USING GAMIFICATION IN MATHEMATICS TO FOSTER BOYS' COLLABORATIVE SKILLS

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"Our minds are partly defined by the intersection with other minds."
(Siegel cited in Markova & McArthur, 2015, p. 107)

Abstract

During Term 4 of 2016, thirty Year Six boys participated in an eight-week action research project that investigated the effect of gamification upon students' use of their collaborative skills during problem-solving in Mathematics. Working in groups, students solved higher-order problems using collaborative skills that had been explicitly taught as part of the initial action. Following the teaching of these skills, students' individual scores were gamified into team scores using a leaderboard and digital badges. Findings indicated that gamification actualised the need for boys to use their collaborative skills within their learning groups in order to achieve better team results. Significantly, the findings of this research project highlight how gamification can be used as a teaching approach that leverages the use of boys' collaborative skills whilst also improving problem-solving skills.

Introduction

As an educator, father, and lifelong learner I am interested in the impact that gamification can have upon the teaching and learning of students within my classroom. My classroom, however, is not located in the Middle Earth, Narnia, nor in a distant galaxy far, far away. Rather, advances in technology, coupled with greater access to educational technology within the classroom, have allowed me to use gamification as a teaching tool. Games provide a structure that promotes social engagement allowing for meaningful learning to occur and encourages students to collaborate and compete (Kim, 2012; Farber, 2015).

The Organisation for Economic Co-operation and Development (OECD) states that the purpose of education is "equipping citizens with the skills necessary to achieve their full potential,

participate in an increasingly interconnected global economy, and ultimately convert better jobs into better lives is a central preoccupation of policy makers around the world" (OECD, 2013, p. 3). Furthermore, Kivunja (2014a) contends that the world has fundamentally changed from the 20th century Industrial Age Economy to the 21st century Knowledge Economy requiring essential life-long learning skills such as collaboration, problem-solving, communication, critical thinking and creativity. In particular, learning to collaborate has been identified as a necessary key skill fundamentally important for leadership, learning, effectiveness, innovation, problem-solving and life-long learning. (Hawkes, 2016; Tapscott, 2013). If we are to be morally responsible educators then we have an obligation to teach collaborative skills to our students so that they are better equipped to meet the challenges beyond the school gates.

Gamification within education can be described as "the trend of using game elements in non-game contexts" (Lynch, 2017, para. 5). It involves the use of "game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems" (Kapp, 2012, p. 10). At the core of gamification is social engagement, which requires students to participate in activities involving shared understandings, the expression of their thoughts, and collaborative interactions between students (Kim, cited in Farber 2015, p. 124).

The research question underpinning my action research project was: *How does gamification in Mathematics foster the use of collaborative skills by Year 6 boys?* Action research was considered to be the best way to conduct this project because its primary focus is on qualitative data that focus on meanings, thereby valuing the social world students create within an authentic setting such as a classroom (Robson & McCartan, 2016).

Literature Review

Schools are faced with both a moral responsibility and the challenge of educating learners with skills that will enable them to become lifelong learners beyond the school gates in an increasingly global and complex world that has become team-based. Krechevsky, Mardell, Rivard and Wilson (2013) assert that globalization and the new economy of the twenty-first century demand that our students have the ability to learn and function as part of increasingly diverse groups. In an interconnected and rapidly changing world, our knowledge of ourselves as individual and group learners becomes increasingly more important. Paradoxically, in education

the acquisition of knowledge is still primarily viewed as an individual process that is teacher-centred and is essentially still tied to educational constructs develop for the Industrial Age.

Notwithstanding this situation, current-day Australian curricula are grounded in the theory of constructivism. Educators using constructivist thinking recognise that, "Learning is a social activity intimately associated with our connection with other human beings, our teachers, our peers" (Hien, 1991, para. 16). Significantly, Vygotsky's (1978) social constructivist paradigm stresses the importance of collaborative learning, placing the co-construction of knowledge at its centre. His notion of the Zone of Proximal Development refers to the gap between what learners know and are able to do on their own to what they are able to do-when guided by more knowledgeable others in the process of collaboration with more capable peers. Linell (cited in Damsa, 2014) argues that knowledge is "constructed as part of the interdependency that involves people interacting with peers, tools, or objects from their environment, primarily through communicative actions" (p. 249).

The literal meaning of the Latin-based term "collaborate" means to co-labour and requires that all participants of a group actively engage by working together towards stated objectives, such as solving mathematical problems (Barkley, Cross & Major, 2014). Kivunja (2014a) advocates that a paradigm shift is needed to teach across all levels to facilitate the purpose of education because it "is shaped by the increasingly powerful technologies we have for communicating, collaborating, and learning" (p.16). Furthermore, McCain (2005) argues that, "We need an instructional approach that will equip students with real-world problem-solving skills plus, teach them the content they must master to be an educated person (p.15)."

Johnson and Johnson (2009) posit five variables, or pillars, that bring about the effectiveness of cooperation: "Positive interdependence, individual accountability, promotive interaction, the appropriate use of social skills, and group processing" (p. 366). Jones & Jones (2008) provide a visual representation of this concept in Figure 1.

Figure 1. Five pillars model of cooperative learning (Jones & Jones, 2008)

Positive interdependence occurs when the actions of individuals promote the achievement of joint goals. It is therefore important for learning groups to have common goals in order to become interdependent: As Johnson and Johnson note, "As members perceive their common goals, a state of tension arises that motivates movement toward the accomplishment of the goals" (p. 366).

Citing research findings on the beneficial impact of positive interdependence in cooperative group learning, Johnson and Johnson (2009) further contend that being aware that an individual's efforts can affect the success of their team members appears to create individual and group responsibility forces. Evaluating studies conducted in cooperative learning, Johnson and Johnson subsumed the structures of interdependence into "outcomes, means and boundary" (p. 367). Outcome interdependence includes rewards and goals. Their findings revealed that regardless of how outcome interdependence was achieved, "Structuring positive outcome interdependence into a situation tends to result in increased achievement and productivity" (p. 367). In this study, gamification provided a platform for social engagement that promoted positive interdependence between team members who strived to collaborate more effectively to achieve success for their teams. Goal setting was a component of the action that required boys to identify key collaborative skills taught. This reflective practice connected teams' past performances to their future performances through recognition via the leaderboard and digital badges.

