

# Students' perception of risks in computer-supported collaborative design teams

Beth Morman and Ross Brisco 

University of Strathclyde, United Kingdom

 [ross.brisco@strath.ac.uk](mailto:ross.brisco@strath.ac.uk)

## Abstract

The recent Covid-19 pandemic created an unprecedented transition to distributed design team collaboration in education and industry, and with the sudden change in working environments, researchers must consider novel risks introduced to the design process. This research established that student perception of risk differs through personal experience and the impact of risks are greater when working online. Recommendations are made on how these risks could be mitigated further to allow the successful implantation of distributed design through computed-supported environment in education.

*Keywords: design teams, collaborative design, design education, digital design*

## 1. Introduction

Collaboration can be used to enhance individual learning by promoting knowledge sharing and working together to achieve common learning outcomes or goals (Johnson & Johnson, 2009). As identified by Kiernan et al., (2017), designers are facing more complex problems which have seen the introduction of multidisciplinary teams in industry, as no individual has the required knowledge to realise a solution. As a result, the ability to collaborate is now a fundamental skill required by designers. This has created a shift in the way designers need to be taught to prepare them for the workplace, to ensure they have the ability to effectively collaborate with others in order to optimise their potential (Maier et al., 2021).

Collaborative learning provides students with benefits not available in traditional learning environments including the development of interpersonal skills necessary for later life and future career prospects, more creative problem-solving, and increased confidence in tackling difficult challenges (Johnson et al., 2007; Shimazoe & Aldrich, 2010). Importantly, collaborative learning provides students the opportunity to gain the experience required to learn how to communicate effectively to combine their knowledge and develop new ideas. Facilitating the development of the necessary skills to provide innovative solutions to complex problems (Maier et al., 2021; Tang & Hsiao, 2013).

The environment in which people collaborate within industry and education has transformed with the introduction of computer-supported learning (Dillenbourg & Fischer, 2007; Shen et al., 2008). The COVID-19 pandemic has seen an unprecedented transition into distributed teams and online learning that required technology to facilitate collaborative teamwork. Distributed design and online education have been documented to bring many benefits (Chen et al., 2018; Chizmar & Walbert, 1999; Petrides, 2002; Shen et al., 2008), although these are not new concepts, the sudden transformation into this new working environment brought new risks. Educators must build their knowledge within this computer-supported environment post-pandemic, ensuring the benefits are not lost but the risks are managed effectively. This paper documents an investigation into the risks that students face while working in collaborative student design teams comparing perceived risks when working online and face-to-face.

## 2. Risk in collaborative design education

Risks have an impact on how students perceive collaborating in a team which can create a negative perception of teamwork in general, impeding the successful implementation of collaboration in future projects (Livingstone & Lynch, 2010). Pauli et al., (2007) states that the source of negative perceptions of teamwork predominantly comes from the opinion that group work presents a significant risk to their overall grade. Students can accept personal responsibility for failures but cannot accept it from others as there is a feeling of unjust related to their awarded grade. A study conducted by Scotland, (2014) validated this perception when comparing individual marks to group marks it was found that the majority of students performed better in group work than in individual work. 15 students failed the individual assessment however no students failed the group assessment. Students benefitted from those with a higher-grade average (Scotland, 2014) highlighting that group work raises students' grades overall, which disadvantages high-performing students who do not receive this benefit. Contradicting this collaborative teamwork does not solely focus on academic achievement but the development of interpersonal skills required for employment (Johnson & Johnson, 2009; Shimazoe & Aldrich, 2010). This highlights that educators must find a balance in the implementation of teamwork with individual work to ensure grades are a true reflection of students' knowledge and skill. Within student teams, there is always the risk that students are unable to collaborate successfully which in turn risks the success of the project or task. For the purpose of this study, a risk is defined as any factor which creates uncertainty about the outcome and has the potential to have a negative impact on any given project (Aven & Renn, 2009).

