PROCEEDINGS OF ASIA DESIGN AND INNOVATION CONFERENCE
5–6 DECEMBER, 2024, SHANGHAI, CHINA

INTRA-GROUP CONFLICT AND STUDENT TEAM'S PERFORMANCES IN DESIGN PROJECT

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ABSTRACT
In recent years, design projects have been held in various educational settings. Students take project-based learning (PBL) courses to learn design approaches and mindsets. Even though students act in the same settings, team performances vary, and researchers have been trying to reveal the differences. Although support for student teams is required, there is a lack of understanding of the team's level activities in a design project and a good way to grasp the student team's status. To bridge these gaps, this study proposes using a questionnaire for perceived intra-group conflict to monitor student teams. The objective is to understand the relationship between dynamic patterns of intra-group conflict and the student team's performance in a design project held as a PBL course at a Japanese university. Three types of conflict (task, relationship, process) were measured weekly with a questionnaire. The results revealed the difference between well-performed and not well-performed teams in task and relationship conflict. In the task conflict, not well-performed teams showed extremely high values at some points, while values of good teams moved moderately. In relationship conflict, not well-performed teams showed higher values than good teams. There were no significant differences in process conflict, possibly because of the fixed schedule of the course. In addition, dynamic conflict patterns extreme points and frequent changes throughout weekly data collection. This research is the first step in using dynamic conflict patterns to monitor the team's condition, and further data collection and analysis are required to make them more credible.

Keywords: Design Education, Intra-group Conflict, Student Team, PBL, Team Monitoring

1 INTRODUCTION

In recent years, there has been a growing emphasis on equipping non-design experts with design skills, leading to integrating design projects across various educational settings. In the design research field, various studies aim to understand novice team behaviour in the project (e.g., [1], [2], [3]). In an educational context, students take project-based learning (PBL) courses to learn design approaches or mindsets and work in teams over several weeks or months to develop new products or services using design thinking(e.g.,[4], [5], [6]).

However, novice designers often face various challenges in the design process, primarily due to the iterative nature of design. This iterative process, coupled with the complex, ill-structured problems it entails, can be particularly challenging for students [5], [7]. Even though students act in the same conditions, teams' performance varies depending on various internal factors. Researchers are interested in the distinction between successful and struggling teams to improve students' practice or learning experience. Some studies report the nature of teams under projects. For instance, Nizam (2022)[8] identified a pattern of behaviour typical to approximately 89 percent of failed projects. As another example, Suk and Lee (2021) [9] compared the problem framing activities carried out by student teams between high and low creative team, and revealed high-creativity teams tended to create a new frame by combining several frames, diving deep into a problem dimension, or framing problems collaboratively. Although some studies have revealed the difference, there are gaps in support development for novice designers or design teams.

One research gap is the limitation of the understanding of teams' behaviour. There is substantial research on individual cognitive processes and short-term team discussions in design [10], [11], [12], studies examining team dynamics on a larger, project-level scale are more prevalent in other fields, such as management. For instance, prior studies in management have explored long-term team activities and the static characteristics of teams. However, as noted by Cash et al. [13], a notable gap in research focused

on the intermediate, meso-scale level of team activities central to the design indicates a need for further investigation. This prevents us from developing support for the student team.
Another possible reason why we are unable to develop support is the difficulty in grasping student teams' status. Students' team activity occurs outside the lecture time, and the interim deliverables and feedback sessions are the few opportunities for instructors to gain insights into the teams' progress. Therefore, providing the teaching team with tools and data to evaluate and intervene in these team dynamics during the project is crucial.
As mentioned above, the enrichment of understanding of the meso-scale level of team activities and developing alternatives to monitor students' behaviour during the project should be achieved to realise a more effective learning experience. Thus, this study addressed these challenges by analysing data from classroom surveys completed weekly by student teams participating in design projects. This research aims to visualise conflict patterns and explore how differences in these patterns correlate with varying levels of team performance. Specifically, this paper addresses the following question: *How do the dynamic properties of conflict differ across teams with varying performance levels?* This study collected intra-group conflicts weekly during the design project and visualised them to compare the appearances between teams with different performances.
This paper is structured as follows: the prior art of design education and existing research on intra-group conflict are described in section 2. The method is explained in section 3, which includes the context of the study, and the way of data collection, evaluation of teams' performance, and data analysis. The dynamic patterns of conflict or comparison between teams are shown in section 4. Section 5 discusses the differences observed in the visualisation and its implications for future research and practice.

