TU Delft

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Document Version
Final published version

Citation (APA)
Kurapati, S., Lukosch, H., Freese, M., & Verbraeck, A. (2017). The influence of team factors and team processes on game based learning in student teams. In *Proceedings of the 11th European Conference on Games Based Learning, ECGBL 2017* (pp. 352-357). Academic Conferences and Publishing International.

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The Influence of Team Factors and Team Processes on Game Based Learning in Student Teams

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Abstract: The significance of teams, teamwork and team performance is unprecedented in many learning environments of institutes in higher education and organizations. While individual and team tasks are quite straightforward to define, teamwork is a set of interrelated cognitions, attitudes and behaviours that contribute to the dynamic processes leading to team performance. To address the research gaps related to team processes and team factors related to game based learning, we conducted a quasi-experimental gaming session using a multi-player game called Yard Crane Scheduler 3. Our analysis of the game session showed that mutual performance monitoring had a significant positive effect on team task performance, while mutual support between team members had a negative effect on the team task performance. Shared mental models and closed loop communication were important for the team task performance but the development of shared mental models through shared displays and the effectiveness of closed loop communication were hindered by time pressure related to the team task. Our findings indicate that knowledge of team factors and team processes that affect team performance can help instructors to design team tasks and evaluate students in an efficient and holistic manner.

Keywords: teams, team factors, team processes, simulation games, board games

1. Introduction

A team consists of two or more individuals that have specific roles or functions who work together dynamically and interdependently towards achieving a shared goal (Kozlowski et al., 2003; Salas, Cooke & Rosen, 2008). In Europe, 60% of all employees already work in teams (Noé, 2012). The tendency of teamwork is increasing, even if the form of teamwork (e.g., virtual teamwork) is changing. In Contrast to other forms of work division, teams are working more efficiently and cost-effectively (Salas, Cooke & Roosen, 2008). Because of effective decisions of teams, forms of teamwork and cooperation will be more and more important not only in the daily business, but also in the context of higher education.

Team performance is characterized by the extent to which team members engage in individual and team level task-work and teamwork processes (Kozlowski et al., 2003). While individual and team tasks are quite straightforward to define, teamwork is a set of interrelated cognitions, attitudes and behaviours that contribute to the dynamic processes leading to team performance (Salas, Cooke & Roosen, 2008). In this chapter we will focus only on the task performance of teams or team task performance because we assembled teams with members that may not be familiar with each other.

In their seminal work on team performance, Salas, Sims and Burke (2005) conducted an extensive literature survey to propose the "big five" team factors that explain team performance additional to three team coordination mechanism. Both categories (factors and mechanisms) will be briefly described. The important big five team factors influencing team performance are:

- *Team leadership* refers to the ability of a team member to direct and coordinate the activities of other team members and provide a motivating and positive work environment where all team members can improve their knowledge and skills.
- *Mutual performance monitoring/ situation monitoring* is the ability of a team member to monitor the team performance at a give time and provide feedback to other team members if necessary.
- *Backup behaviour/ mutual support* is the ability to understand the difficulties faced by other team members and offer support for the related tasks.
- *Adaptability* is the ability to adjust strategies and constantly look to improve the task performance based on new information.
- *Team orientation* reflects the attitude of team members towards the team and their willingness to work toward a shared goal through coordination and utilization of inputs from other team members.

In addition to the team factors Salas, Sims and Burke (2005) synthesized the following three coordinating team mechanisms from their extensive literature study:

- *Shared mental models* is a mechanism through which team members describe, explain and predict events in their environment to create a common operational picture of their environment often by using shared displays and by sharing the work environment.
- *Mutual trust* is the belief among team members that each one of them will perform the tasks well in a timely manner and protect each others' interests.
- *Closed loop communication* involves the exchange of information between team members and making sure that the required information is received to the related team member.