Crowther et al., (2017), Kiernan et al., (2017) and Tang & Hsiao, (2013) discovered similarities between risks identified in design education and general education. Kiernan et al., (2017) examined the collaboration between groups of first-year Bachelor students, Master's students, and professional designers with varying levels of experience. Although all teams demonstrated the ability to collaborate, only professional teams were able to effectively complete the design task. This suggests that a lack of communication and collaboration skills can prevent a task from being completed successfully. Furthermore, Kiernan suggests that a lack of experience may also contribute to the risk's occurrence. Crowther et al., (2017) agreed that communication was a key risk factor but argued that the lack of positive relationships posed greater risks to the project outcome. Crowther agrees with Johnson et al., (2007) by suggesting that a strong relationship is required to foster an environment that allows students to share information and express their opinions. Tang & Hsiao, (2013) studied the impact of this risk through a case study of students at the National Taiwan University of Science and Technology. It was discovered that miscommunication, lack of time management, and relationship conflicts all affect the team's ability to succeed. Although several risks unfolded throughout the project, the study highlighted the benefits of collaboration far outweighed the risks. The study found several suggestions on how this risk could be mitigated for a future project, suggesting the existence of risks within design teams are manageable to ensure the collaboration process remains beneficial.

In addition to the risks shared with collaborating in education, collaborating in design education has specific risks. Research suggests risks specific to design are centred around creativity. Panke, (2019) found that collaborating with others can reduce creativity, as idea generation can become polarised to certain individuals. This aligns with findings from Ehrlenspiel et al., (1997) who finds that often individuals can become fixated on their ideas, ultimately restricting the quantity and quality of innovative solutions later in the design phase. Furthermore, due to the ambiguity surrounding creative design projects, it can often be difficult for teams to collaborate and gain momentum past the initial problem which can lead to frustration (Panke, 2019). Overall, this highlights that risks within student teams are also highly prevalent within design, however, new risks are introduced when transferring creativity as an individual skill into a collaborative one.

Designers' working environments have shifted towards computer-aided design and virtual communication. The section that follows identifies the risks that arise, specifically when students collaborate in a computer-supported design team, helping to develop a cross-comparison between risks when working in various educational environments. Friendship and team member familiarity pose several potential risks when working online (Janssen et al., 2009; Kreijns et al., 2003). Janssen et al., (2009) discovered those team members who are unfamiliar with each other have a lesser understanding

of the task, which results in a greater number of messages required in the discussion. This suggests that a lack of familiarity jeopardises the effectiveness of online team communication. The risk of familiarity is present in both learning environments, suggesting that the risks online and in face-to-face teams are transferable. However, [Kreijns et al., \(2003\)](#) suggests that the risk of familiarity could be worse online due to a lack of multi-sensory communication in a computer-supported environment.

Furthermore, [Stockleben et al., \(2017\)](#) and [Muuro et al., \(2014\)](#) highlight a large majority of the risks in computer-supported design education are relevant to general student collaboration. However, they identify several risks which occur because of failures in the technology itself, suggesting that there are specific risks to collaborating online. Inequalities in technology available to students, internet access and accessibility to software may prevent certain team members from contributing as much as others. This poses a risk as online design projects must use a range of tools to allow the students to share ideas, sketches and images, if these tools are not available then design projects are not feasible online. Additionally, [Koh & Hill, \(2009\)](#) find that students may struggle to effectively collaborate online if they fail to understand the technology they are using, putting a further strain on communication.

Adding to the risk specifically affecting computer-supported design education, [Thakker & Shrivastav, \(2022\)](#) discuss vital parts of the design process such as prototyping and modelling that rely on students being present in person and are simply unable to be facilitated in an online environment. This removes the team's ability to collaborate on assessing the physical model as only a singular team member will have access to it.

### 3. Research methodology

As established by the literature review, a gap in knowledge has been identified that the following research question aims to answer:

*RQ1. How do students perceive risk when working in online computer-supported design teams compared to in-person design teams?*

Three sub questions were created to answer the primary research question. These are:

*RQ1.1 - How do students perceive the occurrence of risks in both environments*

*RQ1.2 - How do students perceive the severity of risks in both environments*

*RQ1.3 - How do students perceive the impact of risks in both environments*

The study was conducted with 25 students studying for a Master's degree in Product Design Engineering and Product Design and Innovation at the University of Strathclyde. This sample was selected as the 2022 cohort has 4 to 5 years of experience working within design team projects. The cohort additionally completed their degrees during the COVID-19 pandemic meaning they spent approximately half their degree working in full online computer-supported projects and half in collocated projects. This would suggest they have experience working both in online computer-supported design teams and in-person design teams and are therefore familiar with the potential risks of both contexts. The respondents had experience working with the same team members and different team members throughout their education in both settings for a holistic understanding of the challenges of teamwork.

