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Enhancing a techno-pedagogical tool for student teamwork growth

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Abstract: Teamwork is one of the core competencies for the 21st century student and it is important to promote the development of the skills needed in teamwork. In this study, we continue the development and trial of a techno-pedagogical tool My Groupwork Buddy (MGB), designed to support student teamwork awareness, reflection and growth. The system has been trialled with students in two Secondary Schools, involved in collaborative inquiry tasks. Employing design-based research, we focus on the latest two trials of MGB. Drawing from feedback obtained during the study, we refined and evaluated MGB with its related design principles. The continued enhancement of MGB through iterative trials has enabled the evolution of a platform capable of supporting the formative assessment approach of teamwork growth for 21st century students.

Keywords: Teamwork, collaboration, 21st century competencies, techno-pedagogical design, design-based research.

1. Introduction

Teamwork is one of the core competencies for the 21st century student and it is important to promote the development of the skills needed in teamwork (Pellegrino et al., 2012). While there are several ways to nurture teamwork in students, a formative assessment approach entailing principles of student agency, awareness, reflection and goal-setting is a promising pedagogy (Koh, Hong, & Tan, 2018; Phielix et al., 2011). In order to encourage student teamwork collaboration and growth, a techno-pedagogical tool, My Groupwork Buddy (MGB) was developed for Secondary School students in Singapore. Employing design-based research, MGB was developed and implemented in four trial cycles in authentic classrooms. Each iteration was a refinement of the previous trial based on feedback from our stakeholders, notably students, teachers, and policy-maker collaborators. This paper focuses on the technological enhancements to MGB and its related design principles for the latest two trials following an earlier paper (Koh et al., 2016), which highlighted iteration one and two.

2. Methodology

Design-based research is the overall methodology for the project. It allows for numerous iterations of the design, which can be refined during a planned time period; a continued implementation in authentic learning environments, and co-design in close collaboration with all stakeholders (Ford et al., 2017; Barab, 2004). MGB has continued its development and delivery of multiple iterations with a team of researchers, educators, policy-maker collaborators and web developers in order to improve student's teamwork collaboration based on a formative assessment approach, the Team and Self Diagnostic Learning (TSDL) Pedagogical Framework (Koh et al., 2016; 2018).

The paper focuses on the technical enhancements made to the system in order to serve the designed purpose of MGB. The feedback data for the changes come from lesson observations, student focus group discussions, students' text on the system, and teacher and collaborator discussions. The key technical refinements are detailed together with the relevant design principles

related to the TSDL framework; these were explicitly drawn out through the process of the development.

3. Background

One of the main aims of the research project is to encourage secondary school students to grow their collaborative and teamwork skills in existing collaborative inquiry learning programs. This paper reports on the third and fourth iteration of MGB where the third iteration was used for about six months in 2016 (two school terms) and the fourth iteration for about a year in 2017 (four school terms). There were two different schools, two different courses that used the system, with 39 and 79 students respectively. In both courses, students were involved in a collaborative inquiry task, and worked in teams of three or four. The lessons are conducted in a blended learning environment and respective teachers facilitated the lessons on a weekly basis.

MGB's design is based on TSDL, which comprises four cyclical stages. Students in *stage one* are to engage in a concrete team experience, which is supported by lesson content, provided by the teacher and uploaded in MGB. Next, in TSDL *stage two*, after completing a team output, students rate themselves and their team members through the MGB self and peer rating survey, and gain awareness about their teamwork competency from a micro-profile data visualisation. The teamwork competencies of focus are the following four dimensions: Coordination, Mutual Performance Monitoring, Constructive Conflict and Team Emotional Support (See Koh et al., 2018 for further details). This is followed by TSDL *stage three*, where students are able to reflect on themselves and as a team to analyse and make sense of the awareness information. Learners answer reflective questions, and proceed to set steps (goal-setting) in order for students to metacognitise and improve their teamwork competency, through TSDL *stage four*. This cycle repeats itself typically twice in the entire team projects' duration.