Two important components for successful cooperative learning are face-to-face interactions and the positive use of social skills. Johnson, Johnson and Smith (cited in Jones & Jones, 2008) state it is essential for students to be given time to ask questions and support each other when completing their cooperative work as part of the process which provides "critical verbal and

non-verbal feedback needed for group success" (p. 67). They stress emphasis is on the process and not the product. Social skills are the second important component of collaborative learning. Jones and Jones (2008) argue that merely placing students next to each other does not guarantee cooperative learning will take place. Cohen (2014) states the initial step in beginning group work within a classroom is to prepare students for cooperative work situations. In particular, Cohen emphasises the fact that it would be a mistake to presume learners know how to work with each other in a constructive collegial fashion. Group collaboration skills, therefore, must be explicitly taught (Harvey & Daniels, 2015). Similarly, Jacob, Powers and Loh (2016) state that, "The time spent teaching collaborative skills is more than made up by the time saved when the group works well" (p. 80). Table 1 below outlines the collaborative strategies and social skills summarised by Harvey and Daniels (2015) and Jacobs, Power and Loh (2016).

Table 1. Summary of collaborative strategies and social skills

Harvey & Daniels (2015)	Jacobs, Power & Loh (2016)
Be responsible to the group	Helping a group stick to a time limit; getting a group back on task; encouraging others to participate.
Listen actively	Asking for help; clarification; giving examples; explanation; and repetition.
Speak Up	Offering suggestions; asking for feedback.
Share the air and encourage others	Taking turns; praising others; thanking others.
Support your views and findings	Giving reasons; providing examples; persuading others.
Show tolerance and respect	Apologising; speaking quietly; compromising.
Reflect and correct	Summarizing ideas, checking that others understand.

Advances in technology have occurred beyond the classroom through globalisation and technological change. The term "Digital Natives" was first coined by Marc Prensky (2001) and refers to either 21st century children born after 1980 or "Net Genners" learning within one-to-one (1:1) classrooms that are supplied with an array of digital devices and connectivity to the world wide web via the Internet. Kivunja (2014b) urges teachers to facilitate the learning of digital natives by embedding within their pedagogical practices, digital technologies in their teaching, learning and assessment, together with "strategies which will enable students to maximize the benefits available from their engagement with digital technologies" (Kivunja, 2014a, p. 106).

Matera (2015) states that, "Gamification has the power to transform the way we teach and the way we learn" (p. 5). To this end, games provide a social construct and structure to deliver meaning to activities (Farber, 2015). In keeping with Kivunja's (2014a) premise to maximise the benefits available from engagement with digital technologies, Nadolny (2016) states that whilst technology is not necessary to be used for designing game-based instruction, "it can provide a superior experience for teachers and students" (p.35). Further, Nadolny suggests Google Sheets as an example of a tool to create leaderboards, calculate grades, or be embedded within a website that is accessible to students.

Glover (2013) states that, "Gamification typically makes use of the competition instinct possessed by most people to motivate and encourage 'productive' behaviours (and, as a result, discourage 'unproductive' ones)" (p. 1999). Badges are another gamification mechanical element which work as a scoring system, "As well as an artefact of achievement … that can promote a feedback of social participation [for demonstrating] social skills, such as sharing, expressing, and collaborating" (Farber, 2015, p. 124). Badges also provide opportunities to "level up" as part of learners' skill development for achieving individual and group goals and rewards. Gamification should not be appended to learning activities, but instead integrated into a learning environment which tells stories of students' achievements that result from ongoing feedback and responding to adaptive challenges (Farber, 2015).

Research Context

Founded in 1831 by command of King William IV of England, The King's School is Australia's oldest independent day and boarding school. The school is located in Parramatta, the geographic and demographic heart of Greater Sydney. King's was established as a boys' school that would provide Australia with its next generation of leaders. Situated on 130 hectares, The King's School comprises two campuses: The Preparatory School (Pre-K – 6) and The Senior School (Years 7 - 12). The total student population is 1600 students with 171 teaching staff. Within the Preparatory School there at approximately 420 students.

The Preparatory School prides itself on being an International Baccalaureate World School that utilises the IB Primary Years Program (PYP) in conjunction with the state (New South Wales) curriculum administered by the NSW Education Standards Authority (NESA). Each boy is encouraged and supported to discover and fulfil his unique potential within a balanced, boy-friendly program that nurtures the whole person–mind, body and soul. The school's teaching resources, particularly for boys' education, boarding, and the development of leadership skills, are used throughout the world. The King's School mission statement is a "Christian community that seeks to make an outstanding impact for the good of society."

Year 6 at The Prep School comprises a cohort of 78 boys. Mathematics is structured into three flexible and fluid groupings of high, middle and low ability students. This action research project focused on the advanced maths group, comprising 30 boys aged between 11and 12 years-old with high academic achievement levels in Mathematics. Consent forms to participate in the project were distributed and returned by all parents and students. The study was conducted over 10 weeks within normal classroom hours as part of normal scheduled problems-solving lessons.

The Action

The action began at the end of Term 3, 2016 and continued through Term 4, 2016. Students were organised into learning groups of three based on average high, middle and low scores achieved in the 2016 Australian Problem Solving Maths Olympiad (APSMO) competition. During the first group problem-solving sessions, students were not provided with any instruction on collaborative skills, but were asked to organise themselves according to a

modified version of Polya's four-step problem solving strategy (see Appendix 2) to engage students' complex thinking skills: 1) understand the problem; 2) plan a strategy; 3) carry out the solution; and 4) look back at the solution. In their teams, the roles of facilitator, scribe, and reader were assigned to team members (see Appendix 3).

