Using Collaborative Real Life Action Games

Using Collaborative Real Life Action Games To Increase Motivation Of Learning

Chemistry In Students

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Abstract

Real life action games harness the immense potential of promoting collaborative learning and increasing the motivation of learning Chemistry in students. At the same time, learning through games build enduring understanding through connection established between action and knowledge. Consequently, this paper describes the effectiveness of using real-life action games à la Amazing Race with Chemistry elements (CHEMazing Race) in a Chemistry lesson through the use of Lesson Study process to structure the lesson. The lesson was conducted on 437 Secondary Three students of high, medium and low abilities to reinforce their understanding of key concepts on the topics of Acids, Bases, Salts and Qualitative Analysis. Students worked in teams to compete with peers from other classes to complete 4 - 5 station games in 45 minutes. Using the Lesson Study framework, the research lesson was put under the microscope and evaluated through 1) a qualitative approach involving pictures of lesson conception, research lesson and lesson post-mortem; 2) data from student surveys about their feelings and perceptions on whether the intervention had a positive effect on the achievement and interest level of the students in the topic of the research lesson. The results highlighted the effectiveness of collaborative real-life action games in increasing the motivation and interest levels of students in learning Chemistry through a fun and enjoyable way.

Keywords: Secondary School, Real Life Action Games, Chemistry, Qualitative Analysis, Lesson Study

Introduction

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As the education system in Singapore continues to evolve to equip the students with 21st century competencies to prepare them for the fast-changing and highly-connected world, a wider spectrum of innovative pedagogies and teaching methodologies are designed to place the students at the heart of teaching and learning. Lesson Study embodies and mirrors this exact strong belief of creating a nurturing and enriching learning environment for the students through research, discussions and improvement of lessons to tailor to the needs of the modern day students.

As a school with a cohort of above average students, there are expectations from teachers that students are motivated and able to grasp concepts in the various subjects well. However, sometimes this is not so for Chemistry for various topics as the concepts taught are difficult to grasp and students faced difficulty in retaining the content knowledge taught. A few of the more difficult topics are Acids, Bases, Salts and Qualitative Analysis.

According to Tan, Goh and Chia (2004), Qualitative Analysis (QA) requires students to make inferences based on observations or recordings of a series of procedures that has been performed. Tan, Goh, Chia and Treagust (2001) also proposed several reasons for students typically finding QA a difficult topic. Firstly, it requires many skills such as manipulative, observational, recording and inferential. Secondly, students have to be well-versed in many topics including acids, bases and salts, oxidation and reduction, reactivity of metals and periodicity, in order to make sense of the experimental procedures and results.

As a considerable amount of interconnected knowledge is required of students at grade 10 (15 to 16 years old) to develop a conceptual understanding of QA, many students are unable to
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make the linkages between the theoretical knowledge taught in classrooms and the understanding of the practical procedures and observations.

Based on a study by Tan and others (2004), 51 Grade 10 students from three different secondary schools in Singapore were interviewed to assess the major sources of students’ difficulties in understanding QA. The data from the interviews revealed that these sources include formation of precipitates, formation of complex salts and lastly, addition of acid. Tan and others (2004) concluded that students were unable to or did not relate the theory they had studied in the classroom to what they were doing in the laboratory during practical sessions. McDermott (1988) suggests that one of the causes for students’ lack of understanding of Chemistry is the failure to integrate their knowledge. A possible reason for this is that lessons were frequently seen by them as isolated events with no connections to prior lessons, experiments or topics (Duit and Treagust (1995) and Berry, Mulhall, Gunstone and Loughran (1999)), hence the students lack appropriate frameworks that could guide their learning.

A group of reflective teachers search for a teaching strategy that will help reinforce and retain content knowledge and concepts for these difficult topics. This forms the background of this research study and it uses the Chemazing Race as an effective reinforcement tool to improve students’ learning.

Literature Review
According to Renchler (1992), motivation involves self-consistency, self-confidence and self-determination. It affects these three aspects of the individual, through which it influences the individual’s overall academic achievement. In regard to self-consistency, an individual is likely to perform better academically if he has a positive self-image, as the individual will try harder to maintain the track record of success he has achieved, and is likely to put more effort into academic attainment in order to fulfil his goal. Pertaining to self-confidence, individuals develop preconceived notions about their success and failure based on notions of self-confidence. If an individual has higher self-confidence, he is more inclined to believe that he succeeded because of his skill, and will thus put more effort into enhancing his academic skills in future. In relating to self-determination, individuals become motivated to act when they have a strong sense of ownership or control over particular situations. Hence, a greater degree of ownership over one’s academic work would bring out better results from students.

