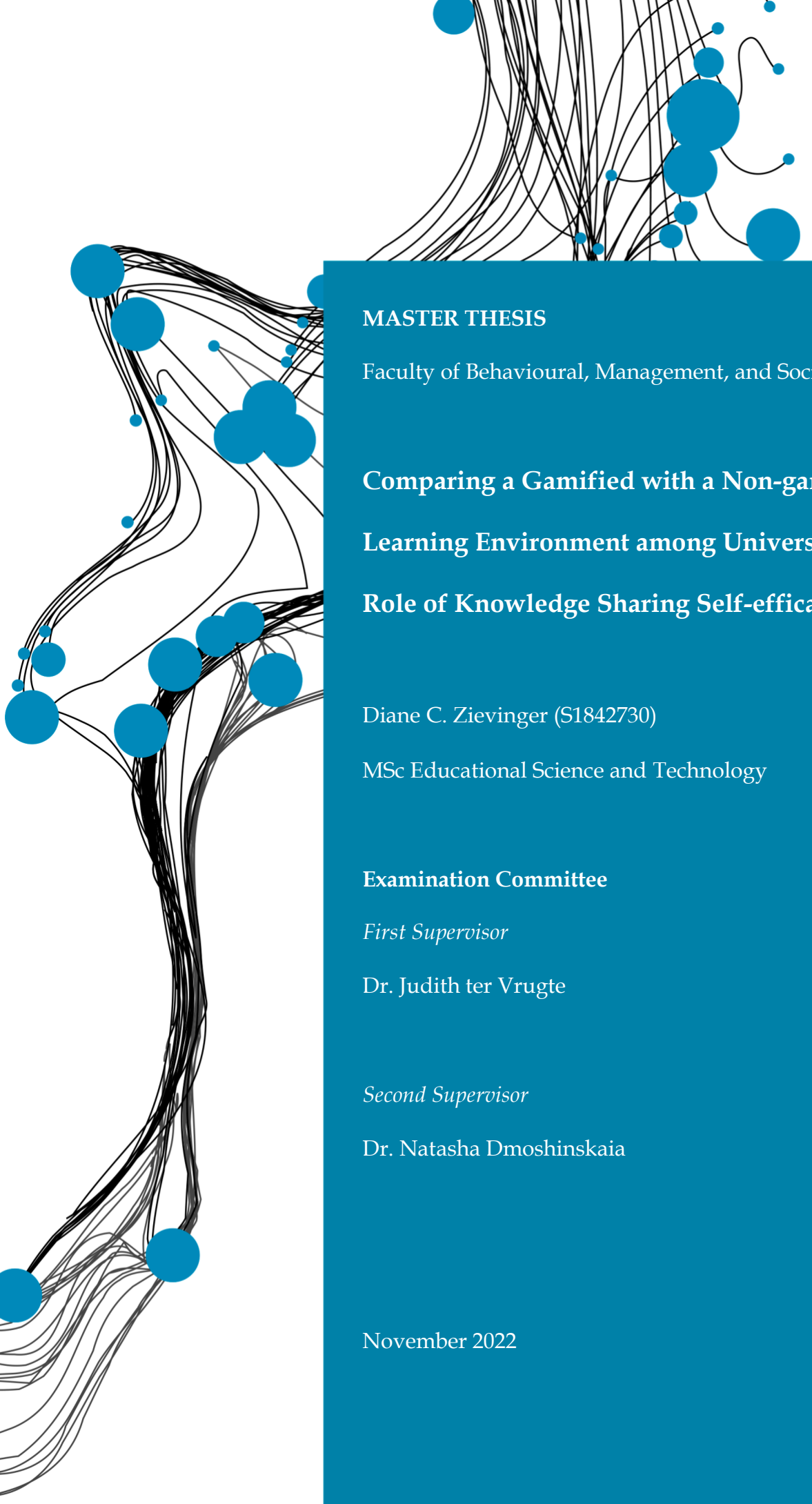

MASTER THESIS

Faculty of Behavioural, Management, and Social Sciences

Comparing a Gamified with a Non-gamified Collaborative Learning Environment among University Students: The Role of Knowledge Sharing Self-efficacy

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Abstract

Instructing students how to engage in good quality collaborations and the integration of avatar and badge game features in a collaborative learning environment can lead to better collaborations. However, students with a perception of having insufficient ability and confidence to share knowledge with others (i.e., Knowledge Sharing Self-Efficacy, KSSE) could impact the effectiveness of the provided instruction and integration of gamification for good collaboration. This study aimed to investigate to what extent this is the case. More specific, it examined to what extent the integration of avatar and badge game features in a collaborative learning environment (gamified vs. non-gamified condition) influenced the collaboration behaviour among university students, and how KSSE influences the student's collaboration behaviour in a gamified and a non-gamified condition. To study this, a quasi-experimental design, comparing a gamified condition and a non-gamified condition during two consecutive assignments, was followed. The sample consisted of 176 first-year Psychology students from a Dutch University. All students had to complete two collaborative assignments and received collaboration instruction, but for 81 students this was gamified (experimental condition). Results indicated that students in the non-gamified condition had a slightly higher collaboration behaviour. Further results showed no differences between the conditions and individual grades, group grades, and collaboration perception. It was also found that KSSE did not affect collaboration behaviour. Possible justifications, limitations, and implications for future studies are considered.

Keywords: university students, collaboration, gamification, grades, Knowledge Sharing Self-Efficacy, collaboration perception

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Comparing a Gamified with a Non-gamified Collaborative Learning Environment among University Students: The Role of Knowledge Sharing Self-Efficacy

Courses at Dutch universities involve a high degree of collaborative assignments (Lange et al., 2018). Collaboration can be defined as people collectively engaging in an organized manner to jointly solve a problem (Roschelle & Teasley, 1995). Having good quality collaboration can enable students to experience cognitive and behavioural benefits from their collaborative assignments (Chan, 2001; Eshuis et al., 2019; Farivar & Webb, 1994; Saab et al., 2007; Webb, 1995). However, the quality of collaboration might be affected by the Self-Efficacy of the students.

Self-Efficacy can be defined as an individual's perceived ability to carry out future tasks (Bandura, 1994; Shaari et al., 2014; Zimmerman, 2000). Collaboration research often discusses a specific type of Self-Efficacy, namely Knowledge Sharing Self-Efficacy (KSSE; van Acker et al., 2014; Bandura, 1994; Ergün & Avcı, 2018; Hsu et al., 2007; Kankanhalli et al., 2005; Tseng & Kuo, 2014). Individuals with insufficient KSSE are less confident about their knowledge-sharing abilities in solving a problem, and hence are less likely to share knowledge with others (Bandura, 1994; Ergün & Avcı, 2018; Hsu et al., 2007; Kankanhalli et al., 2005; Tseng & Kuo, 2014). As a result, the teamwork will be less effective (Chan, 2001), and students within the team will make more effort to complete the task or fail the task altogether (Rummel & Spada, 2005). Currently, there is limited knowledge on how to effectively mitigate the negative impact of KSSE on collaboration. It might be that gamification offers a solution. Gamification is defined as adding game-like features to an environment that is not a game in order to enable engagement and change of behaviour (Robson et al., 2015). Gamification in the environment enables students to feel safer (Huang & Soman, 2013; Lee & Hammer, 2011) and engage further in collaborations (Alsawaier, 2018; Ding et al., 2018; Knutas et al., 2014). Additionally, according to Bandura (1986),

individuals with an insufficient KSSE can overcome low confidence in their perceived abilities when they receive support and are externally encouraged through the environment. This can potentially lead them to engage in desired behaviours such as good collaboration. Thus, it is relevant to understand how university students could be appropriately supported to engage in good collaboration, especially those with insufficient KSSE. This will likely benefit university-related parties and research in the educational field.

Good Collaboration Behaviour

Several studies have defined good collaboration behaviour as individuals who engage in seeking to understand each other, raise questions, elicit explanations, and share knowledge (Chan, 2001; Eshuis et al., 2019; Farivar & Webb, 1994; Saab et al., 2007; Webb, 1995), encourage others, (Eshuis et al., 2019; Farivar & Webb, 1994; Saab et al., 2007; Webb, 1995), decide together, and respect each other (Eshuis et al., 2019; Farivar & Webb, 1994; Saab et al., 2007). To help students develop an understanding of what exemplifies good collaboration, students can be provided with instructions on how they can engage in effective teamwork and discussion (Eshuis et al., 2019; Rummel & Spada, 2005; Saab et al., 2007). Studies conducted by Eshuis et al. (2019) and Saab et al. (2007) have shown that student collaboration can be improved through the instruction of four main collaboration characteristics: Respect, Intelligent collaboration, Deciding together, and Encouraging (RIDE).

Even though providing students with instructions on how to engage in good collaboration showed promising results (e.g., Eshuis et al., 2019; Rummel & Spada, 2005; Saab et al., 2007), not all students might benefit equally from it. Particularly, as the effectiveness of engaging in collaboration might be influenced by the strength of students' Self-Efficacy (Roschelle & Teasley, 1995). More specifically, individuals who feel capable

and confident in a task (i.e., high perception of Self-Efficacy) will be more willing to solve a problem. They will also consider the task as a challenge that they can master, and hence, more likely to engage in it. Contrastingly, individuals who do not feel capable and confident in a task will be less open to solving a problem as they may consider the task as a risk and will therefore more likely avoid it altogether (i.e., low perception of Self-Efficacy) (Bandura, 1994; Pajares, 1996). Thus, Self-Efficacy can either negatively or positively affect their engagement in jointly solving a problem, (i.e., collaboration; Roschelle & Teasley, 1995) and the tasks that individuals want to take (i.e., behaviour; Ajzen, 2002; Bandura, 1994).

Knowledge Sharing Self-Efficacy

According to Bandura (1994), the best manner to predict an individual's future behaviour is to specify Self-Efficacy to the situation. Within the context of collaborative learning, researchers have zoomed in on a specific type of Self-Efficacy, namely, Knowledge Sharing Self-Efficacy (KSSE). KSSE can be defined as an individual's perception of their ability to share knowledge with others (Bandura, 1994; Tseng & Kuo, 2014). Within the existing literature, KSSE has been considered a key determinant of collaboration behaviour among group members. More specifically, several studies have shown that individuals with an insufficient KSSE (i.e., low confidence in their perceived abilities) are less likely to share knowledge than individuals with sufficient KSSE (i.e., higher confidence in their perceived abilities; van Acker et al., 2014; Bandura, 1994; Ergün & Avcı, 2018; Hsu et al., 2007; Kankanhalli et al., 2005; Tseng & Kuo, 2014). Hence, group members with an insufficient KSSE will be naturally less collaborative as they will be less prone to share knowledge with others (Ergün & Avcı, 2018; Hodgkinson, 2006). This is problematic since groups rely on each other's knowledge to effectively complete collaborative assignments (Johnson & Johnson, 1992). Consequently, a lack of knowledge sharing can lead to negative outcomes

for the group, for example, causing them to be less effective or even fail the project altogether (Ismail et al., 2013). Therefore, to minimize these consequences and enable students to engage in good collaboration, individuals with insufficient KSSE could be externally encouraged by considering the environments where they do tasks and providing them with support (Bandura, 1986). The integration of gamification within the collaborative environment could support students with insufficient KSSE.

Gamification in Collaborative Learning Environments

Since individuals with a low perception of Self-Efficacy consider tasks as a risk (Bandura, 1994; Pajares, 1996), gamification can contribute to the individual's perception of a safe environment which can benefit the assessment and development of their behaviour (Boller, 2017; Huang & Soman, 2013; Lee & Hammer, 2011). Avatars seem to be the most suitable game feature as it enables students to feel safer in the environment (Huang & Soman, 2013; Lee & Hammer, 2011), be more proactive when doing tasks (Aldemir et al., 2018; Alsawaier, 2018: Lee & Hammer, 2011), and collaborate more effectively (Alsawaier, 2018). An avatar game feature is a visual computer-generated form used within online environments (Gillen, 2017). Avatar game features reflect an individual's computer-generated form (Antonaci et al., 2019) which is freely created by the individual (Polo-Peña, et al., 2021) and reflects their persona (Bjork & Holopainen, 2004).