At the beginning of Term 4, students were explicitly taught collaborative skills in mini-workshops. These skills included: the home team advantage, active listening, checking for understanding, and disagree politely (see Appendix 4). An explanation of how Student Teams Achievement Divisions (S.T.A.D.) would work (see Appendix 5) and how the point scoring system operated was given (see Appendix 6). S.T.A.D. is a cooperative learning technique that involves assigning students to teams that reflect heterogeneous groupings of high, average and low achieving students. In lessons, material is introduced through the teacher and then group members collaborate on problems designed to expand and reinforce the previous material taught (Armstrong & Palmer, 1998). Following group work sessions, students work independently on assigned material without the help of their teammates. Individual improvement scores from students are calculated into team scores thereby achieving a sense of group accountability. The amount each student contributes to the team score is related to a comparison between the students' prior base score. If a student's individual score is higher than the base score, then the student will contribute positively to the team score. Team scores are awarded to winning teams and improving students, which are then posted in a class newsletter (Slavin, 1990), thereby actualising responsibility forces. The posting of scores in a class newsletter can also be viewed as a leaderboard, which is a gamification element (Farber, 2015; Kapp, 2012; Matera, 2015). With advances in information communication technology (ICT), however, opportunities for the digital gamification of S.T.A.D.'s competitive dimension have grown significantly.

Each scheduled problem-solving session involved the implementation of concepts previously taught in the form of higher-order problems to be solved by the groups. Solutions to the problem were then discussed with a view to looking at the different methods groups may have used to solve their problem. Following this, individual problem-solving sessions took place. Problems with similar concepts were assigned for individual students to attempt without help. The results of these individual problems were scored for each of the boys' learning groups.

Team recognition took place in the following Mathematics class using both the leaderboard (see Appendix 7) and digital badges (see Appendix 8). Both were posted on a class portal for students to access.

Data Collection

Data collection was undertaken at the beginning and end of the projects through a mixture of qualitative and quantitative techniques. Google Forms was the main tool utilised to collect the qualitative data. The pre- and post-surveys contained questions that required students to respond to open-ended statements, which were designed to garner students' thoughts, understandings, impressions and reflections to provide an authentic voice throughout the process (see Appendix 9).

As the starting point, a pre-survey asked students how they felt about working collaboratively to solve mathematical problems. This survey intended to explore students' previous experiences using collaborative skills in learning groups and to ascertain what they knew about collaboration and which skills they believed were relevant for success. A Likert scale was used to assess students' positive and negative responses together with open response questions that required students to reflect on their experiences.

A post-survey identical to the pre-survey was completed by students to identify shifts or changes in their attitudes, experiences, and reflections using collaborative skills. Lastly, focus group meetings were used as a means of summative assessment for data collection. Members of the group were randomly selected from volunteers. The open-style questions asked of focus group members were designed to ensure student voices would be heard throughout the analysing and reporting stages of the study.

Data Analysis

The data were transcribed from videos taken of the focus group and coded with emergent themes relevant to my research question. According to Robson and McCartan (2016), thematic coding provides a "thematic map" of the analysis. The statistical data from the surveys were used to provide a landscape of students' experiences using collaborative skills to solve mathematical problems to prior to the research project. A descriptive approach in analysing

these data was used to identify trends and representational quotations from the videos were used to support the themes identified. This mixed approach to the data analysis provided a holistic picture of my research that tells the story of how gamification supported the teaching of collaborative skills during mathematical problem-solving.

Discussion of Results

Firstly, it can be concluded that as all participants were in their final year of primary schooling, each would have had prior exposure to working in groups, and secondly, that they had a general understanding of the notion of collaboration. The pre-survey of students' experiences with collaborative learning revealed that most boys enjoyed learning collaboratively. Of significance, however, were their generalised responses about what they felt effective collaboration looked like. Responses from boys, such as, "Be kind," "Be positive," and "Work hard and help other group members," suggest a lack of in-depth understanding of the nature of collaboration. Very few responses mentioned respect or listening. At the conclusion of the project, using a web-based word-cloud program, I entered all of the words from the students' discussion during the focus group to achieve a visual representation of the most prevalent words used in reference to collaboration (Figure 2). As the word-cloud suggests, the boys'understanding of collaboration

Figure 2. Word-cloud from student responses in focus group meetings.

Had broadened and

deepened.

Following the intervention, a number of themes emerged from the analysis of the focus group and survey data:

Structured Face-to-Face Interactions Improved Collaboration

Emphasising the importance of roles within groups facilitated the development and improvement of the structure of learning groups during problem-solving sessions. Prior to the intervention, a divide and conquer approach occurred as students split up work according to their self-perceived abilities: A boy recounted, “When we first starting doing group problems solving, everyone was talking over each other and we couldn't hear anything and we couldn’t get the job done.” He also noted, “At the beginning, everyone was fighting for control and like it was their opinion and nobody else’s.”

Following the intervention, the boys realised that respecting each other’s role was a key factor that facilitated the group’s efforts and allowed them to better share their ideas through turn-taking. The same boy added, “Whereas now, people respect each other’s opinions, work together to use their skills to solve the problem.” Discussing the importance of their roles within the groups allowed boys to refocus their efforts during group problems solving. This was important to one particular boy who shared his thoughts on what he felt was an important collaborative skill: “Well, respecting each other’s roles cause some of us were doing two roles at a time. For example, the facilitator was also the scribe. We had to stick to our roles, because it got messed up and it got confusing.” In many cases, boys felt they were doing the best for the group by taking over a role not assigned to them because they felt that they had better skills in the group, such as neater handwriting or could work out a group problem using algebra. As a result, boys had to let go of their natural urge to take control and “do it for them.” By doing so, each group developed a better empathetic understanding of other boys’ abilities within their groups. The comparison between the pre-survey and post-survey responses supports a positive change in how participants felt about sharing within their groups (see Figures 3, 4 and 5).

