How did the pandemic impact interaction in student design groups?

Ksenia Piątkowska† & Rodrigo F. Herrera‡

Gdańsk University of Technology, Gdańsk, Poland†
Pontifical Catholic University of Valparaiso, Valparaíso, Chile‡

ABSTRACT: In this article, the authors discuss the impact of the coronavirus pandemic on students' collaboration in design groups in architecture education. The article includes a quantitative and qualitative analysis of the data collected through a questionnaire distributed to students in the Faculty of Architecture at Gdańsk University of Technology (Gdańsk Tech), Gdańsk, Poland. A brief literature review is also presented to assess observations and findings in the same circumstances in other countries worldwide. The study aimed to evaluate the changes in collaboration and interaction settings, and formulate general conclusions. The presented data allowed for the identification of the main problems in interaction and co-operation between the students during the design studio classes conducted remotely. Some findings of this research are contrary to the most frequently described pandemic effects, while others are congruent with general pandemic-related interaction issues outlined in the reviewed literature.

INTRODUCTION

The research described in this article was focused on the changed circumstances of students' collaboration in design groups in architecture education during the semesters after the outbreak of the coronavirus pandemic. All schools of architecture use a project-based teaching method [1]. In this type of higher education, direct, personal contact between the supervisor and collaborating students is crucial for building effective interaction in the teams working together in the design studio creation process. A good architecture education cannot develop without good communication to explain ideas to others [2]. Therefore, the authors of the present article decided to explore the issue of interaction and collaboration between participants of the didactic process in architecture design studios in the circumstances of pandemic-imposed constraint regulations.

The importance of interaction in architecture teamwork and challenges cannot be overestimated**.** The team interaction process is based above all on internal communication between the team members. Different types of internal and external working together defined as communication, co-ordination and collaboration among the members create the interaction in teamwork [3]. This interaction can be described as the flow of information between the relevant people at the appropriate moment [4].

Poor work team interaction can contribute to poor performance in each stage (design, construction, maintenance, operation and deconstruction). Interaction is a crucial element in active teaching-learning approaches, is a crucial element where learners receive feedback, are motivated to achieve something and get expertise and inspiration to learn [5]. The student's academic self-concept is strongly related to their sense of professors' approachability, accessibility, respect for students and interaction [6].

Collaborative learning through work teams generates spaces for social interaction, allows for direct relationships between peers, and develops conditions that allow for participatory knowledge acquisition, encourage student communication and raise the sense of shared responsibility. When students get the task right, they have a collective sense of achievement. They learn together sharing the learning process, sharing their expertise and learning how to do new things together.

The following section of this article is a literature review on research findings from different countries related to the impact of changing the in-person teaching method to on-line in collaboration and interaction in project design teams in architectural higher education.

According to the analysed articles, the lack of face-to-face contact with the supervisors and peer students at design studio courses in terms of collaboration and interaction resulted in:

1. Difficulties faced by students:

a) Isolation and separation, where experiences like *not seeing others' feedback or panels made us completely blind on which stage are we in exactly* [7] were reported in the National Design Studio Survey which revealed that learning satisfaction decreased by 58% with on-line education [8], and the design studio culture was compromised by students feeling isolated [8-10], indicating the relevance of social connection and informal networks as a vital aspect of learning [11];

b) Dissatisfaction and discouragement, as students were reluctant to use the design studio due to the lack of interactivity [12] and student-student interaction in on-line education was a weak spot in the chain [13];

c) Presentation of their projects on-line, to express their thoughts and ideas as easily as in person [7][9];

d) Understanding teachers' instructions on-line [14];

e) Lack of a sense of support, where students felt unsupported during the pandemic [9], where factors, such as the lack of an appropriate and decent learning atmosphere, lack of interaction and lack of appropriate learning resources could cause severe disruption to the students learning effectiveness [15], and underlined low interaction and communication between students and instructors, and the need to rely on alternative solutions like various modelling and sketching programs due to the insufficiency of communication platforms used during the pandemic [16].