Additionally, studies have suggested that providing students with instructional support might not be enough for them to engage in learning activities and experience its potential benefits (e.g., Challco et al., 2016; Lee & Hammer, 2011; Warden et al., 2013). To support these students further, gamification could be integrated into the educational environment. Gamification has been shown to help students be more engaged in learning activities (Alsawaier, 2018; Kiryakova, et al., 2014; Lee & Hammer, 2011; O'Donovan, et al.,

2013) and improve student collaborations (Alsawaier, 2018; Ding et al., 2018; Knutas et al., 2014) when integrated within the educational environment. From the game features, badges which are visual accomplishments (Hickey, 2017) have been shown to positively affect student engagement. Mainly because badges serve as a reward to individuals when they have achieved a goal (Antonaci et al., 2019) such as reaching a specific skill level (Kiryakova, et al., 2014). As badges enable individuals to view and share their accomplishments (Knutas et al., 2014; Lounis et al., 2014; Richter et al., 2015; Schunk, 1989), feel rewarded for their efforts (Ibanez, et al., 2014; Lee & Hammer, 2011; Schunk, 1989), and see their progress over time (Aldemir et al., 2018; Richter et al., 2015; Schunk, 1989). Hence, students in general could benefit from gamification.

The combination of avatars and badges can encourage students to modify their behaviour, because avatars enable students to see the performance of computer-generated forms through badges (Muntean, 2011). Moreover, both avatars and badges can stimulate students to engage in discussions (Huang et al., 2019; Knutas et al., 2014), and exert higher levels of collaboration behaviour (Boller, 2017; Ding et al., 2018; Knutas et al., 2014; Lee & Hammer, 2011; Morschheuser et al., 2017).

Additional benefits of gamification on the student's collaboration have been mentioned by different studies. More specifically, given that the integration of gamification elements can improve collaboration behaviour, students might be better able to bond together and contribute to a group project, leading them to more likely have a positive collaboration perception. On the other hand, challenges such as group members scarcely contributing to a group project (i.e., free riding) will more likely lead to a negative student collaboration perception (Pfaff & Huddleston, 2003). Aside from collaboration perception, gamification has also been shown to positively affect student grades. In Moreno-Guerrero et al. (2020), students within a gamified environment who engaged in collaborative behaviour were more

likely to have higher grades compared to students who engaged individually in traditional methods such as teachers citing textbooks and providing textbook activities. Students who used badge elements in a gamified condition had higher grades compared to students in the non-gamified context (O'Donovan et al., 2013).

Present Study

From the aforementioned, it can be deduced that providing students with information about what constitutes good collaboration can lead to better collaboration. But the effectiveness of the support might suffer from student engagement. Specifically, for the type of support during collaboration, adding avatars and badges might be effective. These features promote students' perception of safety and could encourage them to be more proactive. As a result, students are likely to collaborate more effectively which translates to better communication, more positive collaboration perception, and better grades. Though instruction and gamification might be beneficial for all students, those with an insufficient KSSE could especially benefit from this.

The current study is a reaction to the above. Its aim was twofold. First, investigate the difference in university students' collaboration behaviour perception within a gamified and non-gamified collaborative learning environment. Second, examine how KSSE can affect the collaboration behaviour perception of students within the gamified and non-gamified collaborative learning environment. The outcomes could provide scientific insights into the distinctive combination of gamification, collaboration, and KSSE which to the best of the researchers’ knowledge has not been investigated to date. Additionally, the results could advance practical insights into how teachers can effectively support students’ online collaboration in a university.

To achieve these goals, this study focused on university students who worked on two successive collaborative projects that were part of their regular curriculum. Two groups of students were created and compared: a student subgroup that made an avatar passport that included avatars and badges and a student subgroup that did not have to do this gamified feature. The students' KSSE was collected before the collaborative assignments of the two projects. After each project, students' collaboration behaviour perception and grades (i.e., individual grades and group grades) were measured.

The following research questions and expectations were explored:

1. *To what extent does the integration of avatar and badge game features (i.e., gamification) in a collaborative learning environment influence the collaboration behaviour among university students?*

It was hypothesized that, on average, students in the gamified condition are more likely to engage in collaboration behaviour than students in the non-gamified condition (H1a). Furthermore, adding gamification elements to an online collaborative learning environment (Moreno-Guerrero et al., 2020; O'Donovan et al., 2013) has been shown to lead to higher grades. Hence, it was also hypothesized that, on average, students in the gamified condition are more likely to have a higher grade (H1b). Additionally, integrating gamification features which stimulates the students' development of their collaboration behaviour (Boller, 2017; Ding et al., 2018; Knutas et al., 2014; Lee & Hammer, 2011; Morschheuser et al., 2017), has been shown to positively affect their collaboration perception. Therefore, it was also hypothesized that, on average, students in the gamified condition are more likely to have a more positive collaboration perception (H1c).

2. *To what extent does Knowledge Sharing Self Efficacy (KSSE) influence university students' collaboration behaviour within the collaborative learning environment (gamified vs. non-gamified condition)?*

Based on previous studies, gamification can contribute to the individual's perception of a safe environment, positively affecting their behaviour (Boller, 2017; Huang & Soman, 2013; Lee & Hammer, 2011). Therefore, it was hypothesized that, on average, students with insufficient KSSE in a gamified condition will be more likely to engage in collaboration behaviour compared to students with insufficient KSSE in a non-gamified condition (H2).

Method

Research Design

The current study followed a quasi-experimental design comparing a gamified condition (experimental group) and a non-gamified condition (control group). In both conditions, students within a group worked on two projects (consecutively) related to the comprehension, replication, and re-design of a cognitive experiment and of a product. Each project included a collaborative assignment and an individual exam. Consequently, students received an individual grade and group grade for Project One and Project Two. In addition, students within the gamified and non-gamified condition were expected to complete four tasks. Particularly, the individual completion of Task 1 and Task 2 as well as group completion of Task 3 and 4. Students' 'Knowledge Sharing Self-Efficacy (KSSE)' was assessed during Task 1 at the start of Project One. The student's 'collaboration behaviour' was assessed during Task 3 and 4 at the end of both Project One and Two. Moreover, student's 'collaboration perception' was assessed during Task 4 at the end of the course.

It should be noted that the data for this study was part of a larger data collection. Aside from the gamified and non-gamified condition, the data collection of the larger study involved an additional condition. Each condition had its unique participants and online collaborative environment. The condition not part of this study was designed to assess the effectiveness of the addition of an expectation management aid and can be reviewed in the master thesis of Lehner (2021).

Respondents

After approval from the BMS ethics committee, all first-year Psychology that followed the *Cognition and Development* course at a university in the Netherlands. students

were approached and asked for (active) consent for participation and data collection. In total, 209 students gave consent and participated.

Inclusion Criteria

The inclusion criteria of the gathered data consisted of the individual given consent, drop out, and completion of Task 1, 3 and/or 4. On these terms, nine students were excluded; five students who did not give consent and four students who did not complete Task 3 and 4 due to them dropping out of the course. Furthermore, if the group did not complete both Task 3 and 4, all group members were excluded from further analysis. This was the case with six students within one group in the non-gamified condition and seventeen students within three groups in the gamified condition. Following these criteria, in total 33 students were removed from the data analysis leaving 81 students (16 student groups) in the gamified condition and 95 students (19 student groups) in the non-gamified condition.

Participant Demographic

The remaining respondents of this research consisted of 176 first-year students (65.3% of whom identified as female). The student's ages ranged from 18 to 38 (M = 20.45 years, SD = 2.55 years). Most of the respondents indicated *German* (59.1%) and *Dutch* (26.1%) as their nationality. The rest of the respondents indicated having a *Finish* (1.7%), *Greek* (1.1 %), *Romanian* (1.1%), *American* (0.6%), *Chinese* (0.6%), *Croatian* (0.6%), *Gambian* (0.6%), *Italian* (0.6%), *Kazakh* (0.6%), *Korean* (0.6%), *Lithuanian* (0.6%), *Mexican* (0.6%), *South African* (0.6%), *Taiwanese* (0.6%), *Ukrainian* (0.6%), and *Zimbabwean* (0.6%) nationality. Other respondents that mentioned having *Other* nationalities did not specify which nationality they had (3.4%). The demographics of the 81 students in the gamified condition and 95 students in the non-gamified condition are depicted in Table 1.

Table 1

Demographic Characteristics of Participants per Condition

	Gamified		Non-gamified	
	n	*%*	*n*	*%*
Gender				
Female	51	63.0	64	67.4
Male	30	37.0	31	32.6
Age				
18	11	13.6	10	10.5
19	20	24.7	24	25.3
20	22	27.2	29	30.5
21	15	18.5	10	10.5
22	4	4.9	10	10.5
≥ 23	9	11.1	12	12.7
Nationality				
Dutch	23	28.4	23	24.2
German	49	60.5	55	57.9
Other	9	11.1	17	17.9

Note. $N = 176$

Instrumentation

The researchers of this study collected all the data online. The online method was chosen due to its feasible nature of being embedded within the online collaborative environment, its cost and time-efficient nature (Fowler, 2009) and the COVID-19 measures that were present at the time of data collection.

Knowledge Sharing Self-Efficacy

Grounded on the definition of KSSE being an individual's perception of their ability to share knowledge with others (Bandura, 1994; Tseng & Kuo, 2014) and three pre-validated KSSE items measuring the teacher's confidence to share knowledge within a virtual community (Hsu et al., 2007), an adapted online survey on Qualtrics was designed to understand the student's perceived KSSE. Three items measured student's perceived confidence to share knowledge within a group (experiences, insights, or expertise) and three items measured students' perceived ability to share knowledge within a group (experiences, insights, or expertise).

Pilot Study. Following Cooper and Schindler's recommendation (2014), a pilot study was conducted prior to the actual data collection of this research in order to test the reliability of its instrumentation and design. The KSSE survey included six items in total that used 7-point Likert scale where three items measured each KSSE aspect (i.e., ability and confidence). Additionally, at the end of the KSSE survey, one final question was included where they were encouraged to reflect on and interpret these scores. The pilot study used convenience sampling by distributing the online survey to the Biomedical Engineering Master students following the Applied Cell Biology course at a University in the Netherlands. From these, 28 completed surveys were obtained.

Using George and Mallery's (2003) reliability index (Cronbach's $\alpha \geq .70$, the pilot study indicated a Cronbach's α of .892 for the KSSE survey. Thus, showing that the six items

measuring KSSE within a 7-point Likert scale are internally consistent and hence a reliable construct. Supporting this further was a reached consensus in the reflection and interpretation question where students agreed that the ability and confidence scores represented them well. The 7-point Likert scale used during the pilot was later replaced by a 0-100% scale in order to match the metrics originally used in the studies derived from Hsu et al. (2007) and Tseng and Kuo (2014).

Current Research. To analyse the second hypothesis, which mentioned an insufficient KSSE, KSSE was categorized into two groups: insufficient KSSE and sufficient KSSE. Sufficient KSSE would indicate that the students perceived ability and confidence to share knowledge with others is of a level that it does positively impacts their collaboration behaviour, while an insufficient KSSE would indicate that the student's perceived ability is likely to negatively impact their collaboration behaviour. Though several studies mention the use of KSSE levels, specific cut-of scores are not mentioned (e.g., Bandura, 1994, Ergün & Avcı, 2018; Hsu et al., 2007; Kankanhalli et al., 2005; Tseng & Kuo, 2014). For this study, based on the 0-100% scale, it was decided to deem a score between 0% and 55.0% as insufficient KSSE (n = 14 students). A score equal or higher than 55.1% would indicate a sufficient KSSE (n = 162 students).

In terms of the reliability of the six *KSSE* items, the reliability index (Cronbach's $\alpha \geq .70$) indicated by George and Mallery (2003) was followed. The Cronbach's α score was .920 which indicated internal consistency and therefore implying that the *KSSE* was a reliable construct. Additionally, the validity of the six KSSE items were tested and subjected to a factor analysis with a Principal Components Extraction. One component with an eigenvalue of 4.31 explained a total of 71.75% of the variance. The actual KSSE survey is shown in Appendix A.

Collaboration Behaviour

The collaboration behaviour was measured using the RIDE assessment tool developed by Eshuis et al. (2019). The tool guided students to score on four essential characteristics of collaboration behaviour, namely, *Respect*, *Intelligent collaboration*, *Deciding together*, and *Encouraging*. These characteristics are based on the work of Saab et al. (2007).

First, students scored their own (i.e., self-assessment) and each other's (i.e., peer assessment) collaboration for each RIDE characteristic using a 10-point Likert scale. In this tool, a score of one indicated a perceived poor collaboration while a score of ten indicated a perceived perfect collaboration behaviour (Appendix B). An information symbol next to each RIDE characteristic provided further details regarding the sub-characteristics of each RIDE characteristic. The reliability of each RIDE characteristic was examined, showing a Cronbach's α score of .879. This indicated internal consistency and therefore implying that the four RIDE characteristics were reliable constructs. The student's self- and peer assessment score of each RIDE characteristic was combined forming the individual collaboration behaviour per project. After the RIDE characteristics had been filled in, all the group members clicked on *ready* to submit their answers.

