Raising Academic Performance in Socio-cognitive Conflict Learning Through Gamification

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Abstract. Drawing on the social interdependence theory, we experimentally compared the between-group effects of social learning gamification, competition gamification, and non-gamification on the academic performance in the within-group socio-cognitive conflict learning. Findings show that the positive learning effects of socio-cognitive conflict in within-group are strengthened when the between-group gamification is designed by social learning or competitive strategy.

Keywords: Gamification · Socio-cognitive conflict · Academic performance

1 Introduction

Socio-cognitive conflict occurs within a group when a learner is confronted with different ideas and conceptions that other group members embrace [1]. We have acknowledged the positive power of socio-cognitive conflict in the setting of within-group learning for a long time, but less understood the outsider between-group effects on within-group socio-cognitive conflict learning. Our aim is the generation of testable prediction about how the between-group effects might shape the learning results of within-group socio-cognitive conflict.

We framed the research in the context of between-group gamification because it is a more selective, funny, and constructive between-group avenue. *Gamification*, generally defined as "the use of game design features in non-game contexts" [2], has been used across a variety of scenarios to motivate people to engage in particularly targeted behaviors. Gamification in group learning situations could be driven by social influence-oriented strategies, such as social learning and competition, which are effective at motivating the learner to accomplish target behavior [2, 3]. *Social learning strategy*, based on Bandura's Social Learning Theory, states that people learn from

I. I. Bittencourt et al. (Eds.): AIED 2020, LNAI 12164, pp. 180–184, 2020.
https://doi.org/10.1007/978-3-030-52240-7_33

others through observing what they are performing towards the target behaviors. While *competition strategy*, derived from the human natural motivation to outperform one another, drives them to perform some desired behavior and provides opportunities for users to compete with one another. In the present study, we adopt a mixed-design experiment to testify experiences of socio-cognitive conflicts in the gamification of social learning or competition that are likely to trigger stronger positive academic performance.

2 Method and Results

Undergraduate Participants. 106 undergraduates at a general university in China were recruited to participate in exchange for extra course credits. They all had no related learning experience in the research method (experimental material). Four volunteers were dropped from the dataset because their finishing time of the experiment was over 3 standard deviations above average time. This resulted in a final sample of 102 participants (68 female and 34 males, mean age = 21.08 yrs).

Mixed Design. The study involved a 4 (Socio-cognitive Conflict Induction: true-false, false-true, false-false, true-true) × 3 (Gamification Strategy: social learning strategy, competition strategy, no gamification) mixed design. Participants received all four types of socio-cognitive conflict induction in a Graeco-Latin Square order and were randomly assigned to one of the gamification strategy conditions. Proportional academic performance was computed as (posttest - midtest)/(1 − midtest).

Socio-cognitive Conflict Induction Manipulation. Similar to D'Mello et al. [4], *socio-cognitive conflict induction* was operationalized by varying contradictory information in agent agreement and information correctness during the trialogues (three-party conversation: a participant and two pedagogical peer agents) phase. In the control condition, both animated agents agreed on the correct information (true-true), while in the other three experimental conditions, two agents either disagreed with each other or agreed with the incorrect information. After both agents presented their respective opinions, then one of them would ask the participant to express himself. The contradiction between the agents' opinions was expected to trigger the participant's socio-cognitive conflict (see Fig. 1).

Gamification Strategy Manipulation. Like the within-group factor of socio-cognitive conflict induction, the between-group factor of gamification strategy was also manipulated during the trialogues phase in the experiment. Following Oinas-Kukkonen's guideline, we operationally defined the *social learning strategy* as providing a game board listing effective cognitive strategies adopted by participants in other groups with higher scores, such as critically writing opinions and reasons contrary to group members [3]. The *competition strategy* was operationalized by presenting a leaderboard after each trialogue round. We drew attention to the group who fell behind on the leaderboard by flashing their teams' names and scores. Their name and score were intentionally showed in the last 16–20 positions. This failure feedback was also reinforced by hue - the late five positions were red and the former fifteen white, and by

toggling the display of the scores. We chose feedback about failure position in competition here as research suggests that individuals contribute more to the group when the group performance is worse [5] (see Fig. 2).

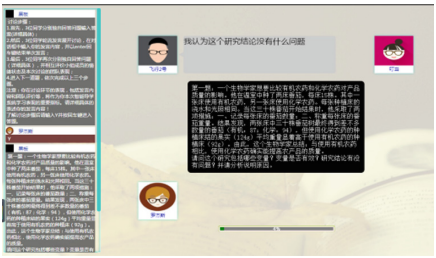

Fig. 1. Screenshot of the learning interface.

