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A Digital Formative Assessment of Teamwork in Collaborative Inquiry Student Teams

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1. Introduction

Working successfully in teams is not to be assumed as issues of social loafing and groupthink occur (Kayes, Kayes, & Kolb, 2005). In helping students become more skilful at working in teams, a digital formative assessment intervention project was designed and implemented for authentic collaborative inquiry teams. Formative assessment is an important pedagogical method, especially in teamwork skills, as it makes visible rubrics and measures, providing students with feedback that they can learn from to improve (Strijbos & Sluijsmans, 2010). Based on a synthesis of literature and pilot tests, teamwork was conceptualized as a four-dimensional teamwork competency that emphasized the process of working with other team members (Koh, Hong, & Tan, 2018). Teamwork competency consisted of coordination (COD), mutual performance monitoring (MPM), constructive conflict (CCF), and team emotional support (TES). A peer-rated teamwork competency instrument was developed for students' to assess their peers in a recent collaborative inquiry experience. Peer assessment adds another level of knowledge, others-ratings, to help understand students' behavior. This paper reports on the results of the digital formative assessment intervention in a year-long authentic collaborative inquiry project for Secondary Two students. We ask: what are students' peer-rated teamwork competency dimensions over the project, and what is the relationship between student peer-rated teamwork competency dimensions and grades?

2. Method

Design-based research was the overall methodology and the digital formative assessment approach was co-designed with a team of researchers, educators and policy-makers. The approach involved a four-stage pedagogical framework, the Team and Self Diagnostic Learning (TSDL), and a techno- pedagogical system, My Groupwork Buddy (MGB). TSDL is rooted in experiential learning, socio-constructivism, socially shared regulation of learning, and the learning analytics process model (Koh et al., 2018). Figure 1 shows the four stages of the TSDL framework cycle supported by the MGB system. At TSDL stage one, students gain team-based concrete experiences when they collaborate in teams to produce a team output. At TSDL stage two, self and team awareness building is triggered by the visualization of self and peer ratings. At TSDL stage three, the reflection and goal-setting scaffolds support the self and team reflection and sensemaking process for students from the visual analytic. At TSDL stage four, students monitor their team and personal teamwork competency growth through checking on their progress.

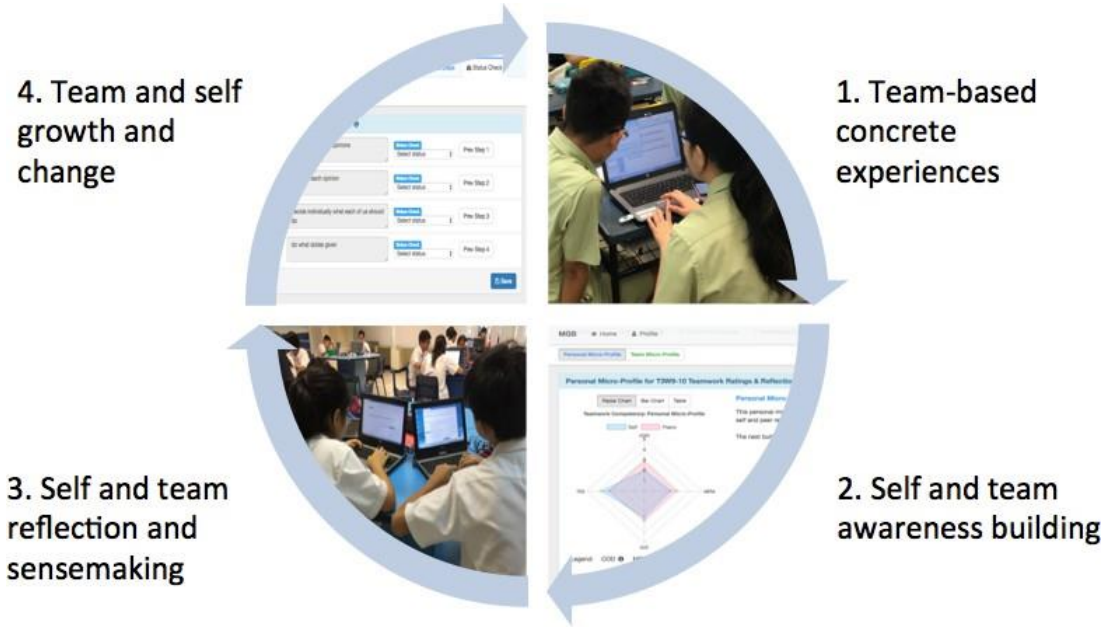


Figure 1. The TSDL cycle supported by the MGB system.

The participants were 71 Secondary Two (fourteen-year-old) students and their teacher in the subject, Design and Technology, from a co-ed school in Singapore. However, only 69 students (29 males and 40 females) received parental consent to participate. In this subject, collaborative inquiry student teams of three or four were to develop an innovative product for the elderly in a welfare organization over a year (four school terms).

In this paper, we focus on the peer-rated teamwork competency dimensions (peer-rated dimensions) and grades. Students were graded by the teacher on the team assignments. Over the year, three TSDL cycles were carried out by the teacher during the normal curriculum, resulting in three peer-rated scores for Term Two, Three and Four (17T2, 17T3, and 17T4 respectively). The peer-rating instrument comprised 13 items and a member rated each of their team members on a five-point Likert scale, with five being "strongly agree". An example item for COD was, "X provided information to team members on time", where X was replaced by the team member's name. This instrument has adequate reliability and internal consistency as validated in other upcoming work (Koh et al., 2018).