Second, each group member was able to first see a graph with the group average score of each RIDE characteristic. Since this study focused on the collaboration behaviour at an individual level, the collaboration behaviour as a group was not considered. Additional information is shown in Appendix B.

Third, group members in both conditions (gamified vs. non-gamified) were prompted to discuss future goals with the group based on the sub-characteristics of each RIDE characteristic. Since this study did not focus on these discussions, the results of the third phase were not analysed. Further information of the third phase can be found in Appendix B. Once all group member completed all three phases, the self- and peer assessment score per

RIDE characteristic for each group and its members would become visible to the researchers in the back end.

Collaboration Perception

Through an online survey on Qualtrics, the collaboration perception of students within conditions (gamified vs. non-gamified) for both Project One and Two was measured. The survey included eight 7-point Likert scale items ranging from one (strongly disagree) to seven (strongly agree). These items have been adapted from Tseng et al.'s study (2009). An example of the main question was *How did you perceive the collaboration in your group?* with statements such as *I really liked working in a collaborative group with my group members* and *I liked solving problems with my group members in the group project.* At the end of the survey, an open question was included where students could share any information related to the assignment. The reason for including this question was to obtain additional information and understanding regarding the student's collaboration behaviour assignment.

When testing the reliability of the eight collaboration perception items, Cronbach's α showed a score of .952 indicating that the eight items were internally consistent and therefore implying that the collaboration perception was a reliable construct. In addition, the validity of the eight collaboration perception items was tested through a factor analysis with a Principal Components Extraction. One component with an eigenvalue of 6.07 explained a total of 75.83% of the variance. The collaboration perception survey is outlined in Appendix C.

Grades

In terms of the grades, using the Dutch grading system of one to ten, the teachers of the course graded an individual exam as well as a collaborative assignment for Project One and Two. More specifically, the individual exam of Project One and Two assessed the student's understanding of concepts and methods that were applied in the collaborative assignments. These individual exams were graded according to an assessment form with a

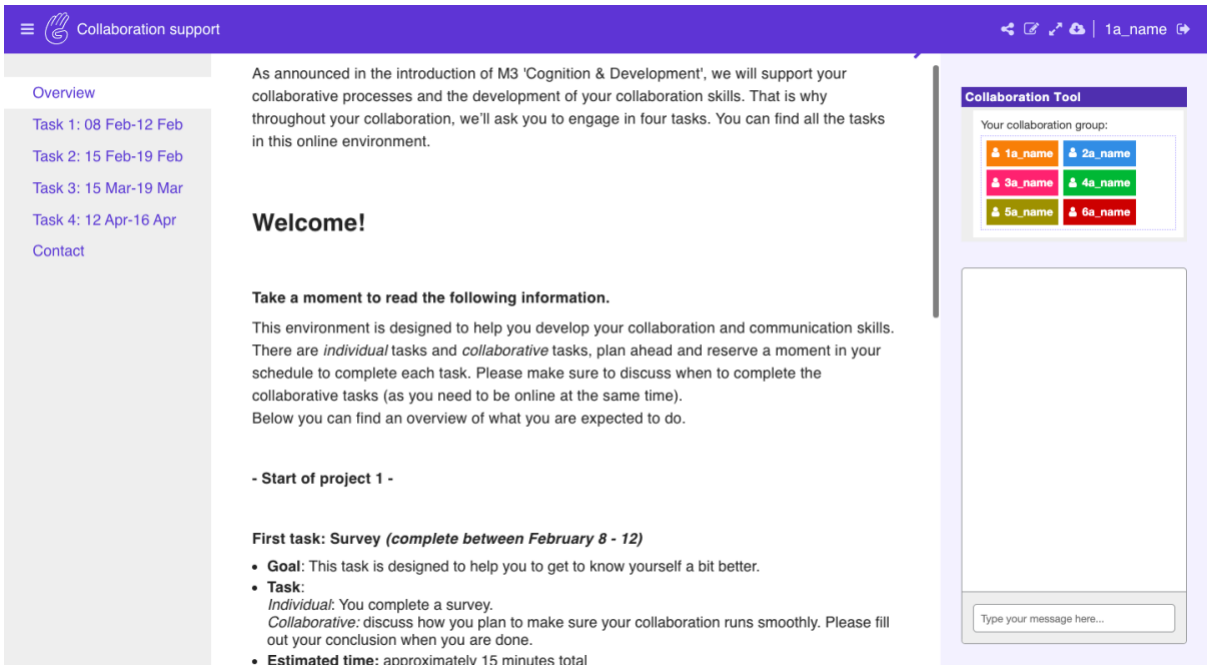
point allocation varying from zero to four points (Appendix D). Furthermore, the collaborative assignment of Project One assessed the student's report regarding their replication of an experiment while the collaborative assignment of Project two graded the student's report about their design of the experiment. Both collaborative assignments were graded based on a rubric with a percentage allocation of zero to ten points per section (Appendix E). The individual and group grades of Projects One and Two were later sent to the research team in order to analyse them further.

Online Collaborative Environment

Two online collaborative environments were created on the Go-lab authoring and learning platform (Go-lab, n.d.). One for the non-gamified condition, the control group (Figure 1), and another for the gamified condition, the experimental group (Figure 4). Both online collaboration environments consisted of several tabs corresponding to the study's overview, Task 1, Task 2, Task, 3, and Task 4, and the contact information of its researchers. Aside from these tabs, both online collaboration environments enabled students to see the members of their group and included a chat tool which could facilitate communication between group members.

Figure 1

User Interface of a Non-Gamified Online Collaboration Environment



Note. The visible text on this figure corresponded to the *Overview* tab. On the left side, students had access to other tabs such as *Task 1* to *Task 4*, and *Contact*. On the right side, students within the same group could see their group members and use the chat tool to communicate with each other.

Overview

The *Overview* tab provided general information regarding *Task 1*, *Task 2*, *Task 3*, and *Task 4*, such as, the goal of each task, the individual and collaborative assignments within these tasks, its estimated completion time, and completion deadline.

Task 1

The *Task 1* tab included instructions for students within the conditions (gamified vs. non-gamified) to fill in a 'KSSE' individual survey.

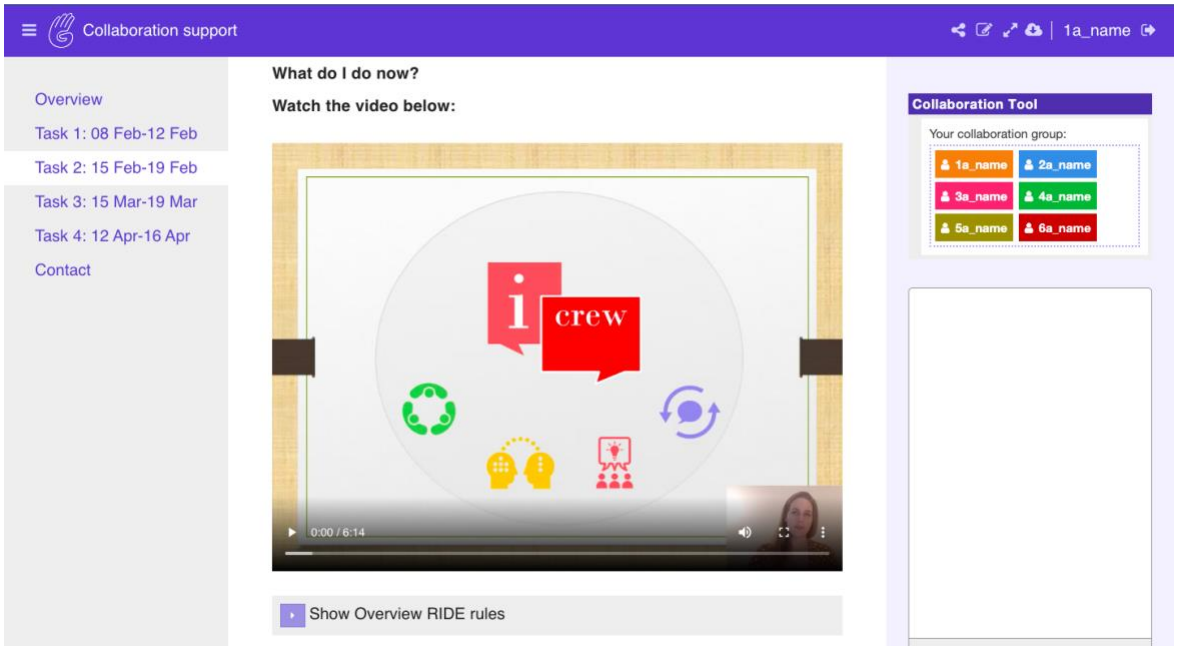
Task 2

As it can be seen in Figure 2, the *Task 2* tab instructed students in both conditions (gamified vs. non-gamified) to individually watch a video of the RIDE characteristics and its

role in good collaboration (Eshuis et al., 2019; Saab et al., 2007). The video was created by the researchers of the study and consisted of a PowerPoint presentation with a researcher narrating the content through a video camera.

Figure 2

RIDE Characteristics

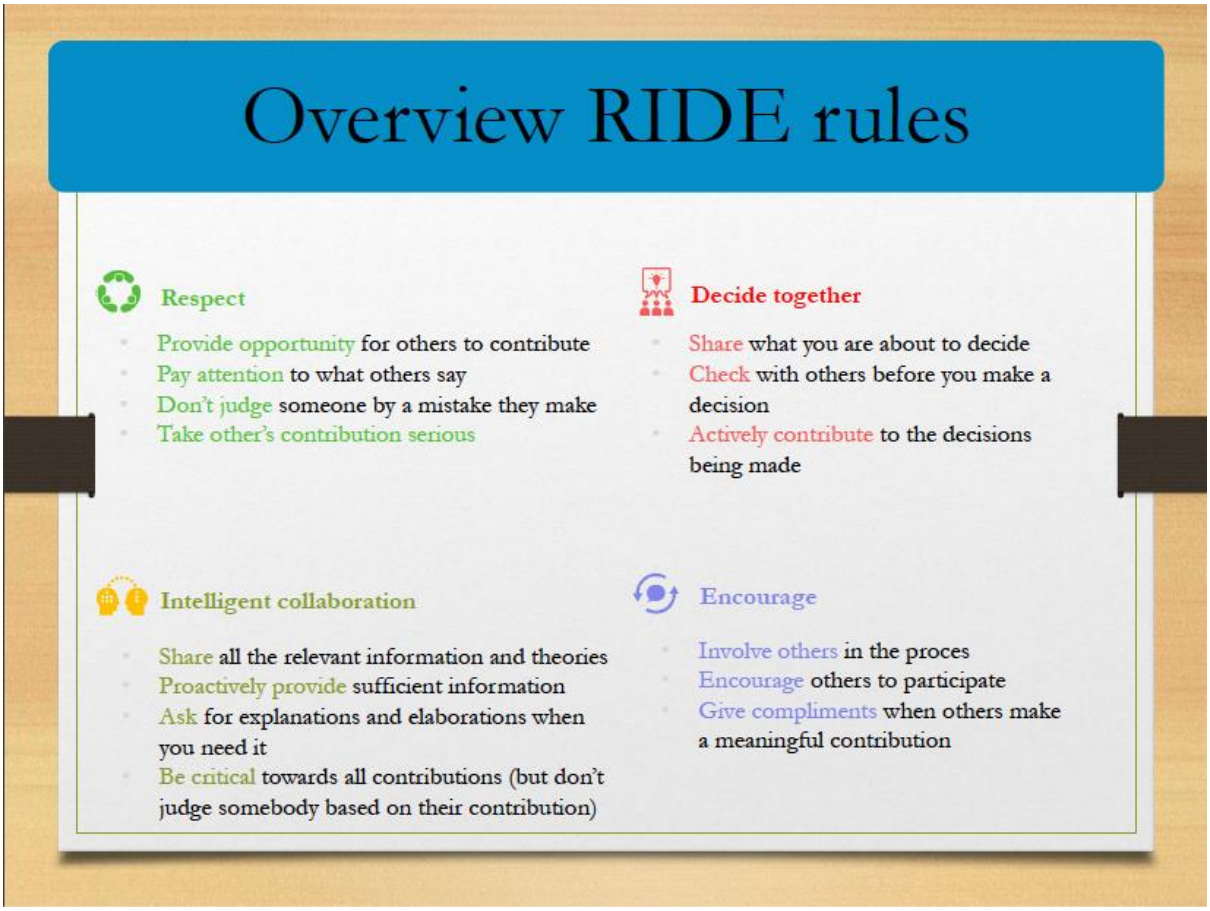


Note. The visible video on this figure corresponds to the *Task 2: 15 Feb – 19 Feb* tab. On the bottom, students could click the purple button to access the RIDE characteristics overview.