Although the above team factors and processes are well known in literature their effects on the team performance within learning environments, including game based learning, is largely unknown. To the best of our knowledge, , the above-mentioned key factors haven't been studied in the context of team performance in a game based learning environment yet. We have already mentioned that assignments in higher education are becoming increasingly team or group based, therefore we believe that studying the team factors and processes that contribute to team performance may be crucial considerations while designing and implementing game based learning modules for students in higher education.

The aim of this paper is to study the role of two team factors (situation monitoring and mutual support) and the role of two coordinating mechanisms (shared mental models and closed loop communication) on team task performance. This was a deliberate choice becausethe teams in our context are not long term and have been set up ad hoc for the study. The adaptability of teams is partially measured by the overall team score of YCS3. Therefore we will focus on the effects of situation monitoring and mutual support on team task performance. We will look into the role of share mental models and close looped communication from a qualitative perspective. We were unable to assess the role of mutual trust in our study due to time constraints. In the following sub-section we will describe the research method followed for this study.

2. Research method

In the following subsections an overview about the participants, the research instruments and the experimental set-up will be given.

2.1 Participants

The sample population of this study was drawn from the students of the Master program of Transportation, Infrastructure and Logistics at the Delft University of Technology. A total of 27 students participated in this study. One student had to be excluded from the study due to identification problem due to incomplete questionnaire data. 24 students completed all the questionnaires, where 2 students did not provide necessary responses in the pre and post game surveys.

Of the 26 students, 11 were female and 15 were male. The mean age of the participants was 23.3 with a standard deviation of 1.7. The majority of the participants were Dutch (N = 20), followed by three Chinese students, and one each from Belgium, Mexico and Greece. The students received partial course credit for their participation. The researchers acted as 'guest lecturers' and were not in a direct power relation with the students and not involved in the evaluation of students for the partial credit. The study was approved by the Human Research Ethics Committee (HREC) of the Delft University of Technology. The following sub-section will describe the various research instruments used for the study.

2.2 Research instruments

The following research instruments *Yard Crane Scheduler multi-player game*, *T-TPQ questionnaire and video recording* were used in our study, which will be explained in detail:

Yard Crane Scheduler multi-player game (YCS3)

YCS3 game (see Figure 1) is a multi-player version of the YCS1 game described in Lukosch et al (2016).The YCS3 game has four roles: Yard planner (Y), Controller (C), Vessel planner (V) and Berth planner (B). In YCS3, the role of the vessel planner is to plan the unloading order of the containers. High priority containers have a gold label,

medium priority containers have a silver label and low priority containers have a bronze label. The YCS3 game does nothave export containers and trucks that carry yellow containers into the hinterland.

In the YCS1 game, the individual player could view all plans and operations of all the roles, whereas in the YCS3, each role has a different access to various planning and operational tasks. The berth planner can only access the quay cranes, while the controller can only access the yard cranes. The yard planner can plan the containers from the ship on the yard, while the vessel planner needs to decide on the order in which the containers need to be unloaded. There is also a certain sequence of actions that has to be followed by the players. The controller cannot allocate yard cranes before the yard planner finalized the yard plan, and the berth planner cannot unload the ships until the vessel planner did not allocate an unloading order. The learning goal of this game is that the players understand the need to communicate and collaborate with each other to align their plans with each other. Only by doing so, they are able to reach a high individual and group score.



Figure 1: Screenshots of the YCS3 game (TU Delft, 2017)

T-TPQ questionnaire

Based on our literature review, the only validated instrument that measured teamwork constructs based on Salas, Cooke and Rosen`s (2008) "big five" team performance constructs was the Team Perceptions Questionnaire (T-TPQ). The T-TPQ is a result of TeamSTEPPS, an evidence-based teamwork system developed by the US Department of Health and Human Services, aimed at improving communication and teamwork skills of teams (Battles & King, 2010). It was originally aimed at the healthcare industry but has been used in other fields to evaluate team performance and provide training for teams (Battles & King, 2010).The main constructs of T-TPQ are team structure, leadership, situation monitoring, mutual support and communication. T-TPQ is therefore a subjective rating scale of team factors that influence team performance. In our research, we did not focus on team structure and leadership, since teams were quite uniform in terms of size and the different roles donned by the participants had an equal footing, with no power differences. Therefore we modified the T-TPQ questionnaire focussing on communication, situation monitoring and mutual support.