3. Results

3.1 Student Peer-rated Dimensions over the Project

Table 1 presents the descriptive statistics of average peer-rated dimensions over the project. Peer ratings were highest in 17T4, and lowest in 17T3. From 17T2 to 17T3, peer ratings decreased for COD and CCF, but remained about the same for MPM and TES. For both pairs of time-points, 17T3 to 17T4, and 17T2 to 17T4, peer ratings increased for all dimensions. The initial dip and subsequent increase in peer ratings across time-points bear a resemblance to Tuckman's (1965) stage model of group development where groups experience some storming in the initial stage, arriving at group norms, and finally performing at the later stages.

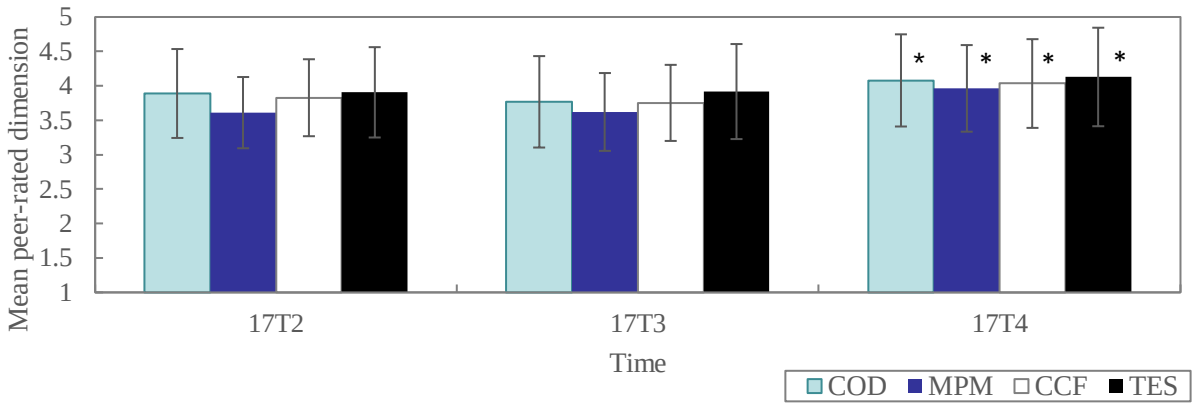
Table 1

Descriptive Statistics of Mean Peer-rated Dimensions over the Project

Teamwork Competency Dimension	17T2 Mean Peer Ratings (SD)	17T3 Mean Peer Ratings (SD)	17T4 Mean Peer Ratings (SD)

COD	3.89 (.65)	3.77 (.66)	4.08 (.67)
MPM	3.61 (.52)	3.62 (.57)	3.96 (.63)
CCF	3.83 (.56)	3.75 (.55)	4.03 (.64)
TES	3.91 (.66)	3.92 (.69)	4.13 (.72)

Figure 2 shows the change in average peer-rated dimensions over the project. A paired samples *t*-test revealed that the dip in 17T2 to 17T3 peer ratings was not significant. Two other paired samples *t*-tests revealed that for 17T3 to 17T4, and 17T2 to 17T4, the increase in peer ratings was significant, and MPM showed the largest effect size. This suggests that students' personal teamwork competency, especially in the dimension of MPM, as rated by their peers, grew over the project.



Notes. Vertical lines are standard deviations. * between T3 and T4, and T2 and T4, the increase for each peer-rated dimension was significant, $p < .01$ - .02, $d = .30$ - .58, and $p < .01$ - .03, $d = .29$ - .61, respectively.

Figure 2. Mean peer-rated dimensions over the project.

3.2 Relationship between Peer-rated Dimensions and Grades

A hierarchical multiple regression was performed to evaluate the ability of peer-rated dimensions over the three time-points in predicting grades, after controlling for the influence of gender (Table 2). The total variance explained by the regression model is 36%, F (13, 55) = 2.38, p = .013. The three time-point peer ratings explained an additional 35.7% of the variance in grades, after controlling for gender, R^2 change = .36, F change (12, 55) = 2.54, p = .009. Table 2 shows that only 17T2 peer-rated COD was significantly and positively related to grades.

This result is interesting and highlights the importance of early coordination efforts of a team member. Students who were perceived as more competent at COD in 17T2 by their team members scored better for the project. During 17T2, students had to inquire and research on ideas for the innovative product as well as plan for the materials required for the ideated product. Students who were able to organize ideas, materials and even roles (as seen by their peers) at this stage, possibly laid the foundation for a strong product for the rest of the project, resulting in higher grades.

Table 2

Multiple Regression Results of Relationship between 17T4 Grades and Peer-rated Dimensions in 17T2, 17T3, and 17T4

Model	Variable	*B*	*t*
1	(Constant)		33.95**
	Gender	.05	.42

2	(Constant)		4.47**
	Gender	-.13	-1.00
	17T2_CODp	.50	2.53*
	17T2_MPMp	.32	1.69
	17T2_CCFp	.05	.22
	17T2_TESp	-.38	-1.86
	17T3_CODp	-.35	-1.24
	17T3_MPMp	-.23	-.92
	17T3_CCFp	.52	1.99
	17T3_TESp	-.11	-.50
	17T4_CODp	.42	1.41
	17T4_MPMp	.03	.09
	17T4_CCFp	-.21	-.65
	17T4_TESp	-.40	-1.34

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

4. Concluding Remarks

A digital formative assessment of teamwork is designed and implemented in authentic collaborative inquiry student teams in Secondary Two. The results show that students' peer-rated dimensions generally increased through this approach and resembled Tuckman's model. Students' personal teamwork competency in the dimension of mutual performance monitoring grew the most. In addition, better peer-rated coordination at the early stages of the project was found to lead to higher grades. A possible pedagogical implication is the need to emphasize the coordination dimension of teamwork in the early stages of the project. Theoretically, the findings also lend themselves to extant research although further analysis is needed to understand certain outcomes. In sum, the work contributes a novel and effective approach to growing teamwork competency in authentic classrooms.

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