2 RELATED STUDIES

2.1 Students' practice in design education

Today, design is essential for dealing with a complex and ambiguous society. As the world's uncertainty increases, personnel with problem-solving skills are required. This is one reason design attracts lots of interest, and design education for non-specialists is becoming more widespread.
In design education, many projects are carried out so that students can acquire the skills or mindsets of design professionals through the experience. Those projects aim to develop new products, services, or systems using a human-centred approach, including design thinking frameworks. ME310 [14] is one of the most famous PBL courses in the world and uses the frameworks structured by five steps: "*empathy*", "*define*", "*ideate*", "*prototype*", and "*test*". The other framework often used is the Double Diamond Model, which Design Council suggests [15]. The model represents two divergence and convergence phases and consists of four stages: "*discover*", "*define*", "*develop*", and "*deliver*". The journey of the student teams in the design project is more complex than other PBLs because of the specific features of the design. Students need to manage an iterative process or tackle "wicked problems".
Challenges in design education are well known, and many researchers have tried to investigate them. For example, Rekonen & Hassi(2018)[5] identified four types of bottlenecks that novice design teams face in practice: resistance to iteration, overlooking the experimentation ideas of others' and oneself, losing sight of the initial problem to be solved, and a bias towards planning. Hölzle & Rhinow (2019)[7] clarified three different dilemmas are caused by teamwork with design thinking, which differs from other types of teamwork. In this sense, students struggle with tasks, relationships between members, or managing processes. Development of support for them is required to decrease the difficulties and improve the learning experience.

2.2 Intra-group conflict

Although design research has investigated intra-group factors affecting team performance, various things have remained to be revealed to deepen our understanding of design teams [16]. For example, intragroup conflict is considered a critical factor influencing team conditions, and it has been studied in management for a long time.
Conflict is defined as awareness on the part of the parties involved of discrepancies, incompatible wishes, or irreconcilable desires [17]. Jehn & Mannix (2001) [18] designed a questionnaire survey, measuring three types of conflict: task, relationship and process conflict.
Task conflict is defined as an awareness of differences in viewpoints and opinions about a group task [19]. It is categorised as cognitive conflict and occurs when ideas or opinions are different among

members [18], [20]. Relationship conflict is defined as an awareness of interpersonal incompatibilities [18]. Relationship conflict is categorised as affective conflict, including feeling tension and friction as well as personal issues such as dislike among group members or annoyance, frustration, or irritation [18], [20]. Process conflict is defined as an awareness of controversies about aspects of how task accomplishment will proceed [18], and represents how well groups are managing decisions about how to manage the logistical accomplishment of tasks and decisions about how to coordinate people in accomplishing the task [21].

The relationship between team performance and conflict has also attracted much attention in previous research. Jehn & Mannix (2001)[18] investigated the relationship between patterns of conflict in a project and performance and found that the dynamic nature of conflict depends on performance differences. The study reported that the low-performing group saw a sharp increase in the three types of conflict in the final week of the project. In contrast, the high-performing group saw a gentle increase in process and relationship conflict and a slight decrease in task conflict.

In the design research field, some studies analyse the conflict of the design team. For example, Paletz et al. (2017)[11] conducted a study focusing on temporal changes of micro-conflict and uncertainty. They analysed temporal relationships between expressed interpersonal disagreements and subsequent spoken individual uncertainty and figured out that successful design teams reduced uncertainty when micro-conflict occurred, whereas unsuccessful teams increased.