To make the information more accessible, a general overview of the RIDE characteristics and its sub-characteristics in PDF format was embedded in *Task 2* of the online collaboration environment. A picture of the PDF file is depicted in Figure 3.

Figure 3

RIDE Characteristics Overview



Note. Sub-characteristics were adopted from Eshuis et al. (2019) and Saab et al. (2007).

Task 3

The *Task 3* tab included instructions for students within the conditions (gamified vs. non-gamified) to fill in the RIDE Assessment Tool as a group for Project One.

Task 4

Like *Task 3*, the *Task 4* tab included instructions for students in both conditions to fill in the RIDE Assessment Tool as a group for Project Two. Additionally, as it was the end of Project One and Two, the *Task 4* tab included instructions for students within the 'conditions' (gamified vs. non-gamified) to fill in an individual 'collaboration perception' survey for Project One and Two.

Contact

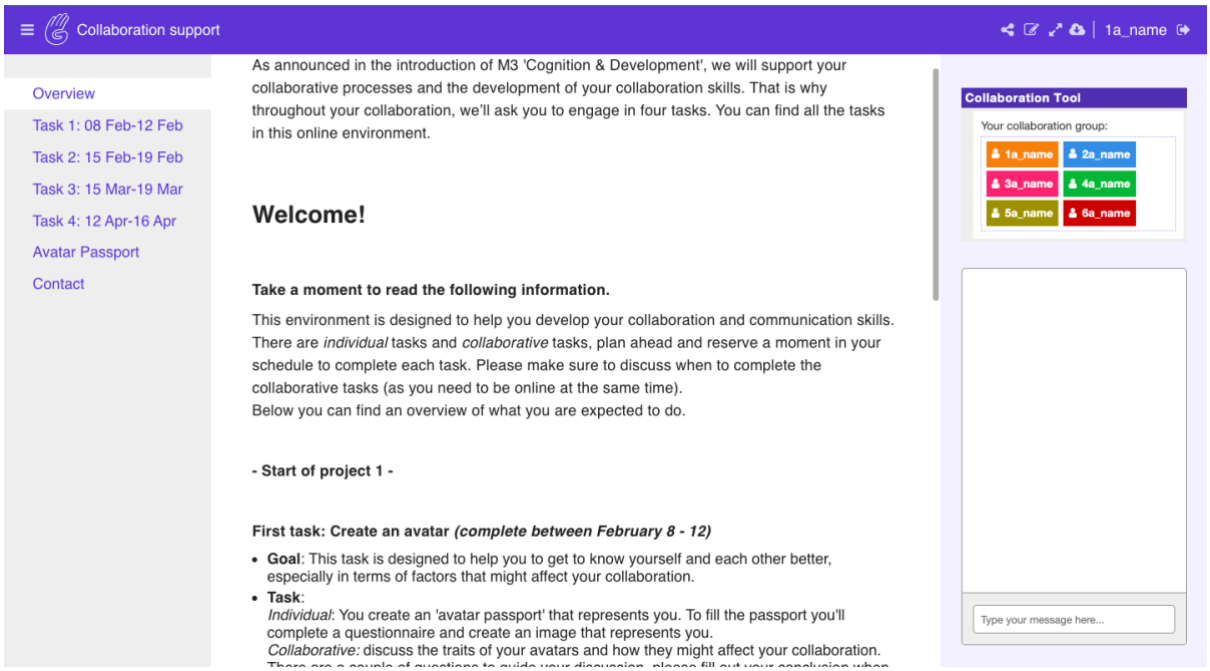
The last tab included an image, name, and email of each researcher of the study, in case the student had any queries.

Gamified Online Collaborative Environment

The gamified online collaborative environment included avatars and badges in the form of avatar passports and badge discussions within tasks.

Figure 4

User Interface of a Gamified Online Collaboration Environment



Note. Similar to the non-gamified condition, the visible text on this figure corresponded to the *Overview* tab. On the left side, students also had access to similar tabs such as *Task 1* to *Task 4*, and *Contact*. The only additional tab was *Avatar Passport*. On the right side, students within the same group were also able to see their group members and use the chat tool to communicate with each other.

Task 1

After students filled in the KSSE individual survey, students in the gamified condition were instructed to create an avatar passport.

Avatar Passport

In terms of the gamified condition, the avatar passport was embedded in the online collaboration environment in the tab named *Avatar Passport*. For the avatar passport, students had to search for their names within the pre-created columns and complete the corresponding field with their competencies and a picture of their avatar. As a reference, within the first column of the avatar passport, an example of a filled in avatar passport was shown to all groups. A clean copy of the avatar passport can be found in Appendix F. To create their avatar, students visited a free avatar maker website (Free Avatar Maker, n.d.) where they could choose different colours and features for the face, clothes, and background of the avatar. After completing the avatar, students downloaded and uploaded a picture of their avatar to their avatar passport. During *Task 1* the avatar's achievement was left blank (Figure 5) but were later filled in during *Task 3* and *Task 4*.

Figure 5

Avatar Passport

Note. Each column in this figure corresponded to a student within the group. Students uploaded their avatar underneath their name.

Task 3

After students filled-in in the RIDE Assessment Tool for Project One, students in the gamified condition engaged in a badges discussion and updated their avatar passport if a badge was won.

Task 4

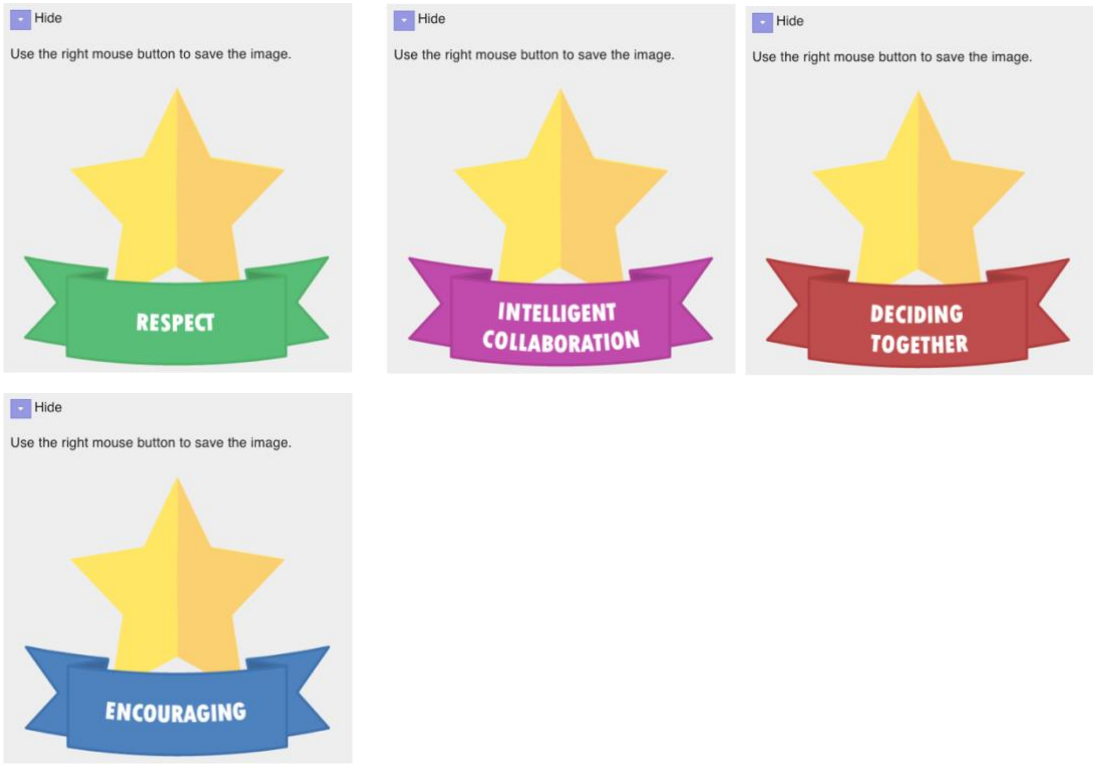
Similar to *Task 3*, after students filled-in in the RIDE Assessment Tool for Project Two, students engaged for the last time in a badges discussion and updated their avatar passport if a badge was won.

Badges

In the gamified condition, four badge images representing each RIDE characteristic was embedded in *Task 3* and *Task 4* of the online collaboration environment (Figure 6).

Figure 6

RIDE Badges

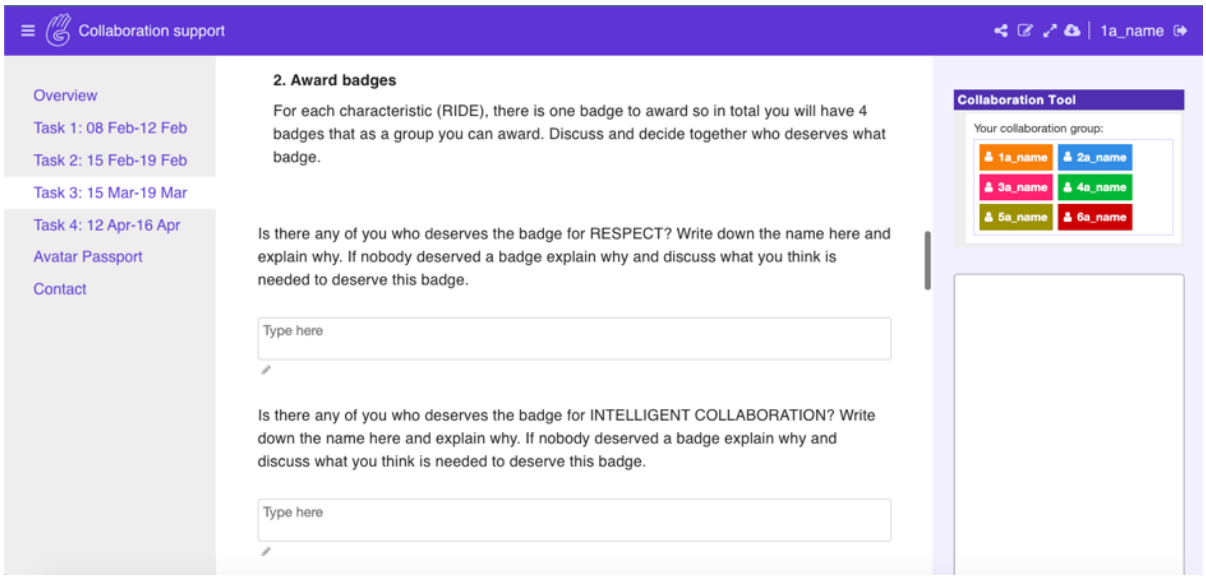


Note. The four badge images in this figure represent each RIDE characteristic. These four images were present in both *Task 3* and *Task 4*.

With the guidance of discussion questions, the group discussed and decided together who did or didn't deserve one or more of the four badges (Figure 7). A group member would then type in the input box who deserved the RIDE characteristic badge and why or if nobody deserved the RIDE characteristic badge, why, and what is needed to deserve the badge. The text in the input box was not analysed as it was meant to ensure the discussion amongst group members. In the latter case, the group expressed the desired collaborative behaviour in order to earn a badge.

Figure 7

RIDE Badges Discussion Questions



Note. The visible discussion questions on this figure corresponds to *Task 3*. These discussion questions were also present in *Task 4*.

If the student won a badge, they downloaded the earned badge image in PNG format, searched for their names within their Avatar Passport and uploaded their earned badge image under their avatar's achievement. This would be done once at the end of Project One (i.e., Task 3) and once at the end of Project Two (i.e., Task 4). At the end of the course, the students had the opportunity to see their avatar evolve through the use of badges under the avatar's achievement (Figure 8).

Figure 8

Avatar Passport Completed

Note. Each column in this figure corresponds to a student within the group. Students uploaded their earned RIDE badge underneath their avatar's achievements.

Procedure

The current research involved four tasks distributed over the complete duration of the course (i.e.,10 weeks) and individual and collaborative assignments grades which were finalized by the course teachers and shared with the researchers of the present study

approximately four weeks after the course has ended. The four tasks together took approximately 90 min (non-gamified condition) and 110 min (gamified condition) per student in total.