4. Technical Developments

From initial iterations, the design and development of the MGB web application has been to allow dynamic delivery of content and response by students, being a Single-Page Application (SPA). The MGB system continues to provide login and lesson content management for students and teachers, and features a real-time chat to allow communication between students and their peers, as well as teacher communication with the whole class or by team.

The technology used to develop the first and second iterations, remains present in the third iteration for 2016 with added features, but given the constraints presented, a new application was designed and developed, MGB Next, for 2017 using a progressive and established programming architecture pattern, the Model-View-ViewModel (MVVM). The technical features are elaborated in subsequent sections.

4.1 Third Iteration

4.1.1 Design and Implementation

In the third iteration, My Groupwork Buddy was used for about six weeks, during two terms. MGB was a web-based system that had been designed to be a SPA. Students needed to be able to navigate through the content without waiting for a page to reload and in order to so, functions can be called from the server asynchronously to load new content using Remote Procedure Calls (RPC). This version had been written using the Haxe programming language (http://haxe.org/), and using the Haxe compiler, codes would be compiled in JavaScript on the client side and PHP on the server side. The real-time chat was developed using a JavaScript library called Firebase (https://www.firebase.com/). Visualizations are delivered using a JavaScript library called Chart.js (http://chartjs.org/). MGB used MySQL (https://www.mysql.com/) to store system and student data and the Apache HTTP server (https://httpd.apache.org/).

Based on trial two's student and teacher feedback, to better engage students in their reflection at TSDL *stage three*, we created a more conducive learning environment for reflection on MGB by simplifying the complexity of the reflection activity and recognising team strengths. Due to feedback that reflecting on all four dimensions was cognitively challenging, the reflections activity was re-designed to focus on a single dimension. By selecting a single dimension, students were able to sufficiently focus on the importance of the chosen dimension and analyse how it enabled them to work collaboratively within their teams. Following the personal self-reflection, students returned to their teams and had a team reflection. The team reflection now allowed the team to first choose their strongest dimension (i.e., their strengths) followed by selecting their weakest dimension and reflecting on it.

A second change was made to the goal-setting page, which had been designed to help students set personal and specific goals in order to improve future teamwork performance. Students had been setting goals for themselves and as a team at the end of previous Term one and two, without the ability to check if progress had been made. In the MGB enhancement for iteration three, goal-setting would include a mid-point and an end-point check, where students are given the opportunity to refine the set goals and assess themselves individually and as a team if they are meeting those goals (e.g., statuses of not yet, almost there and done). This can be seen as a way to provide students' with visible self-regulation and self-monitoring agency.

4.1.2 Evaluation

Through lesson observations, we found that students viewed the changes in the third iteration of MGB to be useful, making the system easier to use. Specifically, by choosing a single dimension to work on for their self-reflections and furthermore, by focusing on the strongest and weakest dimension in their team reflections; it simplified the process and allowed students to pay greater attention on how to improve themselves in that teamwork aspect. As a result, we also found that the students' reflections became deeper and more meaningful, through the students' responses recorded on the system.

For TSDL *stage four*, through individual student feedback, we found that the majority of students found the refinement to the goal-setting page, i.e., mid-point and end-point checks, to be useful. The time given between lessons allowed them to track their self and team improvement. However, some students felt that due to the lack of lessons, they tend to forget initial goals that had been set and failed to work on them. There were also technical constraints of the programming framework and software code which resulted in a slight delay for the time taken to calculate the micro-profile for students as well as difficulty in providing real-time dynamic displays to students and teachers. Also, the user interface was not that mobile compatible, which was highlighted by several students and teachers. Users also suggested providing an additional visualization for the micro-profile such that it would be easy to read. All this feedback was taken into account when deciding on the changes for the next iteration of MGB.