The survey was conducted in the format of an online questionnaire. The online questionnaire was developed using Qualtrics and was distributed using a URL link. Closed and open-ended questions were used to collect responses towards the research question.

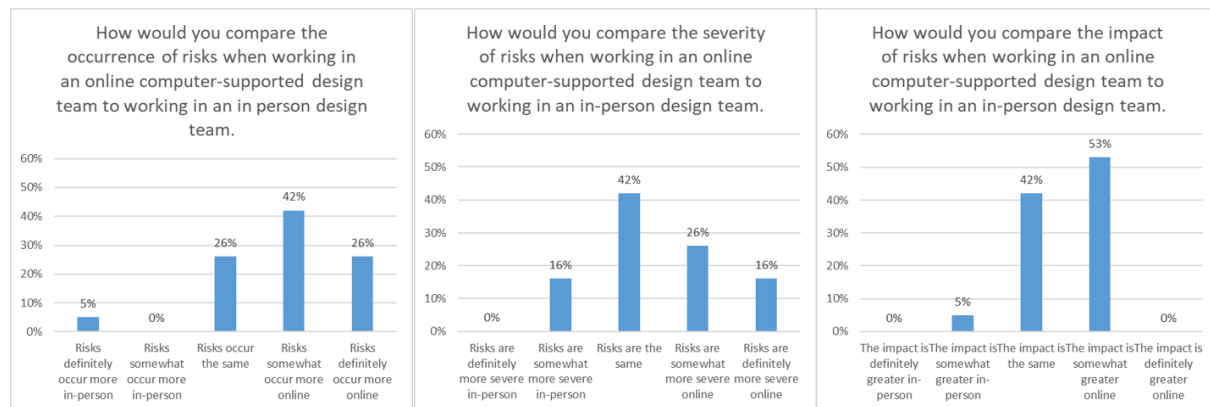
A mixture of scaled answer options was used for closed-ended questions. The categorical scale refers to the yes or no answer options. In addition, a 5-point adjectival answer scale was used when answers were comparing two points of view.

The questionnaire used open-ended questions to collect qualitative data. These questions were coded to allow for meaningful interpretations and analysis. Responses were coded using an inductive approach, which ensures that no information is lost during the coding process. Coding was completed in two stages. First, the text was reviewed to identify the general essence of the responses which then informed the descriptive code. The second stage involved line-by-line coding where the responses were organised into the code ([Wicks, 2017](#)). A matrix table was created to aid this process and was used for all open-ended question coding. The coding was completed by one research and validated by another.

## 4. Results

The questionnaire was split into three sections. Participants consider the occurrence, severity, and impact of risk both in online computer-supported design teams and in-person design teams. Students were asked to provide a direct comparison of their perceptions of risks in both scenarios.

In responses to Question 1 (Figure 1) 42% indicate that students believe risk occurs somewhat more online, with an additional 26% believing risks definitely occur more online. Notably, 26% of students believed that risks occurred in both settings equally. Overall, the data indicate that most students believe risks occur more frequently when working in an online computer-supported design team rather than an in-person one.