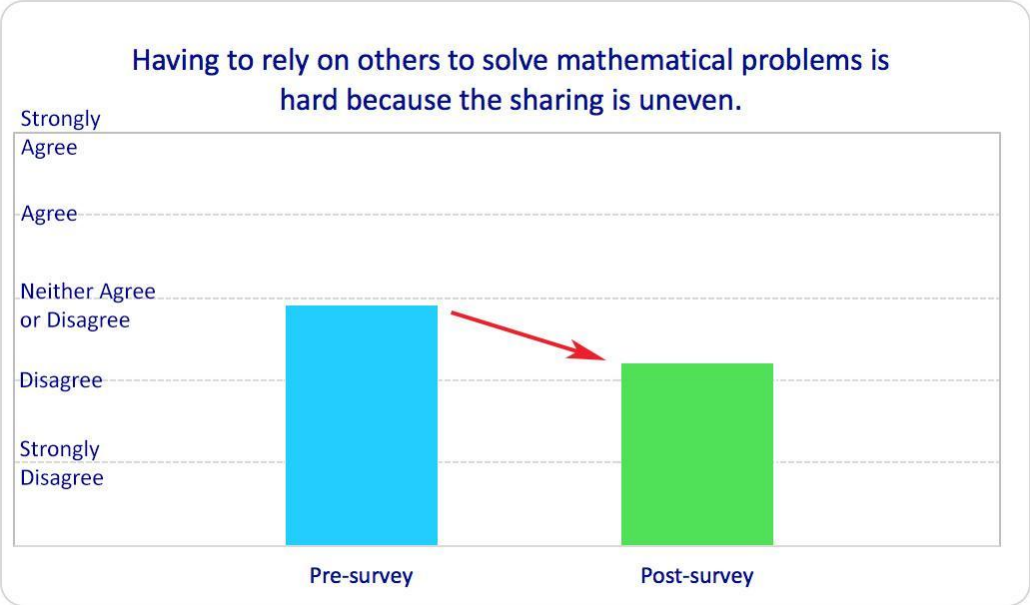

Figure 3. Comparison of pre-survey to post-survey student responses to sharing within groups

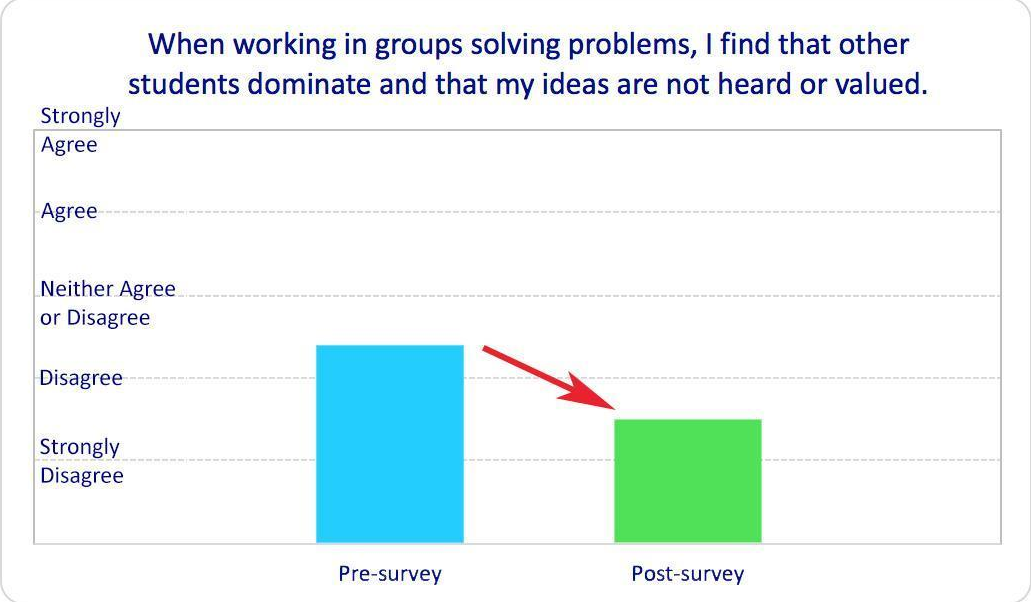

Figure 4. Comparison of pre-survey to post-survey student responses to valuing of each other's contributions.

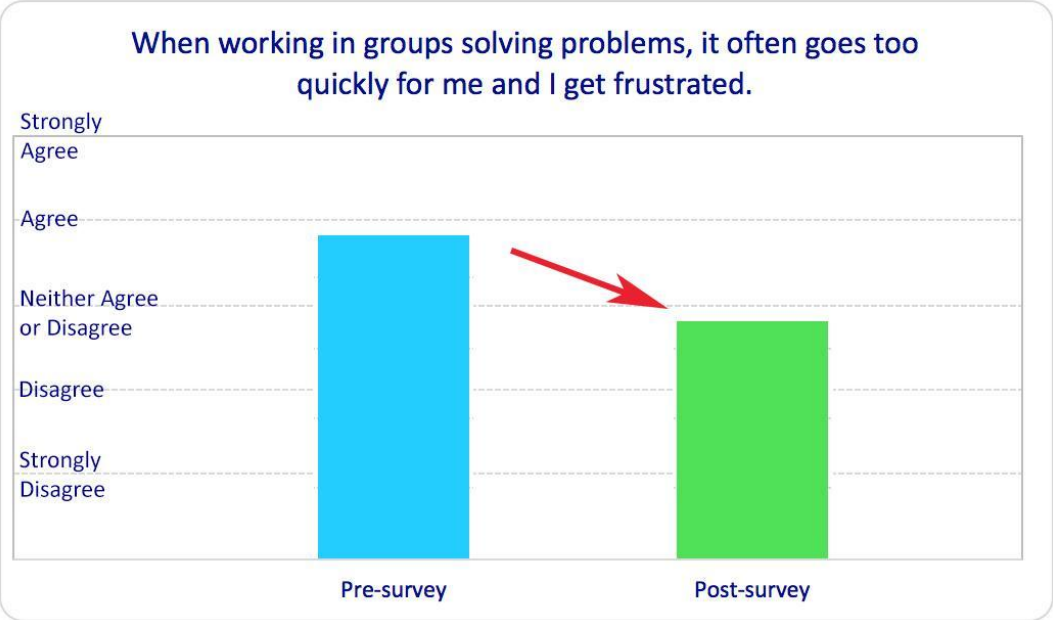

Figure 5. Comparison of pre-survey to post-survey student responses to the nature of personal interactions within groups.

Positive Interdependence Promotes Learning Through Others

Jones and Jones (2008) hold the view that positive interdependence "is the belief that the individual is dependent on the contributions, inclusion, and success of the others in the group in order to be successful" (p. 66). Prior to the intervention, students were allowed to freely work in groups to solve problems, which provided a staging point for the project. Initially, when each group received the problem they would all begin working at once in order to achieve an answer using different methods and then share their answers with each other. From observations made earlier in the year, I noticed that the boys' general approach to problem-solving showed a reliance on an iterative process of guessing and checking using a robust knowledge of retained mathematical concepts. Within the group, only a handful of students were able to consistently demonstrate success with their ability to formulate and reason mathematically using a range of more abstract strategies. When students were able to share their thinking about how they solved problems three further elements surfaced during the project: learning through others, sharing understandings, and an appreciation of each other's abilities. One student expressed his sense of success commenting, "I enjoyed being able to see how other people got to work out the question and see how they find their solutions. So, you have more than one way to work out doing

things. So, you have backup ideas and see how other people solve questions." A comparison of pre and post surveys indicated that boys were developing a greater preparedness to use the strategies of other team members (see Figure 6).

