香港教育大學
The Education University of Hong Kong

Developing Primary Students' Conceptual Understanding of Algebra by Using Games: The Teaching Kit Design

(A Capstone Project)

Submitted by

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Submitted to The Education University of Hong Kong

for the degree of Bachelor of Education (Honours) Primary – Mathematics

May 2020

Declaration

I, *Ho Yau Chun Eugenia* , declare that this research report represents my own work under the supervision of *Assistant Professor of the Department of Mathematics and Information Technology, Dr Zhang Qiaoping*, and that it has not been submitted previously for examination to any tertiary institution.

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7 May 2020

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1. Introduction

The result of TIMSS 2015 shows a meagre percentage of Hong Kong students who like mathematics and feel confident in mathematics (Mullis et al., 2016). Low learning motivation is obviously a significant obstacle in mathematics learning. As a result, teachers need to motivate students in mathematics lessons. 'Game' is always regarded as one of the tools to motivate students (Wong, 1993; Russo, Russo & Bragg, 2018). Other than engaging students, scholars also pointed out many benefits of using games in mathematics lessons, and many of them stress the effectiveness of concepts development (Lee, 1996). However, it seems not a common practice to use games in the concept development stages (Wang, 2009). Besides, A glance at the primary mathematics textbooks in Hong Kong reveals that the use of games in mathematics instruction is rare in primary 5 and 6. Also, no game for algebra strand can be found among the suggested teaching plans of three different textbook publishers. Therefore, this project aimed to explore the possibility and effectiveness of developing algebraic concepts through games by creating a game-based teaching kit for two algebra units in the primary 5 curricula.

2. Literature Review

2.1. Games and Mathematics Teaching

Different people will have different perspectives about what games are. In this project, games are defined as artificial conflicts governed by rules (Salen & Zimmerman, 2004). Moreover, there should be interactions between two or more players that what one player does in one turn will affect what another player can do in the next turn (Gough, 1999). During the game, players can exercise some choices about how to reach a goal (Gough, 1999).

Mathematical games are also games. Besides meeting the criteria mentioned above, mathematical games should also have mathematical rules that the way to win the game is to understand the underlying mathematics (Lee, 1996). The properties of mathematical games are summarized in *Figure 1*.

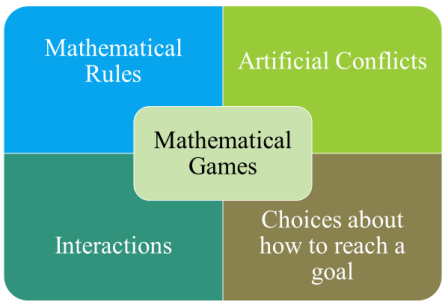

Figure 1: Properties of Mathematical Games

A glance at some articles and the primary mathematics textbooks of three different publishers reveals that games can be used at the beginning, in the middle and at the end of a mathematics lesson. When games are used at the beginning of a lesson, they are adopted to introduce a new mathematics concept or help students to revise their prior knowledge. This kind of games is suggested by some textbook publishers like the Modern Educational Research Society. The function of the games that are used at the end of a lesson is for consolidation. Students can have opportunities to practice particular skills or concepts that they have just learnt in the lesson (Russo, Russo & Bragg, 2018). It is a common way to include games at the end of a lesson (Wang, 2009). However, it seems not a common practice to include games in the middle of a lesson to help concept development. Scholars pointed out that this kind of games can provide opportunities for students to explore new mathematics concepts (Russo et al., 2018).

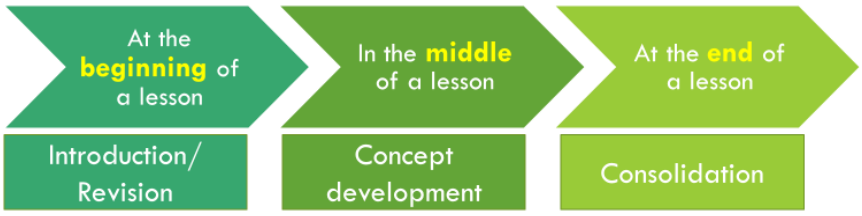

Figure 2: Use of Games in Mathematics Lesson

As games for concept development are rarely found in primary mathematics textbooks in Hong Kong, the author decided to build up a game-based learning teaching kit in which the games are for concept development rather than for revision or consolidation.

2.2. Dienes' Model

Dienes (1971) suggested a model about how to develop mathematics concepts through games. He classified games in the concept development process into three categories. The first kind of games is the *preliminary games*. They are not games under the definition of this project, because there are no rules, they are only 'free play'. Students can do whatever experiments they like and play in any way they want. The second type of games is *structured games*. These games will lead students to the concept that the teacher wants them to acquire. Nevertheless, students may not have a clear realization of what they are learning. The last type is *practice games or analytical games*. Before playing these games, mathematics concepts are already built up. These games provide a chance for concept fixing and application.

Dienes (1971) suggested a six-stage model to use these three kinds of games to develop a mathematics concept. Stage 1 is *free play*, which students will have *preliminary games*. Structured *games* will be introduced in stage 2. After playing the games, students will have time to *search for commonalities* and do a *representation* through tables, diagrams and whatsoever. After that, students will use their own *symbols* to present their idea. The last stage

is *formalization*. The teacher will introduce formal symbols and presentation method to students.