**Figure 1. (Left) Comparing the occurrence of risk online and in-person; (Middle) Comparing the severity of risks online and in-person; (Right) Comparing the impact of risks online and in-person**

Question 2 asked students to explain their reasoning for their response to Question 1. The results gathered were qualitative, therefore the data was coded using the matrix table template. Based on the key themes identified, the responses were coded into the following categories: Technology failing online, Design is more challenging online, Collaboration is more challenging online, Increased amounts of risks online, Different types of risks but the same amount, and Reduced amounts of risks online. Appendix 1 displays the results with colour to communicate the rationale for coding. Key themes identified were Technology failing online, Designing is more challenging online, Collaboration is more challenging online, Increased amount of risk online, Different types of risks but the same amount, and Reduced amount of risk online. The majority of students agreed through responses that collaboration is more challenging online (nine) which corroborates the results to question 1. Six students suggested designing is more challenging online, five agreed that there are the same amount of risks but different types online and offline, three agreed that there is an increased amount of risk online and three also agreed that there is a reduced amount of risk online. The last two results do not seem to corroborate the results of Question 1 but this is perhaps because of a lack of data. One respondent was categorised as technology failing online reflecting technology challenges.

Question 3 enquired on student's perceptions of the severity of risks when working in an online computer-supported design team compared to an in-person design team. As displayed in Figure 2, the results show that 42% of students find the risk to have the same level of severity. This is a significant shift from the previous perception of the occurrence of risks. However, 42% of students found the risks encountered to be somewhat or definitely more severe online.

To understand the reasoning for their perception, Question 4 asked participants to provide their justification for their response to question 3 as displayed in Appendix 1. As before, the results were qualitative and colour coding displays the justification for coding decisions. Key themes identified were Technology failing for online learning, Designing is more challenging online, Collaboration is more challenging Online, Different types of risk but the same severity, Similar types of risks for both, and Collaboration is more challenging in person. The most common response provided referred to there being similar types of risk (six) and that collaboration is more challenging online (five). Two responses

were coded as Designing is more challenging online, Different types of risk but the same severity, and Collaboration is more challenging in person respectively. One respondent was categorised as technology failing online reflecting technology challenges.

Question 5 asked the students to compare the impact of risks in an online computer- supported design team to an in-person design team. The findings as displayed in Figure 3 highlight that 53% of students find the impact to be somewhat greater online suggesting that if a risk occurs then the effect it has on the project is slightly worse when working online. However, 42% found the impact to be the same, inferring that on average, students expect the risk to be slightly higher online.

Question 6 asked participants to provide their justification for their response to Question 5, the results are displayed in Appendix 1. As before, the results were qualitative and colour coding displays the justification for coding decisions. The following themes were identified; Risks are more difficult to resolve online, The impact is more severe online, Impact is equally negative, and The impact is more severe in person. Impact is equally negative was the highest agreed sentiment within the responses (eleven) with Risks are more difficult to resolve online aligning with six responses. The impact is more severe online was coded in three responses, and The impact is more severe in person only aligned with one responses. These last two align with the outcomes of Question 5.

## 5. Discussion

The results of the research revealed that risk plays a defining factor in student collaborative design teams and holds an influence over how students perceive working in online computer-supported design teams compared to in-person design teams.

The results identified that students perceive that both the occurrence and impact of risks are greater when collaborating online. Whilst this was assumed, this exploratory study reveals evidence to support this expectation. Also, the perception of the severity of the risk has greater variance with a slight preference towards greater severity when working online.

Results in Figure 1 display a majority of students perceived risks occur more frequently when working online. This suggests that the risks of collaboration virtually are clearer to students. As highlighted in Appendix 1, students find it more challenging to collaborate in online groups, adding that they feel it is more challenging to stay invested and communicate effectively. This could lead to a breakdown in task distribution and increase the likelihood of risk factors such as freeriding to occur. Problems collaborating are likely to be a consequence of failure in technology which ultimately creates additional risks to online student design teams. Interestingly, several students referred to risks specific to design tasks that were not mentioned when asked to provide examples of risks from general collaboration. This suggests that students feel working in an online design team introduces additional risks making it harder to collaborate. Such risks include the inability to communicate ideas effectively, leading to decreased problem-solving abilities as corroborated by [Thakker & Shrivastav \(2022\)](#).

Similarly, impact was perceived to be greater online. Figure 1 demonstrates that students perceive risks to be more severe in person implying that confrontation is more likely to happen in person. Arguably, this could be interpreted that confrontation is easier to deal with in person allowing team members to communicate effectively.

Appendix 1 highlights that risks have a defining role in a design student preferred working environment. The majority of participants concluded that they prefer working in person than online due to project outcomes impact.