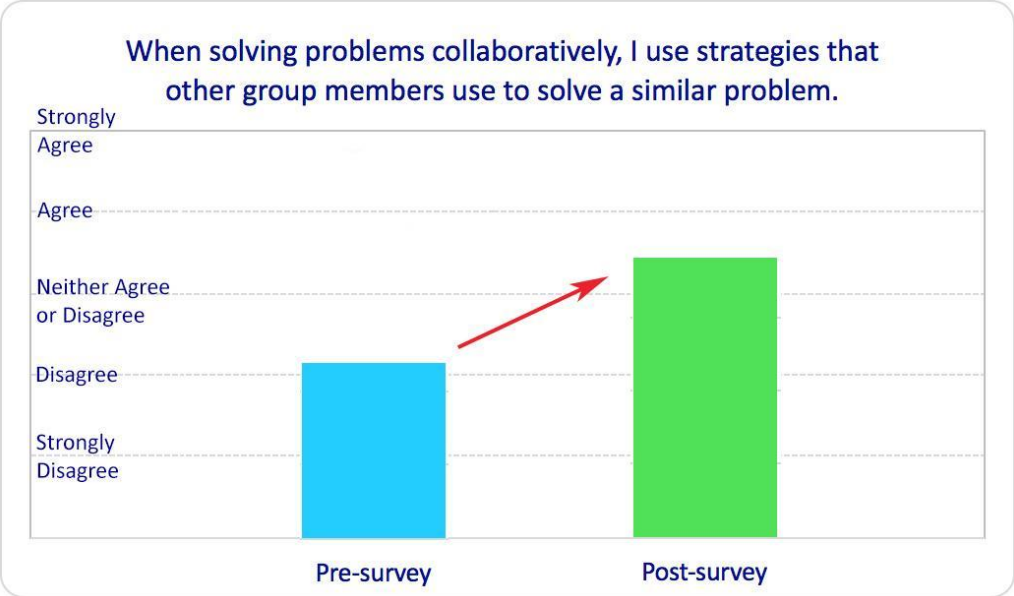

Figure 6. Pre-survey to post-survey comparison of students' attitude to use other students' strategies to solve problems.

Reflecting on his experiences one student stated, "I think it was a sense of satisfaction, not only individually but as the whole group, because I think from memory I used algebra for my two extra Olympiads [questions]. And I learnt that from my group, and so that showed that what we were doing was working." He went on to reflect, "When I think back on problem-solving at other schools, and last year as well, it was all really messy and it wasn't as good as it was doing it this year. And now I think in the future it will be really easy, and instead of going 'Oh, we're doing group [problem] solving …' it will be a bit like, 'Oh yeah, I can learn about from this!' Instead of having to somehow find the answer with other people and struggle with where we had to be."

Interpersonal Skills Allow for the Intersection of Other Minds

To promote greater awareness of interpersonal understandings and social interactions, the action incorporated the explicit teaching of social and interpersonal skills, which included: making eye

contact, leaning in, checking for understanding, listening attentively, paraphrasing, disagreeing politely and using first names (see Appendix 3). At the beginning of group problem-solving sessions, boys set goals by identifying three collaborative skills they would use and then later reflected on the effectiveness of their goals. A boy commented, "As we went along, we started making goals and these goals quite helped." In effect, the process of goal-setting acted as a conduit between the boys' use of the collaborative skills taught and their individual creative solving problems skills. Further into the project, the positive nature of communication within groups changed significantly. Interactions between boys resulted in improved understandings and greater engagement during problem-solving work. Summarising his feelings about this change, a boy reflected, "When we were getting towards the end [of the project] our minds started to think more alike. So one person would say their suggestion on how to solve it [the problem] and another person would say, 'I was also thinking that way.' So our minds started out as separate, but slowly started to come together so we could think more alike."

Gamification / Competition Heightens Students' Use of Collaborative Skills

After the group problem-solving sessions, boys individually attempted problems with similar mathematical concepts. The results of their individual improvement scores were collectively converted into an overall group score and presented on a leaderboard with teams awarded badges. Reichert and Hawley (2010a) state that interactive exchanges and competition are significant factors that contribute to the element of "transitivity" and result in student engagement. Long (2016) uses the term "boyology" for boys' engagement as a critical factor in the teaching of boys. The leaderboard and badges gamified the collaborative problem-solving process, serving to arouse boys' awareness of to the importance of using collaborative skills taught. Highlighting the impact of these two elements on group and individual accountability, a boy reflected:

> The scoring system and having that game or competition element in boys, because we always need competition, really improved and gave people an incentive and it gave them something to work towards. Because you don't want to look up to see that your score had let down your team to be one of the worst teams. So it would make you perform better, and that lifted everybody.

Similarly, another boy commented:

> Having the individual questions in the competition made us collaborate better. You gave us no choice, so you had to collaborate well to get everyone to have an understanding of the problem. Because you'd go to the individual problems which were usually similar to the group problem, you'd have to have and understanding of that problem, so it helped us collaborate greatly.

Overall, I was pleasantly surprised to observe the deep impact gamification had on the boys' use of collaborative skills and their problem-solving skills. A richness within these results has been achieved by presenting and preserving the boys' voices. The findings show that gamification was a significant transitive factor that promoted the use of collaborative skills whilst also improving the problem-solving skills of boys in Mathematics.

Conclusion

In *Reaching Boys, Teaching Boys,* Reichert and Hawley (2010b) contend that competition and teamwork are coextensive. They note further that it would be "a delicate, and perhaps unfruitful, task to attempt to separate or compare the relative degrees of teamwork and competition in a particular lesson." (2010a, p. 121) Additionally, they state that boys appreciate opportunities to compete and cooperate in academic settings, which can result in heightened engagement. The findings from this action research confirmed that gamification had a significant effect resulting in the improved use of the boys' collaborative skills in learning groups to solve problems.