2. Difficulties faced by tutors:

a) A sense of alienation felt by supervisors and serious difficulties in explaining educational issues to students remotely [17]. The lack of tutor proficiency for virtual design training [18][19] and the inability to convey feedback virtually [20] were some of the main obstacles at the beginning of the pandemic. Tutors noticed that the quality of formal teaching interactions had fallen after the move to on-line teaching [21].

RESEARCH QUESTIONS AND METHODOLOGY

In this article, the research question: *How does the pandemic influence interaction in student design groups?* in the field of architectural education is approached through three different ways: a case study (as a quantitative and qualitative method) and a literature review. The case study was based on a survey distributed to students in the Faculty of Architecture at Gdańsk University of Technology (Gdańsk Tech), Poland. The survey was used to record students' responses towards teaching and learning in the virtual architecture studios. It was created using the SurveyMonkey server and sent to 43 students forming two project groups and their three supervising professors after they completed their final submissions between 2nd and 23rd of June 2020.

The survey contained 12 questions, including two main categories: general information (five) and interaction items (seven). The students' responses regarding design studios and theoretical support, technical problems faced by the students during the virtual class, health problems, and their attitude towards the method of assessment are shown in the results section (Table 1). The social network analysis (SNA) methodology was employed to evaluate the interactions between the case study participants. The results section reports on these findings based on the information gathered as a result of the applied methodologies.

The literature review aimed to outline the research background and compare the results of the present research with problems on collaboration and integration in design teams described in other studies. The relevant documents were extracted from the Web of Science (WoS) database. It was decided to use WoS because it contains almost all major research articles and has built-in analytics to output a comprehensive number of records [22] with better citation-matching algorithms than Scopus [23].

To search the WoS database the following retrieval schemes were used: in *ALL FIELDS*, there were chosen 1) architecture education; 2) design studio; and 3) Covid-19, given the timespan (index date) from the 1st of January 2020 until the 1st of March 2024. The search yielded 63 publications. Manual screening was performed to filter out non-essential records. The filtering excluded 53 records. The identified 63 articles were carefully selected based on the defined parameters: field (architecture, education and educational research, remote research, and education), publication language (English) and publication type (all). In the next step, all the obtained documents were reviewed as full text, and 23 documents were removed. The authors read the abstracts, introductions and conclusions of all the papers to confirm that they were relevant. Ultimately, 30 papers were chosen for assessment.

The interaction in student project groups is hypothesised as a component most exposed to pandemic restrictions in architecture teamwork. The role of interaction in architectural education is depicted in Figure 1a and the hypothesised influence of pandemic circumstances on the interaction is depicted in Figure 1b. This initial research model is used as a guiding frame for the research.