Video recordings

Video recording is a valuable research tool that allows the researcher to record and replay the pictures and sounds of an event under study (Penn-Edwards, 2004). Spontaneous and transitory information, which is difficult to script during an experimental setting, can be captured using videos. Recording and analysing such information can assist our understanding of human behaviour and nature as intangible factors such as non-verbal or cultural aspects, characteristic roles can be better observed using videos (Penn-Edwards, 2004). In our study we used videos for observational recording, where we followed subjects engaged in an activity. A team of 4 participants had to align their activities and plans in a container terminal. The observational recording provided material used to interpret and evaluate the behaviour of participants during the game play in a qualitative manner.

2.3 Experimental set-up

The research design was quasi-experimental since the sample population was not randomly drawn. The experimental session begins with a short briefing lecture explaining operations in container terminals and the various planning roles involved to manage these operations. All the participants are provided with laptops. They were directed to play the online game YCS1, which is a single player version of YCS3 (for details see section 2.2).

YCS1 acts as a tutorial to the players before they play YCS3, so that all the participants are on an equal footing to play YCS3.

After playing YCS1, participants are divided into teams of 4. There are 7 teams in total. Each team is seated around a table in a bridge game format (see Figure 2 for an example). Participants begin the experiment by answering a pre-survey that collects demographics, professional, simulation gaming experience and personality type information. The game play lasted for 25 minutes. After finishing the game play, the participants were asked to fill in the T-TPQ questionnaire to measure their SA as wells as their perception of communication, situation monitoring and mutual support during the game play.

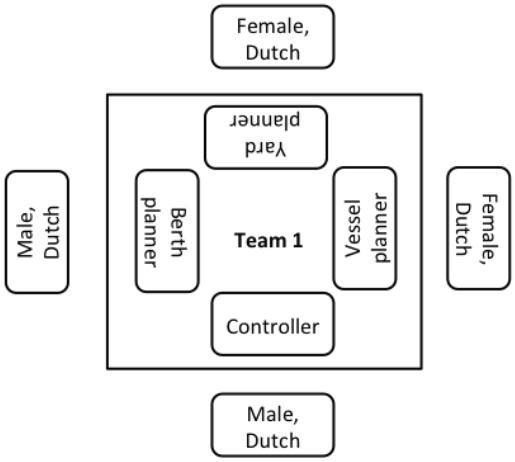


Figure 2: Example set-up of the YCS3 game play session (TU Delft, 2017)

2.4 Base for statistical analysis

The perception of the team members on the various factors that affect team performance was measured using the T-TPQ questionnaire. Situation monitoring, mutual support and mutual support were represented by SAMON, MUSPT. To understand the impact of each of these factors we performed a 2-tailed bivariate correlation analysis between these factors and the individual YCS3 scores

3. Results

The perception of situation monitoring had a strong positive relation with the individual YCS3 score (Person's r=.423*, p =.04). Given the small sample size, there was a substantial positive correlation between situation monitoring and the YCS3 score (Pearson's r=.372, p=.073). Although this correlation falls short of being statistically significant with p = .073, it was not negligible. The correlation between (the perception of) mutual support and individual YCS3 scores (Pearson's r=-.304, p=.149) was negative. Although the value of Pearson's R coefficient is sizeable in both cases, the correlation was not statistically significant due to high p values.

From the video analysis, Team 1 appeared to have a higher grasp on the situation and the events that unfolded in the game because when we observed the contents of their messages sent through sticky notes where team members exchanged information about the position and priorities of containers, and arrival and the position of vessels.

