The Influence of Concept-Maps and Reflection Prompts on Master Students' Self-Efficacy in Managing Uncertainty during Collaborative Problem-Solving

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Summary

Objective: This research explored how concept-maps and reflection prompts influence master students' self-efficacy in managing uncertainty during collaborative problem-solving. The study was conducted in a master course on creating online learning environments. Different student demographics, including the whole class, the student teams, gender, and age, were examined to explore whether the scaffolds had different effects on different student groups.

Method: The mixed-methods research involved 23 students who worked in groups of four. The quantitative data was gathered using two survey instruments, namely the General Self-Efficacy (GSE) and the Positive and Negative Affect Schedule (PANAS). In order to document changes in students' self-efficacy levels and emotional states over nine weeks, the GSE survey was completed three times and the PANAS survey twice. Qualitative data was collected through observations and audio recordings of group discussions in the classroom, as well as open-ended surveys. This combination of methods provided a view on changes in self-efficacy, emotional states, uncertainty management strategies, and group dynamics.

Results: The study showed a significant increase in self-efficacy for all measured groups. Concept-maps and reflection prompts seemed to support students' uncertainty management by initiating discussions and visually breaking down uncertainties. The increase in self-efficacy was mirrored by positive changes in emotional states. Moreover, positive group dynamics were essential when it came to how students positioned themselves in the group, ultimately impacting their self-efficacy in managing uncertainty.

Conclusion: The study highlights that scaffolding uncertainty management and fostering positive group dynamics can support students' self-efficacy. Therefore, teachers should use concept-maps and reflection prompts to improve students' learning experiences.

Keywords: Concept-maps, reflection prompts, self-efficacy, uncertainty management, collaborative problem-solving

Contents

1 Introduction

The present study takes place in a course where students collaboratively create online learning environments. The course is designed around collaborative problem-solving, which combines elements of problem-based learning and collaborative learning (Xu et al., 2023). Problem-based learning happens when students are confronted with problems connected to real life (Nadeak & Naibaho, 2020). When trying to come up with solutions, students strengthen their critical thinking and problem-solving skills (Wahyu et al., 2017). Collaborative learning occurs when students work together to share different ideas and perspectives, giving them the opportunity to learn more than they would if working individually (Bower & Richards, 2006). In the current study, students design solutions for real clients in collaboration with their peers. This process is often associated with uncertainty (Jordan & McDaniel, 2014).

Uncertainty can be understood as a feeling of doubt when a person is not sure about the outcome or meaning of a situation (Jordan & McDaniel, 2014). During collaborative problem-solving, uncertainty can originate from the complexity of the task and from social dynamics within the group (Hartner-Tiefenthaler et al., 2018). In collaborative environments uncertainty cannot be avoided. In fact, it is embedded in the learning process (Jordan, 2015) as it promotes curiosity (Lamnina & Chase, 2021). It also creates “disequilibrium” (Piaget, 1972) where students face contradictions between what they already know and the new information they encounter (Markwell & Courtney, 2006). This is important because it puts students in a position where they need to adapt their thinking which supports their learning. Because uncertainty plays such a big role in learning processes, it is of value to understand how students manage it (Chen, 2020; Jordan & McDaniel, 2014; Kaur & Dasgupta, 2024). Managing uncertainty is a social process, where knowledge is built as a team by interacting with each other (Chen, 2020). A common assumption is that uncertainty should always be

reduced, but sometimes it is helpful to introduce it (Jordan, 2015) with the intention to explore multiple ideas before narrowing down to the best solution (Jordan & McDaniel, 2014).

When students face uncertainty, the concept of self-efficacy becomes relevant. Self-efficacy refers to how confident people feel in their abilities to successfully overcome tasks (Bandura, 1982). While there is research on both uncertainty management (Chen, 2020; Jordan & McDaniel, 2014; Kaur & Dasgupta, 2023) and self-efficacy (Ahmad & Safaria, 2013; Dunbar et al., 2018; Jackson, 2002) in educational contexts, their connection remains underexplored. Self-efficacy contributes to how students manage uncertainty because it can have an influence on the way they respond to it. Zimmerman (1995) notes that students with high self-efficacy see uncertainty as a challenge and are likely to address it. Meanwhile, students who lack confidence in themselves often tend to avoid it (Ahmad & Safaria, 2013). When facing uncertainty, students can feel overwhelmed and question their abilities. They could wonder whether they should manage the uncertainty or avoid it altogether. Students need to believe in themselves to overcome obstacles because it makes them more willing to solve problems, which ultimately leads to better learning outcomes (Jackson, 2002). Thus, understanding how students' self-efficacy in managing uncertainty develops in collaborative problem-solving is useful for identifying ways to support their learning. Furthermore, research has shown that low self-efficacy is connected to experiencing negative emotions (Ahmad & Safaria, 2013). Uncertainty itself can already bring out emotions like anxiety and discomfort (Hirsh et al., 2012), making it essential to take into account both self-efficacy and emotional states when examining how students manage uncertainty.

To support collaborative problem-solving processes, teachers often provide students with scaffolds to help them deal with complex tasks (Ouyang et al., 2021). The current study specifically introduces concept-maps and reflection prompts as scaffolds to facilitate students'

uncertainty management. Concept-maps serve as a way to help students categorize and connect ideas visually (Novak & Canas, 2008). This could help students dissect complex information into smaller parts, meaning it could make their uncertainty more manageable. Reflection prompts encourage reflection and dialogue, helping students articulate and process the content and their uncertainties collaboratively (Menekse et al., 2022). By using this, students are prompted to talk about their uncertainty, potentially leading to them trying to manage it together. Refection prompts were included along with the concept-maps to maximize the uncertainty management support. Ultimately, the present study seeks to explore how these scaffolds might contribute to the development of students' self-efficacy in managing uncertainty during collaborative problem-solving.

2 Theoretical Framework

2.1 Uncertainty

Uncertainty is present in every aspect of life (Li et al., 2013), including domains like economics, psychology, and philosophy (Perminova et al., 2008). Uncertainty is generally perceived as a negative occurrence, leading to efforts to prevent or reduce it (Griffin & Grote, 2020). However, many studies argue that it should be cultivated rather than escaped (Cremin, 2006; Jordan & McDaniel, 2014; Kirch & Siry, 2012). Jordan and McDaniel (2014) describe uncertainty as a personal experience, where one lacks knowledge and feels unsure about a specific situation. The authors highlight its relevance in educational contexts where students regularly encounter uncertainty as they try to learn new things (Jordan & McDaniel, 2014). In educational environments, students often work in teams, which demands both social and cognitive abilities (Care et al., 2016). Roschelle and Teasley (1995) argue that for collaboration to be effective, individuals need to engage actively and continuously align their actions to achieve a common understanding. Jordan & McDaniel (2014) identify two types of uncertainties that arise in student teams, further refined by Hartner-Tiefenthaler et al. (2018)

as epistemological and relational uncertainty. Epistemological uncertainty stems from doubts about the content of the task, including knowledge, process, and result (Hartner-Tiefenthaler et al., 2018). On the other hand, relational uncertainty results from social interactions and relationships with team members (Hartner-Tiefenthaler et al., 2018). Kirch and Siry (2012) note that "uncertainty originates and exists in dialog and is a product of interaction with others and the world" (p. 263), highlighting that uncertainty is rooted in collaborative activities. With that in mind, it is of value to understand how students manage uncertainties in these settings. Previous studies highlight the importance of learning how to manage them, and that students should have an active role in this process throughout their education (Chen, 2020; Jordan & McDaniel, 2014; Kaur & Dasgupta, 2023).

2.2 Managing Uncertainty

Given that uncertainty is inherent in educational settings, managing it is a key aspect of learning (Jordan, 2015). Individuals make use of specific strategies and behaviors to deal with uncertain situations, including reducing (e.g. ask questions to peers and teachers, analyze problems, trial-and-error), maintaining (e.g. doubt an idea, procrastinate), ignoring (e.g. avoid issues, pass off tasks), or even increasing uncertainty (e.g. expand the problem scope, brainstorm alternative ideas) (Jordan & McDaniel, 2014). These strategies can vary depending on the stage of the problem-solving task. People usually try to reduce or avoid uncertainty (Griffin & Grote, 2020), as it can be a source of discomfort and anxiety (Hirsh et al., 2012). Therefore, it seems logical to think that uncertainty should be minimized as much as possible. Nevertheless, in some situations, consciously cultivating uncertainty can have benefits. For instance, introducing uncertainty can promote creative problem-solving by encouraging people to think outside the box and consider various possibilities (Jordan & McDaniel, 2014). During this exploration phase, uncertainty can be increased at first, but this process ultimately allows students to reduce it by refining their options to identify the most

effective solution (Jordan & McDaniel, 2014). Ignoring uncertainty can however hinder the learning process as the issues stay unaddressed when uncertainty is avoided (Jordan & McDaniel, 2014). Students can easily feel overwhelmed when faced with ambiguity, especially in group settings (Kaur & Dasgupta 2024). Teams consist of individuals with different viewpoints, values, and prior experiences, which can make uncertainty management more complex (Hartner-Tiefenthaler et al., 2018). When students keep their uncertainty to themselves without addressing it, it remains a hidden issue (Jordan, 2015). Taking this into account, it is vital to express and discuss uncertainty with other team members to manage it (Baker, 2009). This helps students tackle complex tasks and handle the uncertainties that arise (Jordan & McDaniel, 2014).

To conclude this section, it is useful to take a closer look at two studies that serve as a base for the present research. That is because they show findings on how uncertainty is managed in collaborative problem-solving settings and how group dynamics influence uncertainty management. Jordan & McDaniel (2014) looked at how fifth grade students dealt with uncertainty during a robotics engineering project. They found that peer interactions had a big impact on how students managed uncertainties. Supportive responses from peers enabled students to navigate uncertainties better. Hence, we should recognize positive peer interactions as a key factor in managing uncertainty during group projects. In 2015, Jordan expanded the study to explore how fifth graders manage uncertainty during collaborative engineering tasks (Jordan, 2015). She aimed to identify different propensities for managing uncertainty. The research identified five propensities, namely “Pause for Reflection”, “Seek a Plausible Explanation”, “Request Help”, “Take Action”, and “Deny Uncertainty” (Jordan, 2015). These propensities provide a framework for understanding how different students respond to uncertainty. All things considered, teachers should guide students through the

uncertainty management process and support them in negotiating uncertainties and collaboratively building knowledge (Chen et al., 2019; Chen, 2020).

2.3 Self-efficacy

When talking about uncertainty management, it is valuable to mention the concept of self-efficacy because it influences how students respond to challenges and uncertain situations. Self-efficacy describes the confidence individuals have in their ability to manage tasks and accomplish objectives in different situations (Bandura, 1982). In fact, findings have demonstrated that self-efficacy influences students' motivation, learning and overall performance connected to their education (Jackson, 2002; Zimmerman, 1995). Students who believe in their abilities generally anticipate positive outcomes for themselves. Their confidence therefore serves as a driving force for success (Bandura, 1989). Individuals with high levels of self-efficacy see challenging moments and uncertainties as opportunities to learn (Bandura, 1982; Zimmerman, 2000). Thus, they do not perceive mistakes as negative, but rather as opportunities to grow from them. An additional characteristic of confident students is their tendency to participate and keep going in difficult situations (Zimmerman, 1995). This suggests that they have a strong belief that such times can be overcome. Dunbar et al. (2018) state that these students strongly believe they can do the task successfully, while being aware that they could fail in doing so. Unlike confident students, the ones who possess less self-efficacy are prone to steer clear of complex challenges (Schunk, 1989). It has been shown that this propensity often extends to social environments, where they shy away from peer interactions (Ahmad & Safaria, 2013). An additional factor that is connected to low self-efficacy is the emotional state of students. Negative emotions, such as anxiety or frustration, are often present when students are confronted with uncertainty (Hirsh et al., 2012). Ahmad and Safaria (2013) explained that students with low self-efficacy are more likely to experience such emotions, as they often feel depressed, anxious, and helpless. This can make it harder for

them to deal with the uncertainty. Therefore, it is of value to study not only self-efficacy but also emotional states when it comes to uncertainty management. Knowing the role of self-efficacy in student success, instructors should foster it in school through targeted learning tools and understand the factors that influence it (Dinther et al., 2011).