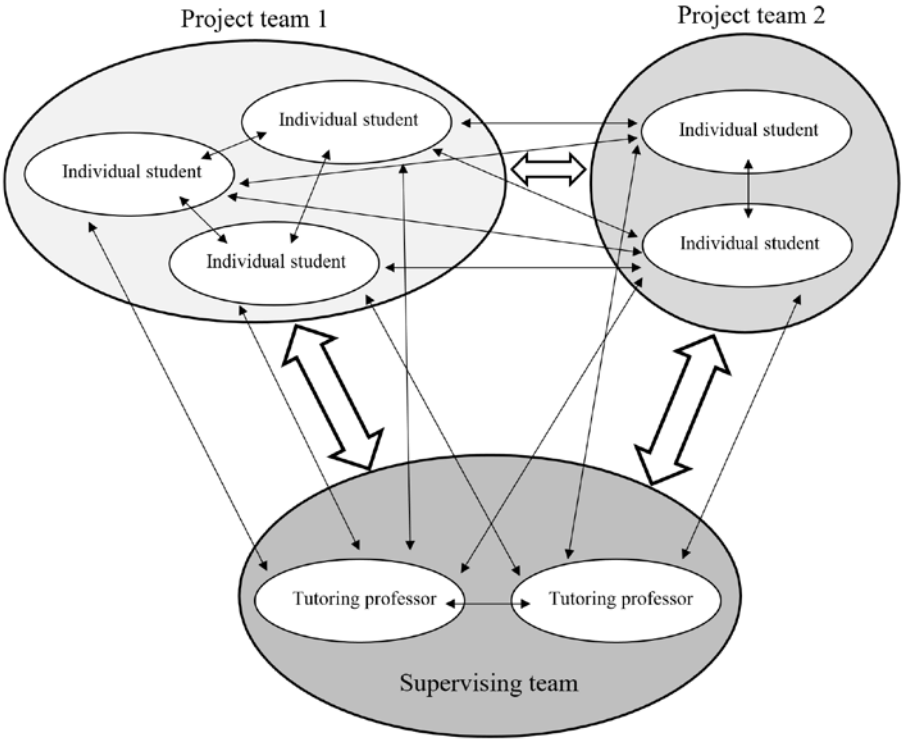


Figure 1: a) system of interaction in architectural education.

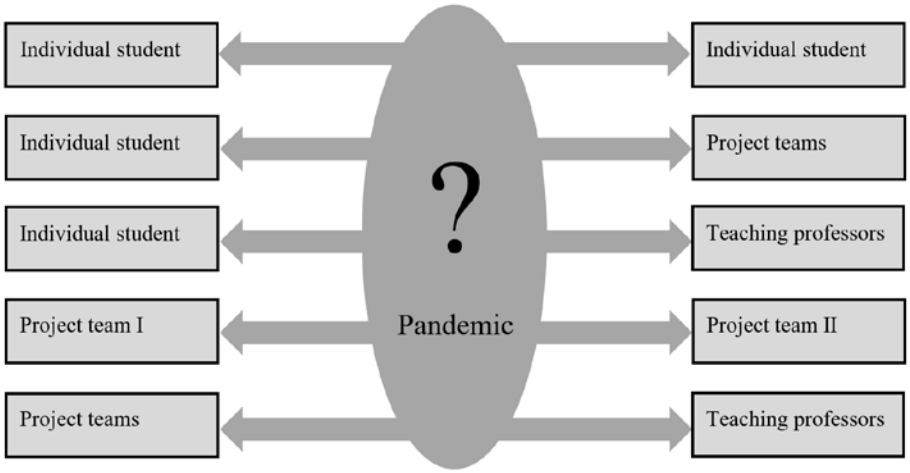


Figure 1: b) initial research model - influence of the pandemic on the interaction in architectural education.

CASE STUDY - GDAŃSK TECH

The research was conducted on students enrolled in the Architectural Design course for the MSc degree, in the Faculty of Architecture, at Gdańsk Tech. The study comprised a group of 43 students, divided into two project groups, along with their three supervising professors. The first group, G1, consisted of 15 Polish and two Ukrainian students, while the second group, G2, comprised 11 foreign and 15 Polish students. Each group was supervised by two professors separately. The SNA methodology was employed to evaluate the interactions between the case study participants. The SNA involves the representation of organisational relationships as a system of nodes linked by precisely classified connections [24], and is a method used to represent relationships among people. In this method, people are represented by nodes, and the connection between them is represented by an edge.

First, the interaction data were organised in an MS Excel sheet, and then processed and analysed using Gephi 0.9.2, which is free software that helps in creating sociograms and calculating the metrics of each type of interaction. The interaction analysis of all participants in the design process consisted of: a) student-professor relations; b) students-students within one project team; and c) students-students outside their project team.

Second, to assess the relationship between students and supervisors, the ratio of the number of actual links and potential links between the members of each team and their supervisors was calculated. This ratio was calculated for each network assessed (Table 1). The student-supervisor ratio (SSR) is a value that oscillates between 0 and 1; therefore, if the SSR is closer to 1, the relationship between the team members and their supervisors will be stronger.

Third, the authors calculated the internal relationship ratio (IRR) of each team as the division between the actual connections and the potential connections of each team. The IRR was calculated for each network evaluated (Table 1); in addition, the IRR has similar behaviour to the SSR, that is, it has a range between 0 and 1.