Since the beginning of the course, the four teachers provided weekly classes and guided students in completing the individual and collaborative assignments of Project and Two. Each teacher had two groups of students that were assigned randomly by the teachers. Students within the same teacher group created their own teams also known as student groups. Since these student groups attended weekly meetings together with the same teacher, the researchers assigned the student groups within the same teacher group to identical conditions. Aside from facilitating the grouping of conditions it also minimized the risk of students sharing information about the tasks leading them to uncover the different conditions within the study and thus compromising the study's validity. Students collaborated in groups of four to six students.

At the start of each task, students in the conditions (gamified vs. non-gamified) received a personalized email with the appropriate login details to the online collaboration environment and a short summary of the task that needed to be completed that week. During the assigned task week, a general reminder was shared on the Canvas course while a personalized reminder was sent to their student email with instructions on how to complete the task.

During the first week (February 8 – 12), the student logged in on their online collaboration environment, clicked on the tab named *Task 1: 08 Feb-12 Feb,* where they accessed the KSSE individual survey. At the start of this survey the study purpose was provided, and consent was asked for students to participate within the study. For the students in the non-gamified condition, students had 30 min to complete the KSSE survey.

Contrastingly, for the gamified condition, 30-40 min was allocated to complete the KSSE survey and make an avatar passport.

In the second week (February 15 – 19), students in the gamified and non-gamified condition logged in to their online collaboration environment again, clicked on the tab named *Task 2: 15 Feb-19 Feb*, and watched a 6-min video individually. Through this video, the goal of each RIDE characteristic, its sub-characteristics and its relevance as well as examples when working in groups was mentioned. Implementation of the RIDE characteristics whenever they worked together during the two projects was encouraged. In total, students in both conditions took around ten min to complete Task 2.

Then, in the fifth week, students in both conditions handed in their collaborative assignment for Project One. The following week, students in both conditions completed their individual assignment for Project One. Students also logged in to their online collaboration environment, clicked on the tab named *Task 3: 15 Mar-19 Mar*, and saw the RIDE Assessment tool. Students in both 'conditions' had 20 min to fill out collaboratively the RIDE assessment tool which measured their perceived collaboration behaviour. For the gamified condition, an addition of 10 min was allocated in order for the group members to discuss together if a group member would earn one of the RIDE characteristic badges, fill in the input box for each RIDE characteristic badge, download the specified badge and then upload it to their avatar passport.

Similarly, in the ninth week, students in both conditions handed in their collaborative assignment for Project Two. The next week, students in the gamified and non-gamified condition completed their individual assignment for Project One. Students also logged on their online collaboration environment again, clicked on the tab named *Task 4: 12 Apr-16 Apr*, and saw the RIDE Assessment tool. After this, the same exact steps described earlier in Task 3 were followed. Similar to Task 3, students in both conditions took approximately 20

min to complete the RIDE Assessment tool collaboratively and ten additional minutes was allocated to the gamified condition to discuss together and update their avatar passport if applicable. Then, as a last step of Task 4, the student filled in a collaboration perception survey individually which took 5 min at most to complete. The estimated total time to complete Task 4 was 25 min for the non-gamified condition and 35 min for the gamified condition.

Data Analysis

Normality Test

The normality for each 'condition' (gamified vs. non-gamified) and individual 'grade' *Project One* and *Two*, group 'grade' *Project One* and *Two*, 'collaboration behaviour' *Project One* and *Two*, 'KSSE', and the 'collaboration perception' were tested using the Shapiro-Wilk test. Results showed that individual 'grades' and group 'grades' in *Project One* and *Project Two* did not violate the normality assumption while 'collaboration behaviour' *Project One* partially violated the normality assumption. More specifically, individual 'grade' *Project One* with $W(85) = .977$, $p = .127$ (non-gamified), individual 'grade' *Project Two* with $W(79) = .974$, $p = .100$ (gamified), $W(85) = .981$, $p = .228$ (non-gamified), group 'grade' *Project One* with $W(16) = .961$, $p = .683$ (gamified), $W(19) = .988$, $p = .995$ (non-gamified), group 'grade' *Project Two* with $W(16) = .890$, $p = .056$ (gamified), $W(19) = .986$, $p = .990$ (non-gamified), *Intelligent collaboration* RIDE characteristic *Project One* with $W(95) = .967$, $p = .160$ (non-gamified) and *Encouraging* RIDE characteristic *Project One* with $W(95) = .978$, $p = .103$ (non-gamified). The normality of all variables was further checked through the histograms showing that 'KSSE', 'collaboration perception', individual 'grade' gamified 'condition' *Project One*, and 'collaboration behaviour' *Project One* and *Project Two* were not normally distributed.

Additional tests using Levene's F test were conducted to examine the assumption of variance homogeneity. The test results indicated that the assumption of variance homogeneity was satisfied for individual 'grade' *Project One* with $F(1,164) = 1.390$, $p = .240$, individual 'grade' *Project Two* $F(1,164) = 0.810$, $p = .369$, group 'grade' *Project One* $F(1,33) = 3.496$, $p = .070$, and group 'grade' *Project Two* $F(1,33) = .218$, $p = .643$. Furthermore, the assumption of variance homogeneity was partially satisfied for 'collaboration behaviour' *Project One* showing *Deciding Together* RIDE characteristic *Project One* with $F(1,170) = 2.873$, $p = .092$ and *Encouraging* RIDE characteristic *Project One* with $F(1,170) = 2.728$, $p = .100$.

To examine the assumption of co-variance homogeneity, Box's M test was performed on individual 'grades', group 'grades', and 'collaboration behaviour' for *Project One and Two*. Results showed no violation assumption for individual 'grades' with $p = .554$, group 'grades' with $p = .054$, and one violation assumption for 'collaboration behaviour' with $p = < .001$. As only the individual 'grades' and group 'grades' *Project One* and *Project Two* showed no violations of homogeneity and co-variance homogeneity assumptions, parametric tests were used. The other variables such as 'collaboration behaviour' *Project One* and *Project Two*, 'KSSE', and the 'collaboration perception' followed non-parametric tests.

Results

Descriptive Statistics of Research Variables

Students with 'Insufficient KSSE' consisted of six students in the gamified condition and eight students in the non-gamified condition. 'Insufficient KSSE' between gamified (M = 50.94, SD = 3.79) and non-gamified 'condition' (M = 43.40, SD = 12.99) was examined through a Mann-Whitney U test and showed no statistically significant differences, U = 13.500, z = -1.36, p = .174. In terms of 'Sufficient KSSE', there were 75 students in the gamified condition and 87 students in the non-gamified condition. 'Sufficient KSSE' between the gamified (M = 78.81, SD = 10.74 and non-gamified 'condition' (M = 80.26, SD = 10.38) was also examined using a Mann-Whitney U test and showed no statistically significant differences, U = 3012.000, z = -.84, p = .400. Descriptive statistics of each variable per 'condition' are depicted in Table 2.

Table 2

Descriptive Statistics of Research Variables

	Gamified			Non-gamified		
	n	*M*	*SD*	*n*	*M*	*SD*
Collaboration Behaviour Project One						
Respect	77	9.13	0.42	95	9.23	0.57
Intelligent Collaboration	77	8.72	0.55	95	8.64	0.81
Deciding Together	77	8.75	0.56	95	8.89	0.66
Encouraging	77	8.67	0.77	95	8.59	0.82
Collaboration Behaviour Project Two						
Respect	76	9.15	0.39	95	9.29	0.60
Intelligent Collaboration	76	8.75	0.50	95	8.77	0.71
Deciding Together	76	8.97	0.37	95	8.86	0.69
Encouraging	76	8.76	0.47	95	8.69	0.80
Grades						
Individual Grade Project One	79	7.17	1.36	87	6.76	1.26
Individual Grade Project Two	79	7.10	1.49	90	6.58	1.40
Group Grade Project One	16	7.39	1.05	19	6.89	0.58
Group Grade Project Two	16	8.90	0.67	19	7.12	0.62
Collaboration Perception	75	6.01	0.96	91	5.73	1.21

Effects of Gamification on Collaboration Behaviour

It was expected that, on average, students in the gamified condition would be more likely to engage in collaboration behaviour compared to students in a non-gamified condition (H1a). Based on this, the differences between the independent variable 'condition' (gamified

vs. non-gamified) and the dependent variable of each 'collaboration behaviour' RIDE characteristic for both *Projects One* and *Two* were examined using a Kruskal-Wallis test. Results revealed that there were several significant differences. Particularly, for *Project One* there was a statistically significant difference between the 'conditions' and *Deciding together* RIDE characteristic with $H(1) = 4.370$, $p = .037$, $\eta 2 = .013$. The mean rank score of 93.61 for the non-gamified 'condition' was significantly higher than the mean rank score of 77.73 for the gamified 'condition'. The rest of RIDE characteristics showed no significant differences between 'conditions': *Respect* RIDE characteristic with $H(1) = 3.852$, $p = .050$, $\eta 2 = .010$. with a mean rank score of 78.27 for the gamified 'condition' and 93.17 for the non-gamified 'condition'. *Intelligent collaboration*, $H(1) = 0.311$, $p = .577$, $\eta 2 = .003$, with a mean rank score of 88.84 for the gamified 'condition' and 84.60 for the non-gamified 'condition'. *Encouraging* RIDE characteristics, $H(1) = 2.102$, $p = .147$, $\eta 2 = .003$, with a mean rank score of 92.60 for the gamified 'condition' and 81.55 for the non-gamified 'condition'.

For *Project Two*, only *Respect* RIDE characteristic differed significantly between 'conditions' with $H(1) = 7.791$, $p = .005$, $\eta 2 = .019$. The mean rank score of 95.40 for the non-gamified 'condition' was significantly higher than the mean rank score of 74.25 for the gamified 'condition'. Other RIDE characteristics showed no significant differences between 'conditions': *Intelligent collaboration*, $H(1) = 0.157$, $p = .692$, $\eta 2 = .000$, with a mean rank score of 84.34 for the gamified 'condition' and 87.33 for the non-gamified 'condition'. *Deciding together* RIDE characteristic $H(1) = 0.384$, $p = .536$, $\eta 2 = .009$, with a mean rank score of 88.61 for the gamified 'condition' and 83.92 for the non-gamified 'condition'. Lastly, *Encouraging* RIDE characteristics, $H(1) = 0.069$, $p = .793$, $\eta 2 = .002$, with a mean rank score of 87.11 for the gamified 'condition' and 85.12 for the non-gamified 'condition'.

Effects of Gamification and Collaboration Behaviour on Grades

For the grades, it was hypothesized that on average, students in the gamified *condition* would be more likely to have a higher *grade* than students in the non-gamified *condition* (H1b). Hence, the effect of individual and group 'grade' for *Project One* and *Two* between 'conditions' (gamified vs. non-gamified) and 'collaboration behaviour' RIDE characteristic was examined.

Individual Grade

To examine the effect of individual 'grade' *Project One* and *Two* between 'conditions' (gamified vs. non-gamified), a one-way repeated measures MANOVA was used. The 'conditions' were considered as a between-groups independent variable, *Project One* and *Two* as a within-groups dependent variable, and individual 'grade' as a continuous dependent variable. Results did not show a multivariate main effect of students being in a 'condition' and their individual 'grade' *Project One* and *Two*, Pillai's trace = 0.004, $F(1,162) = 0.58$, $p = .446$, $\eta 2 = .004$. Hence, student's individual 'grades' did not differ between the gamified and non-gamified 'condition' and over time (i.e., *Project One* and *Two)*.

The extent of each 'collaboration behaviour' per RIDE characteristic predicting individual 'grade' of *Project One* was examined. Each RIDE characteristic of project one was used as the independent variable. The individual 'grade' of *Project One* was used as the dependent variable. Through the multiple regression analysis, it was found that the overall model of 'collaboration behaviour' per RIDE characteristic and individual 'grade' of *Project One* was statistically significant (F (4, 157) = 3.01, $p = .020$, $R^2 = .07$). A closer look into the parameters showed that while keeping the variables constant, the RIDE characteristics affected the individual 'grade' of students during *Project One: Deciding together* ($\beta = -.55$, $SE = .25$, $t(162) = -2.20$, $p = .028$) and *Encouraging* ($\beta = .45$, $SE = .21$, $t(162) = 2.13$, $p = .035$). The other RIDE characteristics did not affect student's individual 'grade': *Respect* (β =

.04, *SE* = .26, *t*(162) = 0.16, *p* = .876), *Intelligent collaboration* (β = .26, *SE* = .25, *t*(162) = 1.06, *p* = .290).