Although intra-group conflict is one of the critical factors affecting a team's performance, only a few studies have attempted to understand the conflict patterns of design teams. Panke (2019)[22] reviewed the literature and reported teamwork conflicts as one of the problems in education using design thinking. From a pedagogical point of view, it is essential to monitor student teams' condition during PBL to assess students' performance and interrupt or support students to improve their experience in the project. However, catching up on all activities outside lecture time is still challenging. Connecting the dynamic patterns of teams and their performance could give us some insightful hints for educators. Moreover, using a small number of questions is an effective means to understand the team's situation because it places a low burden on the design team. Therefore, the relationship between performance and the dynamic nature of conflict should be revealed.

3 METHOD

Since the objective was to compare dynamic patterns of intra-group conflict between different performance teams, evaluating teams' performance and collecting conflict data was conducted. We collected data during the design project at a Japanese university and compared those patterns between teams with different performances. The design educator with several years of experience evaluated the team's performance. Conflict data was collected by questionnaire survey at every lecture date. In the following section, the details are described.

3.1 Context

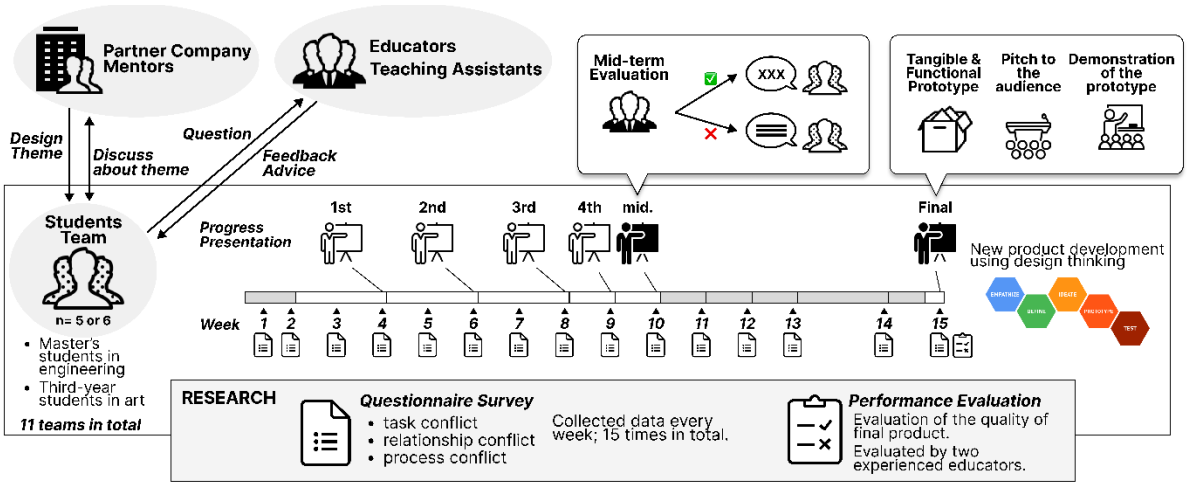

Figure 1. Details of the target project

The participants of this research were the students who joined the industry-academia collaborative project held at a Japanese university. This project is structured based on d.school's ME310 [14], which is held at Stanford University. Students learn the approach and mindset of user-centric design throughout this PBL lecture. This project took five months and aimed to create a new product. Figure 1 shows the details of this project.

Teams consisted of five or six students, including graduate students in engineering and third-year undergraduate students in art or other majors. Each team tackled the different open-ended design themes their partner company gave (e.g., "*In a future where disasters and everyday life are in close proximity, design a product experience that allows users 'NOT' to prepare for disasters*", "*Design playful outing experience for urban elderly people who feel their bodies deteriorating*", etc.). Teams were expected to follow design thinking steps and conduct design activities such as user interviewing, insight formation, ideation, prototyping, or user testing. Unlike projects with detailed requirements or aiming to improve existing products, this project requires students to try to define users, problems, or needs. In the first half of the project, they needed to present their progress once every two weeks; in total, they had five presentations. In the last half of the project, a progress presentation was not required, but a tangible and functional prototype was needed for the final presentation. In the final presentation, they presented their final product with the prototype. In the project, teams planned and conducted design activities independently. During lecture time, teams had a chance to ask advice from educators and teaching assistants or to discuss their perceptions of the design theme with the partner company mentors.