2.4 Concept-Maps and Reflection Prompts

Effective collaboration requires clear communication, a shared understanding, and the ability to manage complex tasks, all of which can be challenging in group settings (Bower & Richards, 2006). To address these challenges and to support students in managing uncertainty during collaborative problem-solving, this study implements two scaffolding tools: concept-maps and reflection prompts. Concept-maps serve as learning tools to visually organize information (Novak & Canas, 2008). They represent concepts, connected through lines, to show how they are related (Schroeder et al., 2018). Typically, the key idea is written at the top of the sheet and the more detailed concepts underneath (Romero et al., 2017). According to Novak and Canas (2008), concept-maps are never one hundred percent completed. Therefore, the maps should be updated regularly by adding new concepts (Novak & Canas, 2008). There is a growing body of research supporting the idea that concept-maps are effective in promoting meaningful learning (Romero et al., 2017; Van Rensburg et al., 2023). By representing the knowledge in a visual manner, students can make connections and form structured mental models (Mayer & Fiorella, 2021). This could be beneficial for managing uncertainty, as it implies that concept-maps might help students break down complex issues and uncertainties into smaller and more manageable pieces. Concept-maps are particularly useful in group settings, because they get students to discuss and negotiate, therefore fostering interdependency (Van Boxtel et al., 2002). They also facilitate brainstorming and provide students with a structured way to organize and explore ideas (Rafaeli & Kent, 2015).

Reflection prompts are structured questions, encouraging students to think deeply about their learning experiences and outcomes (Menekse et al., 2022). They are also effective at getting students to engage in metacognitive and critical thinking, which leads to higher levels of cognitive engagement (Dorn, 2014). Lin et al. (1999) note that "reflective thinking is an active, intentional, and purposeful process of exploration, discovery, and learning" (p. 46). Students can use reflection to track their learning progress, helping them understand and evaluate the knowledge they have built (Chang, 2019). The reasoning behind the decision to implement this tool in this study is that it has the potential to get students to identify and externalize uncertainties together (Chen, 2020). This could help them deal with it because they actively address it. In his study, Chen (2020) found that question prompts by the teacher helped students manage uncertainties as it got them to communicate and reflect on uncertainty. In a similar way, the reflection prompts used in this study could facilitate uncertainty management.

To sum up and connect the scaffolds to the present study, the concept-maps offer a visual structure to organize ideas. In this context, the idea could be about which features students want to add to their learning environment. In addition, the list of reflection prompts encourages dialogue. For instance, students could be uncertain about which design elements are appropriate for children. The reflection prompts would get them to articulate the uncertainty and start the discussion. Based on this reasoning, the integration of these tools could be useful in scaffolding the students' uncertainty management. Together, they allow students to collaboratively address uncertainties in a more structured and reflective way. By implementing those in the classroom, this study explores their potential influence on students' self-efficacy in managing uncertainty during their collaborative problem-solving project. While that is the primary aim, the study also explores the same impact across different subgroups to understand how the effects of the scaffolds might vary depending on group

dynamics, gender, and age. Including gender as a variable is relevant because, although the findings on gender differences are mixed (Huang, 2013), previous research suggests that females often report lower self-efficacy, especially in STEM contexts (Kalender et al., 2020). Therefore, to investigate this further the present study explores whether the scaffolds affect male and female students' self-efficacy differently. Another variable that is often considered in educational research is age. According to Pajares and Miller (1994), the level of self-efficacy depends on previous experiences. In the current context, this could imply that older students show higher self-efficacy in the face of uncertainty because they might have more prior experience with managing complex tasks. These additional variables provide a fuller view on the potential effects of concept-maps and reflection prompts on students' self-efficacy in managing uncertainty. The following research questions were formulated:

RQ1*: How do concept-maps and reflection prompts influence master students' self-efficacy in managing uncertainty during collaborative problem-solving?*

In this study, it is assumed that the use of concept-maps and reflection prompts will support students' uncertainty management by helping them visualize, articulate, and discuss their uncertainties. As a result, their self-efficacy in managing uncertainty might increase as the uncertainties become more manageable through the use of these scaffolds. Successfully managing the challenges could, in turn, strengthen their belief in their abilities to overcome them.

RQ2: *How does the influence of concept-maps and reflection prompts on master students' self-efficacy in managing uncertainty vary across different student teams?*

In this study, it is expected that the influence of concept-maps and reflection prompts might vary depending on group dynamics, including factors like collaboration and communication.

RQ3: *How does the influence of concept-maps and reflection prompts on master students' self-efficacy in managing uncertainty differ between male and female master students?*

It is assumed that female students might show lower self-efficacy compared to male students, as previous research indicates that females often report lower self-efficacy. Concept-maps and reflection prompts are anticipated to support both genders in managing uncertainty, but the degree of influence on self-efficacy might vary.

RQ4: *How does the influence of concept-maps and reflection prompts on master students' self-efficacy in managing uncertainty differ between younger students (below 25 years) and older students (25 years and above)?*

It is expected that students over 25 years old will show higher self-efficacy because they likely have more prior experience. Concept-maps and reflection prompts are anticipated to support both age groups in managing uncertainty. However, students below 25 years might benefit more in terms of building confidence, as they likely have less prior experience in managing uncertainties.

3 Method

3.1 Research Design

This study used a mixed-methods approach with both quantitative and qualitative data to investigate how concept-maps and reflection prompts impact master students' self-efficacy in managing uncertainty during collaborative problem-solving. The quantitative part of the study included two surveys that were administered at different stages of the course. The first survey measured students' general self-efficacy (Schwarzer & Jerusalem, 1995) and was completed three times during nine weeks. This was done to see the evolution of their self-efficacy scores in order to spot possible changes in their confidence levels. Three data points provided a rich view of the change process. The second survey captured the students' emotional states (Watson et al., 1988) at two different time points. This included positive and negative emotions and allowed to observe whether changes in self-efficacy are linked to

improvements in emotional well-being. The emotional data allowed us to see the context in which their self-efficacy was formed.

The qualitative part of this study consisted of observations of team discussions in the classroom. The purpose was to see how students interacted and responded to uncertainty during collaborative problem-solving. They also served to see how students engaged with the scaffolds during that process. The observation notes were accompanied by audio recordings to ensure accuracy. Additionally, open-ended questionnaires were given to the students three times via email and once in the classroom using a QR code. These surveys asked students about their uncertainties, strategies for managing them, and their confidence levels when faced with challenges. The final in-class survey asked why they thought their confidence changed. This was asked to get students to reflect on their experience and think about any changes that might have happened in terms of their self-efficacy.

3.2 Participants

The research sample consisted of 24 master students at the University of Twente (UT). Most of them studied “Educational Science and Technology” (EST). However, there were some students studying “Psychology” or “Educational Psychology”. The selection of participants was carried out through convenience sampling (Etikan et al., 2016), which included all students enrolled in a master course focused on designing online learning environments. Thus, there were no specific criteria required to participate in the study. One student did not want to have his data collected. As a result, the number of participants was reduced to 23. The final sample consisted of 13 females (56.52 %) and 10 males (43.48 %). Moreover, there were 11 students under the age of 25 (47.83 %) and 12 students aged 25 years or older (52.17 %). The youngest student was 22 years old and the oldest was 38. Although a sample size of 23 is relatively small, the gender and age distribution does ensure a representative sample.

The students were organized into six groups of four. They were responsible for creating the groups themselves. To ensure heterogeneity in each group, the teacher encouraged the students to include individuals from different academic backgrounds and areas of expertise (e.g. EST, psychology, teaching experience, design experience etc.). The group that included the student who did not consent to participate was entirely excluded from the observations to ensure his privacy.

3.3 Instruments

3.3.1 General Self-Efficacy Scale (GSE)

For the quantitative part, this study used the General Self-Efficacy Scale (GSE) developed by Schwarzer and Jerusalem (1995) to measure individuals' general self- efficacy levels. The GSE has shown strong reliability with Cronbach's alpha values varying between .76, and .90. (Schwarzer & Jerusalem, 1995). Although the scale was not specifically designed for uncertainty management, small adjustments were made to the phrasing of the survey items to better fit the context of this research (see Appendix A). Some additional words were added to the questions to link them to uncertainty and collaborative problem-solving. For instance, the original statement "It is easy for me to stick to my aims and accomplish my goals." (Schwarzer & Jerusalem, 1995) was changed to "It is easy for me to stick to my aims and accomplish my goals, even when I face uncertainty." Likewise, the statement "I can usually handle whatever comes my way." (Schwarzer & Jerusalem, 1995) was modified to "I can usually handle whatever comes my way during collaborative problem-solving.". The questionnaire consisted of 10 questions and used a 4-point Likert scale ("Not true at all", "Hardly true", "Moderately true", "Exactly true") (Schwarzer & Jerusalem, 1995).

3.3.2 Positive and Negative Affect Schedule (PANAS)

Another instrument used in this study was the Positive and Negative Affect Schedule (PANAS), established by Watson et al. (1988). The scale is reliable with a Cronbach's alpha

of .88 for Positive Affect (PA), and .87 for Negative Affect (NA) (Watson et al., 1988). It was used to measure the participants' emotional states. The survey included 20 emotions in total. Half of them were positive emotions (e.g. excited, strong, enthusiastic), and the other half were negative emotions (e.g. distressed, upset, scared). The students rated each item on a 5-point Likert-scale ("Very slightly or not at all", "A little", "Moderately", "Quite a bit", "Extremely") (see Appendix B). This indicated the degree to which they felt each emotion "at the moment" and "in the past few weeks." (Watson et al., 1988). Ideally, the two surveys would have been administered in separate lectures. However, due to the spontaneous decision to capture emotional states, both were conducted within the same session. To ensure the accuracy of the responses, we planned the surveys as far apart as possible within that session.

3.3.3 Observations and Audio Recordings

The observations were done in the classroom by moving from group to group during the sessions. The researcher listened to the conversations and simultaneously took notes in a prepared Excel template. The template contained columns for several categories relevant to the research questions: time, topic, scaffold use, uncertainty, self-efficacy, group dynamics. These were chosen to make sure that everything central to the study was systematically documented. These categories were guided by the key variables of the research questions. The category "scaffold use" was chosen to see when and how the students used the concept-maps and reflection prompts. "Uncertainty" was included to observe how students responded to ambiguity during discussions. The category "self-efficacy" aimed to identify instances where students expressed confidence. Finally, "group dynamics" was added as a category, as this is crucial to consider in collaborative problem-solving environments. Understanding how students interact with each other is important, because these interactions can influence the group's uncertainty management and how individuals position themselves within their group.

Additionally, “time” and “topic” were included to track the flow of the discussions and highlight what students were talking about.

Due to the limited time spent with each group, it was necessary to complement the in-class observations with voice recorders. These were placed on each group’s table during the sessions. After each session, the recordings were reviewed to fill in the gaps and to transcribe the conversations more accurately, especially where uncertainty was present. This way, any instances of uncertainty that were not captured during the live observations were documented.