Moreover, the 'condition' (gamified vs. non-gamified) and individual 'grade' for *Project One* was further analysed by using an independent samples t-test. The results indicated no statistically significant differences of individual 'grade' for *Project One* for the gamified 'condition' (*M* = 7.17, *SD* = 1.36) and the non-gamified 'condition' (*M* = 6.76, *SD* = 1.26), *t*(78) = 0.37, *p* = .716.

In terms of *Project Two*, the extent of each 'collaboration behaviour' per RIDE characteristic predicting individual 'grade' was investigated. Each RIDE characteristic of *Project Two* was used as the independent variable. The individual 'grade' of *Project Two* was used as the dependent variable. Through the multiple regression analysis, it was found that the overall model of 'collaboration behaviour' per RIDE characteristic and individual 'grade' was statistically insignificant (*F* (4, 159) = 2.13, *p* = .079, R^2 = .05). The parameters showed that while keeping the variables constant, the RIDE characteristics did not affect the student's individual 'grade' during *Project Two*: *Respect* (β = -.33, *SE* = .30, *t*(164) = -1.10, *p* = .275), *Intelligent collaboration* (β = .23, *SE* = .33, *t*(164) = 0.71, *p* = .479), *Deciding together* (β = .33, *SE* = .38, *t*(164) = 0.88, *p* = .381), and *Encouraging* (β = .26, *SE* = .27, *t*(164) = 0.95, *p* = .343).

Comparison of the 'condition' (gamified vs. non-gamified) for individual 'grade' for *Project Two* was done using the independent samples t-test. The results indicated no differences: the individual 'grade' of *Project Two* for the gamified 'condition' (*M* = 7.10, *SD* = 1.49) and the non-gamified 'condition' (*M* = 6.58, *SD* = 1.40), *t*(84) = 1.62, *p* = .109.

Group Grade

The effect of group 'grade' *Project One* and *Project Two* as a dependent variable between 'conditions' (gamified vs. non-gamified) was examined through a one-way repeated

measures MANOVA. The 'conditions' were considered as a between-groups independent variable, *Project One* and *Two* as a within-groups dependent variable, and group 'grade' as a continuous dependent variable. The results did not show a statistically significant effect of students being in a 'condition' and their group 'grade' over time (i.e., *Project One* and *Two*), Pillai's trace = 0.000, $F(1,33) = 0.007$, $p = .936$, $\eta 2 = .000$.

The prediction effect of each 'collaboration behaviour' per RIDE characteristic on group 'grade' of *Project One* was examined. Each RIDE characteristic of *Project One* was used as the independent variable. The group 'grade' of *Project One* was used as the dependent variable. The results of multiple regression analysis indicated that the overall model of 'collaboration behaviour' per RIDE characteristic and group 'grade' of *Project One* was not statistically significant (F (4, 29) = 1.53, $p = .219$, $R^2 = .17$). The parameters showed that while keeping the variables constant, the RIDE characteristics did not affect the group 'grade' of students during *Project One*: *Respect* (β = -.14, *SE* = .41, $t(34) = -0.35$, $p = .728$), *Intelligent collaboration* (β = .74, *SE* = .47, $t(34) = 1.59$, $p = .123$), *Deciding together* (β = .39, *SE* = .25, $t(34) = -0.05$, $p = .958$), and *Encouraging* (β = -.04, *SE* = .35, $t(34) = -0.12$, $p = .909$).

With the intention to examine differences between the 'conditions' (gamified vs. non-gamified) and group 'grade' for *Project One*, an independent samples t-test was performed. The results indicated no differences of the group 'grade' of *Project One* for the gamified 'condition' (*M*=7.39, *SD*= 1.05) and the non-gamified 'condition' (*M*=6.89, *SD*= 0.58), $t(33) = 1.77$, $p = .070$.

The extent of each 'collaboration behaviour' per RIDE characteristic predicting group 'grade' was investigated. Each RIDE characteristic of *Project Two* was used as the independent variable. The group 'grade' of *Project Two* was used as the dependent variable. Through the multiple regression analysis, it was found that the overall model of 'collaboration

behaviour' per RIDE characteristic and group 'grade' was statistically insignificant (F (4, 29) = 1.36, p = .271, R^2 = .16). Keeping the variables constant, the RIDE characteristics did not affect the group 'grade' of students during *Project Two*: *Respect* (β = -.31, *SE* = .34, t(34) = -0.92, p = .367), *Intelligent collaboration* (β = -.51, *SE* = .64, t(34) = -0.80, p = .428), *Deciding together* (β = .49, *SE* = .54, t(34) = 0.90, p = .378), and *Encouraging* (β = .58, *SE* = .37, t(34) = 1.54, p = .134).

The differences between the ‘conditions’ (gamified vs. non-gamified) and group 'grade' for *Project Two* were analysed through an independent samples t-test. Results showed no significant differences of the group 'grade' of *Project Two* for the gamified ‘condition’ (*M* = 8.90, *SD* = 0.67) and the non-gamified ‘condition’ (*M* = 7.12, *SD* = 0.62), t(33) =2.37, p = .643.

Effects of Gamification and Collaboration Behaviour on Collaboration Perception

It was expected that on average, students in the gamified *condition* would be more likely to have a more positive *collaboration perception* than students in the non-gamified *condition* (H1c). Based on this, the effect of 'collaboration perception' between 'conditions' (gamified vs. non-gamified) was examined.

To investigate the difference between the independent variable 'condition' (gamified vs. non-gamified) and the dependent variable of 'collaboration perception', a Kruskal-Wallis test was performed. Results revealed no statistically significant differences between the 'conditions' and 'collaboration perception' with H(1) = 2.047, p = .153, $\eta 2$ = .016, with a mean rank score of 89.36 for the gamified 'condition' and 78.67 for the non-gamified 'condition'. This means that 'collaboration perception' did not significantly differ between the 'conditions'.

For *Project One*, the extent of each 'collaboration behaviour' per RIDE characteristic predicting 'collaboration perception' was investigated. Each RIDE characteristic of *Project One* was considered as the independent variable. The 'collaboration perception' was considered as the dependent variable. Through the multiple regression analysis, it was found that the overall model of 'collaboration behaviour' per RIDE characteristic and 'collaboration perception' was statistically insignificant (F (4, 157) = 2.37, p = .054, R^2 = .06). Keeping the variables constant, RIDE characteristics did not affect the 'collaboration perception': *Respect* (β = .63, *SE* = .23, t(162) = 2.81, p = .367), *Intelligent collaboration* (β = -.10, *SE* = .21, t(162) = -0.46, p = .650), *Deciding together* (β = -.06, *SE* = .21, t(162) = -0.27, p = .785), and *Encouraging* (β = -.02, *SE* = .18, t(162) = -0.10, p = .923).

In the case of *Project Two*, the extent of each 'collaboration behaviour' per RIDE characteristic predicting 'collaboration perception' was investigated through a multiple regression analysis. Each RIDE characteristic of *Project Two* was used as the independent variable. The 'collaboration perception' was used as the dependent variable. The results showed that the overall model of 'collaboration behaviour' per RIDE characteristic and 'collaboration perception' was statistically significant (F (4, 156) = 2.55, p = .042, R^2 = .06). A closer look into the parameters showed that while keeping the variables constant, only the *Encouraging* RIDE characteristics affected 'collaboration perception' (β = .50, *SE* = .19, t(161) = 2.58, p = .011). The rest of RIDE characteristics did not affect 'collaboration perception': *Respect* (β = .05, *SE* = .22, t(161) = 0.22, p = .823), *Intelligent collaboration* (β = -.45, *SE* = .24, t(161) = -1.88, p = .062), and *Deciding together* (β = .17, *SE* = .27, t(161) = 0.65, p = .516).

Moderation Effect of Knowledge Sharing Self-Efficacy on Gamification and Collaboration Behaviour

Next, it was hypothesized that, on average, students with insufficient KSSE in a gamified condition will be more likely to engage in collaboration behaviour compared to students with insufficient KSSE in a non-gamified condition (H2). Hence, the influence of the Knowledge Sharing Self-Efficacy (KSSE) on each student's 'collaboration behaviour' RIDE characteristic of *Project One* and *Project Two* within a 'condition' (gamified vs. non-gamified) was investigated. The 'condition' was considered as an independent variable, 'KSSE' moderator variables, and 'collaboration behaviour' per RIDE characteristic as a dependent variable.

For *Project One*, using Andrew F. Hayes' moderation model analysis with bootstrap standard error estimates, the results showed that the overall model of 'condition', 'KSSE', and the *Respect* RIDE characteristic was not statistically significant $R^2 = .01$, F (1, 168) = 0.76, p = .516. Similar results were obtained from other RIDE characteristics: *Intelligent collaboration* $R^2 = .03$, F (3, 168) = 2.02, p = .113, *Deciding together* RIDE characteristic R^2 = .03, F (3, 168) = 1.04, p = .179, and *Encouraging* $R^2 = .02$, F (3, 168) = 0.97, p = .409. A closer look into the parameters showed that 'KSSE' did not have an interaction effect between 'condition' (gamified and non-gamified) and the 'collaboration behaviour' RIDE characteristics of *Project One*: *Respect* β = -.0043, *SE* = .0059, t(172) = -0.72, p = .469, *Intelligent collaboration* β = -.0008, *SE* = .0080, t(172) = -0.10, p = .920, *Deciding together* β = -.0074, *SE* = .0071, t(172) = -1.04, p = .299, and *Encouraging* β = -.0067, *SE* = .0091, t(172) = -0.73, p = .466.

In terms of *Project Two*, results obtained from Andrew F. Hayes' moderation model analysis with bootstrap standard error estimates, showed that the overall model of 'condition', 'KSSE', and each 'collaboration behaviour' RIDE characteristics were not statistically

significant. More specifically, *Respect* R^2 = .03, F (3, 167) = 1.57, p = .200, *Intelligent collaboration* R^2 = .02, F (3, 167) = 1.37, p = .253, *Deciding together* R^2 = .01, F (3, 167) = 0.64, p = .588, and *Encouraging* R^2 = .01, F (3, 167) = 0.34, p = .799. Additional parameters showed that 'KSSE' did not have an interaction effect between 'condition' (gamified and non-gamified) and the RIDE characteristics: *Respect* β = -.0066, *SE* = .0060, t(171) = -1.12, p = .266, *Intelligent collaboration* β = -.0051, *SE* = .0072, t(171) = -0.71, p = .478, *Deciding together* β = -.0029, *SE* = .0066, t(171) = -.44, p = .659, and *Encouraging* β = .0008, *SE* = .0078, t(171) = 0.10, p = .921.

Discussion and Conclusion

This study aimed to investigate the following research questions: (1) *To what extent does the integration of avatar and badge game features (i.e., gamification) in a collaborative learning environment influence the collaboration behaviour among university students?* and (2) *To what extent does Knowledge Sharing Self Efficacy (KSSE) influence university students' collaboration behaviour within the collaborative learning environment (gamified vs. non-gamified condition)?* To answer these questions, the experiment consisted of two conditions: a gamified and a non-gamified collaborative online learning environment. The two conditions only differed in gamification being present or not, where badges and avatars were used to contribute to the perception of a safe environment, and stimulate students' engagement and development of collaboration behaviour in the gamified condition.

Effects of Gamification on Collaboration Behaviour, Grades, and Collaboration Perception

When examining the effects of gamification on collaboration behaviour, it was found that students in the non-gamified condition had slightly higher collaboration scores on some levels. Particularly, based on the RIDE characteristics which represented their collaboration behaviour, students in the non-gamified condition had a slightly higher Deciding together score for the first measurement and Respect score for the second measurement. This means that during Project One students in the non-gamified condition shared more about what they were about to decide, checked with others before they decided, and actively contributed to the decisions being made (i.e., Deciding together) than in the gamified condition. On the other hand, during Project Two, students in the non-gamified condition provided more opportunities for others to contribute, paid attention to what others had to say, did not pass judgements on other's mistakes, and took other's contributions seriously (i.e., Respect) than

students in the gamified condition. The results in this study were not in line with previous literature, which stated that gamification would lead to better collaboration (Boller, 2017; Ding et al., 2018; Knutas et al., 2014; Lee & Hammer, 2011; Morschheuser et al., 2017). Despite the measured differences being of only a few decimal points on a ten-point scale, they were still significant. This might be due to the combination of multiple tasks, such as: receiving instructions and filling in self- and peer assessments (i.e., RIDE), and additional tasks within the gamified condition (e.g., avatar and badges). These could lead to an increase in the student's workload (Saab et al., 2007) and negatively affect the student's participation in the gamified condition when compared to the non-gamified condition (de-Marcos et al., 2014; Domínguez et al., 2013). The comment made by one student in the gamified condition stating that the tasks made it difficult to keep up seems to support this claim. Although this study contributed to the limited existing studies in the area of student collaboration and gamification (i.e., avatars and badges), more research is needed on avatars, badges, and collaboration in order to better determine the effects of gamification on student collaboration.