3.2 Performance evaluation

Outcomes in the final presentation were evaluated to classify teams as successful or not. The evaluator was involved in the lecture and had several years of experience in design education and design research. The team's performance was scored on a scale of 1-5, with one being not good and five being good.

3.3 Data collection

The questionnaire survey was conducted to understand each team's dynamic patterns of intra-group conflict throughout the project. The questions used in this study are shown in Table 1. Questions were cited from the works of Jehn & Mannix (2001)[18]. The questionnaire consisted of questions to measure three types of conflicts: task conflict, relationship conflict, and process conflict. Three questions were used for each conflict, and participants rated on seven-point Likert scales ranging from 1, "not at all", to 7, "a lot".

Table 1. Conflict Questionnaire cited from Jehn & Mannix (2001)[18]

Types of Conflict	No.	Question
Task Conflict	1	How frequently do you have disagreements within your work group about the task of the project you are working on?
	2	How often do people in your work group have conflicting opinions about the project you are working on?
	3	How much conflict of ideas is there in your work group?
Relationship Conflict	4	How much emotional conflict is there in your work group?
	5	How often do people get angry while working in your group?
	6	How much relationship tension is there in your work group?
Process Conflict	7	How often do you disagree about resource allocation in your work group?
	8	How much conflict is there in your group about how your group drives the project?
	9	How often are there disagreements about who should do what in your group?

All of the collected data was anonymised to protect individuals from identification. Data was collected at the end of the lecture day, so it was collected approximately once a week, fifteen times in total. There were 57 students in 11 teams, but the data analysed in this study was responses from 51 students in 10 teams who agreed to participate in this survey. The response rate to the questionnaire was 85.8%, which was sufficient data to provide an overview of the team's situation.

3.4 Data analysis

The conflict data collected was averaged to display the chronological changes for each team. Due to the limited sample sizes, statistical testing was not conducted. In a calculation procedure, data with no answers or missing data was excluded, and only data that could be handled was used. The calculated mean were used to visualise the chronological changes for each team.

4 RESULTS

The evaluation results are shown in Table 2. The evaluated performance is shown in the second column on a scale of 1-5, where one is not good and five is good. As a result, teams *B* and *F* were evaluated as good, and teams *E*, *I*, and *J* scored lower than others.

Table 2.Evaluation results

Team	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*
Evaluation (1-5)	4	***5***	4	4	***3***	***5***	4	4	***3***	***2***

The results of the conflicts collected during the project are shown below. The data was divided into teams, and the average were calculated for each type of conflict. The change in the time of conflicts for each team is shown in the following Figure 2.