3.3.4 Open-Ended Surveys

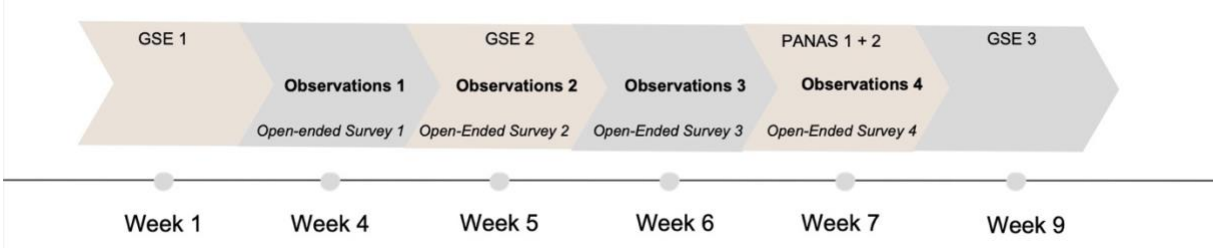
In addition to the observational data, surveys were used to collect qualitative data directly from the students about their experience of uncertainty (see Appendix C). These questionnaires were given to the participants to complement the observational data. The surveys were shared through Google Forms and sent via email to the students every week for four weeks in a row. They were always sent immediately after the lecture. Each survey had three open-ended questions or statements: a) Reflect on your own and group’s uncertainties from working on your project this week b) How did you manage the uncertainties? c) When faced with new challenges during collaborative problem-solving, I feel .... This was done multiple times to have a detailed view on the students’ personal experiences when it comes to uncertainty. Nearing the end of the course, a final open-ended question was asked using a QR code in the classroom: “Why do you think your confidence has changed during the group project?”. This question was formulated to make the students reflect on whether their self-efficacy changed and if so, what the reason(s) for that were.

3.4 Procedure

The data collection took place for a duration of nine weeks and included seven lectures in total. Figure 1 provides a visual timeline of the nine weeks of data collection, showing when the surveys were administered, and when the observations took place.

Figure 1

Timeline



In week 1, on the first day of data collection, the students were introduced to the study and informed about its objectives and ethical considerations. They completed and signed the informed consent forms (see Appendix D) and received a sheet where the aim of the study was explained (see Appendix E). Following the course introduction, the first GSE survey was distributed to the students. This initial survey was conducted before any collaborative activities or scaffolds were introduced. The students were asked to write their names, age, and gender on the survey sheet. However, to ensure anonymity each student received a code (e.g. A1, A2, A3). These were then mapped to the specific students and used in the further process to protect their identity. In week 2, the lecture was not scheduled due to holidays, followed by a lecture in week 3 presented entirely by a guest lecturer, which left no opportunity for data collection. During these two weeks, the students were instructed to form groups of four and email their final group decisions to the teacher (see Appendix F). Additionally, they were required to write and submit a problem statement as a group. During this period, their collaborative discussions happened outside of the classroom and hence could not be collected for this study.

From weeks 4-7, observations of in-class group discussions took place. Each week began with a 45-minute lecture. After a short break, students used the remaining 30 to 40 minutes for their group discussions. These collaborative sessions were recorded with voice recording devices to capture team dynamics, decision-making processes, and uncertainty

management strategies. In week 4, students were introduced to concept-mapping and reflection prompts. The goal was to help them understand how to use these scaffolds and how they can help them articulate their uncertainties. Each group received a large blank sheet, several colored markers and an additional sheet listing possible categories for their concept-map. These categories included prompts to help them initiate their discussions. For instance, the category "target audience" included the prompts "Who is our target audience?" and "What are their learning needs?". Over the course of four weeks, the students had the scaffolds available, but their engagement with them varied. In week 4, the students were prompted to spend at least 15 minutes using the concept maps and reflection prompts. The tools were mostly used to brainstorm initial ideas and plan their group work. The engagement was high during this session and students used the scaffolds for the entire time. In week 5, the students were not prompted to use them. Although the scaffolds were available on their desks, the level of engagement was low, and they were not actively used. In week 6, students were encouraged to revisit their initial ideas and highlight their current uncertainties on the concept-maps. They spent approximately 15 minutes on this activity. In week 7, the students were not prompted to use the tools and there was no engagement with them, even though they were available.

At the end of the lecture in week 5, the midpoint of their collaboration process, students completed the GSE survey for the second time. In week 7, they were introduced to the PANAS emotions survey. At the beginning of the class, students filled out the survey to reflect on their emotional state "in the past few weeks" (Watson et al., 1988). At the end of the class, they completed the same survey to indicate their current emotional state. Finally, in week 9, after their final presentations, students completed the same GSE survey one last time. Once all the data was gathered, the students were thanked for their participation in the study.

3.5 Data Analysis

3.5.1 Descriptive Analysis

The purpose of the quantitative data analysis was to measure changes in students' self-efficacy levels and emotional states over the course of nine weeks. Descriptive statistics were calculated in Excel to outline preliminary trends across time points. For the GSE scale, the average score of the 10 items was calculated for each student, the class, student teams, as well as subgroups like gender (males, females) and age (below 25 years, 25 years or older). For the PANAS scale, the average score of each emotion was calculated for the class and for three focus individuals who experienced the highest increase in self-efficacy.

3.5.2 Repeated Measures ANOVA

In order to determine whether the identified changes were statistically significant, one-way Repeated Measures Analysis of Variance tests were performed using the statistical software R. This decision was made since the current study included repeated measures of the same data over time. The repeated measures ANOVA tests measured whether the shifts in self-efficacy scores were significantly different across the three repeated data points ($p < .05$). To address all the research questions, this test was conducted separately for the whole class, the student teams, males, females, younger students (<25 years) and older students ($\geq$ 25 years). Similarly, the one-way repeated measures ANOVA test was also run for the 20 emotions of the PANAS survey (Watson et al., 1988) to determine which ones had a significant increase or decrease ($p < .05$). Generalized eta-squared (η^2_G) was used to calculate the effect size to measure the extent of the observed changes (Lalongo, 2016). This was done as a part of the repeated measures ANOVA test. Cohen (1988) developed categories to determine whether an effect size is small (η=0.01), medium (η = 0.06), or large (η = 0.14). In this study, the results were interpreted using these guidelines to get a feel of how meaningful

the effects were (Lalongo, 2016). However, it is important to acknowledge that these only serve as a general idea and should not be considered definitive (Funder & Ozer, 2019).

3.5.3 Discourse Analysis

The data of the observations was examined using discourse analysis (Gill, 2000) with a focus on the communication that took place during the students' collaborative sessions (Jordan & McDaniel, 2014). By looking closely at these interactions, the aim was to capture students' uncertainties, strategies for managing those, group dynamics, and use of the scaffolds. The analysis required interpretation due to the ambiguous nature of language (Jordan & McDaniel, 2014). The first stage of the analysis involved refining the observation notes taken during the class to ensure they were clear and organized. After that, the recordings were listened to twice, with a focus on moments where students expressed uncertainty. This was determined by looking at speaking turns and paying attention to what was said and how it was said. These moments were recognized through the paralinguistic (e.g. intonation) and linguistic markers (e.g. verbal hedges) developed by Jordan and McDaniel (2014) (see Appendix G). Due to the absence of video recordings and the limitations of in-class observations, gestures were excluded from the analysis. While listening to the recordings, situations with identified markers of uncertainty were transcribed manually and added to the Excel sheet. This ensured that the focus of the analysis was on the parts where students expressed uncertainty. Re-listening to the recordings made sure that no important details were overlooked and that the markers were accurately identified. Once the observation notes were refined, a color-coding system was used to make the notes organized and ready for coding. The colors highlighted where students expressed uncertainty based on the markers (Jordan & McDaniel, 2014), how they managed uncertainty, where they seemed confident, and when and how scaffolds were used during the sessions. The data analysis was deductive. The

coding scheme by Jordan & McDaniel (2014) was applied to identify the strategies students employed for managing uncertainty (see Table 1).

Table 1

Strategies for Managing Uncertainty (Jordan & McDaniel, 2014)

Reduce	Ignore	Maintain	Increase
Analyze issues	Keep going (persist, bluff)	Delay action, decision, or evaluation	Open the problem space
Test systematically	Avoid	Acknowledge	Purposefully seek multiple alternative action trajectories or opinions
Engage in trial-and-error experimentation	Pass off task	Express doubt	
Explain clearly	Dismiss		
Request information from group members	Blame		
Observe others			
Seek expert other			
Seek information from materials or texts			
Ask for confirmation			
Draw on past experience			
Seek consensus			
Refer to an authority figure			

The coding scheme was applied on the individual level rather than group level. This process included reading excerpts and focusing on the uncertainty management of one person at a time. Below are examples of how the coding scheme was applied by using two excerpts from student discussions in the classroom. These were chosen because they represent codes that were frequently used. In this first episode, the students from group B agreed that they

should contact their client to share their initial ideas. They wanted to narrow down their focus before they met with her. As a result, they discussed what their focus should be.

Figure 2

Application of the Coding Scheme on Student Discussion in Group B

B4: Based on this, are we gonna focus on the cognitive or affective part of—
B3: On cognitive. Because it is about understanding how to write.
B2: So we need to rewrite our problem statement?
B3: Ummm, more like yeah just make sure that it is understandable because now it focuses a bit on cognitive and a bit on affective but um—
B2: Yeah. So we just— (hesitation) delete the affective part?
B3: Yeah because it is easier to control the cognitive part (explains further).

B4 tried to reduce the uncertainty about whether they should lean towards cognition or affection as their focus, by asking a question. Thus, the code "Request information from group members" was applied. B3 replied with a clear answer and provided reasoning as to why they should lean towards cognition. She elaborated on her explanation at the end of the excerpt. This instance was coded as "Explain clearly". B2 sought reassurance from his group members twice regarding what their next steps would be. The suitable code for this behavior is "Ask for confirmation". The second example presents a scenario from group C in week 4, where they used the concept-map and the reflection prompts. Figure 3 happened after they read the prompt "Which technologies do we use?".

Figure 3

Application of the Coding Scheme on Student Discussion in Group C

C3: Do they mean the Go-Lab system or?
C4: I think? (pause) No, maybe (pause) as we go we might (pause) maybe (pause) at some point we can use QR codes, but how that works with Go-Lab I don't know yet.

After reading out the prompt, C3 questioned whether it refers to the Go-Lab system or something else. Hence, the situation was coded as "Ask for confirmation". C4 replied with the possible idea of using a QR code for their learning environment. However, he highlighted that this was only an initial idea that they could not agree on yet. This is an example of increasing

uncertainty by “opening the problem space“ because the student made a suggestion, yet left room for other possible ideas for their project.

To make sure that the data analysis is reliable, 20 % of the total observation notes were coded by two researchers independently. Both coders collaboratively discussed and defined each code to ensure a shared understanding. This process involved a few pauses to clarify any emerging questions. In the end, the coders reached a 74.3 % inter-rater reliability agreement, which is considered substantial according to Landis and Koch (1977).

3.5.4 Thematic Analysis

In addition to the observations, open-ended surveys were conducted to get a better understanding of the students' experiences connected to uncertainty. This part of the analysis brought in the students' own perspectives on the challenges they faced. As the discourse in the observations is naturally ambiguous and interpretive (Jordan & McDaniel, 2014), the survey responses provided evidence and helped understand their experiences. This was of value to confirm that the students were indeed uncertain at times and what specific strategies they used to manage these uncertainties. The qualitative data from the open-ended survey responses was analyzed using thematic analysis (Braun & Clarke, 2012). The first step was reading all the survey responses. This was done to become familiar with the data. During this process, recurring themes and patterns began to emerge, which lead to the development of codes. The next step was to go over the responses and link the developed codes to the relevant student replies. After the initial themes were identified through coding, the next phase involved reviewing and refining these themes to ensure that they represented the data accurately.