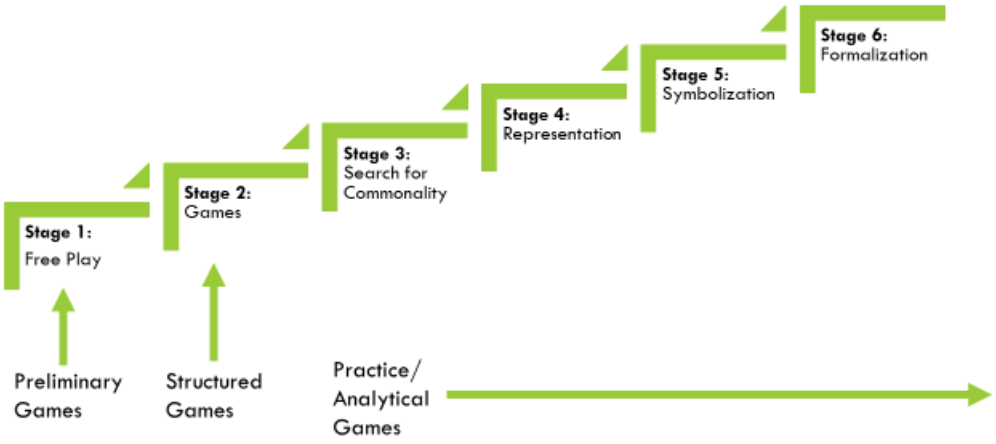

Figure 3: Dienes' Model

3. Two Learning Units in Algebra Strand in Primary 5

After a brief look at the primary mathematics textbooks of three different publishers, it is found that there are fewer games in the books of primary 4 to 6. Furthermore, there are no games found in algebra strand in the textbooks of all these publishers. In order to explore the possibility of developing algebra concepts through games, the author chose two learning units in algebra strand in primary 5, 5A1 and 5A2. It will be the first time students come across things in algebra, and most of the concepts should be developed in these two units.

According to the curriculum document, in the unit 5A1, students will learn about algebraic symbols and algebraic expression; while in 5A2, they will learn about equations, the ways to solve them, and how to solve word problems by using equations (Curriculum Development Council, 2017).

There are some possible learning difficulties in these two learning units. In terms of conceptual problems, if students are having a weak concept about four operations, they will find much

trouble in presenting relations among quantities in algebraic expressions. The obstacles will be even more significant when new ways to write multiplication and division sentences are introduced. The concept of equality is also crucial in unit 5A2. Scholars pointed out that many students treat equal sign as a signal of answering a problem, and they always neglect whether the expressions on the two sides are equivalent in value or not (Wong & Lee, 2007).

Beside conceptual problem, there are also some practical problems. In unit 5A1, students may feel hard to use unfamiliar ways to present multiplication and division expressions (Fung & Cheung, 2014). Furthermore, as they have built up a habit of using numbers as a final answer, they may feel strange to use algebraic expressions as answers (Lin, 2011). The other serious problem is that they will confuse when to add brackets to algebraic expressions. If we say 'we have (3+x) candies' (i.e., 糖果(3+x)), brackets are needed. Once the brackets are missing, the '3' in the front will become a number without a unit, cannot add up with 'x' which is having a unit '粒'. However, if we say 'we have 3x candies' (i.e., 糖果 3x 粒), the situation is different (Fung & Cheung, 2014). Teachers need to spend time to clarify when to use brackets.

In the unit 5A2, one common mistake can be found in equation solving is the inability of adding the same operation to both sides of an equation. It may be a conceptual problem of not caring about the equal value of both sides of an equation. However, it can also be a mistake due to carelessness. The next challenge is that students should adopt a new way to present calculation steps. They are used to solve a mathematics problem by writing steps with an equal sign on the left, but now the equal sign is in the middle of the line. When it comes to word problem solving, some students may build up equations like 'x=11+5' to solve problems. Some teachers may struggle about whether it is an equation or not. It is an equation, but not an equation that

correctly presents the relations among quantities described in words (Wong & Lee, 2007). Algebra is a study of relations among quantities (Cheng, 2001). Therefore, the objective of solving word problems by equations is to present relations among quantities described in words; finding answers is not the main point (Wong & Lee, 2007).

Table 1 listed out all learning objectives for all stages. In the teaching design, there will be revisions on ‘four operations’ and ‘equal’. The lessons will also help students to develop the habit of using ‘expressions’ as final answers and explain the function of brackets in algebraic expressions. ‘Relation’ will also be highlighted when teaching ‘equation’.

Unit	Stage	Objectives
5A1	1	• Use letters to present unknowns • Tell that expressions with unknowns are 'algebraic expressions.' • Recognise algebraic expressions
	2	• Tell that addition and subtraction can only be done on quantities with same nature and unit (e.g. the number of objects cannot sum up with the weight of an object, the weight in kg cannot directly sum up with the weight in g) • Tell that the two numbers adding together, and their sum are having the same unit (e.g. 2 dollars plus 3 dollars equals 5 dollars; 2, 3 and 5 are having the same unit 'dollars') • Use addition and subtraction expressions without unknown to present quantities of something described in words (e.g. $(2+3)$pencils and $(5-2)$books) • Use algebraic expressions involving addition and subtraction to present quantities of something described in words (e.g. $(2+y)$pencils and $(x-2)$books)
	3	• Tell that multiplication is repeated addition • Tell that a multiplier is the number of times the multiplicand repeated in repeated addition • Use multiplication expressions without unknown to present quantities of something described in words (e.g. (3×5) pencils) • Use algebraic expressions involving multiplication to present quantities of something described in words (e.g. $3y$ pencils)
	4	• Tell that division is equal sharing or equal grouping • Use division expressions without unknown to present quantities of something described in words (e.g. $(6\div3)$pencils/ $(6\times\frac{1}{3})$pencils/ $\frac{6}{3}$ pencils) • Use algebraic expressions involve division to present quantities of something described in words (e.g. $(x\div3)$pencils/ $(x\times\frac{1}{3})$pencils/ $\frac{x}{3}$ pencils)
	5	• (Revision and practice) Use algebraic expressions involving addition, subtraction, multiplication or division to present quantities described in words
5A2	1	• Tell that the function of equal sign is to link up two expressions with same value and form equation (等式) • Tell that an equation (等式) is presenting an equal value relationship between two expressions • Tell that '等式' with unknown(s) is '方程'
	2	• Set up equations with one operation (e.g. '$x-1=4$ ' involves only one subtraction operation) to present the relations among quantities according to the scenario described in word problems
	3	• Set up equations with two operations (e.g. '$2x-1=4$ ' involves one multiplication operation and one subtraction operation) to present the relations among quantities according to the scenario described in word problems
	4	• Form new equations by doing the same operations on both sides of the old equations (e.g. old equation: $x-3=2$, by adding 2 on both sides a new equation is formed: $x-1=4$)
	5	• Solve equations involving one step in the solutions
	6	• Solve equations involving two steps in the solutions
	7	• Solve word problems by setting up equations

Table 1:Learning Objectives by Stages

4. Teaching Kit Design

4.1. The Games

A card game called *'the Building Tribe'* (建屋部落) is created. It consists of 201 playing cards. Five games with several variations can be played by using the same set of cards. For game instructions, please refer to Appendix 1. *Table 2* shows the use of games in each teaching stages.