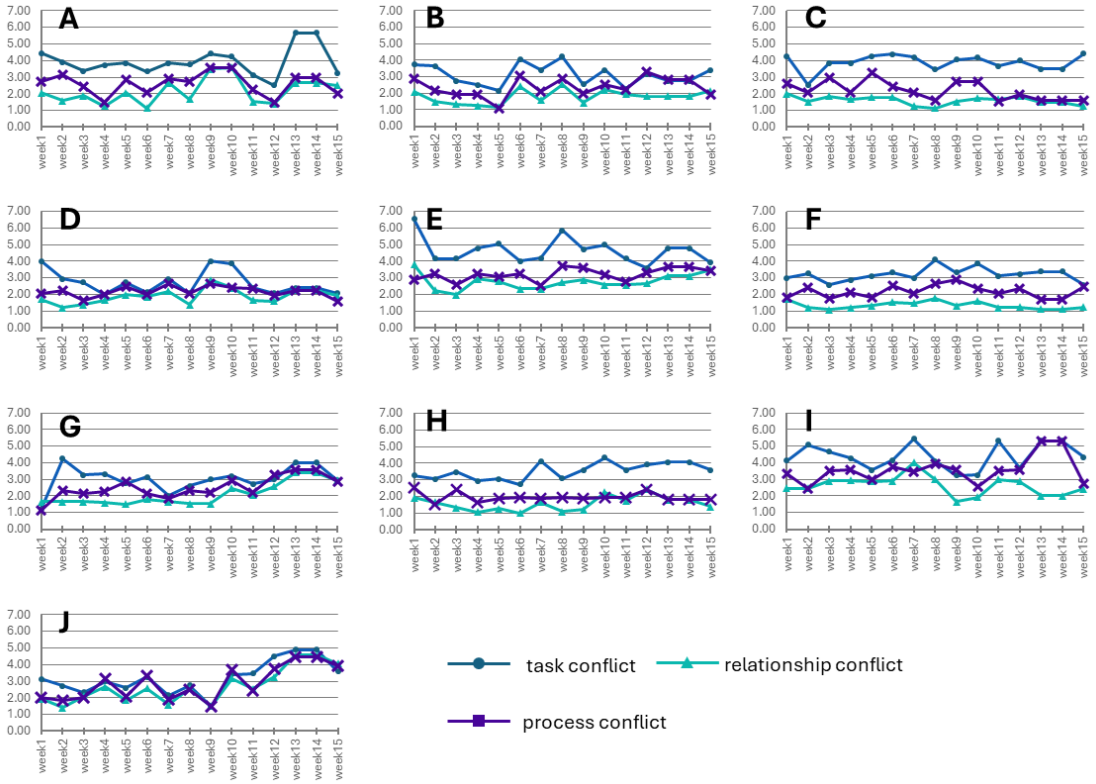

Figure 2. Visualisation results of dynamic conflict patterns for each team

All teams showed a general trend of highest values for task conflict, followed by process conflict and relationship conflict in descending order. The time series change of conflict shows the different natures depending on the teams. For example, *A*, *E*, *I*, and *J* continuously scored high task conflict; sometimes, they scored more than four or five points, significantly higher than other teams. Those teams also scored high in relationship conflict, around three points, while others scored low, around one or two. Some teams, such as *B* or *J*, show the corresponding between different types of conflict.

In addition, the conflict collected each week shows frequent changes every week. This means that intra-group conflict is not static but more dynamic than expected. The dramatic increase/decrease was significantly captured through the continuous data collection. For instance, *E*, *I*, and *J,* which were evaluated as not good, show frequent changes; *E* shows a significant decrease in task and relationship conflict between weeks 1 and 2, *I* shows that every conflict frequently moves up and down, and *J* shows

continuous up and down move from week 3 to week 11 and increasing from week 11 to week 14. These changes are not observed through traditional two-point pre-post or three-point pre, interim and post data collection.