Using S.T.A.D. to gamify problem-solving provided a structure for social engagement that tapped into boys' innate desire to compete and collaborate in learning situations. Gamifying the scoring system using a leaderboard and awarding digital badges sent a powerful signal to the boys about their collaborative efforts. Recognising team efforts made the boys realise that they were individually accountable to their groups because their improvement scores contributed to team scores. Being accountable to the team promoted positive interdependence between group members and emphasised the importance of using collaborative skills taught. Boys realised that in order to achieve success for their teams, learning through others was far more efficient and rewarding.

As the action was applied over the course of the study, boys' behaviours and attitudes towards each other changed significantly during problem-solving sessions. Firstly, there was a

realisation that using collaborative skills during group problem-solving sessions promoted better face-to-face interactions and improved social skills. As a result, the boys developed an appreciation and awareness of each other's abilities. Secondly, gamification engendered a cohesive, collaborative working atmosphere resulting in deeper respect for each other's roles within groups. This in turn allowed the boys to have a voice within their group, knowing that they would be listened to, or helped, if they did not understand a concept.

Gamification in the classroom can be likened to the *Tour de France*, arguably the world's most prestigious annual cycling event. Just as individual cyclists compete collectively as members of a team within the *Tour de France*, boys in their learning groups soon realised that they were in fact on the same team competing to do well. Building on their strengths and their weaknesses, boys negotiate the challenges of algebra and probability, just as cyclists negotiate mountain and sprint sections. Such a comparison may at first glance seem far-fetched, however, once boys understand how a game works they become adept at using it to achieve success. Essentially, the boys in this study, "*learned to play the game and then played the game to learn."* In the real world of business and economics, such analogies to some degree hold true for individuals who need to work collaboratively in teams to achieve a larger common goal.

Implications for Future Practice

This study has shown that gamification successfully heightened boys' awareness and use of collaborative skills during problem-solving in Mathematics. It showed that it improved the boys' overall problems-solving abilities. My experience has allowed me to reflect on my teaching practice and to ask several questions. How can I incorporate the explicit teaching of collaborative skills in my teaching? How can my lessons be gamified to promote the use collaborative skills to tap into boys' attraction to competition? What other subjects can I incorporate elements of my results to improve student learning outcomes? How can I support my colleagues at The King's School using gamification and the explicit teaching of collaborative skills?

In 2017, The National Boys' Education Conference is to be held at The King's School and I will be presenting the findings of my action research project at the conference. I will also be sharing my findings with my colleagues in The Prep School. 2017 has also brought about a

change to my teaching with a move to Year 5. Encouraged by the results of my action research, I feel inspired to replicate aspects of my study using cooperative teaching strategies like S.T.A.D. to teach Year 5 students problem-solving and grammar concepts. Lastly, as part of a formalised professional learning goal at The Prep School, I have nominated to use S.T.A.D. as part of my Personal Professional Learning Plan that meets the criteria for the Australian Professional Teaching Standards.

Reflection Statement

Teachers lead busy professional lives within schools that have the best interests of their students at heart. Students are at the centre of schools' policies and teaching programmes that strive to provide the best quality academic and character education possible. In reality, my action research project stands as a microcosm in the larger picture of King's. Participating in this project was challenging, as it should be. Yet in saying this, I found my action research project to be an uplifting and refreshing experience that allowed me to connect more deeply with my teaching practice and philosophy. My journey with the project has made me more reflective in the way I question my teaching with "why" questions, before the "how" or "what" questions. Paradoxically, my action research project was about investigating an action on a group of boys participating in problem-solving; however, my action research itself was to a large degree, a measure of my own problem-solving experiences for that were both rich and fulfilling.

The IBSC Action Research Program is a valuable experience and attending the 2016 IBSC Conference in Vancouver was both an outstanding and memorable event providing a meeting place for the intersection of like-minded people. Who would ever forget the presentation by Rick Hansen and his wonderful message about attitude and hope? I am indeed grateful to Dr Tim Hawkes, The Headmaster of The King's School, for having the courage and faith in approving my application. Thanks also goes to Peter Allison, The Head of The King's School Preparatory School for supporting my application and encouraging me and to the other teaching staff within The Prep School who supported me in one way or another. My mentor, Di Laycock, found precious time during moments of her life when time was not always readily available. Her advice was timely, measured and insightful which went a long way from our very first meeting, through to the end. Finally, Trish Cislak my Team Advisor, whose patience, good

humour and positive support encouraged me throughout despite transglobal discrepancies in time zones between our two hemispheres. Trish's ideas and wealth of knowledge provided invaluable insights and she deservedly earns my sincerest gratitude for the excellent job that she does.

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Appendices List

1. **Glossary**
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Appendix 1: Glossary

Collaborative work refers to work that students do together in groups by exploring a solution to a problem or the different strategies students use to interact with each other (Osman, Duffy, Chang, & Lee, 2011; cited in Wismath, 2015).

Cooperative work can also be defined as a form of collaborative learning that is characterised by: clear, straightforward assigned tasks; student dependency upon each other to complete the task; the teacher acts a guide and students being ultimately responsible for accomplishing a collective goal (Slavin, 1990; Willis 2007; cited in Wismath & Orr, 2015).

Learning groups as defined by the Harvard Graduate School of Education are "a collection of persons who are emotionally, intellectually, and aesthetically engaged in solving problems, creating products, and making meaning - an assemblage in which each person learns autonomously and through the ways of learning of others" (2005).

Student Teams Achievement Divisions (S.T.A.D.) is a cooperative learning strategy that requires every member to perform. The teacher presents lesson materials based on the mathematical concepts to be covered and then students work within their learning groups to make sure that all team members can understand how a problem(s)can be solved. Finally, all students attempt individual solve problems based on similar mathematical concepts, at which time they may not help one another. Students' individual scores are compared to their past averages, and improvement points are awarded on the basis of the degree to which students meet or exceed their own earlier performance. These improvement points are then converted to form team scores, and teams that meet certain criteria earn team awards and digital badges.

Gamification within education "is the trend of using game elements in non-game contexts" (Lynch, 2017). According to Kapp gamification is defined as "using game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems" (2012, p. 10).

Appendix 2: Polya's (modified) four step problem solving strategy

Problem Solving: 4 Step Strategy

Date: _____

Names: _____

Q. 1B

In a group of dogs and their owners, there are exactly 20 heads and 64 legs.
How many dogs are in the group?