When compared to risk occurrence, student perception of risk severity was skewed towards indifference, although it was still concluded that the severity of risks is worse online (Figure 1). Results suggest that the increased number of risks online makes them more challenging to deal with, leading to fewer risks being mitigated. As displayed in Appendix 1, students found the severity of risks to be more similar in the two environments as the university projects were of similar nature. This resulted in students encountering similar types of risks. Furthermore, respondents highlight that several participants suggested severity of risks online are worse as it takes longer to deal with problems due to communication breakdowns. The increase in severity could also be explained by the additional challenges faced online such as students being less familiar with this way of working or a lack of intervention from lectures on how to adapt their style of working.

There was one disconnect identified within the coding which requires further investigation. In response to Question 2 on occurrence, a high number of responses were coded as same amount of risks but different types; online and offline. However, in response to Question 4 on severity a high number of responses were coded as similar types of risk; online and offline. Given the experimental setup we cannot define why this disconnect occurred. It may be that for severity and occurrence there are differences in the characteristics of risk online and offline. Further research is required.

The increased occurrence, severity and impact of risks within an online computer-supported environment indicates towards external factors contributing to the additional risk such as a lack of design tools or appropriate technology. In order to reduce the number of risks occurring, a possible solution could be to encourage lecturers to intervene and demonstrate how risks may be avoided or resolved. The introduction of established online tools and software could aid students with working online by providing more structure.

Furthermore, the increased risks could be interpreted as students lacking the knowledge and skill to know how to effectively collaborate and therefore mitigate the risk online. Thus, introducing more online projects with increased supervision and instruction throughout their education would allow students to proactively improve this skill, better preparing them for the workplace.

As educators, the outcomes of this study lead us to conclude that the perception that the occurrence and impact of risk in projects is higher online could result in students reducing the effort they make in online projects compared with in-person. This is supported with the perception that the severity of risks is reduced online meaning there are less consequences. To combat this, educators should ensure a high level of awareness of team issues early in the project and ensure suitable penalties are distributed when warranted. This can be difficult as there can be less justification or evidence to depend on.

## 6. Conclusions

In this paper, the results of research into students perception of risk are revealed. A primary research question and three sub questions were created to fill a gap in knowledge on students' perception of risk when working in online computer-supported design teams compared to in-person design teams. The outcomes of surveys of 25 Product Design students revealed that they consider the occurrence and impact of risks higher online than the severity of risks online. Students revealed the reasons for these perceptions which were categorised to identify the most frequently occurring, the most severe and the most impactful challenges commonly faced by students.

Risk plays a defining factor in student perception of collaborating in student design teams and determined students preferred working environment. Further research on this topic could aid educators in mitigating these risks and allow the successful incorporation of collaboration while also gaining a better understanding of how to introduce fully digital online design projects.

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## Appendix 1 - Coded reasoning for students' perceptions of the occurrence of risks online and in-person.

Response	Technology failing online	Designing is more challenging online	Collaboration is more challenging Online	Increased amount of risk Online	Different types of risks but the same amount	Reduced amount of risk online
It's <b>Difficult to work online together</b> people tend to just do their own part and not really communication so there more risks of stuff going wrong.			1	1		
It is challenging to work effectively online as a team as people don't reply to messages and can ignore you easily.			1			
Risk can happen both online and offline, but I think there are more risks online, especially when doing a design project as it can be difficult to share sketches and CAD virtually.		1		1		
The team doesn't work together as closely, and it can be difficult to work together online.			1			
Lack of communication and can allow people not to contribute.			1			
It can be easier to arrange virtual meetings, due to the increased flexibility. This can enable more frequent communication, perhaps at the expense of increased difficulty in communicating physical ideas through the computer. The challenges faced in projects are largely the same in both.		1			1	1
People feel less invested in the team while working remotely.			1			
A greater level of separation makes communicating ideas harder between team members. This can lead to differences in interpretation more often than in person.		1				
Because it is easier to oversee aspects of design when only working online.						1
Mostly regarding illness risks, you're sort of protected from them when working online.						1
It is harder to communicate and share work digitally which can make working as a design team far more challenging and results in more issues between teams.		1	1			
Different types of risks appear in both settings.					1	
Online working is a lot less personal, and members of the team are therefore less engaged in the project. This prevents them combating potential risks as effectively as in person learning?			1	1		
There are different risk depending on if you're working online or in person.					1	
I think it balances, sometimes it's harder to get a hold of people but I find when working online people are better with time of meetings, agree on things more quickly.					1	
If someone's internet cuts out, then all members can't attend the meeting. More difficult to conduct design activities (e.g. 6-3-5).	1	1				
Same amount of risks but different risks.					1	
Miscommunication is much more likely when working online. Working in person can allow for a lot more free flowing design thinking.		1	1			
Team mates can ghost you.			1			
	1	6	9	3	5	3