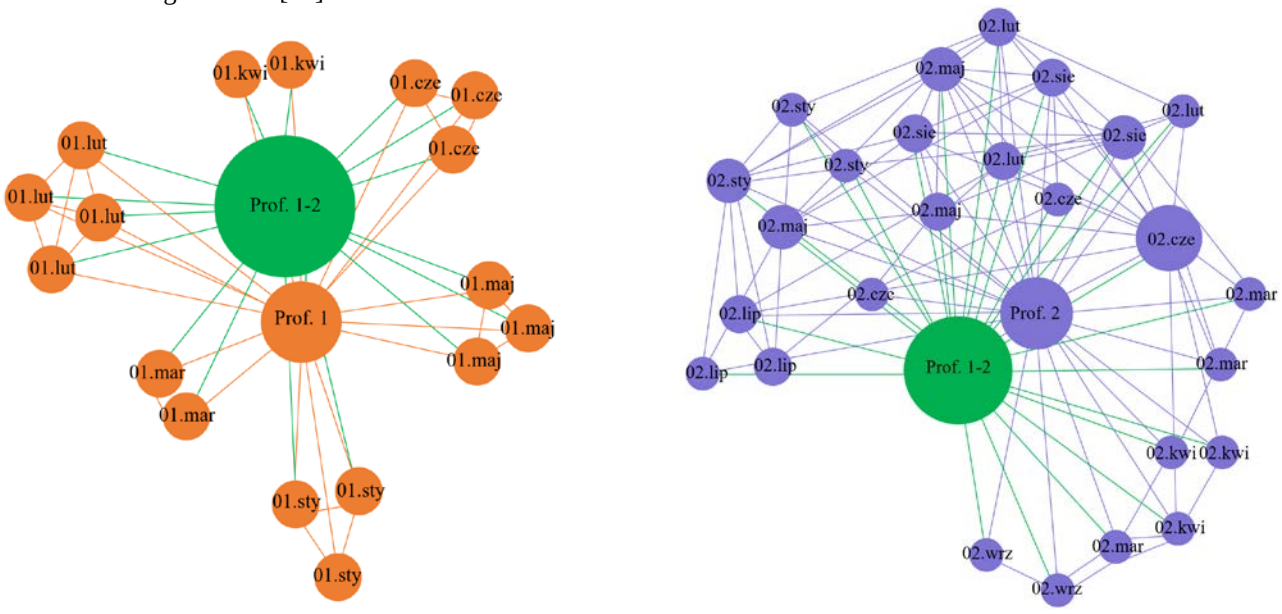
Fourth, for each team, the percentage of external teams connected (PET) was calculated. The PET is obtained as the division between the number of external teams that have some relation and the total number of teams in the case study (15). The PET was calculated for each team in each type of interaction evaluated (Table 1).

Table 1. Interaction questions.

Type of interaction	Question	Possible answers
Interaction	Please indicate which of the following people you have had an interaction with. Examples of interaction are telephone conversation, effective e-mail exchange (with a response from the other party), live conversation regarding a work-related situation and on-line consultations.	All students and professors
Planning and problem-solving	Indicate how often you plan and solve problems with the following people in the project. Consider the last four months.	All students and professors marked in the *interaction question*
Collaboration	Indicate how often you work together with the following people in the project. Consider the last four months and the following definition as a reference. Working together involves working with another person on the same task at the same time, whether it is face-to-face or not (by telephone, video conference, etc).	All students and professors marked in the *interaction question*
Learning	Select all the people from whom you have learned something new during the project. Consider the last four months and the following definition as a reference. The *learned* can be something technical related to the knowledge, some skill or competence or some attitude during the work.	All students and professors marked in the *interaction question*
Trust	Select all the people in the project that you consider trustworthy in your work. A trustworthy person will execute his or her work according to the quality requirements and the deadline established.	All students and professors marked in the *interaction question*

RESULTS

Figure 2 shows the interaction network of groups 1 and 2, respectively. From the first approach, group 1 concentrates its interactions inside the work teams, and both supervisors are in the centre (Figure 2a). On the other hand, group 2 shows internal interactions in each work team and also external relations, in other words, there are interactions with members who are external to the work team itself (Figure 2b). Both teams present two different types of networks - group 1 a star network, that symbolises vertical organisations with low levels of horizontal interaction and with greater obstacles to creating innovative ideas, group 2 a round network - with high horizontal and vertical flow of information, flexibility and effective organisation [25].



a) b)

Figure 2: a) group 1 interaction network; and b) group 2 interaction network.