Unit	Stage	Games	Variations
5A1	1	A. Great Building Materials (嚴選材料建竹屋)	A1
	2		A2
	3		A3
	4		A4
	5	B. Houses Scrap Dealer (竹屋收買佬)	B1
5A2	1	C. Fight with the Landlord (等式竹屋鬥地主)	/
	2	B. Houses Scrap Dealer (竹屋收買佬)	B2
		D. Fast Some, Slow None 眼明手快搶竹屋	/
	3	B. Houses Scrap Dealer (竹屋收買佬)	B3
	4	E. Pay All for a House 傾家蕩產建竹屋	E1
	5		E2
	6		
	7	/	/

Table 2: Use of Games by Stages

Possible learning difficulties mentioned in *Section 4* were being concerned during the game design process. In order to strengthen students' concepts in four operations, the card games stress the identification of objects and units. There are four kinds of object cards. The objects are either rope (繩子) or bamboo (竹枝), with units '條', '米', or '公斤' (see *Figure 4*). This design is to arouse students' awareness of objects and units in

four operations. For example, students will be aware that only the numbers describing the same object and with the same unit can be sum up together.

Figure 4: Object cards

'Relationship' and 'Equality' is highlighted in the games in 5A2. In Game C, students would win the game if they made two expressions equal in value; in Game E, students would win the game if they use up their cards and keep the values of two sides of the equation equivalent. As the final goal of these games is to make equivalent expressions, students will focus on the concept of 'equality' during the whole game. Furthermore, all the games about equations are about how to use equations to describe a relationship between numbers, but not finding the value of the unknown.

4.2. Lesson Plans

The instructional design is a repetition of a teaching cycle begins with a pre-test and end up by a post-test. In the cycle, students will experience all six stages of Dienes' Model. The paragraphs below will show how it works by introducing two example lessons.

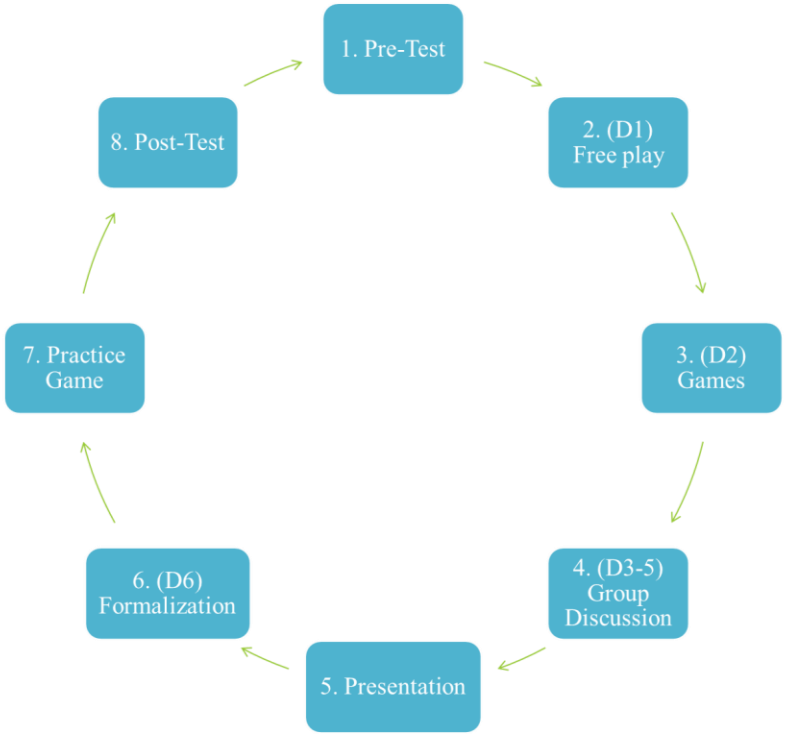

Figure 5: Teaching Cycle

The third variation of Game A will be used in the lessons about algebraic expressions involving multiplication (For detail lesson plan, please refer to Appendix 2). Before entering this lesson, students are supposed to know how to use algebraic expressions involving addition or subtraction to present quantities of something described in words. Also, they should have leant multiplication operation and ways to solve word problems by multiplication in primary 3 and 4. These are the learning objectives of the lesson:

- Tell that multiplication is repeated addition
- Tell that a multiplier is the number of times the multiplicand repeated in repeated addition
- Use algebraic expressions involving multiplication to present quantities of something described in words

Pre-Test

A pre-test will be done before teaching. It is a short test with only four questions. The first two questions will test whether students know multiplication is repeated addition and their awareness about multiplier and multiplicand. The last two questions will ask students to use expressions to present quantities, to see how much they know about the things that they are going to learn.

Dienes' Stage 1: Free Play

After the pre-test, the lesson will immediately get into stage 1 of Dienes' Six-Stage Model. Students will be divided into groups of 4 or 5. A set of game cards will be given to each group, and they will have 8 minutes to have free play and observation. After the free playtime, the teacher will have a short debriefing with the class by asking questions like 'How this set of cards differ from the set you played last time?', 'How would you classify the cards?' 'How your group played?'.