When the students are motivated, there will be improvement in their academic achievements. Zusho, Pintrich and Coppola (2003) theorize that self-efficacy and task value are the best predictors of performance in Chemistry. Self-efficacy is defined as the belief that people have of their capabilities to produce designated levels of performance.

According to Zusho et al. (2003), students excel in Chemistry if they perceive that the effort they put in translates into improvements in their attainment. This is crucial as it theorizes that motivation and achievement share a symbiotic relationship and in the absence of initial achievement, individuals lack the motivation to excel. Task value determines whether a particular process is worth pursuing or engaging in. Hence small group activities which are highly interactive with appropriate difficulty level can help engage students with the aim of increasing their motivation and interest level in Chemistry.
Best practices in the classroom, from kindergarten to college, is shifting as teachers break out of the lecture rut to find innovative games that spark their students' interest. Specific advantages and challenges appear when using games in the Chemistry classroom, where much of the learning is on a microscopic level (J. Grabowski, M. Price, 2003). Learning occurs when new concepts can be related to the existing concepts in the memory store (Dorothy Gabel, 1999). As many Chemistry concepts are abstract, learning can be made more effective when new information are linked to the existing concept network. Only when the network is expanded, students can experience the joy of seeing the linkage between concepts. These linkages can be made to the long-term memory and the information can be retained for a longer period of time. While memorizing the basics in chemistry is a must, calling on memorized facts accesses one's crystallized, or static knowledge (J. Grabowski, M. Price, 2003).

Percival, 1976 cited that games can be used to achieve a wide range of educational objectives, both cognitive and affective. At present, the main uses of games are in teaching communication skills, inter-personal skills, problem-solving skills, decision-making skills and attitudes through the subject-matter (Ellington & Percival, 1977). J. Grabowski, M. Price cited the use of fluid reasoning when students engage in problem-solving, such as Web-based interactive learning sessions across continents or small group games within a classroom. By raising interest through creativity, social interaction and an element of surprise, games surpass lecture in effectively reinforcing crystallized knowledge (J. Grabowski, M. Price, 2003). Indeed, games have an important supportive role to play in reinforcement or the demonstration of applications as citied by Reid, 1976. However, games are not recommended to replace teacher interaction with students, but merely as a catalyst to learning.
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Well-designed games and simulations may achieve positive transfer of learning and allow the students to apply skills acquired during the exercise in other situations (Twelker, 1971). Several papers from the Journal of Chemical Education cited some examples of games such as matching card games, "Jeopardy" style games, board games and student interaction games. One universally observed advantage which games and simulations have over more traditional teaching methods is active student involvement and high motivation among students and in addition, most participants find such exercises enjoyable (Ellington & Percival, 1977). Games also trump by providing feedback, either from a computer or classmate, assisting students by instantly reinforcing their Chemistry knowledge. The necessary concentration and participation of some games also help reduce disruptive behaviour.

Using games in lessons increases students’ motivation as well as social and academic abilities. If teacher turns learning into playing, students are naturally motivated to participate (Baines & Slutsky, 2009). Research studies by Aycan et al. (2002), Smith (2002), Cardoso et al. (2008), supported the belief that educational games not only increases students’ knowledge of facts, it helps retain the information as well as to increase the interest level of the students in the subject. As cited in Songur’s (2006) research, students’ remembrance level, attitudes and interests towards the subject was increased by the lessons which were taught with games. Kan and Akbas (2006) also confirmed the hypothesis that attitudes towards Chemistry are a significant predictor of Chemistry achievement.

Games present Chemistry teachers unique opportunities where magnified, animated representations provide unparalleled visual aids. Interactive problem-solving games promote global thinking and real-world application of concepts. Immediate feedback and
reinforcement of learning help cement facts necessary for understanding more complex chemical concepts. With proper planning of lessons, understanding of available media and teacher's guidance, games can significantly improve students' experiences and learning in the chemistry classroom.

**Purpose of Study**

This study aims to evaluate the effectiveness of real-life action games in the reinforcement and retention of content knowledge and concepts in Chemistry, in particular, the topics of Acids, Bases, Salts and Qualitative Analysis.

Research has shown that Chemistry can be a tough subject for students. In particular, Acids, Bases, Salts and Qualitative Analysis are difficult topics for students as they require many skills and interconnected knowledge in order for the students to grasp and develop a conceptual understanding of the topic. A group of 5 principal investigators selected the topics to focus the lesson study in the planning, research and development of research lesson phase to gain a better understanding of students' conceptions of Chemistry concepts in the topic and also to investigate the effectiveness of real-life action games in reinforcing and retention of content knowledge and concepts taught in the topic.