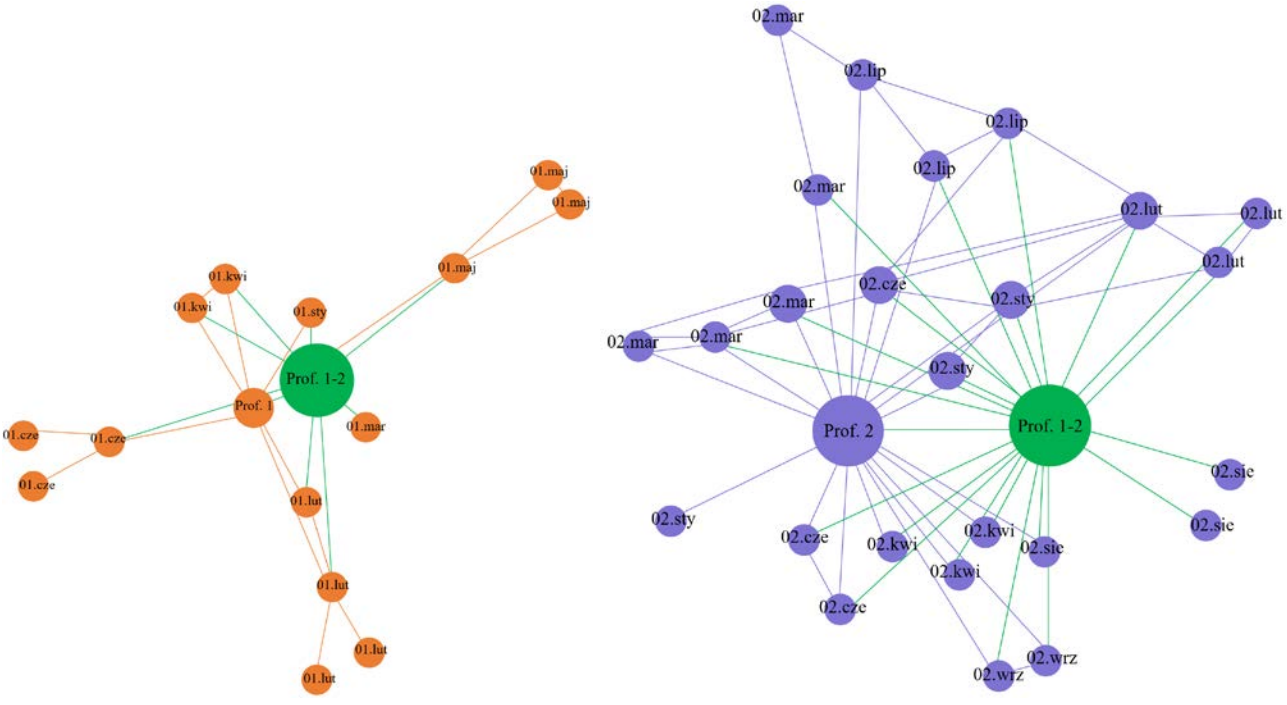
Table 2 shows the network metrics for the full group and for groups 1 and 2 independently (G1 and G2). In all types of interaction, the average degree ratifies a greater interaction in group 2 than in group 1. However, the densities of the interactions do not present evident differences between groups 1 and 2, since group 1 has a high flow of interaction concentrated internally in each work team. The main difference between students from group 1 and group 2 lies in the number of people they connect with. Students from group 2 have a larger network compared to those from group 1. In the interaction network, there is one connected component, and supervisors play a crucial role in allowing connections between all students. This is especially important for group 1, where there are no pre-existing relationships between work teams.

