experience with the technique. Students familiar with DT adapted quickly, showing that the method is both accessible and effective within educational settings.

This study fills a gap in the literature by examining how a less frequently studied Design Thinking technique can be used in computing education to support collaboration. Our contribution includes (i) adapting the technique to a real classroom setting, (ii) evaluating it through the 3C collaboration model, and (iii) providing a replicable protocol for educators and researchers.

Most participants had experience with collaborative techniques, which helped them engage more easily. Still, we observed that even students with no previous exposure to Design Thinking could follow the activity and contribute meaningfully. This suggests that the technique requires minimal onboarding and is suitable for students with varied backgrounds. Future studies could examine its use in contexts where students have no prior experience, to better understand its learning curve.

Several studies provide context for evaluating collaborative techniques in education. For example, the World Café method encourages deep reflection and insight generation through extended discussion sessions over several weeks [Dornelles et al. 2024]. While effective, it is time-consuming. In contrast, Lotus Blossom supports collaboration in a single session, making it ideal for time-constrained academic settings [Dornelles et al. 2024].

Other methods like Computer-Supported Collaborative Learning (CSCL) work well for large digital groups [Knutas et al. 2019], and machine learning-based approaches support collaboration through data-driven tasks. However, these often require technical expertise and longer durations, which can lead to lower engagement [Anaya and Boticario 2011]. The Lotus Blossom technique, by contrast, is simple, cost-effective, and well-suited for small groups. It promotes structured brainstorming and soft skills, aligning with the goals of computing education. It also compares well with Problem-Based Learning (PBL) and Augmented Reality methods, offering similar educational benefits with fewer resources and greater flexibility [Jesionkowska et al. 2020, Pérez and Rubio 2020].

5.1. Challenges and Student Adaptation

Although the technique was well-received, students noted difficulties with time management, particularly during the sheet rotation phase. These challenges were understandable, given that it was their first exposure to the method. While the activity was planned for a regular 2.5-hour class, the size of the class and the complexity of the task demanded more time for transitions and coordination.

Even so, all groups completed the activity, and the quality of the output—in both ideas and clarity—justified the time spent. These insights suggest that future implemen-

tations should consider adjustments in facilitation and timing, especially in larger groups, to further improve the learning experience.

6. Final Considerations

This section summarizes the key insights, outcomes, limitations, and future directions of this study, which investigated the use of the Lotus Blossom technique as a tool for fostering collaboration in computing education. The study involved a 2.5-hour classroom activity in which undergraduate software development students used the technique to identify and analyze a central problem in either agriculture or education. Using post-its and A4 sheets, students collaboratively organized ideas, engaged in discussions, and refined their problem definitions—supporting a structured and cooperative ideation process.

The results indicate that the Lotus Blossom technique enhances student engagement, collaborative behavior, and communication clarity. Participants reported feeling encouraged to share ideas openly and contribute meaningfully, reinforcing the method's role in cultivating a cooperative learning environment. The activity also stimulated creativity and innovative thinking, demonstrating its effectiveness for educational problem-solving. However, feedback on time constraints highlights the need for adjustments in timing and logistics, especially for first-time users or larger groups.

This study contributes to filling a gap in computing education by applying a structured yet underused Design Thinking technique to support collaborative skill development. The technique's simplicity, low resource requirements, and ability to engage diverse student profiles make it a strong fit for academic settings. By promoting communication, coordination, cooperation, and problem-solving, Lotus Blossom strengthens competencies essential for professional teamwork.

While the findings are promising, some threats to validity must be acknowledged. The study relied on a small, single-institution sample and self-reported data, which may introduce bias. To mitigate this, the research protocol was reviewed by a senior Software Engineering researcher, and measures were taken to ensure data confidentiality and voluntary participation. Additionally, challenges in time management were expected due to students' unfamiliarity with the technique, though observations suggest that smaller groups helped reduce coordination difficulties. Minor procedural refinements could further enhance future implementations.

To build on this work, future research should examine the transferability of the technique to other contexts, including different educational levels and interdisciplinary teams. Comparative studies with more traditional collaboration techniques may yield deeper insights into its relative advantages. Additionally, longitudinal research could investigate the long-term impact on soft skills and group performance, offering valuable evidence for integrating the technique into computing curricula.

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