Step 1: Understanding The Problem

What do you know?
List in point form.

What do you have to find?
State the in your own words what we need to find.

Step 2:Plan - Steps to Solve the Problem

Step 3: Solve the Problem by: _____
Write a suggested strategy, e.g. draw a diagram, make a table, use a smaller problem, etc.

Step 4: Reflect on Your Answer
Write you answer in a sentence form. How is your answer a reasonable answer?

Checking for Reasonableness:
Does your answer make sense? WHY? Can you work it out another way?

(Front of student worksheet)

(Goal Setting section on reverse side of student worksheet)

Achievement
Write 0 – 5
0 – Not Successful
3 – Some Success
5 – Fully Successful

Goal #1 We will_____ _____

Goal #2 We will_____ _____

Goal #3 We will_____ _____

Possible Goals Areas:

Turn taking
Respect each other's roles
Check for understanding
Listen attentively
Disagree politely
Making eye contact
Using first names
Paraphrasing each other words

Appendix 3: Learning Group Roles

Learning Group Roles

- Facilitator
  - The leader / manager of the group. They make sure you work as a team; that only one person speaks at a time; and that everyone fulfils their role.
- Reader
  - The reader reads out the problem, and reads back parts of the solution.
- Scribe
  - The scribe writes down the team's solution.

Swap roles for each new problem

Appendix 4: Mini-workshops on Explicitly Teaching Collaborative Skills

1.) Home Team Advantage

a. National Rugby League (NRL) Cronulla Sharks Winning Season 2016
b. Showing Friendliness and Support.
    i. Fans cheer you! We're all on the same team.
    ii. Eye contact.
    iii. Using first names.
    iv. Seating positions and leaning in together.
    v. You feel comfortable.
c. What do you do when one of your teammates makes a mistake?
d. What do you say when someone drops a catch in cricket or misses a tackle in rugby?
e. Supportive comments as a group…"That's a great idea, Matt."
f. Avoiding put downs?
g. Use the "home game" to remind people we are a team.
h. Share the air and encourage others.

2.) Listen attentively

a. Listening carefully to the other person with your face and body.
b. Use eye contact.
c. Express Reactions.
d. Understanding the other person's point of view.
e. Disagreeing Respectfully
f. Disagree Politely.
g. Correctly phrasing your differences "…I beg to differ."

3.) Checking for Understanding

a. Paraphrasing.
b. Summarising.
c. Connect your idea with what others have said.
d. Use appropriate tone and voice volume levels to engage in discussion.

Appendix 5: Problem Solving / Explanation of S.T.A.D. (1 hour per week)

A - Group Problem Solving Session:

NB: Content and concepts had been introduced in previous lessons prior to group problem solving session.

1. Students move to sit in classroom within their groups.
   a.) Groups formed based on high, middle and low base scores.
   b.) Each group decide whose turn it is to be facilitator, scribe and reader.
2. Plenary – recall and recap main points of content previous taught in the week.
3. Facilitator of each group receive group problem solving sheet.
4. Groups discuss and identify which strategies they will target for this session based on previous performance(s).
5. Groups work collaboratively for 8 - 12 minutes on problem.
6. Groups received second group problem to solve.
   a.) Students switch roles.
7. Groups work collaboratively for 8 - 12 minutes on second problem.
8. Students asked to finish and solutions to problems are discussed.

B - Individual Problem Solving Session:

1. Students move to individual seating arrangements within classroom.
2. Teacher hands out first individual problem-solving sheets.
3. Students work for 8-10 minutes on each problem.
4. Students received second individual problem-solving sheet.
5. Fast finishers are given additional problems to solve with greater complexity and challenge.
6. Time called and individual problem-solving sheets are collected.

C - Team Recognition (next lesson)

1. Results of students' individual problem-solving sessions are discussed in class.
2. Team recognition leaderboard and badges shown to students.
3. Discussion of any questions or issues.

Steps A, B and C are repeated in each weekly problem-solving session

Appendix 6: S.T.A.D. Point Scoring System – Improvement Points and Team Scores

STAD - Student Teams Achievement Divisions

Team Scores

Criterion (Team Average)	Award
15	Good Team
20	Great Team
25	Awesome Team

STAD - Student Teams Achievement Divisions

Improvement Points

Problem Solving Score	Improvement Points
More that 10 points below base score	0
10 points below to 1 point below base score	10
base score to 10 points above base score	20
more than 10 points above base score	30
perfect score (regardless of base score)	30