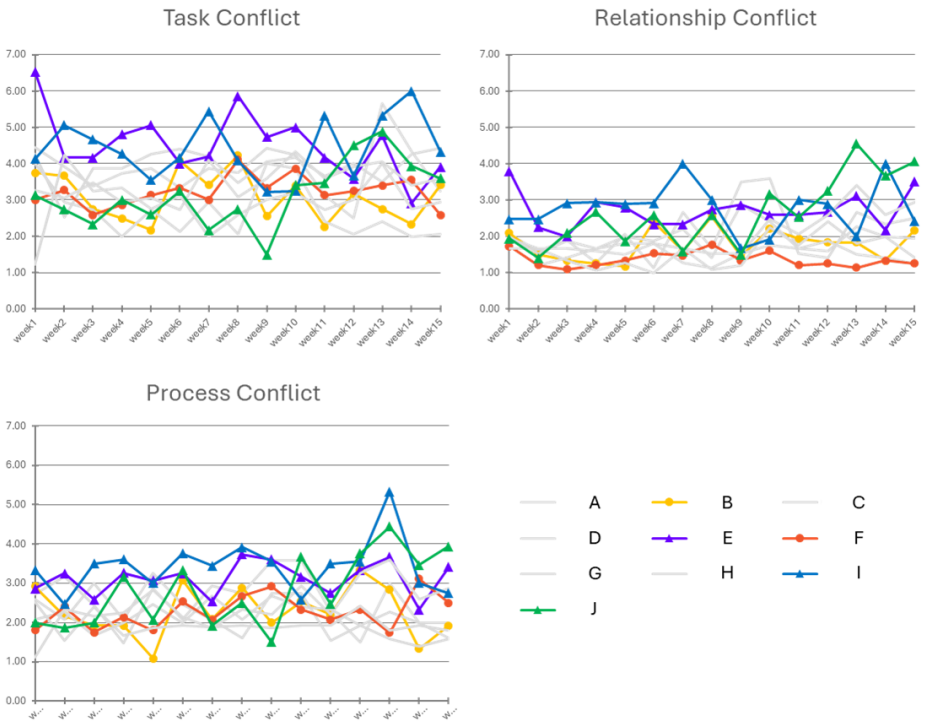

Figure 3. Comparison between teams by each conflict

Figure 3 shows the differences between teams based on three kinds of conflict. It reflects the evaluation results of the final presentation. Teams *B* and *F*, evaluated as a well-performed team, are shown with warm colours and circle markers, and teams *E*, *I*, and *J*, evaluated as not having good performance, are shown with cool colours and cross markers. The results show the difference between teams with different performances. Regarding task conflict, the well-performed team showed moderate value, slightly increased towards the project's midpoint and slightly decreased towards the end. However, teams evaluated as not good tended to remain high task conflict, more than four points. Team *E* and *I* maintained high values throughout the project, while Team *J* showed high values only at the end of the project. Regarding the relationship conflict, we can see a similar tendency. The well-performed team always shows less conflict, between one to two points, while not well-performed teams show higher conflict value and sometimes score more than three points. In relationship conflict, not well-performed teams have similar tendencies. Process conflict shows only a little difference among teams with different performances; however, teams evaluated as not good score higher conflict rather than a good team.

5 DISCUSSIONS

This research aims to visualise patterns of conflict measured weekly in a long-term design project and explore how differences in these patterns correlate with team performance. This is to enrich the understanding of the mesoscale team behaviour and develop a way to grasp student teams' status. In this section, the relationships between performance and dynamic patterns are discussed, and additionally, possibilities of the dynamic patterns of conflict are discussed from academic and practical points of view.

5.1 Relationship between performance and conflict pattern

Generally, dynamic conflict patterns differ among teams. Low-performance teams showed extreme peaks in each type of conflict. For example, in a relationship conflict, each team scored high at a different point; *E* scored at week 1 and 15, *I* scored at week 7, and *J* scored at week 13. In a process conflict, *I* and *J* showed high conflict in week 13. It was possible to observe this only through weekly data collection, unlike in the traditional way. These extreme points may reflect the team's problematic conditions, so further research is expected.

Regarding task conflict, the teams evaluated as not well-performed showed higher task conflict during the whole project than the well-performed team: in this survey, bad teams tend to have high task conflict, scoring more than 4 points. The value of a well-performing team seems to increase slightly from the start to mid-term and slightly decrease from mid-term to the end. This result is supported by the past study[18]. The project's midpoint is crucial for teams to promote progress or discussion. Not well-performed teams scored extremely high values at some points, and generally, values move around three to five points. Precisely, the values of teams *E* and *I* move in a higher range than those of other teams. Team J showed different results from existing research[18]. Due to the complexity or ambiguity of the design process, teams might need help managing the aggressive discussion. The relationship between process and conflict patterns is expected to be explored in future research.
Regarding relationship conflict, patterns showed differences between teams with different evaluation scores. The teams that were evaluated as not well-performed also showed higher values in relationship and task conflicts, so the aggressive discussion might cause tension or frustration. Controversy failure in team building might cause conflict in relationships and influence discussions. Relationship conflict could reflect the team's condition and help understand the team's tension or frustration.
Process conflict did not show a significant difference between teams. It might be because teams act under a structured process. They must present their progress once every two weeks until the project's midpoint, meaning they have to iterate five steps at least once every two weeks. During the last half of the project, they worked hard on creating the final prototype, which is required to be tangible and functional. Therefore, there were typical cycles naturally defined by the project's structure. They might not need to determine the due date by themselves, which could decrease process conflict compared to the condition without this structure. In PBL, process conflict may not indicate the team's performance, especially when there are exact requirements or structures.