**Research Questions**

The research questions examined in this study are as follows:

1. Do real-life action games help increase students' interest level in Chemistry, in particular, the topics of Acids, Bases, Salts and QA?
2. How does the use of the Chemazing Race help to reinforce content knowledge and retain the concepts taught in Chemistry?

**Methodology**

**Participants**

Pre-Race discussions was conducted to decide on the details of the race. The study involved 437 Secondary Three Chemistry students of mixed abilities and varying interest towards the subject. The Chemazing Race was primarily targeted at reinforcing content knowledge and concepts of Acids, Bases and Salts. It also serves to retain the students’ knowledge in Qualitative Analysis. The level was selected due to the wider coverage of the Chemistry syllabus as compared to the lower secondary levels. Due to logistics and manpower constraints, the principal investigators have to decide on the number of students to be involved in the study and the number of activities. After much deliberation and discussion, we decided to implement the race to all the students so as to provide an enriching experience for all.

**Instrument**

Firstly, the Specific Instructional Objectives (SIOs) of Acids, Bases and Salts and Qualitative Analysis (Identification of ions and gases) were identified:

1) describe the meanings of the terms acid and alkali in terms of the ions they produce in aqueous solution and their effects on Universal Indicator
2) describe how to test hydrogen ion concentration and hence relative acidity using Universal Indicator and the pH scale

3) describe qualitatively the difference between strong and weak acids in terms of the extent of ionisation

4) describe the characteristic properties of acids as in reactions with metals, bases and carbonates

5) describe the reaction between hydrogen ions and hydroxide ions to produce water, 
\[ \text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O} \], as neutralisation

6) describe the importance of controlling the pH in soils and how excess acidity can be treated using calcium hydroxide

7) describe the characteristic properties of bases in reactions with acids and with ammonium salts

8) classify oxides as acidic, basic, amphoteric or neutral based on metallic/non-metallic character

9) describe the techniques used in the preparation, separation and purification of salts as examples of some of the techniques specified in Section 1.2(a)(methods for preparation should include precipitation and titration together with reactions of acids with metals, insoluble bases and insoluble carbonates)
10) describe the general rules of solubility for common salts to include nitrates, chlorides (including silver and lead), sulfates (including barium, calcium and lead), carbonates, hydroxides, Group I cations and ammonium salts

11) suggest a method of preparing a given salt from suitable starting materials, given appropriate information

12) describe the use of aqueous sodium hydroxide and aqueous ammonia to identify the following aqueous cations: aluminium, ammonium, calcium, copper(II), iron(II), iron(III), lead(II) and zinc (formulae of complex ions are not required)

13) describe tests to identify the following anions: carbonate (by the addition of dilute acid and subsequent use of limewater); chloride (by reaction of an aqueous solution with nitric acid and aqueous silver nitrate); iodide (by reaction of an aqueous solution with nitric acid and aqueous lead(II) nitrate); nitrate (by reduction with aluminium and aqueous sodium hydroxide to ammonia and subsequent use of litmus paper) and sulfate (by reaction of an aqueous solution with nitric acid and aqueous barium nitrate)

14) describe tests to identify the following gases: ammonia (using damp red litmus paper); carbon dioxide (using limewater); chlorine (using damp litmus paper); hydrogen (using a burning splint); oxygen (using a glowing splint) and sulfur dioxide (using acidified potassium dichromate(VI))
Lesson: Using real-life action games to reinforce concepts taught in Acids, Bases, Salts and Qualitative Analysis

As the purpose of the study was to evaluate the effectiveness of games on the motivation of students in learning Chemistry, considerations were made to plan appropriate activities for the Race that could evoke the interest of the students and reinforce their learning. To ensure that the students will be highly engaged, elements of collaborative learning and competitiveness were introduced. Students worked in groups of 5 and they were given clues to their destinations. They were to proceed to 5 different stations based on the clues given and complete the activity at each station within the stipulated time. The points scored at each station were then tallied on a scorecard and the group with the highest scores from each class wins a prize.

The details of the activity at each station are given below:

Station 1:
Students will use the iPad at the station and launch Safari: http://education.jlab.org/elementhangman/
They will play game of Chemical Element Hangman and record their answers in an answer sheet provided. They show the teacher their answers after the time is up.

Station 2:
Students will watch a video on how supersaturated sodium acetate forms a sculpture from a solution. They will then try their hands on making a sculpture from the supersaturated sodium
acetate solution provided tied to the Value of the Month (Courtesy). The score they get from this station will be based on the creativity of the sculpture as well as their explanation of how the sculpture represents the Value of the Month.