4 Results

4.1 Quantitative Results

4.1.1 General Self-Efficacy (GSE)

To address the primary research question, the first part of analysis examined the self-efficacy levels of the entire sample (n=23) at the beginning, middle and end of the course. Over the course of nine weeks, there was a positive change in how students perceived their confidence. The mean score at the beginning was 2.92, which is already relatively high, considering that the maximum possible score is 4. It increased progressively to 3.10 at the mid-point of the course and to 3.25 at the end. A one-way repeated measures ANOVA test was conducted to see whether the change was statistically significant. The results showed a significant increase in their self-efficacy over time, $F(2,44) = 13.24$, $p = < .001$. The effect size, calculated as generalized eta-squared (η^2_G) was .38, indicating a large effect according to Cohen (1988). This highlights that the increase in self-efficacy of the master students was not only significant, but also meaningful (Lalongo, 2016). However, Funder and Ozer (2019) stress that these categories should be interpreted carefully as they should only provide a general idea of the size of the effect.

With regard to the second research question, the analysis was extended by looking into the scores of the student teams. This was done to assess whether there were visible differences in confidence levels among different teams. Table 2 lists the self-efficacy scores for each group at the three different time points.

Table 2

One-way Repeated Measures ANOVA, Groups, n = 23

	Beginning	Mid-point	End
Group A	2.53	2.78	3.18
Group B	2.85	3.25	3.20
Group C	3	3.18	3.40
Group D	3.25	3.28	3.40
Group E	2.78	2.90	3.05
Group F	3.20	3.23	3.27
p-value: .004**			
Effect size: .30			

Note. ***p < .001, ** p < .01, * p < .05

The data revealed a similar positive trend for each team. The self-efficacy levels increased progressively over time. Statistical significance was analyzed by using a one-way repeated measures ANOVA. The result was significant, indicating that self-efficacy levels improved over time across all teams, $F(2, 10) = 10.37$, $p = .004$. The effect size, generalized eta squared (η^2_G), was .30, indicating a large effect (Cohen, 1988). Again, although this large effect size points to a meaningful improvement in self-efficacy, it is important to interpret these categories carefully (Funder & Ozer, 2019).

To explore the third and fourth research questions, further analysis focused on the self-efficacy of different student demographics, like gender and age groups. First, the scores were compared for females and males. Females (n=13) started with a mean self-efficacy score of 2.78, which gradually increased to 2.95 at the mid-point and finally to 3.19 by the end. To assess whether these changes were statistically significant, a repeated measures ANOVA was conducted. The results revealed that the change in their confidence levels was significant, $F(2, 24) = 8.53$, $p = .002$. Male students (n=10) showed a similar upward trend, going from 3.11 to 3.28 and to 3.32 by the end. Again, the one-way repeated measures ANOVA test confirmed a significant change in self-efficacy, $F(2, 18) = 7.68$, $p = .004$. The effect size for females (η^2_G) was .12, and the effect size for males (η^2_G) was .14. This means that the change showed a medium effect for females and a large effect for males (Cohen, 1988). These indicate that the changes observed were moderately and substantially impactful. Also, it is worth noting that male students started with a higher confidence in managing uncertainty (M=3.11) compared to females (M=2.78). Although male scores were higher at all three points, the gap between genders got smaller towards the end, showing that the increase in self-efficacy was higher for females.

Finally, the same tests were conducted for students under the age of 25 years (n=11) and students aged 25 years and older (n=12). The self-efficacy of students below 25 started

with a mean score of 2.82, which progressively increased to 2.94 and eventually to 3.20. The repeated measures ANOVA indicated a statistically significant change over time, $F(2, 20) = 5.68$, $p = .011$. Students aged 25 years and above experienced an increase from 3.02 to 3.24 to 3.29. For this group, the ANOVA test also showed a significant increase in self-efficacy, $F(2, 22) = 13.33$, $p < .001$. The effect size for slightly younger students ($\eta^2_G = .09$) falls in the medium range (Cohen, 1988), suggesting a moderate improvement in self-efficacy over time. In contrast, the effect size for older students ($\eta^2_G = .18$) is considered large, which indicates a slightly more substantial increase (Cohen, 1988). However, these categories are only approximate guides (Funder & Ozer, 2019). Although older students began the course with a higher self-efficacy score (M=3.02) than younger students (M=2.82), the younger group showed more growth in confidence. This increase reduced the gap in self-efficacy between the two age groups by the end of the course. However, the smaller p-value and higher effect size for the older sample indicate that the overall improvement in self-efficacy was more significant in the older group.

Overall, the results show statistically significant increases in self-efficacy for the whole class, including the different student demographics. The use of concept-maps and reflection prompts in weeks 4 and 6 enabled students to organize their thoughts and reflect on their progress. These scaffolds were introduced to support students during their uncertainty management and might align with the observed increases in self-efficacy.

4.1.2 Positive and Negative Affect Schedule (PANAS)

In addition to self-efficacy changes, this study also observed shifts in students' emotional states by using the Positive and Negative Affect Schedule (PANAS). The participants were asked twice to rate the extent to which they felt specific emotions. For this analysis, the sample size decreased to 21 students because two students did not want to rate

their emotions. A summary of the results for all emotions (average scores, p-values, effect sizes) can be found in Appendix H. The most significant findings are reported below.

The analysis showed statistically significant changes in the following five emotions: Nervousness saw the most significant decrease and dropped by 32.14 %, $F(1, 20) = 20.83$, $p = < .001$. Distress decreased by 21.92 %, $F(1, 20) = 10.31$, $p = .004$. Moreover, pride increased by 22.06 %, $F(1, 20) = 12.43$, $p = .002$, and strength by 24.12 %, $F(1, 20) = 7.01$, $p = .015$. Finally, feelings of shame decreased by 17.39 %, $F(1, 20) = 6.25$, $p = .021$.

Several other emotions showed visible trends, but they did not reach statistical significance. Among the positive emotions, determination increased by 11.53 % and inspiration by 10.32 %, which suggests slight but positive changes. Among the negative emotions, irritability decreased by 16.50 %, and fear by 15.13 %. Additionally, upset feelings decreased by 21.59 %, and guilt by 17.83 %. Although these changes did not reach statistical significance, the trends do suggest an improvement in their emotional well-being.

In terms of effect sizes, the data shows a clear pattern: the significant emotions generally have larger effect sizes compared to the non-significant ones. Nervousness, pride, distress, strength and shame show medium effect sizes (η^2_G=.12; η^2_G=.11; η^2_G=.08; η^2_G=.06; η^2_G=.06) (Cohen, 1988). In contrast, the non-significant emotions, such as upset, guilty, determined, afraid, inspired, and irritable, have effect sizes mostly in the small range. This indicates less substantial changes (Cohen, 1988). All in all, the results reveal a pattern where negative emotions decreased, and positive emotions increased. This shows an overall improvement in students' emotional states over the course of the study.

4.2 Qualitative Results

4.2.1 Types of Uncertainty

The next section presents the qualitative findings from the observations and surveys that explored students' uncertainty management and group dynamics. Throughout the project,

it was evident that all five groups experienced uncertainty regularly. Through the open-ended surveys and the observations, the following lists the types of uncertainties they faced. The thematic analysis revealed four main themes of uncertainty that occurred in the process of creating the online learning environments.

Choosing Appropriate Theories and Formulating the Problem Statement. In the early stage of their group project (week 4), numerous students were uncertain about defining what their exact focus should be and identifying suitable theories:

A3: We are not sure about choosing the appropriate theories based on the needs of the teacher.

B2: We found it challenging to create a good problem statement.

C4: We found it difficult to find a direction we should focus on. The problem statement could be solved in many different ways, narrowing it down and identifying the core issue took some time.

D3: We found it challenging to set on one problem, as there were bigger problems.

Finding Clients. A second source of uncertainty in week 4 was the challenge of finding clients that are open to do the pilot testing with the groups. At the same time, one group even found it challenging to choose between clients, as they had a few options:

A4: We found it challenging to find a teacher that is willing to do the testing.

E2: We had an uncertainty about which client we were going to use since we had two options and they were both interesting.

Applying Theoretical Knowledge to Practical Design. By week 5, students arrived at the stage, where they already wrote their problem statement and narrowed down their focus. Here, the focus lies on applying their theory to practice, where they need to transform abstract concepts into design elements:

A3: We found it challenging to apply the theoretical knowledge we have into a real learning system.

B4: Solution design.

E3: We felt uncertain about how to properly translate our problem into learning objectives.

Technical Challenges and Limitations of Go-Lab. In weeks 4 and 5, as the students were working on designing the learning environments many expressed uncertainty regarding technical issues and restrictions of Go-Lab. This problem seemed to be particularly present for groups that created environments not related to STEM:

A4: Our biggest concern right now is to find suitable apps in Go-Lab that work for a non-STEM activity.

C1: Our biggest challenge right now is to find a way to incorporate our game idea into Go-Lab.

C4: Our biggest concern right now is using the available apps in Go Labs. Our topic is communication/teamwork and many of the apps in Go Lab is directed towards science.

D3: Our biggest concern right now is making the technological aspect in regards to Go-Lab work.

E3: Our biggest concern is the implementation of our game into go-Lab, as Go-lab is restricting our design choices.

4.2.2 Uncertainty Management Strategies

The following findings demonstrate how students managed these uncertainties based on their discussions. Table 3 shows the frequency of strategies employed by the class in general across all four lectures, using the coding scheme by Jordan & McDaniel (2014). Table 3 shows that reducing uncertainty was the most popular strategy across all lectures. In contrast, ignoring uncertainty was less common. This number derives primarily from two students, which means that the majority of the students preferred to engage with uncertainty

rather than ignoring it. Maintaining uncertainty was the second most used strategy, reflecting that students sometimes kept uncertainties unresolved to further explore possibilities before making final decisions. Finally, increasing uncertainty revealed a similar frequency and was particularly visible in the early stages of the project.

Table 3

Frequency of Uncertainty Management Strategies Employed by the Class

Week	Reduce	Ignore	Maintain	Increase
4	78	11	31	29
5	116	18	28	17
6	90	7	14	11
7	60	2	8	2
Total	344	38	81	59

In week 4, students used concept-maps to generate initial ideas, which resulted in quite a few instances of increasing and maintaining uncertainty. This aligns with the brainstorming and problem formulation phase, where exploring various ideas was key. By week 5, reducing uncertainty peaked, which showed a strong shift toward resolving uncertainties as they entered the design phase. At the same time, the use of maintaining and increasing uncertainty began to decline. In week 6, students revisited and clarified their initial ideas using concept-maps, which lead to further reduction in maintaining and increasing uncertainties. This suggests that discussing initial ideas helped students focus on refining them rather than introducing new uncertainties. By weeks 6 and 7, maintaining and increasing uncertainty continued to decrease. This trend highlights the transition towards making concrete decisions and finalizing their project.

The students' survey responses provide a deeper understanding of how they managed uncertainty. The answers appear to be mostly related to uncertainties at the group level. Their responses confirm the patterns observed in Table 3, showing that they primarily used strategies to reduce uncertainty:

Seeking Help from Teachers and Peers. The first strategy for dealing with uncertainty was to ask help from teachers and group members:

B2: Asked the teacher and others for help.

D3: Asking the teacher and feeling supported by the team.

E3: We asked for help from the teacher. We decided to work around Go-Lab and design in Unity and upload it.

E3: We asked for help from the teacher and discussed it within our group.