4.2 Fourth Iteration: MGB Next

4.2.1 Design and Implementation

In light of the earlier evaluation, a brand new design using the MVVM architecture was ideated. Specifically it used the ViewModel layer by using Vue.js (https://vuejs.org/), a mobile friendly and progressive framework, designed to be incrementally adoptable and easier to integrate with other JavaScript libraries. The strength of Vue.js is also to power complex Single-Page Applications. MGB Next features Node.js (https://nodejs.org/), to execute JavaScript code server-side and Socket.io (https://socket.io/), to enable real-time two-way communication between the client and server. Given the potential scalability of MGB Next, NGINX server (https://www.nginx.com/) was chosen due to its high performance and ability to handle thousands of HTTP connections. As existing JavaScript libraries can be integrated with Vue.js, Chart.js remained as the visualization library. MGB Next used MySQL to store system and student data.

We describe the key changes to MGB Next using one cycle of TSDL in the fourth iteration. For TSDL *stage one*, students were able to view lesson content uploaded by teachers (Figure 1) in

desk-based or mobile devices. The right-hand side of Figure 1 displays the real-time team chat enabling students to communicate and share online resources. This change reflects the design principle of increasing accessibility for team collaboration through multiple devices.

In TSDL *stage two*, awareness information was displayed through multiple representations. In response to student and teacher feedback, two options of graphical visualizations were developed so that students could choose between seeing their micro-profile in a radar chart (Figure 2) and in a bar chart (Figure 3).