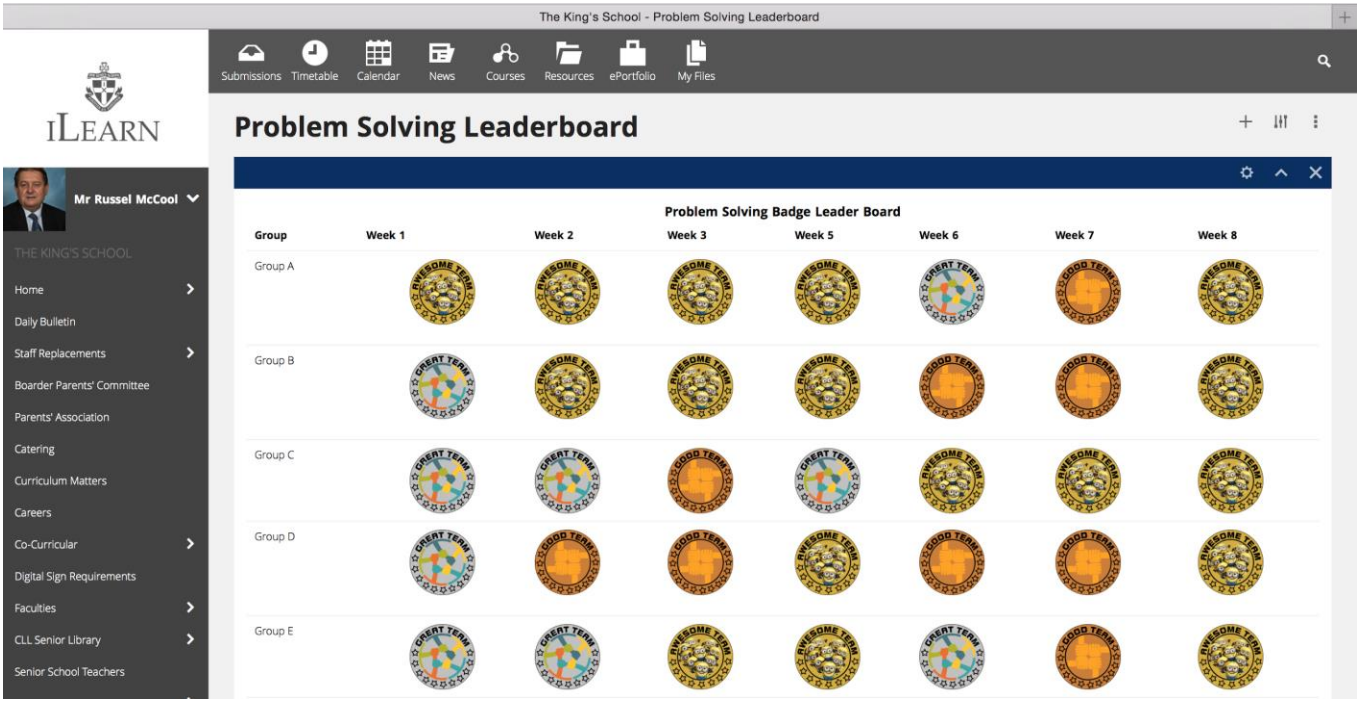
Appendix 7: Learning Group Leaderboard

S.T.A.D. Group Points	A	B	C	D	E	F	G	H	I	J
	20	0	30	7	23	13	30	30	10	20

Week 6

Name	New Base Scores	Base-score (x 20)	Independent Session Scores	Total Points	Improvement Points	Team Points	Team Award
Student #15	5	100	5	100	30		
Student #14	3.8	76.7	2	40	0	20	Great Team
Student #18	3.5	70.7	5	100	30		
Student #29	4.3	86.7	3	60	0		
Student #26	4.2	84.0	2	40	0	0	Good Team
Student #5	3.5	70.7	3	60	0		
Student #17	4.5	89.3	5	100	30		
Student #12	3.8	76.0	5	100	30	30	Awesome Team
Student #9	3.5	69.3	5	100	30		
Student #24	3.8	76.0	2	40	0		
Student #22	3.4	68.0	3.7	74	20	7	Good Team
Student #4	3.0	60.0	2	40	0		
Student #25	4.1	82.7	3.7	74	10		
Student #23	4.5	89.3	5	100	30	23	Great Team
Student #3	2.5	49.3	3.7	74	30		
Student #30	4.8	96.0	2	40	0		
Student #2	4.5	89.3	5	100	30	13	Good Team
Student #19	2.4	48.0	2	40	10		
Student #6	4.4	88.0	5	100	30		
Student #7	3.5	69.3	5	100	30	30	Awesome Team
Student #21	3.6	71.7	5	100	30		
Student #10	3.7	74.7	5	100	30		
Student #20	4.8	96.7	5	100	30	30	Awesome Team
Student #27	3.4	68.0	5	100	30		
Student #1	4.3	85.0	2	40	0		
Student #13	1.9	38.7	2	40	20	10	Good Team
Student #28	2.1	41.7	2	40	10		
Student #11	4.2	84.0	2	40	0		
Student #8	3.9	78.7	5	100	30	20	Great Team
Student #16	2.0	40.0	5	100	30		

Appendix 8: Learning Group Digital Badges via School iLearn Portal



Awesome Team Digital Badge

Great Team Digital Badge

Good Team Digital Badge

Appendix 9: Student Attitudes and Attributes to Group Work Solving Problems*

Please read the statement carefully and choose a response.

N.B. This survey was delivered to students by Google Forms

	Statements	Strongly Disagree	Disagree	Never Agree or Disagree	Agree	Strongly Agree
1.	When I work on mathematic problems I prefer to work alone.	☐	☐	☐	☐	☐
2.	I like to work alone on maths problems because I want to be the first to solve the problem.	☐	☐	☐	☐	☐
3.	When I solve a maths problem by myself, I get great satisfaction from solving it by myself.	☐	☐	☐	☐	☐
4.	I feel a greater sense of accomplishment when I solve problems by myself rather than in a group.	☐	☐	☐	☐	☐
5.	When solving mathematical problems, I am shy and feel awkward when I make mistakes in front of my peers.	☐	☐	☐	☐	☐
6.	I am shy and feel uncomfortable talking in front of others when solving maths problems working in groups.	☐	☐	☐	☐	☐
7.	When working in groups solving mathematical problems it often goes too quickly for me to keep up and I get frustrated.	☐	☐	☐	☐	☐
8.	When working in groups solving mathematical problems, I feel dumb when others find solutions and I don't.	☐	☐	☐	☐	☐
9.	When working in groups, solving mathematical problems I get easily distracted and lose focus.	☐	☐	☐	☐	☐
10.	When working in groups solving mathematical problems, I find other students dominate and my ideas are not heard or valued.	☐	☐	☐	☐	☐
11.	When working in groups solving mathematical problems, I feel that other group members interfere with my process of solving problems at the time.	☐	☐	☐	☐	☐
12.	Having to rely on others when working in groups to solving mathematical problems is hard because sharing is uneven.	☐	☐	☐	☐	☐
13.	When I work on mathematic problems, I prefer to work collaboratively in groups.	☐	☐	☐	☐	☐
14.	When working collaboratively on solving mathematical problems, I like to talk with other group members and use different strategies to solve problems.	☐	☐	☐	☐	☐
15.	When solving mathematical problems collaboratively in a group, I like to bounce ideas of other people and build on them.	☐	☐	☐	☐	☐
16.	When solving mathematical problems collaboratively in a group, I like to actually solve the problem myself once a strategy or method has been found by the group.	☐	☐	☐	☐	☐
17.	When solving mathematical problems collaboratively in a group, I like to reflect with another student or group member.	☐	☐	☐	☐	☐
18.	When solving mathematical problems collaboratively in a group, talking out loud and gaining the perspective of everyone in the group helps me to figure out the problem better.	☐	☐	☐	☐	☐
19.	When solving mathematical problems collaboratively in a group, I use the strategies that other group members come up with when I come across a similar problem.	☐	☐	☐	☐	☐