Another reason might be the acquaintance level when doing the collaborative course assignments. Particularly, for the first group project, students might have not been acquainted yet. In accordance with Paulhus and Nadine Bruce (1992), it is natural that at the beginning of the group project, low-acquainted students will actively contribute to the decisions in order to reach an agreement about the upcoming tasks. For Project Two, as students stayed in the same group, they might have gotten better acquainted with each other. As shown by Daradoumis and Marquès (2000), better-acquainted students will listen to each other and consider each other's contribution to the project. As the acquaintance level amongst students was out of the scope of the present study, future studies could take this factor into account and examine if it affected the students' collaboration.

In addition, the effects of gamification and collaboration behaviour indicated that the student's individual and group grades did not differ between conditions. This is not in line with existing studies of Moreno-Guerrero et al. (2020) and O'Donovan et al. (2013) that observed higher grades in the gamified condition. A possible reason why the predictive value of collaboration behaviour might have not led to higher grades is the small difference of a few decimal points between conditions. Since the present study integrated different gamification elements (i.e., avatar and badges) in one condition and almost all these students engaged with the creation of their avatar and provision of badges, it is hard to pinpoint where the effect came from. It can also be speculated that the use of badges might have an impact on grades. In a study conducted by O'Donovan et al. (2013), the ability of badges to share accomplishments and show students' progress over time had a positive effect on students' grades. Another influential aspect could lie in the features of the badge. As remarked by Alsawaier (2018), the design of the badge might impact its effectiveness. Due to the inconclusive results and in line with arguments for value-added studies (Domínguez et al., 2013; Feldon et al., 2021; Lee & Hammer, 2011), we recommend further investigating badges to check for the unique added value of increased collaboration engagement among students.

Despite this, results did show that better collaboration behaviour predicted higher individual grades (i.e., for the first measurement of Encouraging). The results are similar to the study conducted by Johnson and Johnson (1999), which found that students who encourage each other to participate in the group process had higher individual grades because they can understand the material better. At the same time, results indicated that better collaboration behaviour predicted lower individual grades (i.e., for the first measurement of Deciding together). In this study, the sample was university students following a psychology program. According to Vedel et al.'s study (2015), psychology students tend to have a high

level of agreeableness compared to other studies such as economics. It has been shown that student groups with a high level of agreeableness can lead to lower individual grades. This is due to students within groups not contributing much to the group project and other group members that are agreeable being more willing to do the work (Schippers & Scheepers, 2020). Future studies should consider that the level of agreeableness might differ depending on the program followed by the student which can affect the student's grade.

When looking at the effects of gamification and collaboration behaviour on collaboration perception, results showed no differences between conditions. This was not in line with previous literature, which found that gamification can affect their collaboration behaviour (Boller, 2014; Ding et al., 2018; Knutas et al., 2014; Lee & Hammer, 2011; Morschheuser et al., 2017) and positively affect their collaboration perception (Pfaff & Huddleston, 2003). Still, results did show that better collaboration behaviour predicted better collaboration perceptions (i.e., for the second measurement of Encouraging). Similar to other studies, it is mentioned that collaboration enables students to involve each other in the project through tasks (Pfaff & Huddleston, 2003), which might have led to a positive collaboration perception (Pfaff & Huddleston, 2003; O'Donnell et al., 1987). In the present study, it seems to be the case with most groups. Only three groups reported free riding and communication challenges with a group member, which reflected negatively on the collaboration perception score. This is also suggested by Pfaff and Huddleston (2003) who state that free riding can lead to a negative collaboration perception. Despite this, these three groups still scored themselves and each other high on collaboration. Existing studies suggest that perceived assessments might lead to students overestimating themselves and scoring themselves higher (Saavedra & Kwun, 1993), being more lenient towards their peers, and scoring each other higher (Le et al., 2018). Although the RIDE assessment tool provided a rough indication of how students perceived collaboration behaviour, and what they considered when assessing

themselves and other group members, these scores were self-, and peer assessed by students within their self-made group. Hence, the scores might not represent the actual collaboration behaviour of students. Future studies should investigate this further by, for example, observing how students tried to apply the RIDE characteristics when completing the collaborative assignments or conducting a follow-up qualitative research to inquire more detailed information about the perceived collaboration behaviour both at a self and peer-assessed level.

Moderation Effect of Knowledge Sharing Self-Efficacy on Gamification and Collaboration Behaviour

Looking at the moderated effect of KSSE on gamification and collaboration behaviour, the results indicated no effect on the gamified and non-gamified condition and collaboration behaviour (both measurements). This is not in line with the posed hypothesis and previous studies. Research showed that all individuals, especially the ones with insufficient KSSE could benefit more from their collaboration through support (Bandura, 1986) and rewards (Bandura, 1994), avatars (Boller, 2017; Lee & Hammer, 2011), and badges (Ibanez, et al., 2014; Lee & Hammer, 2011; Schunk, 1989). A possible reason for the contrast in the current results is that the badges served as a self-assessment of the student's performance. Seeing their progress over time could have increased the students' KSSE (Aldemir et al., 2018; Bandura, 1994; Lounis et al., 2014; Richter et al., 2015; Schunk, 1989) which would have enabled them to engage in collaboration behaviour (Aldemir et al., 2018). Future studies should investigate if the student's KSSE changed through time and if this would affect their collaboration behaviour differently based on the condition they are in (gamified vs. non-gamified). In addition, although avatars and badges were both combined in the gamified condition, each game feature might have had a different effect on students with

insufficient KSSE. This is in line with previous literature stating that badges enable students to feel rewarded (Ibanez, et al., 2014; Lee & Hammer, 2011; Schunk, 1989) and avatars enable students to feel safer (Boller, 2017; Lee & Hammer, 2011) leading them to collaborate more (Boller, 2017; Huang & Soman, 2013; Lee & Hammer, 2011). Therefore, it would be recommended for future studies to integrate badges and avatars separately to examine their effect on the collaboration of insufficient KSSE students. Another possible reason for the results in this study is that there was only a small group of insufficient KSSE students who collaborated with a larger group of sufficient KSSE students. Hence, its effects on collaboration behaviour would have not been significant.

Still, from the small group of insufficient KSSE students, their scores were relatively closer to the average. This suggests that students did not perceive their knowledge-sharing abilities and confidence too negatively. However, due to the small sample size of students with insufficient KSSE compared to sufficient KSSE, future studies should aim to have a higher sample size. This can be achieved by finding more sensitive alternatives for the KSSE self-assessment. Literature suggests that individuals self-reporting might be unsure of their capabilities leading to individuals often filling in higher and sometimes lower self-efficacy scores than what they perceive (Bandura, 1986). To help students better understand and assess their KSSE, future studies could provide examples of insufficient as well as sufficient KSSE and inquire examples from students when reporting their KSSE. As a result, it might provide a better comparison between groups and further insights into the influence of KSSE on students' collaboration behaviour based on the gamified and non-gamified condition that they were in.

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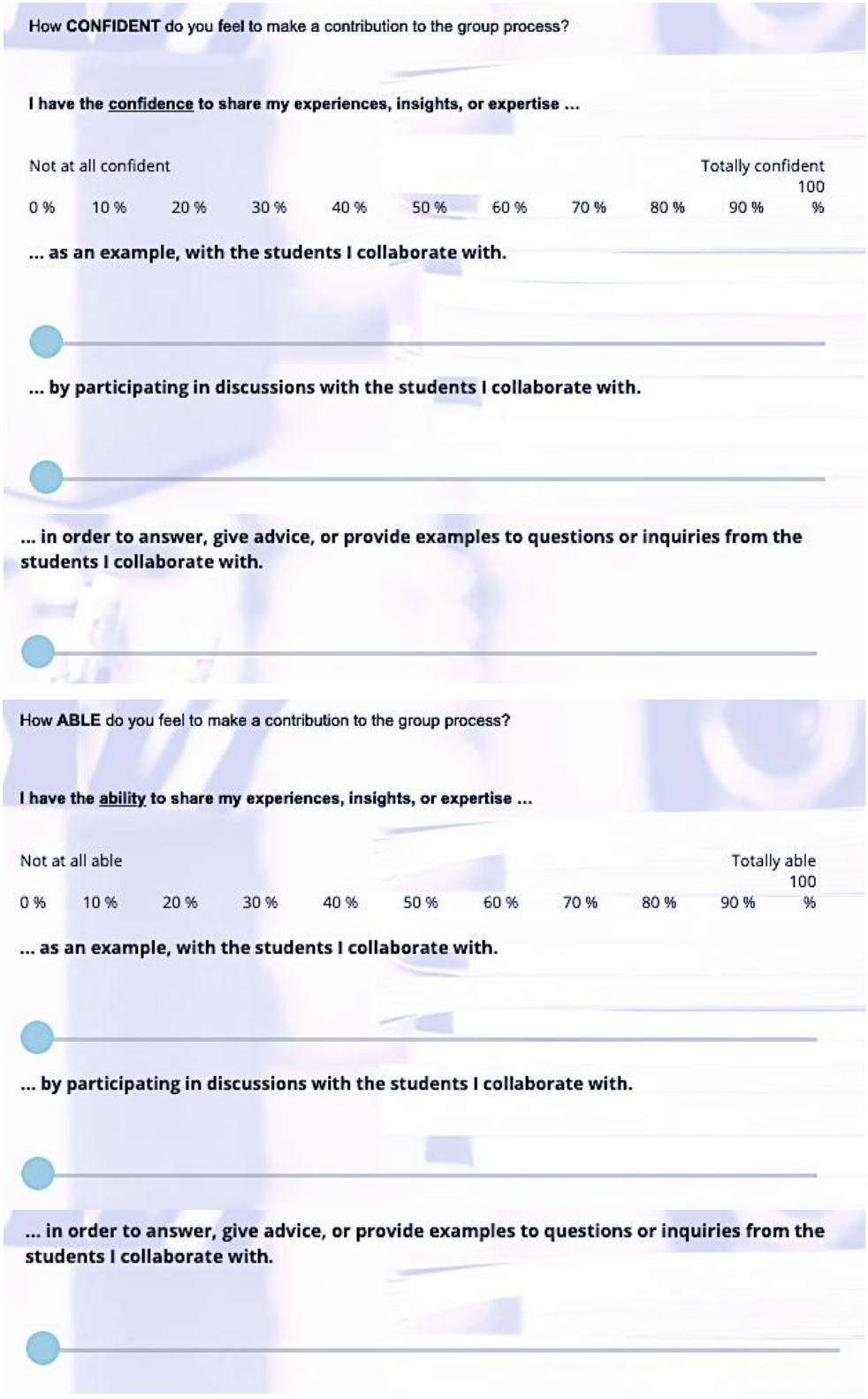
Appendix A