**Station 3:**
Students will be given instructions and ingredients to make a bouncy polymer ball. The score they get from this station depends on the height that the ball bounces to.

**Station 4:**
Two teams of students line up parallel facing each other. They take turns to open the cards that face down in front of them. The cards contain questions and their respective answers. When a question they open matches an answer, they win a point and get to continue. They get to go one more turn. When they fail to match a question to its answer, they lose the turn. The game ends when all the cards have been opened or when 10 minutes is up.

**Station 5:**
Charts of questions are put up, and answers to the questions are printed on slips of paper that are mixed in a bucket. Students line up in two teams. The rows take turns to go to their team’s bucket to find an answer to any question. They can only retrieve one slip from the bucket per turn. All students must all go one round before anyone is allowed to go the second time.

**Station 6 (Bonus station):**
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All groups are given a slip of paper titled ‘Bonus’. Students will answer the questions at their own time and pace from the start of the Race to the end. Each correct answer earns them one point.

Results

Based on the data analysis of the pre- and post-Race student surveys carried out by the principal investigators, it is clear that the games had evoked positive responses from the students. The main focus area which we are examining is the effectiveness of the games in increasing interest level of the students in the topic.

The games are indeed effective in increasing the interest level of the students in the topic based on the positive feedback from the students during the surveys. In the post-Race survey, 77.0% of the students indicated that they ‘always’ or ‘usually’ found learning Chemistry interesting as compared to 68.5% in the pre-Race survey. Interest in the subject is a good indicator of the level of motivation of a student (A. Elliot, J. Harackiewicz, 1994).

Self-efficacy of the students have also improved after the research lesson. 50.3% of the students indicated that they ‘always’ or ‘usually’ have confidence in doing well for Chemistry in the pre-Race survey, as compared to 57.6% in the post-Race survey. An increase in the self-efficacy level of students translates into higher motivation levels.

Discussion and Findings
Generally, the interactive and competitive nature of the games engage the students on many levels and forces them to participate actively in solving the challenges at the various stations by tapping on their Chemistry conceptual knowledge for the topic of Acids, Bases and salts and also on Qualitative Analysis.

The use of games in itself enhances the fun factor in learning which is directly translated into an increase in the interest level of the students in learning Chemistry. This can be seen from the Post-survey results by the almost 10% increase in students population who found learning Chemistry “always” or “almost” interesting after the Chemazing race. The games at the various stations have aided conceptual understanding and stimulated further interest in the topic. Students also expressed an interest in wanting to be taught by games for other topics.

As the students were grouped in groups of 5, the games enhance peer to peer learning as the students can discuss with their peers during the games and tap on each other’s knowledge which help students to internalise the concepts further. Since the group can only move onto the next station after the challenge at the previous station is completed, members have to really work together as a team and students who are weaker in Chemistry are motivated by the rest of their team to try their best so as to ensure their teams do not lag behind. Interestingly, it was observed that the greatest impact were seen in kinesthetic learners.

Limitations of Study

1. Subsequent classes already know where are the venues of the stations. ==> hence subsequent knows what to expect and hence finish in a shorter time
2. Missing clues from envelopes, some groups not aware where should they go and hence they just go any stations randomly
3. Some groups never follow instructions or clues given
4. Initial groups (1st day) are supposed to solve the scavenger hunt w/o use of internet, based on what they have learnt so far. Not a fair test when subsequent allowed the use of handphone where they mainly press a search button
5. Station that only requires the physical data eg mp/bp of elements can be further improved by asking the group to explain the trends or to predict data for another element to make the activity more meaningful
6. Station that is related to crystallisation of sodium acetate requires a seed which is not always made available to the teacher ic. Resulting in some groups (esp the 1st day) not able to do the crystallisation

**Conclusion**

Through the rigour of the Chemazing Race, the students were able to increase motivation and increase levels of learning Chemistry in students. The introduction of real-life action games allowed the teachers to enhance the understanding as well as to build on the linkages of Chemistry concepts found in O Level syllabus, giving the students an alternative way of learning instead of the traditional drill and practice method.

The effectiveness of the real-life action game and the benefits of this alternative method of reinforcement is well reflected through the data collected. However, the real-life action game should not be used as an innovative stop-gap for individual lessons but should be
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a continual processes of learning and improvement of quality of lessons over a considerable period of time. Bearing in mind the limitations faced, the team has done a commendable job in making the real-life action game a meaningful teaching and learning tool for both the students and teachers.

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