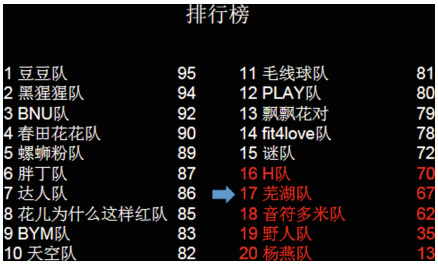

Fig. 2. Leaderboard with both color feedback and displayed score. (Color figure online)

Procedure. All research content and procedure were presented via an intelligent tutoring system environment developed for the purposes of this study (see Fig. 1 for a screenshot). The experiment occurred over five phases (total 2.5 h): the participants (1) took a pretest for prior knowledge, (2) acquired research method knowledge through multimedia learning to identify the contradictory of information in later trialogues, (3) took a mid-test to assess and control over academic performance in multimedia learning, (4) attended eight trialogues (each about one concept) that offer contradictory and gamification information to induce the participant's socio-cognitive conflict in between-group different atmospheres (see Fig. 1 and 2), and last (5) took a post-test to check each one's overall academic performance. Each trialogue in the fourth phase began with a description of a research method practice case. The research methods contents mainly consist of fundamental design principles (e.g., random assignment and control groups).

Academic Performance Measurement. We tested the learning content about eight concepts of research method covered in eight trialogues for three times, including pretest, mid-test, and post-test. The academic performance served as the dependent variable was used to assess the benefit of socio-cognitive conflict induction, indicated by the score gap between the post-test and mid-test. Each test had 24 multiple-choice questions with three questions per concept. The three types of items were based on the

Table 1. Means (*M*) and Standard Deviations (*SD*) of academic performances.

	SLS (*N* = 34) *M* (*SD*)	CS (*N* = 34) *M* (*SD*)	NS (*N* = 34) *M* (*SD*)	Total (*N* = 102) *M* (*SD*)
True-false	.37 (.16)	.39 (.19)	.26 (.2)	.34 (.19)
False-true	.39 (.13)	.33 (.16)	.28 (.22)	.33 (.18)
False-false	.33 (.12)	.2 (.14)	.19 (.11)	.24 (.14)
True-true	.18 (.09)	.21 (.16)	.2 (.09)	.2 (.11)

Notes. SLS = Social Learning Strategy, CS = Competition Strategy, NS = No Gamification.

first three levels of Bloom's Taxonomy (knowledge, comprehension, and application). Three alternate test versions and assignments were counterbalanced across participants.

Results of Academic Performance. To test which strategy of gamification benefited the participant's academic performances and whether these effects were dependent on the socio-cognitive conflict occurrence, we ran a 4 (Socio-cognitive Conflict Induction) × 3 (Gamification Strategy) mixed-model analysis of variance (ANOVA), with repeated measures on the factor of Socio-cognitive Conflict Induction. This analysis yielded a significant interaction between socio-cognitive conflict induction and gamification strategy, $F(6, 297) = 4.46$, $p < .001$, $\eta_p^2 = .09$. Simple-effects analyses suggested that participants experiencing socio-cognitive conflict under the true-false condition reported more learning gains in social learning (Table 1, $M_{SLS\text{-}NS} = .12$, $SD = .04$, $p < .05$) and competition strategy gamification groups (Table 1, $M_{CS\text{-}NS} = .13$, $SD = .04$, $p < .05$) than the control group. However, socio-cognitive conflict experience under false-false condition only showed better performances in the social learning strategy group (Table 1, $M_{SLS\text{-}NS} = .15$, $SD = .03$, $p < .001$) than the control group and a nonsignificant pattern in the competition strategy group. As anticipated, there was no significant difference in the none socio-cognitive conflict experience condition (Table 1, $M_{SLS\text{-}NS} = -.02$, $SD = .02$, $p = .79$; $M_{CS\text{-}NS} = .01$, $SD = .01$, $p = .98$).

3 Discussion

Drawing on social-functional perspectives on group learning [5] and Social Interdependence Theory [6] in particular, we developed and tested the idea that learners facing within-group socio-cognitive conflicts acquire more knowledge when they are in between-group gamification. Due to using the between-group gamification design, this study extended the preceding studies by addressing the issue of environmental boundary conditions of socio-cognitive conflict in learning. We also obtained additional evidence about the different impacts of the outside between-group gamification environment on the complex learning effects of within-group socio-cognitive conflict. More specifically, under simple and clear socio-cognitive conflict condition (true-false), participants acquired more knowledge about scientific research content in the social learning and competition gamification strategy group rather than the control condition. However, among the participants in the false-false condition of socio-cognitive conflict which were complex and obscure the effect for them was only observed in the social learning gamification strategy group. An explanation could be that when the participants with low knowledge background face complex learning tasks, they need cognitive support more than motivational support.

This conclusion suggests that between-group environments should not be treated as little relevant cues. Instead, they should be incorporated in team learning, theorizing as informative social signals that help learners make sense of both within-group and between-group social situations. The next step is to investigate whether between-group gamification strategies have the power to change other forms of within-group learning activities.

Acknowledgments. We would like to thank the supports from the Project of Research on the Confusion Emotion in the Problem Solving of Normal School Students Adjusted by Intelligent Tutoring System (Grant NO. 18B491), and the Project of Research on the Intervention of Confusion Emotion of Normal School Students under the Context of Intelligent Education (Grant NO. XSP20YBZ175).

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