Group Discussions and Brainstorming. Students valued group discussions and brainstorming as a way of handling uncertainty. This suggests that they explored ideas together and considered different perspectives to overcome issues and reach the best solution:

A3: We mainly engaged in discussions and talked about different ways to approach the problem.

B3: Discuss with teammates and teacher, brainstorm on possible definitions.

C1: We look into the features of Go-Lab and we brainstorm together of other ways to incorporate the game.

Dividing Responsibilities. A common tactic was to divide responsibilities in the group. Students liked planning who does what by seeing everyone's strengths and weaknesses:

A3: We divided the responsibilities and let people design that feel more comfortable with the tasks.

A4: We divided tasks, so that 2 persons who prefer working with technology will design the lab and the 2 others will write the text.

Using External Resources. Another popular way for managing uncertainty was to use external resources. As students experienced difficulties with the Go-Lab platform, they used alternative tools to outweigh its limitations:

A4: Find external apps, not yet completely managed.

C4: Would have been great if we could link other sites or online games, but those URLs are blocked and don't work in go-Lab.

E2: We ended up still using Go-Lab but also embed something from another program to have both options there.

Feedback and Reflection. Several students noted that they managed uncertainties by getting feedback from teachers, students, or guest lecturers:

B2: We got feedback on the issue.

B4: After determining our main topic and problem based on the interview we had with the teacher, we wrote a problem statement and got feedback from her to ensure we were on the same page.

4.2.3 Factors Influencing Students' Self-Efficacy

Through the students' survey responses, the data was further strengthened by asking them why their confidence changed throughout the project. The thematic analysis revealed five main themes from their reflections:

Acceptance and Support from Group Members. Feeling accepted and supported by peers was a major factor that influenced students' confidence. This implies that students viewed positive group dynamics as valuable:

A1: Because the group members accepted me and teach me kindly.

C4: You find your place within the team and feel more comfortable voicing your opinion.

E1: Because I had new experiences with new people and they taught me new things about myself.

Familiarity with the Project. Some students noted that their confidence grew as they were becoming more familiar with the project. This likely led to a better understanding of the subject and ultimately made the project more manageable:

A2: The more we moved forward the clearer the objective and the way to achieve it became. So I think that the more effort we put in it the more confident we felt about it.

A4: Because we have now a better overview of what is expected and what is probable to do.

E3: I got a bit more grip on the subject and positive results motivate.

Overcoming Challenges. Several students explained that as they overcame difficult situations, they saw their abilities, which seemed to have reinforced their self-efficacy:

C1: I think we have overcome a lot of problems and found solutions so now we know that we can handle challenges coming our way.

F4: I learn how to incorporate principles in our design.

Personal Growth. Personal growth also played a role in the confidence shift. The answers below show two different variations of this theme:

B2: Group projects give the chance to go out of the comfort zone and therefore there is a chance of growth. And therefore feeling more confident.

B1: Because we had someone in the group that did not feel that competent. Now I could see my own competences and parts that I am actually quite good at. I normally only compare myself with people that are more competent than me.

Team Dynamics and Collaboration. Some students mentioned the team dynamics and collaboration. This again validates, that students valued teamwork:

B1: the group work was flowing, other members did pick up some tasks out of own initiative, so the team work felt nice.

D1: Because of the collaborative work.

E2: We got to know each other and our working styles and knew what each person in the group was good at and what you can ask each other.

4.3 Triangulation of Focus Individuals

The following section combines the qualitative and quantitative data for three focus individuals who showed the highest increases in self-efficacy over time. This is done to examine their uncertainty management strategies, the dynamics of their groups, and their personal development. They will also be discussed through the lens of positional and epistemological framing. This framework was outlined by Kaur and Dasgupta (2024) and provides a perspective for understanding the individual cases in different group dynamics. Positional framing refers to how individuals perceive their own roles and the roles of others in their team (Kaur & Dasgupta, 2024). Epistemological framing is how students see knowledge and how it should be constructed (Kaur & Dasgupta, 2024).

4.3.1 Student A1

Group A worked together on designing an online learning environment for a music lesson. Over 9 weeks, the groups' mean self-efficacy score increased from 2.53 to 3.18. However, this general increase does not show individual differences. Student A1's self-efficacy score increased by 140 %. She started with a mean self-efficacy score of 1, which is the lowest possible score. By the end of the course, her score increased to 2.4. She described her initial confidence as a "strong zero" which reflects her low starting point. In addition, the student's emotional state showed that she was quite distressed and extremely upset. She also reported feeling moderately scared and quite nervous. A1's initial lack of confidence was evident in week 4, where she hesitated to participate in discussions and often ignored uncertainties. She relied heavily on her peers for guidance and understanding. For example, during their discussion about theories, A1 seemed confused and was reassured by A3 (see Figure 4). In this interaction, A1 contributed to the conversation but then immediately retracted her response. She did not give herself or anyone else the chance to think about her answer first. She doubted her own.

Figure 4

Student A1's Hesitation

A3: ILS is inquiry learning systems, right?

A1: Instrument learning system. Ah no, no, no, no. It's not.

A3: No, it's inquiry learning systems.

A1: Thank you, ok.

The strategies that A1 used to manage uncertainties were visible in her interactions. The tables below summarize the strategies for A1 and for group A as a whole:

Table 4

Frequency of Uncertainty Management Strategies Employed by A1

Week	Reduce	Ignore	Maintain	Increase
4	1	4	1	0
5	2	1	1	0
6	2	3	1	0
7	2	1	0	0
Total	7	9	3	0

Table 5

Frequency of Uncertainty Management Strategies Employed by Group A

Week	Reduce	Ignore	Maintain	Increase
4	19	4	6	7
5	11	2	1	2
6	22	3	6	3
7	11	1	1	0
Total	63	10	14	12

At first, A1's main strategy was to ignore uncertainties. For example, in week 4 when the group was uncertain about what features to include, A1 did not take part in handling the uncertainty. Instead, she observed the group discussion and avoided the problem. The group mainly focused on reducing uncertainty, especially during weeks 4 and 6 when they used the scaffolds. Compared to the group's overall strategies, A1's approach was less proactive. As the group project went on, A1 continued to avoid uncertainty. However, she started to show

minimal improvements. The student started to ask her peers for confirmation on several occasions. An example from week 5 shows A1 asking her teammates about the ethical application (see Figure 5). In this interaction, A1 addressed her uncertainty by asking questions instead of ignoring it.

Figure 5

Student A1 Seeking Clarification

A1: So, is (inaudible) different for the ethical application? (quiet and hesitant inquiry)
A2: Yes, there is multiple files, that's an example.
A3: This is the website where you do the application.
A1: So different from this?
A2: No, no, no that's an example.
A4: If we finish with this, we can print it and it will look exactly like this.
A1: Ahhh I see, thank you.

Surprisingly, in weeks 4 and 6 when the group used the concept-map, A1's tendency to ignore uncertainty was at its highest. In week 4, the group focused on reducing uncertainties. However, A1 did not participate. This suggests that while she did not engage directly with the concept-map, she might have benefited from observing her group mates using it. In week 6 the group showed the most instances of reducing uncertainty. A1 showed some improvement in her uncertainty management. The instructor's prompt to reflect on uncertainties led A1 to share her reasons for uncertainty with the group. This gave her the chance to voice her thoughts and be open with her teammates. This likely increased their support because they understood the reasons for her passive role (see Figure 6). This conversation highlights that A1's uncertainty comes from both language barrier and unfamiliarity with the content of the course. This makes her involvement in the group more difficult.

The group dynamic played a big role in A1's development. In the survey when she was asked why her confidence changed, she answered: "Because the group members accepted me and taught me kindly." This support is reflected in several interactions. For example, in

week 6 when A1 shared the reason for her uncertainty, A4 boosted her confidence by giving her a compliment (see Figure 7).

Figure 6

Student A1 Explaining her Uncertainty

A3: A1, do you sometimes feel uncertainty?
A1: Uncertainty? Like it would mean?
A4: Unsure about how the future unfolds.
A1: Future?
A3: Or you're not sure about what you have to do or if you understand something. Do you experience this?
A1: During the class all the time.
(everyone laughing)
A3: Because of the language? Or because of the concepts in general?
A1: Maybe? Of course language is one big reason and um also the contents? Like it's all contents are new to me so. (…) And it's Master level.

Figure 7

Student A1 Receiving Encouragement

A4: But you did very well with the collaboration thing.
A1: Oh, thank you so much! (seems relieved)

Another moment that shows the positive group dynamic, happened in week 4 during a private conversation about "Manga", Japanese comic books. This topic came up because A1 is from Japan and A2 showed interest in her background. This conversation ended with A2 saying that he and the other teammates are A1's "teachers" (see Figure 8). Although A1 did not directly ask the others to be her teachers, her acceptance of the idea suggests that she valued their help.

Figure 8

Peers as Teachers

A2 to A1: So we are your senseis. (Japanese word for "teachers")
A1: yeah. (laughing)

In week 5, A3 noticed that A1 looked troubled and asked if she is doing alright (see Figure 9). This interaction shows that the group provided both academic and emotional

support. Moreover, towards the end of their project, A1 engaged more actively in private conversations than she did in the beginning. This indicates that she became more comfortable with the group on a personal level.

Figure 9

Student A3 Checking on Student A1's Well-Being

A3 to A1: Are you good?
A1: Hm?
A3 repeats: Are you good?
A1: Yeah, yeah. I am just trying to understand number 3 and 7.

Finally, A1's emotional state revealed a notable improvement. She felt more enthusiastic (+50 %), inspired (+50 %), and active (+50 %). This reflects a positive shift in her motivation. A1 began to feel stronger (+200 %), which likely contributed to her increasing willingness to seek confirmation rather than just ignore uncertainties. Her pride also increased by 200 %, which could mean that she started to recognize her own contributions to the project and her capabilities.

Framing. In the beginning, A1 positioned herself as a passive team member and saw her peers as the primary holders of knowledge and authority. Her low self-efficacy score and hesitation to participate reflected her self-perception as less knowledgeable. This was evident in her tendency to follow her peers' ideas and doubt her own, which shows a lack of confidence in her contributions. This demonstrates her epistemological framing, where she perceived knowledge as something others had. The supportive group dynamics influenced A1's positional and epistemological framing. The group's acceptance and encouragement helped change A1's self-perception. This improved both her self-efficacy and emotional state. For instance, A4's compliment on A1's work (see Figure 7) showed her that she was a capable and valued team member. This likely led to a positional shift where she felt more important to the project's success. Similarly, A2's suggestion for them to be her "teachers"

(see Figure 8) showed that they were willing to support her learning and created a safe space for A1 to gradually build confidence.

In the beginning, A1's main strategy for managing uncertainty was to ignore it, which aligns with her epistemological framing of seeing knowledge as held by others. As she became more confident, her approach to managing uncertainty began to change slightly. The data shows that A1 avoided less and made more efforts to reduce uncertainty, mainly by seeking confirmation from her peers. However, her participation in managing uncertainties remained relatively low compared to her peers. This means that her increased confidence did not fully translate into proactive uncertainty management.

4.3.2 Student A4

After examining A1's experience in group A, the next section focuses on her teammate, A4. Unlike A1, A4 started with a relatively high mean self-efficacy score of 3 which stayed consistent during the project and significantly increased to 3.9 by the end. In week 4, she stated that she is "100 %" confident, which was reflected in her ongoing proactive behavior. Table 6 summarizes her strategies for managing uncertainty over the weeks.

Table 6

Frequency of Uncertainty Management Strategies Employed by A4

Week	Reduce	Ignore	Maintain	Increase
4	8	0	1	2
5	3	0	0	1
6	8	0	1	1
7	5	0	0	0
Total	24	0	2	4

A4 reduced uncertainty most of the time, especially in weeks 4 and 6 when the concept-map was used. Her main tactic to reduce uncertainty was to request information from her group members. This is visible in an interaction from week 4 (see Figure 10). This shows A4's

effort to clarify their doubts. Prior to this conversation, they read the prompt that asked which technologies they use in their project. This question served as a conversation starter.