Code



## Appendix 2 - Coded reasoning for students' perceptions of the severity of risks online and in-person

Response	Technology failing for online learning	Designing is more challenging online	Collaboration is more challenging Online	Different types of risk but the same severity	Similar types of risks for both	Collaboration is more challenging in person
Risk both on online and offline are pretty similar overall so the risk are pretty much the same severity		1			1	
Completing design work online is challenging therefore there tends to be more severe risk online such		1				
The risk are pretty similar but there are more sever risks that occurs online such as people not replying in group chat and generally not added work to the project close to the deadline this doesn't really happen in person.			1			
I think risks are more severe online as there are more challenges to overcome when designing and therefore it can be really difficult to overcome compared with in person.		1				
Not having the correct tools & technology	1					
I think the greatest risk to any group project is down to the individuals in the group, and their work ethic, standards, motivations, disciplines, and time management skills.					1	
People will often say things online that they wouldn't otherwise say, possibly leading to a more toxic work environment.						
I think the severity of risks is the same in both versions, but the fact that they are more likely online is what makes them pose a greater threat.					1	
Similar tasks - similar severity of risks				1	1	
The risks are different, but they are equally as sever						
The risks have the same outcomes both in person and online					1	
The risk of a team breaking down is greater in person						1
I believe the severity risks are the same but may be perceived as more severe during online learning, this is because a team working online lacks a feeling of togetherness when viewing the risk			1			
Different risks depending on online or in person				1		
As above, it balances						
lack of teamwork can impact the project progress more severely online					1	
It is harder to communicate online			1			
The risk is severe as it is hard to keep track of work and so things could go completely unchecked			1			
It's harder to ask people to change their working style in person						
	1	2	5	2	6	1
						2

Code

### Appendix 3 - Coded reasoning for students' perceptions of the impact of risks online and in-person

Response	Risks are more difficult to resolve online	The impact is more severe online	Impact is equally negative	The impact is more severe in person
If a risk occurs then the impact is bad their way but I can be more difficult to resolve online	1		1	
the impact of a risk is pretty bad both online and in person			1	
as the risk are more sever online if they happen then the impact is a worse		1	1	
if a risk occurs then the impact is the same online and offline			1	
If a risk occurs it's bad either way			1	
I think the impact is the same in the university group project context, because for me the greatest risk in group work is the loss of marks or failing to meet criteria. As such, I think the tangible output of the project (report, presentation, other deliverable) can be the same whether working in-person or remotely, and so the impact on marks is roughly the same.			1	
Issues can go unresolved for longer in online groups, leading to an increased impact	1			
Code				
compared to in person. The presence of more frequent risks online can lead to a greater impact on the team dynamic resulting in distrust etc.		1		
Similar tasks - similar impacts			1	
Being ill doesn't stop you from working online, but it's likely to stop you from meeting in person	1			1
It can be harder to resolve issues through online systems so the impact can be worse	1			
The severity may be lower but it is harder to amend over online	1			
Greater online due to it being harder to work as a team to fix the problem.	1			
Risks tends to be a person not showing up for meetings or not completing the work which happens online and in person			1	
Different risks can happen in both so it balances out			1	
The impact is bigger as if something goes wrong online, its harder to resolve			1	
Similar impact on uni grades but different risks			1	
For example if you cannot get in contact with a group member the impact of this online is massive as you can't physically go and find them.		1		
	6	3	11	1