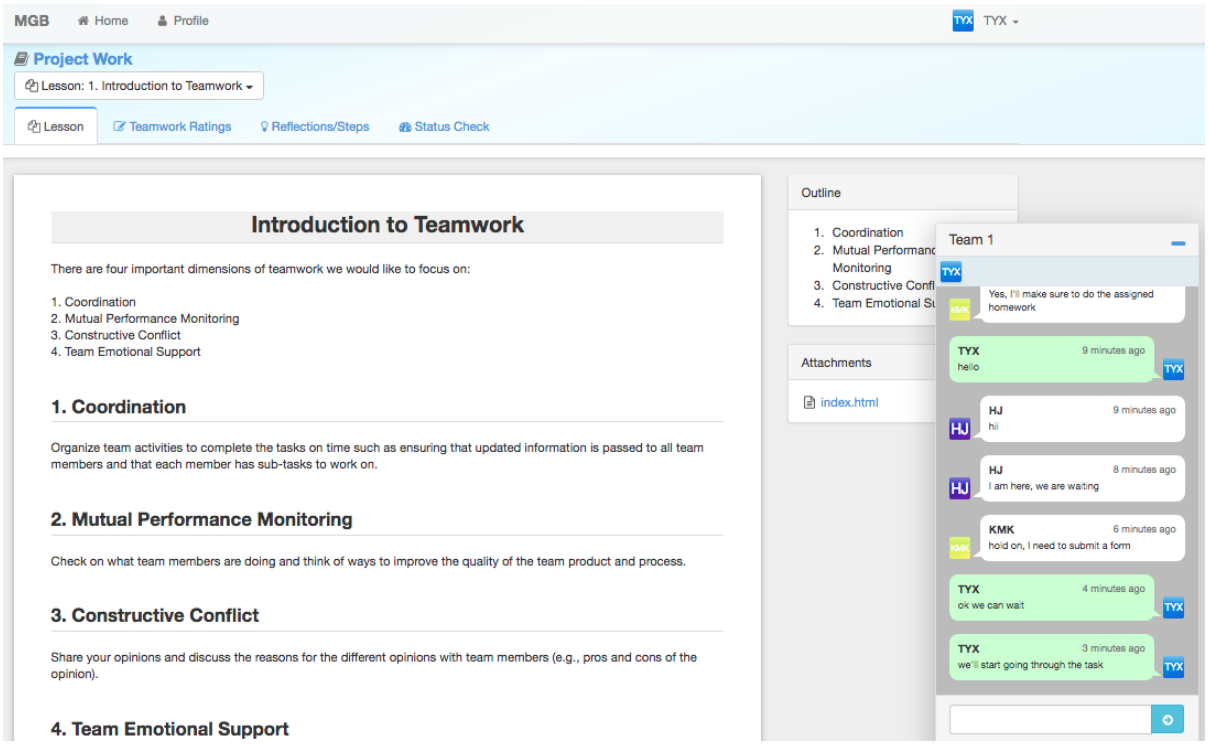

Figure 1. Screenshot of MGB Next Lesson content page and real-time team chat

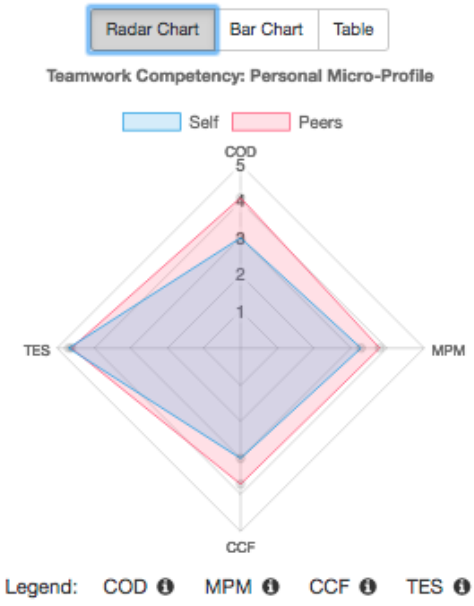

Figure 2. MGB Next micro-profile (Radar)

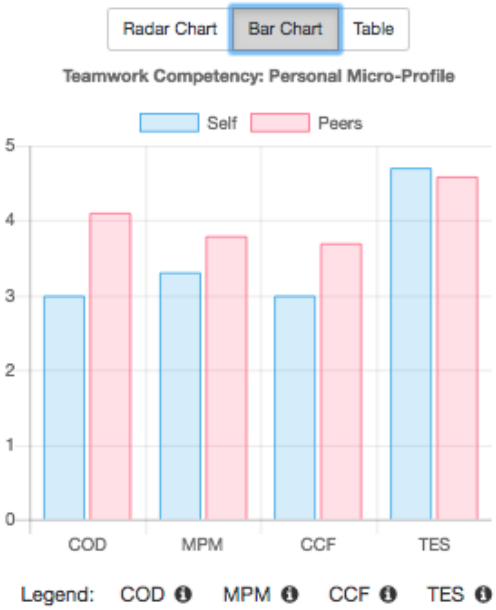

Figure 3. MGB Next micro-profile (Bar)

In addition to these changes, we provided instantaneous teacher monitoring dashboards for descriptive feedback to teachers through the new dynamic system as students completed their self and peer ratings survey (Figure 4). The survey follows a HTML form structure with a maximum of twelve tabs. The students could proceed to answer the questions of the survey per tab, while the teacher could see each student's progress per tab in real-time.

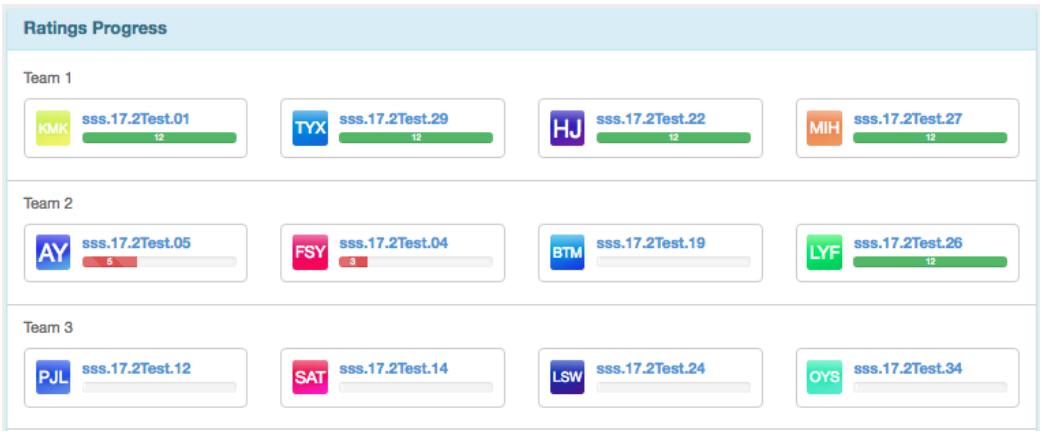

Figure 4. Screenshot of MGB Next teacher tracking dashboard

For TSDL *stage three* where students were presented with the reflection space, we created a more conducive reflection environment adding a retrospective function. Students were now allowed to go back to review and edit their answers. Only the last entered text is saved in both self and team reflections.