Table 2: Overall network metrics.

Groups	Average degree	Density	Connected components	Diameter	Average path length
Full interaction	8.04	0.18	1	3	1.85
G1 interaction	5.37	0.30	1	2	1.70
G2 interaction	9.07	0.34	1	2	1.66
Full planning	6.57	0.15	2	3	1.90
G1 planning	4.95	0.28	2	2	1.69
G2 planning	7.36	0.27	1	2	1.73
Full collaboration	6.30	0.14	2	3	1.91
G1 collaboration	4.95	0.28	2	2	1.69
G2 collaboration	6.93	0.26	1	2	1.74
Full learning	2.15	0.05	5	7	2.22
G1 learning	1.53	0.09	4	2	1.22
G2 learning	2.46	0.09	2	7	2.34
Full trust	2.89	0.06	3	13	3.69
G1 trust	2.32	0.13	3	4	1.78
G2 trust	3.18	0.12	1	13	4.06

Group 1 in the types of interaction of planning, collaboration, learning and trust has more than one connected component, i.e. in this group there are students or isolated subgroups of students that do not even achieve an interaction of this type with the supervisors, which would allow to keep the group connected. On the other hand, group 2 in the types of interaction of planning, collaboration and trust has only one connected component, i.e. there is no isolation. However, in the learning network, there is a team isolated that does not connect with the whole group 2.

In the networks of interaction, planning and collaboration, there is an average degree of more than five, in other words, on average each member of the group relates to five other members. However, in the trust and learning network, the average degree drops to approximately two or three people (Table 2). This value is low, considering that two supervisors participate in the network, therefore, the trust and learning network would drop even more if these were not considered.



a) b)

Figure 3: a) group 1 learning network; and b) group 2 learning network.

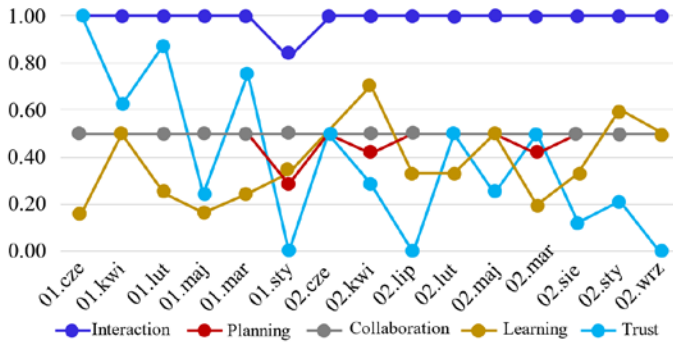


Figure 4: Student-supervisor ratio (SSR) of each team.

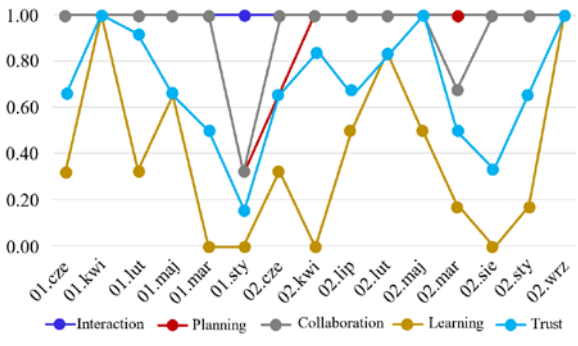


Figure 5: Internal relationship ratio (IRR) of each team.

Figure 4 shows the student-supervisor ratio (SSR) of each type of interaction of each team. The labels of teams starting with 01 and 02 belong to groups 1 and 2, respectively. The SSR of the global interaction network is 1 in most teams, which shows that in both groups there was a high level of interaction with the supervisors. The SSRs for the planning and collaboration network are similar. In both cases, the SSR has a value of around 0.5, which is explained by two reasons: 1) planning and collaboration were done with only one of the two supervisors; and 2) planning and collaborative interaction with supervisors was focused on some student leaders. There were also no significant differences between the teams in groups 1 and 2.