Our quantitative results show that mutual support had a negative but statistically insignificant effect on the team task performance. From the video analysis, comparing teams 1 and 5, we observed that mutual support between team members was exhibited most in team 5. The yard planner of team 5 constantly tried to help the controller to perform her tasks. The berth and vessel planners of team 5 spent considerable amount of time discussing

potential issues for a given strategy. The members of team 1 were more independent in taking decisions and only communicated information rather than solve each other's problems. The performance of team 1 was superior to that of team 5. The qualitative results therefore support the quantitative results with respect to mutual support and team task performance.

We evaluated the role of shared mental models and closed loop communication only through our qualitative analysis of the behaviour of teams 1 and 5. In the game play, although the team members tried to create a common operational picture of container positions and ship arrivals they could not exchange all the required information to significantly improve their score due to insufficient time. This could explain the effective closed loop communication between team members. In team 5 the communication was uneven and was heavily between two players (B and V). The other players did not make use of the sticky notes to communicate and share information. Although berth planner and vessel planner communicated a lot, they also disagreed a lot on their joint plans, which led to late decision and lower scores. The yard planner was very enthusiastic and was involved in a one-way conversation with the controller, who took orders from the yard planner without giving her opinion. This communication style might also be attributed to difference in culture between the Dutch yard planner and Chinese controller. Although shared mental models and closed loop communication seem useful for superior task performance, time pressure is a major constraint for their development and effectiveness.

4. Discussion and conclusion

In summary, this study investigates the influence of team factors on game based learning with 26 students. Therefore, the students had the task to play the YCS3. After finishing the game, the students filled out the T-TPQ questionnaire. The results showed that situation monitoring had a significant positive correlation to team task performance. Our finding is supported by works of McIntyre et al. (1995) and Salas, Cooke and Rosen (2008). They state that team members who monitor each other's performance and are observant of possible flaws can rectify the errors in time leading to superior team task performance.

Counter intuitive to our expectation, mutual support among team members had a negative effect on the team task performance. This could also be attributed to the time pressure under which the teams operated because helping another team member might boost team cohesion but is time consuming when the tasks at hand are dynamic and fast paced (Porter et al., 2003).

Although shared mental models are considered to be an important mechanism responsible for team performance, we could not observe their effectiveness in the game play. This could be attributed to the 'ad-hoc' nature of teams who were not familiar with each other in a working environment. Ad-hoc teams don't understand each other as well as long-term teams (Klein et al., 2003). Shared mental models or team mental models rely on implicit communication that needs team cohesion and team orientation that needs time and effort to build (Klein et al., 2003).

Closed loop communication was achieved when the required information was received by the right person at the right time (Salas, Cooke & Rosen, 2008), which is close to the information pull approach. Good closed loop communication could be attributed to superior performance of most participants in the game play. In a stressful, time pressed environment, closed loop communication may be hindered when members focus on individual tasks rather than think about how their tasks can affect other team members (Salas, Cooke & Rosen, 2008). Also, information overload due to excessive communication could hinder team task performance (Williges, Johnston & Briggs, 1966).

The results of the study have the potential to add value towards developing a framework to design simulation games to foster group activity and evaluate team performance of students in higher education.

Nevertheless, there are some limitations in this study. On the one hand the limited number of students has to be considered. This leads to the fact that the external validity is strongly restricted. Future work will include a larger number of participants, to validate our first findings here. On the other hand, our teams only consisted out of 4 players, representing an ad-hoc working group. Our findings might only be applicable to small, ad-hoc groups, while larger groups who work together over a longer period of time might lead to different results.

Despite these limitations, due to the fact that teamwork has been developed into an integral part of higher education during the last years, our results can contribute to the field of game based learning on a team level. Based on our findings we can conclude that a better understanding of the team task performance factors and mechanisms that affect team task performance can help educators to better support students in higher education by evaluating and improving their information sharing approach, paying attention to team allocation and composition and devising better ways for information exchange under time pressure in organizations of higher learning.

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