5.2 Implications for studies

The results reveal that teams score significantly high in task conflict values and comparatively high in relationship conflict in the project. This was not clarified until continuous data collection was conducted. In other words, collecting dynamic patterns of conflict might give us insight into the team's behaviour. In many existing studies, conflict has been measured only after the project. Still, if we genuinely want to understand the team's condition, a few times measures may not be enough, especially in a design project with a complex and iterative process.
The other exciting trend was the correlation between different types of conflict. The correlation between process conflict and relationship conflict can be seen in teams *B* or *J*; this means that the conflict in how they manage the project and the conflict of emotions or intra-team tension interact. The existing research [21] pointed out that the construct validity of the process scale should be improved since it might have failed to separate construct concepts. On the other hand, the results of this study indicated that conflict from some teams did not correlate with different types of conflict. Past research relied on the theoretical construction by concept mapping and validation of the measurement by only one-time data collection after two months of group work. Therefore, the data collection settings differ, so further research is required to reveal the correlation between different conflict types.
Furthermore, the dynamic conflict patterns varied from team to team. The values fluctuated frequently as the project progressed and sometimes showed extremely high values. In the future, it is expected that analysis will be carried out in conjunction with changes in the internal situations to deepen our understanding of mesoscale team activities.

5.3 Implications for the practice

This research is the first step in developing a method for monitoring teams in design projects. As we discussed the limitations below, it is not currently possible to show statistical differences due to the limited sample sizes. However, the results of this survey show the qualitative differences between teams that perform differently. In a practical situation, real-time monitoring with qualitative use of conflict patterns might help determine the teams' conditions. For example, this study revealed different tendencies in task and relationship conflict. Thus, when teams show high values in task and relationship conflict, a teaching team may use them to signal the problematic situation in the student's team or supplement information to decide when to interrupt the team. To use a dynamic conflict pattern as such, further data sampling and analysis might make this system more credible.

Another implication of this research is the possibility of using it as a reflection material. Students have difficulties conducting appropriate reflection by themselves because they face various challenges and must manage complex tasks and processes. There are some gaps between the proposed frameworks and practices of students[23], so the frameworks must be improved. At this point, dynamic conflict patterns might help them objectively understand teams' conditions. In addition, since conflict can be measured with simple questions, there is no need to care about the risks or costs loaded on students. Again, further data sampling and analysis are required to use these practically.

5.4 Limitations

There are two limitations. The first is the limited sample sizes. A reasonable number of data and statistical treatment would be required to determine the team's situation based on the dynamic pattern of quantitative data from questionnaires. The second is the limited control within the research setting. While data was collected in the practical situation to capture teams' actual behaviours, some potential factors might influence the performance or the relationship between performance and conflict. This means the findings may confine generalizability. The relationship found in this research might be proven only in the exact context. The team's conditions and the qualities of their outcomes are affected by various factors, including the internal and external environment. Further research will be expected.

6 CONCLUSIONS

This research is the first step in identifying the difference between teams with different performances by analysing dynamic patterns of conflict. In this study, we collected approximately weekly conflict data, visualised time series changes, and compared teams. The results revealed the difference between well-performed and not well-performed teams in task and relationship conflict patterns. Poorly well-performed teams scored significantly high values in task conflict, around five points. Two of the three teams showed high values throughout the project. In the relationship conflict, teams evaluated as not good also showed higher values than good teams. In process conflict, teams show similar patterns, possibly because of the fixed schedule. Furthermore, the weekly conflict patterns show the extreme points in some teams; it was possible to observe only by this approach, unlike data collection at two or three points in the project. Teaching teams can use the data to infer the team's condition or as supplemental information to decide when to interrupt and support student teams. Students can use this to reflect and analyse themselves more objectively. To use the data in a practical situation such as the above, further data collection and statistical analysis are required to make them more credible.

ACKNOWLEDGEMENTS

This work was supported by JST SPRING, Japan Grant Number JPMJSP2106 and SECOM Science and Technology Foundation. The authors would like to thank the Amano Institute of Technology for the financial support.

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