Motion Blitz: a new card game for assessing students’ thinking level about physics

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Abstract. Critical thinking and problem-solving skills are crucial for the 21st century. Game-based learning (GBL) is a powerful teaching strategy for fostering these skills amongst students. GBL can reinforce knowledge and bridge the gap between what is learned by creating dynamic, fun, and exciting learning environments. This research developed a card game called "Motion Blitz" for teaching the physics concept of motion in one and two dimensions. Motion Blitz is a quick matching card game that consists of a deck of "Motion Cards" which picture motions in daily life and a selection of "Motion Symbols" displaying a path of motions: linear, projectile, circular, rotational, rolling, and simple harmonic motions. To play the game, one player starts by flipping over one of the "Motion Cards", then simultaneously everyone tries to figure out the proper "Motion Symbol" to grab. Figure it out and grab the right one to get the card/point. After playing, the teacher uses questions to stimulate student thinking and help students construct scientific knowledge. Finally, 12 questions according to Bloom's taxonomy are administrated to students. These questions are classified according to different cognitive levels ranging from low-level thinking (knowledge, comprehension) to high-level thinking (application, analysis, synthesis, and evaluation). Data analyses showed Motion Blitz’s ability to elevate students' thinking level, over 90% of students scored well at a low level and 59% at a high level approximately. In addition, data indicated that students' thinking scores became lower at a higher level of thinking.

1. Introduction
The primary purpose of teaching is to improve students' thinking to become a critical thinker and creative problem solver for working life after they graduate. These skills are required by employers for the 21st century [1]. Therefore, the teacher must enhance students’ thinking skills, problem-solving skills, and self-constructivist learning. Game-based learning is a powerful teaching strategy to promote these skills. Moreover, GBL can stimulate an active imagination, enquiring mind, and be enjoyable in the classroom [2,3]. In physics lessons especially, students have negative attitudes such as physics lessons are boring, difficult, and do not relate to real-life [4]. A questioning approach can engage students to think more critically and creatively beyond mere recall [5]. A teacher's question will encourage student thinking and enable them to become independent learners [6]. Moreover, classroom questions are used as a tool for a teacher to enhance student motivation and increase the participation of reluctant students, and different types of questions also evaluate students’ thinking level [7].
For this research, the new “Motion Blitz” card game was adapted from the “Ghost Blitz” card game which is very popular amongst teenage players [8]. It was designed using a picture of physics motion in daily life events: linear (horizontal and vertical), projectile, circular, rotational, rolling, and simple harmonic motions. After playing, the teacher uses questions to engage student thinking and students produce self-scientific knowledge from the game.

Finally, questions grouped according to different cognitive levels ranging from lower to higher level thinking as per Bloom’s taxonomy are given to students to evaluate their learning. These questions include level 1 knowledge: the remembering and recalling of previous lessons, level 2 comprehension: the ability to grasp the meaning of material and translate material from the meaning to one another meaning, level 3 application: the ability to use learned material in a new situation, level 4 analysis: the ability to break down material into its component parts so that the relationships between parts can be analyzed, level 5 synthesis: the ability to resolve contradictions and to put parts together to form a new whole, and level 6 evaluation: the ability to judge the value of compiled material for a given purpose [9]. In addition, the questionnaire asked the pupils to respond after playing the "Motion Blitz" card game.

2. Methods
The research was carried out in a secondary school (M5) in the science classroom, with 31 pupils. There are 3 steps as follow:

First stage: Playing the game, students play the "Motion Blitz" card game which takes 30 minutes (3 – 5 rounds). The set contains a deck of 35 cards called “Motion Cards”: each has a picture of one of 7 physics motion types in daily life events: 1) horizontal linear motion 2) vertical linear motion 3) projectile motion 4) circular motion 5) rotational motion 6) rolling motion and 7) simple harmonic motion, and 7 items of “Motion Symbols” which display the path of motions, as shown in figure 1. To play the game, groups of 4-5 students play together, they start by one player flipping over one of the “Motion Cards”, then everyone in the group has to think fast and quickly grab the proper “Motion Symbol” to match the “Motion Card”, whoever figures it out and grabs the right “Motion Symbol” gets the card, the group check the sign in the inner round circle of the card for the correct answer. The player with the highest amount of cards wins the round.

Second stage: Questions to stimulate thinking and produce self-scientific knowledge. After playing the “Motion Blitz” card game, the teacher uses 30 verbal questions to stimulate student thinking and help students construct scientific concepts from playing the game, students’ respond both individually and in groups. The teacher asks questions such as, what are the key features of each type, what is the correct motion symbol appropriate to a motion card that has not been seen during the gameplay and, describe what similarities and differences you notice between each motion, etc.