Figure 10

Student A4 Seeking Clarification

A4: What does this mean “which technologies do we use”? Because we only use I-
A3: Yeah, um I don't know I mean like if we want to use other technologies as well? or if they want to use technologies to learn?
A4: Is pictures a technology?
A3: If they're digital?
A4: Digital pictures. (pause) Do we use videos?

In week 5, at the end of the lecture, the students finished talking about the content of their project and started talking about their planning. A4 initiated this conversation and acknowledged the limited time they have available. As a result, she suggested to divide the tasks to coordinate everyone’s efforts (see Figure 11). A4 tried to keep the process focused and organized and was leading the conversation.

Figure 11

Student A4 Organizing the Group Tasks

A4: We have to be finished by Monday by the way. Also writing the report. (…) Maybe we can divide some tasks? I would prefer writing.
A3: I would prefer not writing.
A4: Okay so you want to do ILS and I would do some writing and what would you like? (directed at A2).
A2: Probably writing.
A4: And what do you like? (directed at A1)
A1: Writing is about the theory? (quietly, almost inaudible)
A3: Writing would be about theory.
A2: Ok then A1 writes and I will do ILS with A3.
A4: You will give us an update when the ILS is done and we will write theories and then adapt them so that it will fit to their design.

A4’s problem-solving skills were also visible when the group faced challenges. For example, in week 6, the students talked about including a video of a violin and a bass scale to their learning environment. However, they only found a video of a violin. The group was unsure about where they could find a video of a bass scale. A4 suggested using AI to create

the video (see Figure 12). But there were doubts about the availability and cost of this idea. She quickly proposed another creative alternative.

Figure 12

Student A4 Proposing Solutions to the Group's Challenge

A4: I didn't even find a video of the bass scale, so I'm thinking you can create one with AI.
A2: There is a couple of AI that do video.
A3: Yeah? For free?
A2: (Laughing) I don't know. I can tell you the name of one in like 3 seconds (starts searching)
A4: I mean if someone has an instrument at home, we can also create it ourselves.
A3: My brother has an instrument.
A4: Maybe he can film him playing the violin scale or the bass scale?
A2: Sora?
A3: Sora is from OpenAI but it is not open yet. it's only for like few people.
A2: I thought it was open.
A3: Some people can use it but only specific people.

The group used the concept-map during weeks 4 and 6, where A4 usually lead the discussions and the documentation. In week 4, the group focused heavily on reducing uncertainties (see Table 5). A4 actively reduced uncertainty and did not ignore uncertainties at all. Week 6 had the highest number of uncertainty reduction for the group, and A4 reduced 8 times. However, in week 5 when the concept map was not used, there was a decrease in A4's efforts to reduce uncertainty. This change could indicate that without the visual help of the concept map, A4 might have found it more challenging to manage uncertainties effectively.

Despite her proactive behavior, A4's survey responses revealed emotional tension. In lecture 5, she noted: "I feel overwhelmed, as I think my other group members are more laid back than me. They do not mind finishing everything at the last minute, while it stresses me out." She expressed a similar feeling in lecture 3, where she stated, "I feel left alone, the others have another perception of what is important." These responses indicate that A4's proactive attitude conflicted with her peers' more relaxed attitudes, which caused her to feel isolated. Her emotional survey scores show that she felt moderately distressed, irritable, and nervous. This group dynamic is further illustrated in their group conversations. For example,

in week 6 when A4 noticed that a specific video had not been added to the learning environment as planned she expressed her disappointment and frustration (see Figure 13).

Figure 13

Student A4's Frustration with Group Responsibilities

A4: Okay um so we forgot to add the video for the um violin and bass scale.
A2: Yeah I know.
A4: Technically, you and A3 were responsible, so… (sounds disappointed and stressed)
A2: Yeah, yeah, yeah. (annoyed tone)
A3: Technically.

Another example happened in week 4. While A4 was actively doing research for their project on her laptop, her group members were discussing private topics. A2 looked at her and said: "Thank you, A4, for working for us (laughing)."

The negative feelings reported by A4 decreased over time. Her distress and irritability both decreased by 66.67 %, suggesting that her group members may have worked more effectively towards the end and made her feel more at ease. Additionally, A4 reported feeling 50 % more excited and 200 % more attentive, reflecting her continuous effort to reduce uncertainty. From the beginning, she consistently felt strong. Despite feeling isolated at times, A4 showed a continuous commitment to organize tasks and find solutions. Seeing that she could manage difficult situations may have boosted her confidence.

Framing. Throughout the project, A4 consistently positioned herself as an active leader. Although she felt alone at times due to her peers' more relaxed attitudes towards deadlines, she maintained her proactive role. The emotional friction that she experienced highlighted the challenges she faced. Nevertheless, her confidence in her leadership role remained strong, and drove her to actively manage uncertainties. A4's primary strategy for managing uncertainty was requesting information from her group members. This approach not only helped reduce uncertainty but also fostered a collaborative environment. She invited her peers to participate in the discussions. Her consistent use of this strategy reflects a stable

epistemological framing, where she viewed knowledge as a shared resource that should be co-constructed.

While A4 was persistent in reducing uncertainty, her self-efficacy score did not change at the midpoint of the project. The emotional situation within the group likely hindered an earlier increase. Although she effectively reduced uncertainty, this did not immediately translate into a higher self-efficacy score. However, by the end of the course, A4 experienced a significant increase in self-efficacy. Her persistence allowed her to see her own capabilities, despite the challenges she faced. By overcoming these obstacles and leading the group, her belief in her abilities was likely reinforced. Additionally, the group dynamics likely improved towards the end, which can be seen in her decreased feelings of irritation and distress. It is probable that in the end her peers began to take deadlines more seriously as they approached.

A4’s stable epistemological framing and strong positional framing as a leader enabled her to manage the complexities of the project, which ultimately boosted her confidence and reinforced her proactive approach in managing uncertainty. While A4's self-efficacy increased, her approach to managing uncertainty showed some changes. Table 6 shows that she initially increased uncertainty during the brainstorming phase, but primarily focused on reducing it as the project progressed. This indicates a slight shift in her overall strategies, but her specific tactic of asking questions remained consistent throughout.

4.3.3 Student E3

Group E created an online learning environment for a primary school mathematics lesson. The group's mean self-efficacy scores progressively increased from 2.78 to 3.05. This section focuses on student E3, whose confidence increased by 15 %. E3 started the course with a moderate perceived self-efficacy score of 2.6, which gradually increased to 3 by the end. She was proactive from the beginning by actively engaging in discussions, contributing

ideas, and taking the lead. E3 used several strategies to manage uncertainties, with a focus on reducing uncertainty through clear explanations. Below is a summary of her and her group's strategies across the lectures.

Table 7

Frequency of Uncertainty Management Strategies Employed by E3

Week	Reduce	Ignore	Maintain	Increase
4	9	0	0	3
5	11	0	1	1
6	9	0	1	0
7	4	0	0	1
Total	33	0	2	5

Table 8

Frequency of Uncertainty Management Strategies Employed by Group E

Week	Reduce	Ignore	Maintain	Increase
4	24	1	7	10
5	26	3	4	2
6	17	0	3	1
7	15	0	0	1
Total	82	4	14	14

E3 consistently reduced uncertainty across all lectures by providing clear explanations. Her efforts were especially visible in weeks 4 to 6. This pattern was also visible for the group as a whole. The following discussions show moments where E3's group mates expressed uncertainty. In response, E3 tried to reduce the uncertainty by explaining clearly. Figure 14 shows a conversation from week 5, where the students talked about the game they wanted to create. The game should explain easy mathematical concepts to small children. E4 expressed uncertainty, and E3 immediately responded with a clear explanation.

Figure 14

Student E3 Explaining the Game Concept

E4: I'm wondering if the game should be an interactive finished product that already kind of like- so in the beginning we wouldn't see the line right? Or we would just see this-
E3: I think for us the easy thing to do is to keep in mind that we want this story with the frog and the jumps and some parts we will do in Go-lab with fill in the blanks and some reflection things and the game will be a part for experimentation where they can jump around (...)
E4: Basically, that's my question. So the game would not explain the procedure?
E3: No (...) we just have to remind them and try to push them to ask their neighbor and see what he does and compare questions that's like deeper understanding and if you get stuck then ask mama frog and your neighbor.

Similarly, Figure 15 from week 5 shows a conversation between E3 and E4 about how to make the game suitable for children. Once again, E3 replied to E4's uncertainty with detailed explanations to reduce uncertainty.

Figure 15

Student E3 Explaining Learning Goals

E4: I just think it is weird. I think they are making it more complex than it is.
E3: What they are trying to do is make it understandable for them and they try to follow always the same steps, because they know if I follow these steps I get the right answer. Because the problem is this is surface learning for them. They don't understand it at all. They don't have any understanding of numbers and we want them to be able to get through this first step.
E4: That would be deep understanding?
E3: Yes, when they get this, then we can get to the deep understanding.
E4: Yeah.

E3's peak in reducing uncertainty is in week 5. This implies that her clear explanations and leadership played a role in navigating the design phase they were in. During this period, E3 expressed her growing confidence by stating "I feel confident that together we can come to a good solution if everyone participates and is open to discussions and compromise", and "I feel confident that we can manage." These statements reflect her belief in the collaborative process and the group's ability to overcome challenges. The use of the concept-map might have helped E3 visualize and organize her ideas, which likely contributed to her clear explanations. By explaining and writing on the concept-map, she might have helped the group

better understand their uncertainties and likely benefitted herself by clarifying her own thoughts.

E3's emotional states showed improvement over the course of the project. Initially, she felt distressed and upset, but these emotions decreased by 50 %, and 75 %. By the end of the course, she reported feeling these emotions very slightly or not at all. As her confidence grew, E3 also felt a lot stronger (+200 %) and more determined (+50 %). E3 felt more enthusiastic and inspired, with each emotion increasing by 50 %. This indicates a positive shift in her motivation, which can be seen in her explanation about why she felt more confident: "I got a bit more grip on the subject and positive results motivate." An example that illustrates her increased motivation and the positive feedback they received from their client can be seen in Figure 16. The conversation happened in week 6, where they discussed the feedback they got.

Figure 16

Student E3 Expressing Excitement about Feedback

E3: She said it would be absolutely perfect (…) She liked that this jump is bigger than the other ones because in our visual they were all the same and in the game they are different. (laughing) It's perfect! It's perfect! (excited tone)
(...)
E2: It looks so cool.
E3: It looks so cool!
E2: So good, yeah.
E4: It will be even better still.
E3: For like pilot testing this is fine, she LOVED it.
E4: I was having a lot of fun with it as well.
E3: This is REALLY cool.

Framing. E3 positioned herself as a leader in the group and took on a central role in terms of guiding the groups' discussions and the project's direction. Her epistemological framing is visible in her belief that knowledge is built collaboratively. This is reflected in her survey response where she emphasized the importance of active participation, open discussion, and compromise. Throughout the project, E3's primary strategy for managing uncertainty was to reduce it by providing clear explanations. Her peers often accepted her

explanations without much questioning, likely because she was one of the oldest among her peers. This reinforced her positional framing as a knowledgeable member of the group. Her ability to provide clear explanations likely made it easier for her peers to understand the material.