Dienes' Stage 2: Game

Then it will come to stage 2. The teacher will explain the rule of the game (see Appendix 1, Game A3) and provide students 15 minutes of game time. Students need to record the expressions on a recording sheet (*Figure 6*) during the game. The teacher will allow students to record in their own way without any suggestions or clarifications. Students may not have a clear realization of what they are learning by this moment.

嚴選材料建竹屋

遊戲記錄表 3

組別:_____

屋子卡	式子	代數式 (✓/×)	代數符號	記錄人 (換屋人)
繩子____(　)	繩子_____(　)			
繩子____(　)	繩子_____(　)			
繩子____(　)	繩子_____(　)			
繩子____(　)	繩子_____(　)			

Figure 6: Recording Sheet

Group Discussion: Dienes' Stages 3-5

Ten minutes discussion time will be provided after the game. Students should discuss how to classify the expressions they have recorded on the recording sheet. It is stage 3 to 5 of Dienes' Model. Through classification, students *search for commonality* among expressions. Through present the classification method in table, diagram or words, students do *representation*. Through using their own way to name each type of expressions, students do *symbolization*.

Presentation

After the discussion time, the teacher will show the works of each group to the whole class by visualizer. The teacher will ask some of the groups to present their ideas and drop-down essential points on the blackboard.

Dienes' Stage 6: Formalization

It comes to the last stage of Dienes' model—formalization. In this stage, the teacher will introduce formal symbols and mathematical presentation of the algebraic expression involving multiplication. Figure 7 shows the suggested illustration.

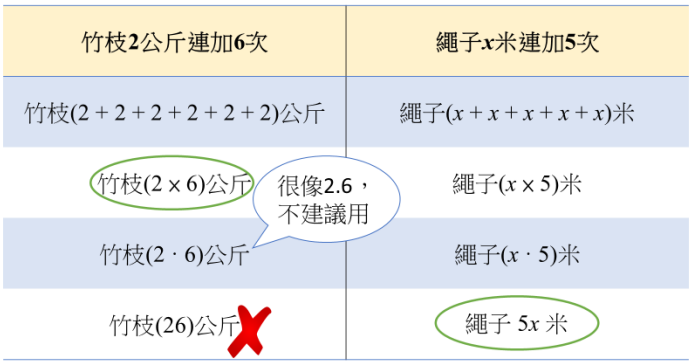

Figure 7: Algebraic Expression involving Multiplication

Practice Game

Finally, students will play the same game again, but this time, they should record the expressions by the method that they have just learnt (*Figure 8*). The same game will become a practice game for students to practice the skills and concepts they have acquired.

嚴選材料建竹屋

遊戲記錄表 3

組別:_____

屋子卡	式子	代數式 (✓/×)	代數符號	記錄人 (換屋人)
繩子_6_(米)	繩子_(2×3)_(米)	×	／	陳小明
繩子_4_(條)	繩子_2z_(條)	✓	z	黃文文
繩子____(　)	繩子____(　)			
繩子____(　)	繩子____(　)			

Figure 8: Recording Method during Practice Game

Post-Test

At the end of the lesson, students should do a post-test to show their understanding of the mathematics concepts. The test is similar to the pre-test. The teacher can compare students' performance before and after the lesson.

Other lessons designed are following a similar teaching cycle. However, not every cycle will include the stage of 'free play'. In the fourth and fifth cycles in unit 5A2, there will be no time for free play, because the same set of materials have undergone the free play process in the 3rd cycle. *Tables 3 and 4* below illustrates how the cycle repeated throughout the two learning units.

單元5A1教學流程一覽					
教學循環	1	2	3	4	鞏固課節:「建屋部落」遊戲玩法B1及5A1_總結性評估
前測	5A1_1前測試卷	5A1_2前測試卷	5A1_3前測試卷	5A1_4 前測試卷	
自由玩耍	「建屋部落」遊戲玩法A1卡牌	「建屋部落」遊戲玩法A2卡牌	「建屋部落」遊戲玩法A3卡牌	「建屋部落」遊戲玩法A4卡牌	
找尋共同結構	「建屋部落」遊戲玩法A1	「建屋部落」遊戲玩法A2	「建屋部落」遊戲玩法A3	「建屋部落」遊戲玩法A4	
小組討論	將式子分類及命名	比較式子記錄方式、自定傳意方法	將式子分類及命名	將式子分類及命名	
匯報					
形式化	數學語言: 未知數、代數符號、代數式	以加和減代數式表示物件的量的正規方式	以乘法代數式表示物件的量的正規方式	除法均分和包含的概念：以除法代數式表示物件的量的正規方式	
練習遊戲	「建屋部落」遊戲玩法A1 (練習辨認代數式及代數符號)	「建屋部落」遊戲玩法A2 (練習以加和減代數式表示物件的量)	「建屋部落」遊戲玩法A3 (練習以乘法代數式表示物件的量)	「建屋部落」遊戲玩法A4 (練習以除法代數式表示物件的量：辨別「均分除」與「包含除」)	
後測	5A1_1後測試卷	5A1_2後測試卷	5A1_3後測試卷	5A1_4後測試卷	
需用課時 (分鐘)	80	80	80	80	40