For TSDL *stage four*, mid-point and end-point checks were re-designed to a Status Check section, where students were allowed to complete multiple status checks for the selected dimension they wished to work on over the course of the project, allowing greater flexibility (Figure 5). In sum, this provides students' with greater agency to self-regulate and self-monitor their teamwork targets.

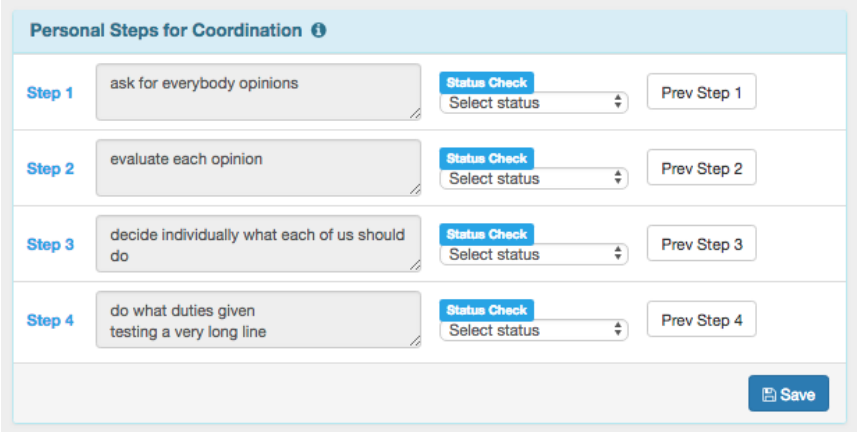

Figure 5. Screenshot of MGB Next Status Check page

4.2.2 Evaluation

The new fourth iteration that introduced MGB Next to students and teachers was seen as a positive change. It allowed the web application to be mobile friendly. Moreover, in TSDL *stage one,* students found it comfortable to view their lessons in a clean simple page, and easy to access the resources that the teachers had provided at any given time. Teachers were able to upload lesson content seamlessly as well as present embedded videos and images to students. The real-time chat application was well received for its ease of use and quick response. Additional features, such as automatic notifications were requested, as well as rapid navigation from login to lesson.

The additional visualization was found helpful to students and teachers who tend to be more familiar with bar charts, but they also appreciated the novelty of the radar charts. The real-time monitoring of students' progress was generally seen as impressive by teachers and collaborators who could now have an up-to-date view of the students' activity on the system.

On the other hand, teachers' feedback suggested that TSDL *stage three* which aimed to encourage students' reflection and sense making was not thoughtfully performed. Suggestions included adding more control on the section tabs in MGB Next to allow students necessary time to reflect. Other suggestions included providing students with dynamic and/or responsive tips to improving teamwork behaviours as they used the system.

5. Conclusion and Future Work

In general, the transition from the previous iteration to the fourth iteration, MGB Next, was well received. Both, students and teachers viewed MGB Next as user-friendly and responsive. However, it was found that several students were not taking the activity seriously to reflect and set steps for future team activities. Our next development plan aims to provide increased student support. We hope to implement personalized suggestions based on students' peer ratings, where struggling students could ask the MGB application for assistance. In addition, we hope to provide teachers with more actionable insight of their students' teamwork competency. We plan to incorporate a teacher dashboard, not only to check progress of activities, but also to visualize the class averages of students' peer ratings, for teachers to identify and target their content to a specific dimension. This refinement will also highlight how students are rated, which allows teachers to see which students are rated poorly by their team members and take necessary action.

In this paper, we detail the iterative design, related design principles, and evaluation of the latest trial cycles of a techno-pedagogical tool, MGB. Although we did not focus on students' teamwork competency data (this is in an upcoming work), initial evidence shows that peer-rated teamwork competency grew over the course of the students' group project. The enhancement of MGB through iterative trials has enabled the evolution of a platform capable of supporting the formative assessment approach of teamwork growth for 21st century students.

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