E3's survey response showed that the positive group dynamics, such as praising each other's contributions, boosted her confidence and motivation. For instance, the group's positive reaction to the game design and their excitement about the feedback they received created a supportive environment. E3's positive attitude and proactive approach to managing uncertainty likely contributed to the group's overall motivation. Thus, she fostered a positive and collaborative environment.

Her initial self-positioning as a leader remained consistent and was reinforced by the group dynamics. Her stable epistemological framing of knowledge as a collaborative resource, combined with her strong positional framing as a leader, enabled her to manage the complexities of the project. Despite the initial moderate confidence, her persistent efforts in reducing uncertainty and leading the group contributed to a significant increase in her self-efficacy. Like student A4, E3 showed a slight change in her uncertainty management. As shown in Table 7, she initially increased uncertainty during the brainstorming phase, but primarily focused on reducing it as the project progressed. This indicates a slight shift in her general strategies, but her specific tactic of explaining clearly remained stable.

5 Discussion

The primary objective of this study was to investigate the influence of scaffolds on master students' self-efficacy in managing uncertainty during their collaborative problem-solving project. Concept-maps and reflection prompts were introduced to the students as a way of helping them articulate their uncertainties. The combination of quantitative and qualitative data allowed for a thorough exploration of self-efficacy, uncertainty management

and emotional states. In general, the findings showed that students experienced an increase in self-efficacy and an improvement in emotional states over time. Across all teams, the use of scaffolds appeared to help students navigate and articulate uncertainties. Notably, females and students below 25 years showed the greatest gains in self-efficacy.

The first notable finding was that all student teams often experienced challenges and uncertainties while working together. This observation from the qualitative data is in line with the notion that uncertainty is an inevitable part of group projects (Jordan, 2015). This finding underscores the importance of guiding the students through uncertainty management (Chen, 2020).

As the teams navigated uncertain situations with the support of the provided scaffolds, their perceived self-efficacy in working on the collaborative problem-solving activity and managing the inherent uncertainties increased. When looking at the results of the PANAS surveys (Watson et al, 1988), it was interesting to see that they revealed a general pattern of improved positive emotions and decreased negative ones. This finding aligns with Ahmad and Safaria's (2013) statement that students with low self-efficacy experience negative emotions more often than students with higher self-efficacy. In line with this, the data of the current study shows that, as the students became more confident in dealing with uncertainty, they experienced fewer negative emotions. The discussion of emotions is relevant because these emotional changes might reflect shifts in uncertainty management and self-efficacy. Although emotional states are not explicitly mentioned in the research questions, they provide important context for understanding how the scaffolds influenced students' self-efficacy in managing uncertainty. This positive trend is not only visible for the overall emotional states of the students, but also for specific feelings that can be interpreted as linked to self-efficacy and uncertainty management. With regards to self-efficacy, pride and strength both showed significant increases over time. The students likely felt stronger and prouder at the end of the

course from seeing their vision come to life and realizing that they reached their goal, despite the challenges and uncertainties they faced along the way. Essentially, the increase in strength could reflect the students' growing belief in their ability to overcome obstacles and uncertainties (Bandura, 1982). Meanwhile, feeling prouder could be a sign that participants recognized their abilities as they nearly reached the end of the course with success. Moreover, there was an increase in several emotions related to motivation, such as determination, and inspiration. While these did not show statistical significance, it is worth including them in the discussion because they are relevant in the context of uncertainty management. That is, because motivation drives students to engage with uncertainties. Hence, this might imply that as the students became more confident in their abilities to deal with uncertainty, they also became more determined and inspired to take on challenges.

Given the improvement of participants' confidence levels and the emotions related to these concepts, it was of interest to investigate whether there were any changes in the ways they managed uncertainty during that time frame. Discussing the general strategies students used to manage uncertainty (reduce, increase, maintain, ignore) provides context for understanding how concept-maps and reflection prompts might have influenced their behavior in managing uncertainty which is relevant to RQ1. The data about the general strategies gathered from coding the observation notes show that reducing uncertainty was the most popular approach during the whole duration of the observations. This proactive pattern suggests that the participants managed to consistently focus on resolving problems and making sure they work towards their goals. A possible explanation for this tendency may be the fact that the course was an elective (Ulusoy et al., 2012). This means that the students chose to enroll, as they were genuinely interested in the topic. In that case, it makes sense to believe that they were generally proactive due to their interest in the task. This general behavior is in line with the observation that ignoring uncertainty was the least used strategy.

As a matter of fact, the situations in which uncertainty was ignored came almost entirely from two students, meaning that most students engaged with uncertainties rather than avoid them. It is also important to acknowledge that maintaining and even increasing uncertainty were prominent, especially in earlier lectures. This observation is consistent with Jordan & McDaniel's (2014) notion that the early stages of group projects often consist of increasing and maintaining uncertainty, as they are brainstorming multiple ideas. Increasing ambiguity naturally decreases as the project becomes more focused. The findings seem to represent a natural progress of a team task (Jordan & McDaniel, 2014). In the early phases of the project, students placed more value on the concept-maps and reflection prompts compared to later sessions. They used the scaffolds longer during brainstorming sessions. These tools supported the maintenance and exploration of uncertainty, helping students generate and organize ideas. This is an essential phase for learning, as emphasized in the theoretical framework. However, as the project advanced, the scaffolds were used less frequently. While they initially facilitated brainstorming and the exploration of ideas, students became less reliant on these tools as their confidence grew and as their project moved towards resolution.

To explore this further, the next part of the discussion focuses on the more specific tactics for managing uncertainty, that exist within these underlying strategies. The thematic analysis of the open-ended surveys has shown that the most common ways students responded to uncertainties were the following: asking help from teachers and peers, engaging in group discussions and brainstorm sessions, dividing responsibilities, using external resources, and reflecting. Interestingly, there seem to be overlaps between the tactics seen in the current study and the propensities for managing uncertainty identified by Jordan (2015). As previously mentioned, these propensities include "Request Help", "Seek a Plausible Explanation", "Take Action", "Pause for Reflection", and "Deny Uncertainty" (Jordan, 2015). For example, the tactic of seeking help from teachers and peers connects to the tendency of

requesting help (Jordan, 2015). Equally, the approach to reflect overlaps with the tendency of pausing for reflection (Jordan, 2015). The tactics identified in this research were not influenced by Jordan's (2015) propensities. In fact, they naturally emerged from the qualitative data. Since the findings align by chance, the grouping of Jordan's framework is validated (Jordan, 2015). However, it is important to highlight that Jordan's (2015) findings came from a school context with fifth graders engaging in a robotics design challenge. The current study took place in a different context with master students working on an open-ended technology-enhanced learning design activity. This suggests that Jordan's (2015) findings might apply in different educational contexts.

The qualitative analysis provided further understanding on how students managed uncertainty by focusing on three individuals who experienced the greatest increase in self-efficacy over time. Individual uncertainty management strategies were examined to bring together different elements, like emotions and group dynamics, to build a clearer picture of how self-efficacy developed throughout the project. According to the findings, each focus individual had one primary and consistent way of dealing with uncertainty: A first student primarily avoided uncertainty (ignore), another mainly sought information from peers (reduce), and a third focused on providing explanations to group members (reduce). Student A1 experienced a slight shift in her uncertainty management from solely avoiding uncertainty to occasionally asking her peers for confirmation. Generally, students with low self-efficacy tend to avoid uncertainty (Schunk, 1989) and not participate in group activities (Zimmerman, 1995). This was evident for A1 at the very beginning, where her self-efficacy was at the lowest. She was very hesitant to take part in discussions. According to Zimmerman (1995) students with higher self-efficacy are more motivated to overcome challenges and more likely to participate. As A1's confidence increased, her participation indeed showed a slight improvement, although her main tactic for managing uncertainty remained avoidance. For A4

and E3, however, the specific tactics for managing uncertainty did not reveal notable changes. This observation implies that as students became more confident, their specific strategies did not necessarily change. Rather, their tactics remained stable, but they felt more confident in employing them.

Throughout the course, several factors contributed to the changes in self-efficacy to manage uncertainty. Among others, these include acceptance and support from group members, familiarity with the project, and collaboration. The discussion of group dynamics and collaboration is relevant to understanding how students' self-efficacy evolved in different contexts. In RQ1 and RQ2, the role of scaffolds and teamwork were assumed to influence students' confidence in managing uncertainty. The findings from the focus individuals support the idea that positive group dynamics and collaboration were vital in shaping the students' confidence. For example, A1's group members consistently provided support and recognized her efforts, which helped A1 position herself as a more valued and active member. Student A4 maintained a strong positional framing (Kaur & Dasgupta, 2024) as a leader, which aligned with her high self-efficacy and proactive approach for managing uncertainty. However, when the group dynamics did not seem to be supportive and engaging, her confidence was challenged. This was visible in the second survey where her score was stagnant. In the very end, it strongly increased as the group dynamics likely improved. Finally, student E3 believed that knowledge is constructed collaboratively. She felt more motivated to manage uncertainty when the group encouraged open discussion. Similar to Jordan & McDaniel (2014), these findings emphasize the importance of positive group dynamics. The data suggests that supportive collaboration is a key element to manage uncertainty and support self-efficacy in collaborative problem-solving environments.

While group dynamics and framing were important in boosting students' confidence, the use of scaffolds also likely contributed to that increase. The primary research question

(RQ1) explored how the use of concept-maps and reflection prompts influenced master students' self-efficacy in managing uncertainty during collaborative problem-solving. Rafaeli and Kent (2015) note that concept-maps are often used for brainstorming. In the present study, they were mainly used to brainstorm and to plan their project. The reflection prompts helped them initiate their discussions. The additional verbal prompt of the teacher to highlight their uncertainties on the concept-map, further encouraged articulation of what they were unsure about. This shows that the tools were used like it was initially intended. The fact that the concept-maps divided the uncertainties into more manageable pieces and the reflection prompts encouraged discussions about uncertainties, likely led to easier uncertainty management. As a result, their confidence in dealing with the uncertainty likely improved because it got less overwhelming. Other than that, several observations in class showed that students saw a value in using these tools. For instance, several students took pictures of their concept-maps before they were collected and asked for additional sheets when theirs were full. Moreover, an interesting observation during coding was that a group revisited their initial ideas. As they looked at their concept-map, they realized they had previously written an interesting idea, turning out to be the solution to their problem.

It is also valuable to mention that students only used the concept-maps when they were prompted to do so by the teacher. This highlights the importance of regular reminders to use it. Although this research is exploratory and cannot make a direct correlation, it is likely that these scaffolds contributed to increases in self-efficacy.

To address RQ2, which examined how the influence of the scaffolds varied across different student teams, the quantitative analysis showed a significant increase in self-efficacy for all teams. This finding suggests that the possible influence of concept-maps and reflection prompts on their confidence in managing uncertainty was visible across all teams. The fact that concept-maps can help students structure complex information (Novak & Canas, 2008)

and reflection prompts can initiate discourse (Menekse et al., 2022), could explain why these scaffolds might have been effective in this context of collaborative problem-solving.

With regard to RQ3 and RQ4, the findings revealed that different student demographics (females, males, aged <25, aged ≤ 25) experienced significant increases in their self-efficacy. However, males started with a higher self-efficacy score than females. At the end of the course, the difference remained, but was far less prominent as the increase for females was double compared to their male peers. This could indicate that the concept-maps and reflection prompts may have had a bigger influence on female students regarding their self-efficacy. Females often have lower self-efficacy compared to males (Kalender et al., 2020), so concept-maps and reflection prompts might have provided them with extra support to help build their confidence. Moreover, the same pattern was visible for students of different ages. Students above 25 years showed higher self-efficacy scores across all three data points. This could be the case because they have more experience in dealing with challenging situations (Pajares & Miller, 1994). However, students below the age of 25 showed a higher increase in self-efficacy, leading to a more narrow gap in the end. This might imply that the scaffolds were especially helpful for younger students. As they have less prior experience in managing uncertainty, concept-maps and reflection prompts might have been helpful to facilitate this process, thereby increasing their confidence.