Table 3: Overview of the Teaching in 5A1

單元5A2教學流程一覽							
教學循環	1	2	進階學習課節: 以二步方程表示文字所描述量的關係 (進階遊戲: 「建屋部落」遊戲玩法B3)	3	4	5	應用題教學課節及完成單元總結性評估
前測	5A2_1前測試卷	5A2_2前測試卷		5A2_4 前測試卷	5A2_5 前測試卷	5A2_6 前測試卷	
自由玩耍	「建屋部落」遊戲玩法C卡牌	「建屋部落」遊戲玩法D卡牌		「建屋部落」遊戲玩法E1卡牌、天平教具	不適用	不適用	
找尋共同結構	「建屋部落」遊戲玩法C	「建屋部落」遊戲玩法D		「建屋部落」遊戲玩法E1	「建屋部落」遊戲玩法E2	「建屋部落」遊戲玩法E2	
小組討論	尋找及用自己的方法表達算式之間的關係；將等式分類及命名	將方程分類、將題目分類、指出類別之間的異同		辨認最有利和最不利遊戲的手牌組合；觀察等式改變的規律	辨認最有利遊戲的手牌組合；探討找出未知數數值的計算步驟	辨認最有利遊戲的手牌組合；探討找出未知數數值的計算步驟	
匯報							
形式化	數學語言及符號: 數值相同、等號、等式、方程	說明方程是表示一些東西之間「數值相等」的關係；講解建立方程的技巧		說明在方程兩端進行同樣的計算步驟方程兩方的式子仍維持數值相等的關係	講解解一步方程的方法	講解解二步方程的方法	
練習	「建屋部落」遊戲玩法C (練習辨認等式及方程)	「建屋部落」遊戲玩法B2 (練習建立方程的技巧)		「建屋部落」遊戲玩法E1 (練習透過在方程左右兩方加上同樣的運算，保持方程兩方數值相等)	紙筆練習: 完成解一步方程的題目	紙筆練習: 完成解二步方程的題目	
後測	5A2_1後測試卷	5A2_2後測試卷		5A2_4後測試卷	5A2_5後測試卷	5A2_6後測試卷	
需用課時 (分鐘)	80	80	40	80	80	80	40

Table 4: Overview of the Teaching in 5A2

5. Discussion

Bell (1978, in Wong, 1993) has listed 12 evaluation criteria for instructional games. He stated that games rules should be clearly understood by students, do not need too much time to explain and will not be too complicated. The game itself should not be too easy or too hard, and all students can have equal involvement in the whole game and enjoy the game. A game-based lesson should maintain a pleasant learning atmosphere with no disciplinary problem brought by games. Learning objectives should not be ignored, and mathematics will be the focus of the lesson.

Game Rule	1. Student clearly understands 2. Do not need much time to explain 3. Not so complicated
Engagement	4. Not so easy, not so hard 5. All students can have equal involvement 6. All students can join the whole game 7. Students enjoy the game
Learning atmosphere	8. No disciplinary problem 9. Learning objectives will not be ignored 10. Mathematics is highlighted 11. Foster mathematical cognition 12. Improve performance in mathematics

Table 5: Bell's 12 Evaluation Criteria for Instructional Games

These criteria had been considered before the start of the design process. For example, in order to help teachers to explain the rule of the game more clearly, the backs of the cards have a special design—all house cards have a blueback, while all other cards have a greenback (see Figure 9). Teachers can simply call the cards by their colours, and then students will immediately understand which kind of cards the teacher is referring to.

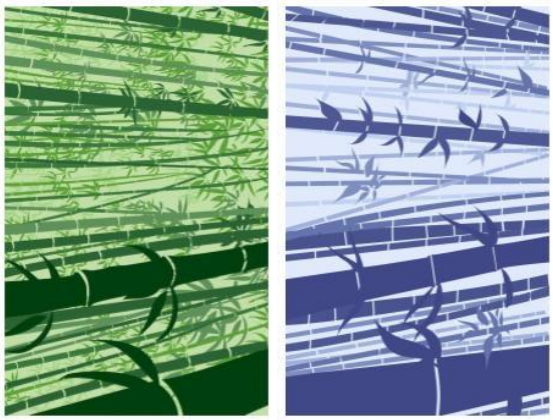

Figure 9: Design of Card Back

Nevertheless, the teaching kit still needs implementation in a real classroom context. Only in a real classroom, teachers can observe whether the game rules are easy for students, whether

they enjoy the games and whether disciplinary problems will occur. Also, students' performance of their pre-test and post-test can be compared to see the effectiveness of the teaching method. Unfortunately, as schools are closed this year due to the outbroke of COVID-19, the implementation cannot be done by this moment.

6. Conclusion

To conclude, in this project, games are defined as artificial conflicts governed by mathematical rules. They are also interactions between players and players can exercise choices to reach a goal. A card game called *'the Building Tribe'* (建屋部落) is designed for two units in algebra strand, 5A1 and 5A2, in order to explore the possibility of developing algebraic concepts through games. Dienes' Six-Stage Model is adopted to create lesson plans. The project is successful in creating a teaching kit that aims to develop students' algebraic concepts through games. However, the teaching kit still needs implementation in a real classroom in the future for better evaluation about its effectiveness.

Word Count: 2710

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8. Appendix

Appendix 1: Game Instructions

建屋部落遊戲說明書

故事背景:

多多里部落的居民在竹林生活了數百年，竹是他們的好朋友。他們種植竹，又用竹製作各種各樣的生活用品，例如桌椅、食具、船隻……不得不提的是他們引以為傲的竹屋吧! 竹屋雖只是由簡單的竹枝和繩子建成，但它是多多里部落中智慧與財富的象徵，竹屋的數量與設計正反映個人財力與設計天賦。因此，建屋成為多多里部落每天的重要事情，歡迎有智慧的你加入這個建屋部落。

(1) 遊戲配件

i. 卡牌: 共有卡牌 201 張，卡牌種類如下:

材料卡(綠色卡背) (148 張)		屋子卡(藍色卡背) (53 張)	
	**A 款: 繩子卡(條) (17 張)** 含數字 1-13 及字母 w (1、6 和 12 各 2 張，其餘的卡各 1 張)	**A 款: 積分換領 (9 張)** 含數字 1-6、12、18、24 各 1 張	
	**B 款: 繩子卡(米) (17 張)** 含數字 1-13 及字母 x (1、6 和 12 各 2 張，其餘的卡各 1 張)	**B 款: 繩子(條)換領 (9 張)** 含數字 1-6、12、18、24 各 1 張	
	**C 款: 竹枝卡(米) (17 張)** 含數字 1-13 及字母 y (1、6 和 12 各 2 張，其餘的卡各 1 張)	**C 款: 繩子(米)換領 (9 張)** 含數字 1-6、12、18、24 各 1 張	