The networks that show the greatest variability in social support rating (SSR) are undoubtedly the learning and trust networks. The average SSR value in the learning network is 0.38, with a maximum value of 0.7 and a minimum value of 0.17. These values are relatively low, especially when one considers that the most significant learning expected in a university course comes from the student-teacher relationships. The average SSR value for the learning network is 0.28 in group 1 and 0.44 in group 2. On the other hand, the SSR in the trust network has an average value of 0.39, with a maximum value of 1.0 and a minimum value of 0. The average SSR value for the trust network is 0.58 in group 1 and 0.28 in group 2.

Figure 5 shows the internal relationship ratio (IRR) of each type of interaction of each team. The IRR of the global interaction network is 1 in most teams, which shows that in both groups there was a high level of internal interaction. The IRR for the planning and collaboration network are similar and close to 1 in almost all teams (except for team 01.sty and 02.mar). In both cases, the SSR has a value around 0.93; and there were no significant differences between the teams in groups 1 and 2. Similarly to the SSR, the IRR with the highest variability are the learning and trust networks. The IRR in the learning network has an average value of 0.39, a maximum value of 1.00 and a minimum value of 0. These values are similar to the SSR, and the average of groups 1 and 2 has the same value. Complementarily, the IRR in the trust network has an average value of 0.69, a maximum value of 1.0, and a minimum value of 0.17. The average value of the IRR for the trust network is 0.65 in group 1 and 0.72 in group 2. The trust between the teams of students is even greater than the trust generated by the teams towards the supervisors. This is especially important in group 2 teams where there are students of different nationalities.

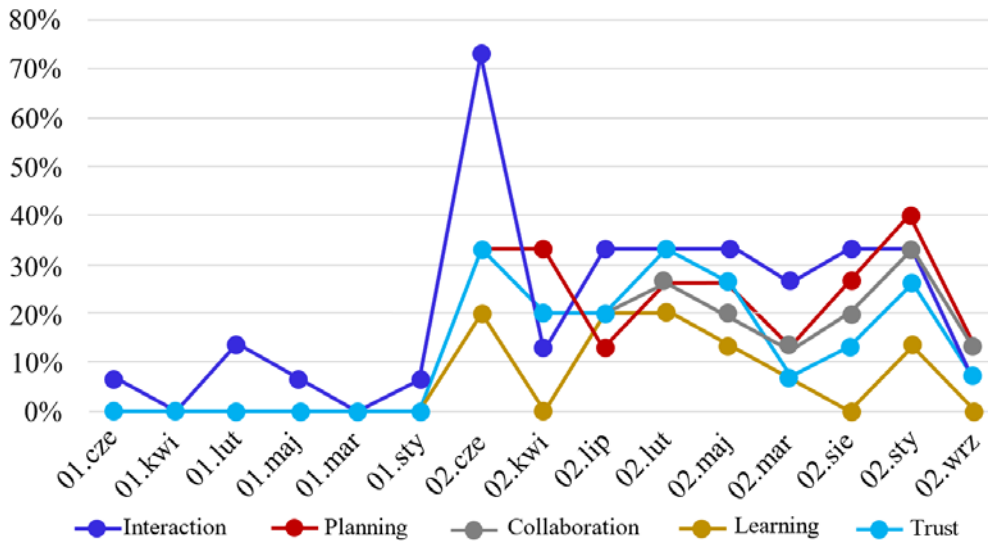


Figure 6: Percentage of external teams connected (PET) of each team.

Figure 6 shows the percentage of external teams connected (PET) of each type of interaction of each team. This indicator shows the biggest difference between the teams in group 1 and group 2. The teams in group 1 have no connection among the teams in the same group; the only connections in the interaction network with other teams are

teams in group 2. Figure 6 shows how group 1 teams have no relationship with other teams in matters of planning, collaboration, learning and trust. On the other hand, the teams of group 2 have higher percentages of external relations than the teams of group 1, which ratifies the horizontal interaction observed in Figure 3. The team of group 2 interact with the other five teams on average, they meet to plan with the other four teams on average, and collaborate with the other three teams on average. Additionally, these teams have links of trust with the other three teams and learn from at least one or two other teams.