KSSE Survey Appearance



Appendix B

RIDE Assessment Tool

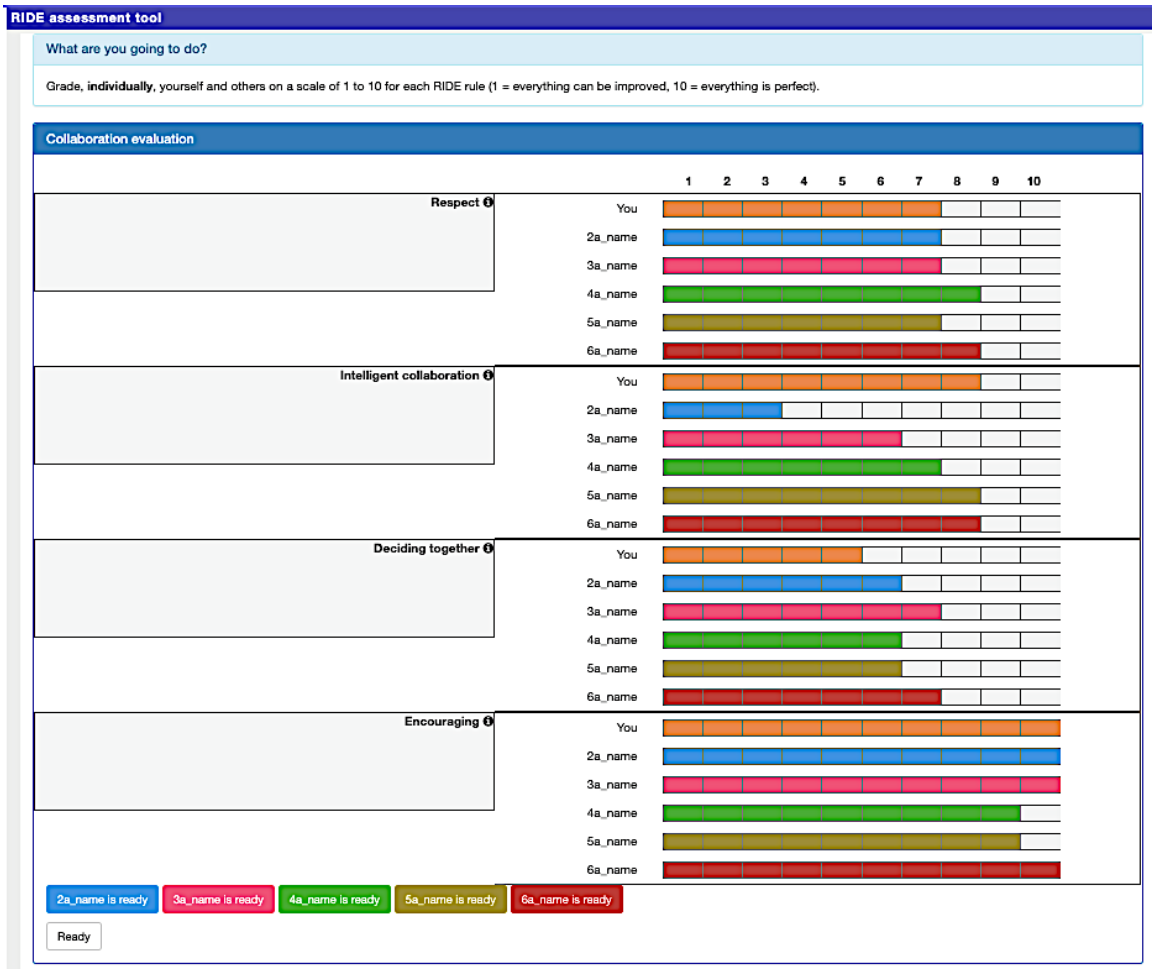


Figure B1. The RIDE assessment tool first showed a filled-in evaluation by a group member. On the left side, there is an information symbol next to each RIDE characteristic.

Figure B2. The RIDE assessment tool in this figure shows the group average based on each *RIDE* characteristic.

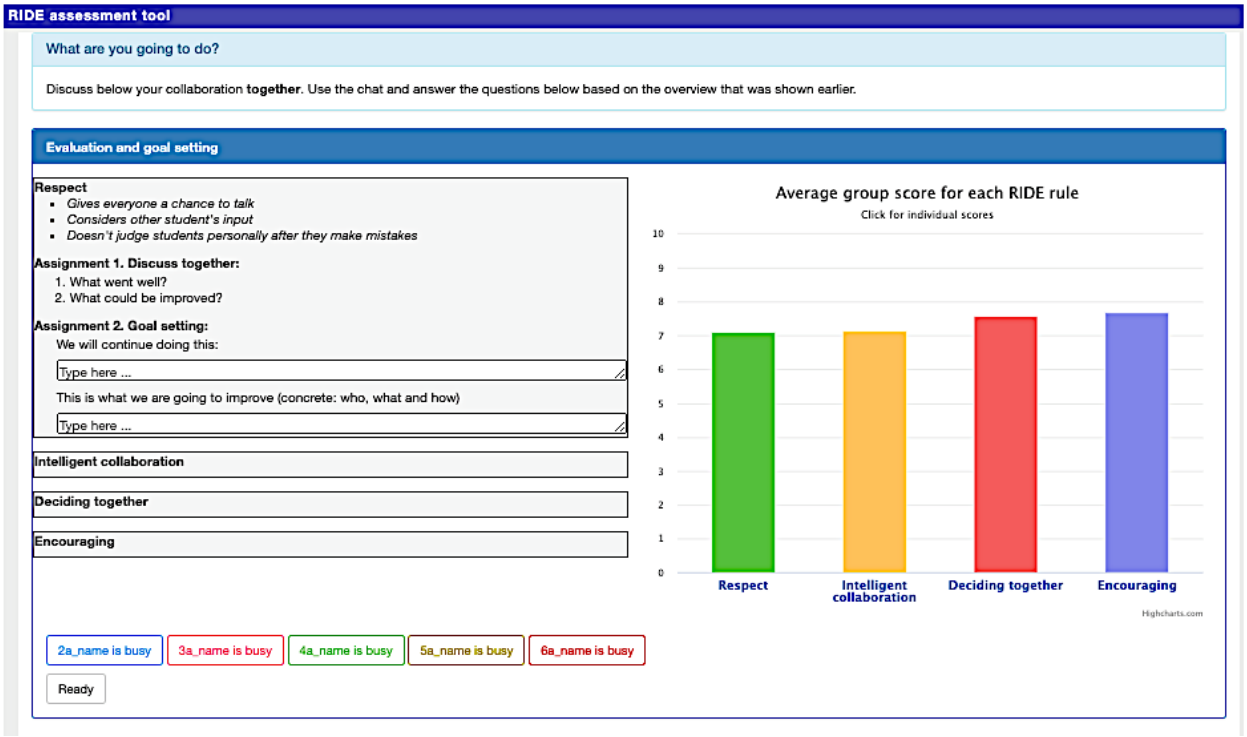


Figure B3. Lastly, the RIDE assessment tool showed the discussion and goal-setting guidance questions for each RIDE characteristic.

Group members in both conditions (gamified vs. non-gamified) could see the same scores for the sub-characteristics of each RIDE characteristic that were previously shown while being prompted to discuss them with the group. Particularly, for each RIDE characteristic, group members discussed together what went well and what could be improved and set a goal by indicating what they will continue doing and who, what, and how it will be improved in the future. Each of these discussion points were typed in a text field by a group member. Again, after the discussion part has been filled in, all the group members had to click on *ready* in order for the results to be recorded in the system.

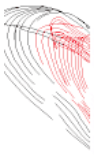
Appendix C

Collaboration Perception Survey Appearance

How did you **perceive** the collaboration in your group?

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
I really liked working in a collaborative group with my group members.	○	○	○	○	○	○	○
I liked solving problems with my group members in the group project.	○	○	○	○	○	○	○
I have benefited from interacting with my group members.	○	○	○	○	○	○	○
I have benefited from my group member's feedback.	○	○	○	○	○	○	○
I enjoyed the experience of collaborative learning with my group members.	○	○	○	○	○	○	○
Working with my group has resulted in better project quality than individual work would have.	○	○	○	○	○	○	○
My group members were sharing their knowledge during the collaboration process.	○	○	○	○	○	○	○
I gained (online) collaboration skills from the group work process.	○	○	○	○	○	○	○

Is there anything you need us to know or consider? Please feel free to comment here.



Would you like to stay updated on the I-crew project?

- ○ yes
- ○ no

Appendix D

Assessment Form of Individual Exams

Assessment form of the Individual Exams for Project One and Project Two

	Points
1. Evidence	
• The answers cover all the main aspects and provides necessary details so that a person who is not aware of the project goal and its context could understand the answer.	**(0 - 4)**
2. Accurateness	
• Used accurate terminology/jargon and statements.	**(0 - 3)**
3. Coherence	
• Used logical organization of contents.	**(0 - 2)**
Final Grade (1 – 10)	

Appendix E

Assessment Forms of Collaborative Assignments

	Points (0 – 10)
1. Introduction (15%)	
• introduce the scope in the first paragraph. • Provide a clear definition and / or explanation of concepts, terminologies and theories that are relevant to the hypothesis. Use the original article, Module book Brain and Cognition and the micro lecture for inspiration. • Introduce previous research, and the hypothesis and results of the original study. • Conclude the introduction by clarifying the type of replication you are aiming to perform and if there is any major difference in terms of procedure and controlled variables in your replication.	
2. Method (20%)	
• Describe the research methods in a correct way with the appropriate sections (Participants, Materials, Design & Procedure, Data Analysis). You can complement your section with the Appendices (not included in the word count). • Data analysis for the replication is appropriately reported • Make sure your Method section would allow another researcher to replicate the experiment.	
3. Results (20%)	
• Write down the results in a logical order. • Add descriptive statistics to provide insight into data patterns. Add inferential statistics to provide statistical grounding for answering the research question.	
4. Discussion (25%)	
• Paraphrase the hypothesis and answer it. This answer is explained and supported by referring to the described results. Report if results are in line or not with the results of the original study. • Discuss and support the results of this experiment (both if replication succeeds or fails) in the light of the theories mentioned in the introduction, and findings and theories from at least 3 other relevant scientific articles you find your-self. • Discuss and support the limitations (when relevant) shortly (< 200 words) insofar they limit the ability of the current findings to address the hypothesis. And (only if replication fails) add a brief explanation of the probable reasons, consequences and future work needed. • Reflect on and give support for possible implications of the results for practical domains or research. • End the discussion with two to three sentences providing a clear conclusion to the article.	
5. Work attitude (10%)	
• Communication with the tutor has been good; clear agreements have been made and have been met. • The group has shown an active and professional attitude (the group: spoke English during project meetings, has attended the majority of the project meetings, was on time and has shown initiative and constructive project management skills). • Feedback and suggestions for improvement have been handled professionally and implemented properly.	
6. Quality of reporting (10%)	
• There is a clear integration and coherence between the different elements of the report. • The report has a logic and consistent structure • The language used is scientific and spelling and grammar are correct • All references in the text and the reference list are in accordance with the APA guidelines.	
Final Grade (1 – 10)	

Table E1. Assessment form of the Collaborative Assignment for Project One

	Points (0 – 10)
1. Heuristic assessment (25%)	

• Provide a clear description of the product; i.e., what is it? How is it used? Which are the main functions?
• Introduce and explain the importance of Heuristic evaluation and the 11 design principles to inform a redesign.
  ○ A short background on Heuristic Analysis and Wickens principles.
  ○ Brief connection of the Wickens principles to the cognitive factors of attention, memory and perception.
• Perform an overall inspection of the product. Describe weaknesses (potential issues) and strengths of the product you identified in the overall inspection.
• Discuss at least 5 principles you selected that you consider important for the redesign, connect these to the cognitive factors (attention, memory and perception) i.e., here you can extend the analysis you made before about the 11 principles and the theory handbook.
• Explain why you selected these principles and excluded the others for the evaluation of the product.	

2. Redesign and Rapid Prototyping (15%)	
• Justify and explain at least three solutions you want to implement under the light of the cognitive factors (attention, memory and perception) i.e., Which interactive aspects do you aim to improve? How will the changes affect the interaction you aim to achieve? • Ensure cohesion between the solutions and problems identified in HE. • Describe your prototype. • Explain and justify the design choices in light of your HE, cognition, and your target group. • Report the link to the prototype.	
3. Usability Protocol and advice (30%)	

• Describe the methods of the usability test.
• Report and describe the context of use and the findings of the usability test in terms of effectiveness (major and minor issues), and satisfaction.
• Analyse the data and discuss results by answering the following questions:
  ○ How many and which problems were experienced by participants
  ○ Does the new design solve the issues you identified in the HE? Are there new/unexpected issues identified by the end-users? Is the prototype usable?
  ○ To what extent is the prototype satisfactory?
• Draw a general conclusion about the usability of the prototype.
• Based on your conclusion on the prototype's usability, advise future steps that should be taken in the iterative design process to further progress the design of your prototype.	

4. Work attitude (15%)	
• Communication with the tutor has been good; clear agreements have been made and have been met. • The group has shown an active and professional attitude (the group: spoke English during project meetings, has attended the majority of the project meetings, was on time and has shown initiative and constructive project management skills). • Feedback and suggestions for improvement have been handled professionally and implemented properly.	
5. Quality of reporting (15%)	
• There is clear integration and coherence between the different elements of the report. • The report has a logical and consistent structure. • The language used is scientific and spelling and grammar are correct. • All references in the text and the reference list are in accordance with the APA guidelines.	
Final Grade (1 – 10)	

Table E2. Assessment form of the Collaborative Assignment for Project Two

Appendix F

Avatar Passport Clean Design