材料卡(綠色卡背) (148 張)		屋子卡(藍色卡背) (53 張)	
	**D 款: 竹枝卡(公斤) (17 張)** 含數字 1-13 及字母 z (1、6 和 12 各 2 張，其餘的卡各 1 張)	**D 款: 竹枝(米)換領 (9 張)** 含數字 1-6、12、18、24 各 1 張	
	**E 款: 數字卡 (80 張)** 含數字 1-13 及字母 w、x、y、z (1-6 各 8 張，7-13 各 4 張，字母各 1 張)	**E 款: 竹枝(公斤)換領 (9 張)** 含數字 1-6、12、18、24 各 1 張	
		F 款: 圖案卡 (8 張)	

ii. 遊戲簡報

有 4 個遊戲玩法需要配合簡報遊戲，檔案名稱如下:

- 遊戲簡報_「建屋部落」遊戲玩法 B1
- 遊戲簡報_「建屋部落」遊戲玩法 B2
- 遊戲簡報_「建屋部落」遊戲玩法 B3
- 遊戲簡報_「建屋部落」遊戲玩法 D

iii. 遊戲記錄表

部份遊戲過程需要記錄，記錄表檔案名稱如下:

- A_嚴選材料建竹屋記錄表 1
- A_嚴選材料建竹屋記錄表 2
- A_嚴選材料建竹屋記錄表 3
- A_嚴選材料建竹屋記錄表 4
- C_等式竹屋鬥地主記錄表 1
- C_等式竹屋鬥地主記錄表 2
- E_傾家蕩產建竹屋記錄表 1
- E_傾家蕩產建竹屋記錄表 2

(2) 配合教學進程概覽

單元	階段	教學目標	遊戲	玩法
5A1	1	• 以字母表示未知的數 • 說出含未知數的式子稱為「代數式」 • 辨認代數式	A. 嚴選材料建竹屋	A1
	2	• 說出加減兩個概念: ○ 同樣性質、同樣單位的量(例: 同樣是重量，同樣是以公斤為單位)才能相加或相減 ○ 相加或相減的兩數，與計算結果有着一樣的單位 ○ (例: 2 元+3 元=5 元；2、3 和 5 同樣以「元」為單位) • 以加法或減法式子表示物件的量 • 以涉及加或減的代數式表示物件的量		A2
	3	• 說出乘法兩個概念: ○ 乘法是連加 ○ 乘數是被乘數被連加的次數 • 以乘法式子表示物件的量 • 以涉及乘法的代數式表示物件的量		A3
	4	• 說出除法兩個概念: ○ 均分 ○ 包含 • 以除法式子表示物件的量 • 以涉及除法的代數式表示物件的量		A4
	5	• 更熟習如何以代數式表示物件的量	B. 竹屋收買佬	B1
5A2	1	• 說出「等號」的功能是將兩個數值相等的數或式子連結，組成「等式」 • 說出「等式」陳述兩個數或式子數值相等的關係 • 說出含未知數的等式是「方程」	C. 等式竹屋鬥地主	/
	2	• 以一步方程表示文字所描述量的關係	B. 竹屋收買佬	B2
			D. 眼明手快搶竹屋	/
	3	• 以二步方程表示文字所描述量的關係	B. 竹屋收買佬	B3
	4	• 透過在方程左右兩方加上同樣的運算，保持方程兩方數值相等	E. 傾家蕩產建竹屋	E1
	5	• 解一步方程		E2
	6	• 解不多於兩步的方程		
	7	• 列方程解答應用題	/	/

(3) 各遊戲玩法

i. 嚴選材料建竹屋 (A1)

配件:

- 卡牌:
  綠色卡: E 款(全部)
  藍色卡: A 款(全部)
- 記錄表:
  A_嚴選材料建竹屋記錄表 1
  A_嚴選材料建竹屋記錄表 2

設置:

將綠色卡洗勻，然後向每位玩家派發 6 張，其餘的卡則疊起，背向上放在桌子上供遊戲時抽卡用。將藍色卡洗勻，然後抽出 4 張打開放在桌子中央，其餘的則背向上疊起來。遊戲開始前，玩家需決定一處為「棄牌處」。

遊戲過程:

玩家會輪流遊戲，輪到自己的時候可以做下面其中一項事情:

- **[換屋子]** 用手中其中 2 張卡組成式子，換取桌上打開的其中一張屋子卡。換到後，在記錄表上記錄式子，屋子卡自行儲存，組成式子的卡則放到「棄牌處」，再到抽牌處抽卡 2 張，使得手上卡牌數量仍維持 6 張。在桌上添置一張屋子卡(如有)，然後輪下一位玩家。
  註: 英文字母卡可當作任何一個正整數
- **[換手牌]** 選 1 張手牌放到「棄牌處」，再抽卡 1 張，然後輪下一位玩家。

當抽卡處再沒有卡可抽或所有屋子被換完時，遊戲結束，各玩家點算換到屋子卡的數量，數量最多者勝，數量相同者則和。

ii. 嚴選材料建竹屋 (A2)

配件:

- 卡牌:
  綠色卡: A 至 D 款(所有數字及字母: 各 1 張)
  藍色卡: B 至 E 款(全部)
- 記錄表:
  A_嚴選材料建竹屋記錄表 3

設置:

將綠色卡洗勻，然後向每位玩家派發 6 張，其餘的卡則疊起，背向上放在桌子上供遊戲時抽卡用。將藍色卡洗勻，然後抽出 4 張打開放在桌子中央，其餘的則背向上疊起來。遊戲開始前，玩家需決定一處為「棄牌處」。

遊戲過程:

玩家會輪流遊戲，輪到自己的時候可以做下面其中一項事情:

- **[換屋子]** 用手中其中 2 張卡組成**加法或減法**式子，換取桌上打開的其中一張屋子卡。**組成式子的卡和所換取的屋子卡必須為同一物件，同一單位** (例:「繩子 1 條」和「繩子 3 條」兩將手牌可換去「繩子 4 條」的屋子卡，因為 3 張卡也是以「繩子」為物件並以「條」為單位)。換屋子後，在記錄表上記錄式子，屋子卡自行儲存，組成式子的卡則放到「棄牌處」，再到抽牌處抽卡 2 張，使得手上卡牌數量仍維持 6 張。在桌上添置一張屋子卡(如有)，然後輪下一位玩家。
  註: 英文字母卡可當作任何一個正整數
- **[換手牌]** 選 1 張手牌放到「棄牌處」，再抽卡 1 張，然後輪下一位玩家。

當抽卡處再沒有卡可抽或所有屋子被換完時，遊戲結束，各玩家點算換到屋子卡的數量，數量最多者勝，數量相同者則和。

iii. 嚴選材料建竹屋 (A3)

配件:

- 卡牌:

  綠色卡:

  A 至 D 款 (數字 1: 各 2 張；數字 2-6 及所有字母: 各 1 張)、
  E 款 (數字 1: 8 張；數字 2-6: 各 4 張)

  藍色卡:

  B 至 E 款(全部)

- 記錄表:

  A_嚴選材料建竹屋記錄表 3

設置:

將綠色卡洗勻，然後向每位玩家派發 6 張，其餘的卡則疊起，背向上放在桌子上供遊戲時抽卡用。將藍色卡洗勻，然後抽出 4 張打開放在桌子中央，其餘的則背向上疊起來。遊戲開始前，玩家需決定一處為「棄牌處」。

遊戲過程:

玩家會輪流遊戲，輪到自己的時候可以做下面其中一項事情:

- **[換屋子]** 用手中其中 2 張卡組成**加法**式子，換取桌上打開的其中一張屋子卡。式子的組成有下面兩種方法:
  - 出 2 張綠色材料卡:
    組成式子的卡和所換取的屋子卡必須為同一物件，同一單位 (例: 「繩子 1 條」和「繩子 3 條」兩將手牌可換去「繩子 4 條」的屋子卡，因為 3 張卡也是以「繩子」為物件並以「條」為單位)。
  - 出 1 張綠色材料卡及 1 張綠色數字卡:
    E 款的綠色卡是「連加卡」，玩家可用 1 張 A 至 D 款的綠色卡及 1 張「連加卡」代表將數連加，以換取適當的屋子卡 (例: 當玩家出「竹枝 3 公斤」及「4」這張「連加卡」，即代表式子「竹枝 (3+3+3+3)公斤」可換去「竹枝 12 公斤」的屋子卡)。

  玩家換屋子後，在記錄表上記錄式子，屋子卡自行儲存，組成式子的卡則放到「棄牌處」，再到抽牌處抽卡 2 張，使得手上卡牌數量仍維持 6 張。在桌上添置一張屋子卡(如有)，然後輪下一位玩家。

  註: 英文字母卡可當作任何一個正整數

- **[換手牌]** 選 1 張手牌放到「棄牌處」，再抽卡 1 張，然後輪下一位玩家。

當抽卡處再沒有卡可抽或所有屋子被換完時，遊戲結束，各玩家點算換到屋子卡的數量，數量最多者勝，數量相同者則和。

iv. 嚴選材料建竹屋 (A4)

配件:

- 卡牌:

  綠色卡:

  A 至 D 款 (數字 1、6、12: 各 2 張；數字 2-5、8-10 及所有字母: 各 1 張)、

  E 款 (數字 1-5: 各 4 張；數字 6: 8 張)

  藍色卡:

  A 至 E 款 (數字 1-6 及 12)

- 記錄表:

  A_嚴選材料建竹屋記錄表 4

設置:

將綠色卡洗勻，然後向每位玩家派發 6 張，其餘的卡則疊起，背向上放在桌子上供遊戲時抽卡用。將藍色卡洗勻，然後抽出 4 張打開放在桌子中央，其餘的則背向上疊起來。遊戲開始前，玩家需決定一處為「棄牌處」。

遊戲過程:

玩家會輪流遊戲，輪到自己的時候可以做下面其中一項事情:

- **[換屋子]** 用手中其中 2 張卡組成**除法**式子，換取桌上打開的其中一張屋子卡。式子的組成有下面兩種方法:
  - 2 張綠色材料卡換 1 張藍色數字卡 (包含除):
    組成式子的卡必須為同一物件，同一單位 (例:「繩子 12 條」和「繩子 3 條」兩將手牌可換去數字「4」的屋子卡，代表「繩子 12 條」包含 4 個「繩子 3 條」)。
  - 1 張綠色材料卡及 1 張綠色數字卡換 1 張藍色材料卡(均分除):
    E 款的綠色卡是「均分卡」，玩家可用 1 張 A 至 D 款的綠色卡及 1 張「均分卡」代表將數量均分若干等分，以換取適當的屋子卡 (例: 當玩家出「竹枝 12 公斤」及「4」這張「均分卡」，即代表將「竹枝 12 公斤」均分 4 等分，可換去「竹枝 3 公斤」的屋子卡)。

  玩家換屋子後，在記錄表上記錄式子，屋子卡自行儲存，組成式子的卡則放到「棄牌處」，再到抽牌處抽卡 2 張，使得手上卡牌數量仍維持 6 張。在桌上添置一張屋子卡(如有)，然後輪下一位玩家。

  註: 英文字母卡可當作任何一個正整數

- **[換手牌]** 選 1 張手牌放到「棄牌處」，再抽卡 1 張，然後輪下一位玩家。

當抽卡處再沒有卡可抽或所有屋子被換完時，遊戲結束，各玩家點算換到屋子卡的數量，數量最多者勝，數量相同者則和。

v. 竹屋收買佬 (B1)

配件:

- 卡牌:
  藍色卡: F 款 (全部)
- 遊戲簡報_「建屋部落」遊戲玩法 B1
- 白板筆

玩法:

玩家分組遊戲，每組會收到 8 張屋子卡及一支白板筆，老師向玩家展示文字，各玩家需根據文字描述，以**代數式**表示物件的量，鬥快在屋子卡上寫好正確算式，然後到老師前排隊。答錯的組別要將手上的屋子卡交給老師，最快且答對的組別可多得屋子卡一張。用畢屋子卡的組別出局，所有回合結束後，手上有最多屋子卡的組別勝。

vi. 竹屋收買佬 (B2)

配件:

- 卡牌:
  藍色卡: F 款 (全部)
- 遊戲簡報_「建屋部落」遊戲玩法 B2
- 白板筆

玩法:

玩家分組遊戲，每組會收到 8 張屋子卡及一支白板筆，老師向玩家展示文字，各玩家需根據文字描述，以**一步方程**表示各量之間的關係，鬥快在屋子卡上寫好正確算式，然後到老師前排隊。答錯的組別要將手上的屋子卡交給老師，最快且答對的組別可多得屋子卡一張。用畢屋子卡的組別出局，所有回合結束後，手上有最多屋子卡的組別勝。

vii. 竹屋收買佬 (B3)

配件:

- 卡牌:
  藍色卡: F 款 (全部)
- 遊戲簡報_「建屋部落」遊戲玩法 B3
- 白板筆

玩法:

玩家分組遊戲，每組會收到 8 張屋子卡及一支白板筆，老師向玩家展示文字，各玩家需根據文字描述，以**二步方程**表示各量之間的關係，鬥快在屋子卡上寫好正確算式，然後到老師前排隊。答錯的組別要將手上的屋子卡交給老師，最快且答對的組別可多得屋子卡一張。用畢屋子卡的組別出局，所有回合結束後，手上有最多屋子卡的組別勝。

viii. 等式竹屋鬥地主 (C)

配件:

- 卡牌:
  綠色卡: E 款 (全部)
  藍色卡: F 款 (全部)
- 記錄表:
  C_等式竹屋鬥地主記錄表 1
  C_等式竹屋鬥地主記錄表 2

設置:

將綠色卡洗勻，然後向每位玩家派發 6 張，其餘的卡則疊起，背向上放在桌子上供遊戲時抽卡用。遊戲開始前，玩家需決定一處為「棄牌處」，並選一玩家當「地主」，其餘的玩家當「平民」。「地主」先保管所有藍色卡。「地主」抽出 2 張綠色卡組成一式子作為竹屋的底價，然後遊戲開始。

遊戲過程:

所有玩家輪流出牌，「平民」輪到自己的時候可以做下面其中一項事情:

- **[改變付款金額算式]**出卡 1 張，用該卡的數字改變付款金額算式，抽卡 1 張，然後輪下一位玩家。例如原本的算式為「3+2」，某「買家」出數字卡「4」，可改為「3+2-4」、「3×4+2」等等的算式，惟「3」、「+」和「2」不能刪去，先後次序也不可改。
- **[換手牌]** 選 1 張手牌放到「棄牌處」，再抽卡 1 張，然後輪下一位玩家。

「地主」輪到自己的時候可以做下面其中一項事情:

- **[改變竹屋售價算式]**出卡 1 張，用該卡的數字改變竹屋售價算式，抽卡 1 張，然後輪下一位玩家。例如原本的算式為「3+2」，「賣家」出數字卡「4」，可改為「3+2-4」、「3×4+2」等等的算式，惟「3」、「+」和「2」不能刪去，先後次序也不可改。

- **[換手牌]** 選 1 張手牌放到「棄牌處」，再抽卡 1 張，然後輪下一位玩家。

當某「地主」令付款金額算式的數值與竹屋售價算式的數值相等時，該「平民」可取去「地主」藍色卡一張，然後開新回合。遊戲繼續直到所有綠色卡被抽完或「地主」失去所有藍色卡。遊戲結束後各玩家點算換到屋子卡的數量，數量最多者勝，數量相同者則和。

ix. 眼明手快搶竹屋 (D)

配件:

- 卡牌
  藍色卡: F 款 (全部)
- 白板筆
- 遊戲簡報_「建屋部落」遊戲玩法 D

玩法:

老師在簡報展示 8 道方程，着學生用白板筆分別寫在 8 張屋子卡上，然後隨意將 8 張卡平舖在桌上。老師在簡報上展示文字，學生閱讀後，鬥快在桌上找出能表示文字所述數之間關係的方程，然後將手放在該卡上，最快而正確者勝。

x. 傾家蕩產建竹屋 (E1)

配件:

- 卡牌
  綠色卡: E 款 (全部)
  藍色卡: F 款 (全部)
- 天平教具
- 記錄表:
  E_傾家蕩產建竹屋記錄表 1
  E_傾家蕩產建竹屋記錄表 2

設置:

遊戲分組進行，每組會收到一副卡牌及一份記錄表。老師在天平上放置法碼，使得天平兩邊平行，學生在記錄表上記錄天平起始狀態。各組將綠色卡洗勻，平均分發給組內每一位玩家。

遊戲過程:

玩家會輪流遊戲，輪到自己的時候可以做下面其中一項事情:

- [抽牌及出牌] 從左方玩家手牌中抽 1 張，然後出不少於 2 張牌，改變天平的狀態，但保持天平兩方數值相等。例如本來的天平狀態為「左方:3+2；右方:5」，某玩家出 2 張數字「1」，可改寫為「左方: 3+2+1；右方: 5+1」、「左方: 3-1+2；右方: 5-1」等等，惟原有的數字及運算符號不能刪去，先後次序也不可改。記錄改變後的等式後輪下一位玩家。
- [抽牌] 從左方玩家手牌中抽 1 張，然後輪下一位玩家。

最快出完手牌者取去屋子卡 1 張，然後進入下一回合。數回合後，各玩家點算換到屋子卡的數量，數量最多者勝，數量相同者則和。

Appendix 2: The Teaching Kit

Please access the teaching kit via this URL:
https://drive.google.com/drive/folders/1wq97mruQTXjpJ0VarlGBOnn9X_Aq84F0?usp=sharing