Each team had the right to contact the supervisors as often as it felt necessary. However, not all teams used the opportunity to meet regularly, and significant downtime was observed. In group 1 with six project teams, it was observed that three teams were working intensively on their design concept sending the materials to be revised regularly once a week or more often. Three other teams contacted the supervisors seldom, one of the teams stopped sending the advanced materials at the end of April, which indisposed the substantive tutoring. Group 2 consisted of nine project teams, all teams worked at a similar level of commitment until the end of May. In May, one of the teams lost a member, leaving the team with only two students. This had a significant impact on the team's dynamics, but on the positive side, the remaining two members were motivated to compensate for the loss by intensifying their communication with supervisors. They were able to make better decisions and implement them more efficiently, thus optimising their processing forces.

DISCUSSION

In Figure 4, it can be observed that most design teams interact with only one supervisor, even though two supervisors are available. This could be due to limited time for feedback and communication opportunities or the unavailability of one of the professors for remote consultations. This finding is consistent with the limitations in the availability of supervisors as observed in the analysed articles [14][17][18][20].

The case study demonstrates that each project group had different ways of developing their interactions and collaboration abilities. Group 1 (G1) had very little contact with their peers, while group 2 (G2) was more willing to co-operate externally, although there was also one isolated team. This could be attributed to varying levels of trust and approach to the content transmitted through remote learning, as indicated in the studies of Alnusairat et al [9] and Grover [21]. Studies have demonstrated the relevance of social connections and informal networks as a vital aspect of learning [11].

The case study presented in SSR, Figure 4 reveals that the most significant variation in the learning and trust networks is due to the student-teacher relationships. This emphasises the importance of the relationship between the students and teachers in a university course. This finding is consistent with the above-mentioned articles written by Alnusairat et al [9] and Grover [21].

According to the case study, both project groups (G1 and G2) had a high level of internal interaction. There were no significant differences between the teams in those groups, which suggested a situation quite opposite to those most frequently described in reviewed articles, where students felt isolated and separated [7][8], and were dissatisfied and discouraged due to the lack of interactivity [12] and insufficient opportunities for peer connections in general [10]. Furthermore, in pandemic circumstances, teams of students exhibit greater trust towards each other than towards their supervisors, which contradicts the overall description of collaboration.

The results of the case study showed that a group of students from one nationality (G1) did not communicate with each other within their project group. In contrast, a group of international students (G2) had higher levels of interaction and trust with other teams. This result is in contrast to most cases described in the reviewed literature. The literature suggested that students from outside a given country face greater difficulties in connecting with their peers during remote education at design studios [21][26].

The case study revealed that some teams did not take advantage of the opportunity to meet regularly, leading to significant downtime. Some teams rarely contacted their supervisors, and one team even stopped sending advanced materials, which hindered the quality of tutoring. One of the teams ended up with only two members, which had a significant impact on the team's dynamics and work. This lack of motivation is similar to the reasons mentioned in the reviewed papers for students not participating in classes, such as the absence of a positive and conducive learning environment, limited opportunities for interaction and inadequate learning resources. These factors could greatly impede students' ability to learn effectively [9][12][15].

CONCLUDING REMARKS

The summary above outlines the results of a case study conducted during the pandemic on the students of the Faculty of Architecture at Gdańsk Tech. The presented literature review of relevant papers published from 2020-2024 demonstrates the difficulties of collaboration and integration in design teams on a global scale. The reviewed papers indicate that the pandemic has had a similar impact on these issues globally, although there are differences. The case study reveals that students have difficulty adapting to the on-line studio in terms of social interaction, peer learning,

group collaboration and instant feedback from instructors. While remote teaching may be a substitute in an emergency for projects involving group work and discussion, it cannot replace the real classroom experience. It is important to note that this study has limitations concerning the sample group, as it only reflects the perspectives of students from a single university. For future studies, it is essential to use a larger sample group from different universities to obtain more detailed results.

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