In conclusion, while group dynamics and framing played a big role in shaping students' confidence, the use of the scaffolds likely had an influence, too. The combination of these tools with positive group dynamics created a supportive learning environment, where the students are encouraged to engage with uncertainty. This emphasizes the idea that teachers should foster positive team dynamics and scaffold uncertainty management.

6 Limitations and Directions for Future Research

While the current study offered useful results, it is important to recognize its limitations. The first limitation is the relatively small sample size of 23 participants. Although the combination of quantitative and qualitative data enhanced the quality of the results, the statistical validity and reliability can be impacted. Future research should aim to increase the sample size in order to strengthen the generalizability of the findings. Another limitation is that not all respondents chose to answer the open-ended survey questions they received per e-mail. Although it was beneficial that at least one student from each group replied, the information was restricted. Further research should address this by conducting the surveys during the class. This would most likely increase the number of answers.

Moreover, there were several limitations connected to the observations. Firstly, the data collection focused solely on verbal interactions and excluded gestures. Unfortunately, that was not feasible to do in the current study. Jordan & McDaniel (2014) highlight the importance of gestures in the context of uncertainty management because they can indicate uncertain moments. It is suggested that future research takes that into account. Second, there were students missing on a regular basis. On one occasion, an entire group was absent, which affected the quality of the data. Additionally, most of the students' group discussions happened outside of the classroom. As a result, many key interactions were not analyzed. What's more, as the course progressed, their conversations became less focused. For instance, in the last lecture the conversations included many private interactions as the students did not have much left to discuss. This caused the smaller numbers of codes applied in week 7, which impacted the validity of the findings. Figure 17 illustrates this limitation. It captures a conversation from group E in week 7, where they note that their discussions in the classroom are just secondary.

Figure 17

E3: I think our group work discussion is like random today (laughing).
E4: But we do have a lot of things (inaudible).
E3: Yeah, but we did all of that before class, we did all of that in the last 2 hours.

Moreover, the number of observed group sessions was limited. Future studies should aim for more than four sessions to capture more interactions and behaviors. This would ensure a better understanding of group dynamics and progression of uncertainty management strategies.

As reported in the discussion section, it is difficult to determine whether the observed changes in self-efficacy are in fact due to the introduction of concept-maps and reflection prompts or whether that is the result of other factors. The findings of this study can only suggest that scaffolds may have contributed to the increase in self-efficacy. An interesting avenue for future research would be to add a control group in order to compare changes in self-efficacy between the scaffolded group and the control group. Lastly, future studies could refine the learning tools and investigate different variations of them. For instance, they could consider different types of prompts or concept-map activities. Another option would be to introduce other scaffolds. This would provide valuable data to teachers and as a result, they could better support students in dealing with uncertainty.

Finally, it is important to note that the study assumes that students above 25 years have more experience. This is an assumption that should be addressed, as actual experience data was not collected.

7 Conclusion

This research investigated the impact of concept-maps and reflection prompts on master students' self-efficacy in managing uncertainty during collaborative problem-solving. Through the mixed-methods approach, data from surveys, observations, and audio recordings suggest that the scaffolds might have contributed to the students' increase in self-efficacy and

improvement in emotional states. The results revealed significant increases in self-efficacy across all measured groups, including the class, teams, gender and age groups. This growth in self-efficacy was visible in students' emotions as many reported feeling stronger and prouder. The results indicate that the scaffolds might be especially useful for slightly younger students. They generally started with lower confidence and showed the most growth, suggesting that the scaffolds were especially beneficial for the ones with less experience (Pajares & Miller, 1994). The concept-maps and reflection prompts were particularly useful in the early stages of the project when brainstorming and idea generation were most needed. The scaffolds facilitated their discussions and helped organize and plan the project visually. Although they were not used in every group discussion, the findings show that many students perceived them as valuable. In week 4, students were told to work with the scaffolds for 15 minutes but ended up using them for the whole 45-minute session. This implies that the scaffolds might be most useful at the beginning of a group project, when many options are still open. In terms of uncertainty management, students primarily employed strategies to reduce uncertainty, such as asking questions and seeking expert advice, while they rarely ignored uncertainty. Strategies like maintaining and increasing uncertainty were more common at the beginning of their group project, so they slowly lead towards the direct resolution of problems to achieve the end goal.

Finally, it is essential to note that positive group dynamics helped students manage uncertainties, which aligns with Jordan & McDaniel's (2014) findings that positive peer responses positively influence uncertainty management. Overall, this thesis shows that concept-maps, reflection prompts and supportive group environments enhance the management of uncertainty and self-efficacy in educational settings. This research clearly has some limitations. Nevertheless, the results offer useful information for teachers who want to foster effective collaboration and improve the learning experience of their students.

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Appendices

Appendix A

General Self-Efficacy Survey Instrument (Modified Version)

Name:

Self-efficacy Survey (2)

	Not at all true	Hardly true	Moderately true	Exactly true
1. I can always manage to solve difficult problems during collaborative problem-solving if I try hard enough.	☐	☐	☐	☐
2. If someone in my team opposes me, I can find the means and ways to get what I want.	☐	☐	☐	☐
3. It is easy for me to stick to my aims and accomplish my goals, even when I face uncertainties.	☐	☐	☐	☐
4. I am confident that I could deal efficiently with unexpected events during collaborative problem-solving.	☐	☐	☐	☐
5. Thanks to my resourcefulness, I know how to handle unforeseen situations during collaborative problem-solving.	☐	☐	☐	☐
6. I can solve most problems occurring during collaborative problem-solving if I invest the necessary effort.	☐	☐	☐	☐
7. I can remain calm when facing difficulties during collaborative problem-solving because I can rely on my coping abilities.	☐	☐	☐	☐
8. When I am confronted with a problem in a team setting, I can usually find several solutions.	☐	☐	☐	☐
9. If I am in trouble during the collaborative task, I can usually think of a solution.	☐	☐	☐	☐
10. I can usually handle whatever comes my way during collaborative problem-solving.	☐	☐	☐	☐

Appendix B

Positive and Negative Affect Schedule (PANAS) Survey Instrument

Name: _____

This scale consists of a number of words that describe different feelings and emotions related to the group project in this course. Read each item and then mark the appropriate answer in the space next to that word.

Indicate to what extent you felt in the **past few weeks**:

	Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
Interested					
Distressed					
Excited					
Upset					
Strong					
Guilty					
Scared					
Hostile					
Enthusiastic					
Proud					
Irritable					
Alert					
Ashamed					
Inspired					
Nervous					
Determined					
Attentive					
Jittery					
Active					
Afraid					

Name: _____

This scale consists of a number of words that describe different feelings and emotions related to the group project in this course. Read each item and then mark the appropriate answer in the space next to that word.

Indicate to what extent you feel **at the moment**:

	Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
Interested					
Distressed					
Excited					
Upset					
Strong					
Guilty					
Scared					
Hostile					
Enthusiastic					
Proud					
Irritable					
Alert					
Ashamed					
Inspired					
Nervous					
Determined					
Attentive					
Jittery					
Active					
Afraid					

Appendix C

Open-Ended Survey Questions

Questions:

Thank you for participating in this short survey. It consists of 3 open questions that aim to capture 1) the uncertainties you face in your group project and 2) how you manage your uncertainties.

You may use one (or more) of the following phrases in your response.

Our biggest concern right now is …

One uncertainty we keep coming back to is …

We are not sure about handling …

We found it challenging to …

When faced with new uncertainty, we feel …

When solving a difficult problem, we doubt our ability to …

Name: _____

(Your data will be processed anonymously. Your name will just help me in the beginning to map you to the groups and organize the data. Then, I will use code names. No one else will see your name.)

1)Use one or more phrases from above to reflect on your own and group's uncertainties from working on your project this week.

2) How did you manage the uncertainties?

3) When faced with new challenges during collaborative problem-solving, I feel …

Appendix D

Informed Consent Forms

Consent Form for: The influence of scaffolds on master students' self-efficacy in managing uncertainty during collaborative problem-solving

YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read and understood the study information dated 13/02/2024, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	□	□
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	□	□
I understand that taking part in the study involves answering 3 questionnaires, being observed during group-discussions, participating in group interviews, and having the discussions audio-recorded in case observation notes need clarification.	□	□
Use of the information in the study		
I understand that information I provide will be used for a master's thesis project	□	□
I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team.	□	□
I agree that my information can be quoted in research outputs	□	□
I agree to be audio recorded	□	□

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Appendix E

Information Sheet

Information Sheet

The purpose of this research is to explore the influence of scaffolds on master students' self-efficacy in managing uncertainty within collaborative problem-solving environments.

Self-efficacy refers to an individual's belief in his or her capacity to execute behaviors necessary to produce specific performance attainments.

There are no risks associated with this research and this research project has been reviewed and approved by the BMS Ethics Committee.

If you would like to withdraw from the study at any point please contact one of the researchers on this project (details mentioned below).

During the research no personal information will be collected. Any personal information will be anonymized. All data will be destroyed after 5 years. Safety will be ensured by anonymizing all the data and only the researchers mentioned in this list will have access to the data.

Researchers:

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Appendix F

Team Compositions

Gender and Age of the Students

Group	Student 1	Student 2	Student 3	Student 4
A	Female (23)	Male (26)	Male (23)	Female (24)
B	Female (29)	Male (25)	Female (25)	Male (28)
C	Female (25)	Female (23)	Female (22)	Male (38)
D	Male (33)	Female (24)	Female (23)	Female (22)
E	Female (23)	Female (23)	Female (31)	Male (32)
F	Male (25)	Male (22)	Male (35)	/

Note. The fourth student in group F did not participate in the study.

Appendix G

Markers of Uncertainty (Jordan & McDaniel, 2014)

Marker	Explanation	Examples
Paralinguistic markers	Non-verbal cues that reflect hesitation, uncertainty, or doubt.	Pausing (pauses before or during speaking), filler words (“um”, “uh”), rising intonation at the end of statements (“we could try this?”), lower volume in tone, breaking up sentence (“I mean- I mean- we could try-“)
Linguistic markers	Verbal expressions that explicitly or implicitly indicate uncertainty or doubt.	“I don’t know”, “I’m not sure”, “I have no idea”, “Maybe”, “Perhaps”, “I guess”

Appendix H

Results of the Positive and Negative Affect Schedule (PANAS)

One-way Repeated Measures ANOVA, Changes in Emotional States, n = 21

Emotion	"Past few weeks"	"At the moment"	p-value	Effect-size (η^2_G)
Nervous	2.24	1.52	.000188***	.12
Proud	2.81	3.43	.002**	.11
Distressed	2.19	1.71	.004**	.08
Strong	2.57	3.19	.015*	.06
Ashamed	1.38	1.14	.021*	.06
Guilty	1.57	1.29	.055	.04
Upset	1.76	1.38	.057	.05
Determined	2.95	3.29	.090	.02
Afraid	1.52	1.29	.096	.03
Inspired	2.81	3.10	.110	.04
Irritable	2.00	1.67	.110	.04
Jittery	1.76	1.48	.110	.03
Scared	1.38	1.19	.162	.03
Attentive	2.67	2.95	.229	.02
Hostile	1.10	1.14	.329	.01
Alert	2.29	2.14	.419	.01
Interested	3.24	3.14	.428	.01
Enthusiastic	2.95	3.05	.629	.003
Active	3.05	2.95	.666	.003
Excited	2.90	2.90	/	/

Note. ***p < .001, ** p < .01, * p < .05