Figure 1. (a) Example of “Motion Card”, a picture of daily life motion and check correct answer sign and (b) Example of “Motion Symbol”, a horizontal linear, projectile and rolling motion symbol.
Final stage: Student Thinking Skill (STS) test, 12 multiple-choice questions, were administrated to evaluate students’ thinking skill. The questions were classified into 6 cognitive levels according to Bloom’s taxonomy: ranging from low-level thinking (knowledge, comprehension) to high-level thinking (application, analysis, synthesis and evaluation). There are 2 questions from each level. The questions in each level were adapted from the prototype in an article by Professor Christine Chin: an expert in how to scaffold students’ thinking, to promote more active learning [5]. The STS test was validated in physics content by 3 university professors with 5–10 years teaching experience. Students’ thinking skills were categorized by students’ answers at each level. Students who answer both questions correctly in each level will be evaluated as having thinking skills in those levels. Questions were analysis and synthesis questions. Analysis questions, such as: figure 2 (a) the bicycle wheel rotates around a fixed center and (b) the bicycle wheel is translationally pushed, asked what is the same and different for each motion of the wheel? Synthesis questions, such as: figure 3 (a) wheel translation without rotation, (b) wheel rotation without translation and (c) wheel translation with rotation, asked what is the relationship of (a) and (b) to (c)?

3. Results and discussion
The results of the 31 students response to thinking level questions evaluated according to Bloom’s taxonomy are presented in figure 4. The results indicate that students’ thinking scores decreased between the lowest to highest level of thinking respectively. Over 90% of the students scored well at level 1 (knowledge) and level 2 (comprehension) showed excellent ability to recall previous lessons and to interpret the facts. Over 80% of the students at level 3 (application) showed a good ability to apply the knowledge they have learned in a new situation. Less than 70% of students at level 4 (analysis) showed the ability to break down the material into its component parts. Only 56.5% of students at level 5 (synthesis) showed the ability to resolve contradictions and to put parts together. At the level 6 (evaluation) only 33.9% of students were able to judge the value of compiled material. This result is similar to results announced in a report from OECD (Organisation for Economic Co-operation and Development) of international student test scores known as PISA (Programme for International Student Assessment) in December 2016, which indicated that the critical thinking of Thai students was lower than that of Vietnamese students [10]. Therefore, the learning approach must be improved to promote students’ thinking.

Figure 2. Picture of the analysis question.

Figure 3. Picture of a synthesis question.

Figure 4. Chart showing the percentage of students classified by 6 thinking levels.
Student' responses to the to "Motion Blitz" card game from 31 completed questionnaires are shown in Table 1. All students (100 %) believed the game pushed them to learn more about motions in physics that relate to everyday life. In addition, most of the motions students had never known before and were happy for learning physics with "Motion Blitz". Secondly, over 85 % of students believed that the "Motion symbol" was suitable to explain types of motion. Most students agreed that the rules of the game were simple and the period of playing time was not too long. 71 % of students agreed that the pictures on each “Motion card” can illustrate the motion of persons or objects; however, some students disagreed about the illustration of pictures stating that some cards look ambiguous. Other remarks suggested that some players only noticed the answer check signs but did not consider the motion pictures.

Table 1. Student responses to the "Motion Blitz" card game in the questionnaire.

| Question                                                                 | Agree (%) | Disagree (%) |
|--------------------------------------------------------------------------|-----------|--------------|
| 1) The “Motion card” obvious representation of the person/object motion. | 71.0      | 29.0         |
| 2) The “Motion symbol” proper representation of each type of motion.     | 87.1      | 12.9         |
| 3) The rules of the game are proper.                                    | 90.3      | 9.7          |
| 4) The time limitation for play game are proper.                        | 87.1      | 9.7          |
| 5) The game is provided many motions in real-world situation.            | 100       | 0            |
| 6) The game offers students for new types of motion which students have never known before. | 100       | 0            |
| 7) Students' attitude is more positive towards physics after playing the game. | 100       | 0            |

With reference to the student suggestions after playing “Motion Blitz”, we will develop clearer pictures of motion, reduce the size and increase the number of check answer signs so that they are not too obvious to players, and produce an answer flap of each picture for self-learning and trying again.

4. Conclusion
The new “Motion Blitz” card game was combined with a questioning approach to evaluate student thinking levels. Students learned more about physics motions in daily life from this game. In addition, the students learned the physics lessons in a fun way.

References
[1] Ritman O and Rohitsthean B 2015 MOU research to develop creativity and analytical thinking skills (in Thai) Online: https://www.moe.go.th/websm/2015/dec/470.html (accessed 10 January 2019)
[2] Dunac P S and Demir K 2013 J. Phys. Educ. 48 736
[3] Smith D R and Munro E 2009 J. Phys. Educ. 44 479
[4] Kaya H and Boyuk U 2011 Eur. J. Phys. Educ. 2 23
[5] Chin C 2004 J. Au. Sci. Teach. Assoc. 50 16
[6] Koufetta-Menicou C and Scaife J 2000 J. School Sci. Rev. 81 79
[7] Chin C 2007 J. Res. Sci. Teach. 44 815
[8] Zoch 2010 Ghost Blitz Online: https://boardgaming.com/games/card-games/geistesblitz (accessed 20 January 2019)
[9] Bloom B S 1956 Taxonomy of Educational Objectives, Handbook 1: Cognitive Domain 2nd edn (New York: Longman) pp 20–4
[10] TRF 2017 Report: from the PISA score to the critical thinking ability of Thai children (in Thai) Online: https://www.knowledgefarm.in.th/from-pisa-to-thai-education-crisis) (accessed 20 January 2019)