

Map-Puzzle Application for the Evaluation of Children's Spatial Knowledge

Pyoung-Woo Yang¹, Hyun Gu Cho², Jeong Hye Han^{3*} and Kwang Woo Nam⁴

¹Department of Computer Information Engineering, Kunsan National University, Gunsan-si, 573-701, Republic of Korea

²Department of Computer Information Engineering, Kunsan National University, Gunsan-si, 573-701, Republic of Korea

³Department of Computer Education, Cheongju National University of Education, Cheongju-si, 361-712, Republic of Korea; hanjh@cje.ac.kr

⁴Department of Computer Information Engineering, Kunsan National University, Gunsan-si, 573-701, Republic of Korea; kwnam@kunsan.ac.kr

Abstract

This paper proposes a model for geographic jigsaw-puzzle for identifying and supporting spatial knowledge in young children. We implemented this application on the android platform for convenient with an easy usage in educational purposes. This geographic puzzle application which is runnable in android smart phones and tablets is usable for educating and evaluating children's location and spatial knowledge.

Keywords: Geographic Education, Jigsaw Puzzle, Spatial Intelligence

1. Introduction

With the rapid development of computer and mobile technologies as educational tools, the computerized education is becoming important part of geography education in the elementary school^{1,2}. Smart phone and tablets are perceived as ideal tools for providing individualized instruction, which various learners receive and process geographic information^{3,4}. However, educators have been suffered from a lack of computer-aided education tool and models about instruction and measurement in their discipline.

Jigsaw-puzzles are popular approach to provide geographic knowledge. Recent researches already proposed map-like jigsaw-puzzle applications for raising interests and measuring of spatial knowledge and intelligence^{3,5}. But the formal model of the geographical jigsaw-puzzle and measurement of educational effectiveness have been almost not researched.

Especially, Hall proposed map-like jigsaw-puzzle program. And the program measured time necessary to complete the given tasks (time) and the number of attempts made to complete tasks (accuracy)⁵.

In this paper, we describes the design and implementation of geographical jigsaw puzzles application, and the objects of this paper are to provide a simple and effective measurement of young children's spatial intelligence, which as well as affording amusement will be capable of imparting considerable instruction in geographical facts.

2. Problem Statement

2.1 A Model of Map Jigsaw-Puzzle

A map jigsaw-puzzle comprising a map divided transversely into a plurality of sections, one or more of the sections comprising an outer ring and a plurality of interlocking sub-sections. The jigsaw-puzzle app consists of

*Author for correspondence

puzzle pieces and solution area. Figure 1 shows the model of map jigsaw-puzzle.

DEFINITION 1. (SA)

When the puzzle pieces, $P = \{p_1, p_2, \dots, p_n\}$, and when solution area, $S = \{s_1, s_2, \dots, s_n\}$, a solving attempt, SA, is a tuple of $p_i \in P, s_i \in S$, true/false, and time.

$$SA = (p, s, \text{is Success}, \text{time}).$$

Therefore, solving map jigsaw puzzle is a sequence of solving attempts, SSA. And, we can express the sequence as the following.

$$SSA = \langle SA_1, SA_2, \dots, SA_m \rangle.$$

A map jigsaw-puzzle application maintains two information tables. One is a log table for solving tries including the detail of each solving attempt sequence, start time, elapsed time, and number of true/false SA. Another is a student table for profile information for each student.

The information tables in Figure 2 would be used for personalization of the puzzle solving records and measurement.

2.2 Measurements of Spatial Intelligence

We can measure young children's spatial intelligence using log table of map jigsaw-puzzle. The simplest naive

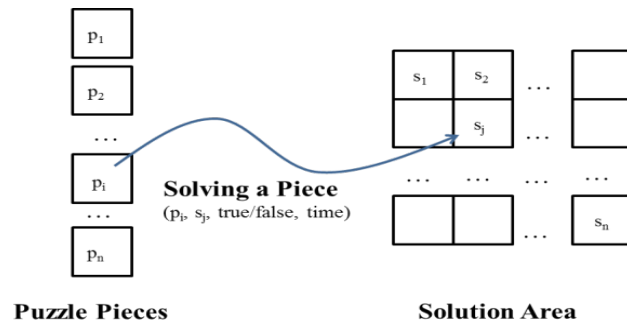


Figure 1. Model of Map Jigsaw-Puzzle.

Map Jigsaw Puzzle Log Table						
gid	studentid	start_time	SSA	total SA	num. of true SA	num. of false SA
1	200	05/08/2014	$\langle (p_1, s_1, f, t_1), (p_2, s_2, f, t_2), \dots \rangle$			
...	...	...	...	...	...	...

Student Table				
studentid	name	birthdate(age)	sex	others
200	James	10y 9m	male	...
...	...	...	...	...

Figure 2. An Example of Information Tables.

approach is using the *start time* and *last time of SSA*. Let a student's measured value call score S.

Naive approach

$$s_k^{naive} = \frac{\alpha}{last(SSA_k) - start_time_k}$$

The α is a constant for the expected time of solving the puzzle. When the student solved the puzzle in equal time with α , the value is 1. This method considers only the time, and thus it cannot be deemed an accurate evaluation. In order to evaluate a student's spatial knowledge, it is important to evaluate how many puzzle pieces the student moves in order to complete the jigsaw-puzzle and how accurately each puzzle piece is moved. Thus, to evaluate the accuracy, it is desirable to include an accuracy approach.

Accuracy approach

$$s_k^{accuracy} = \frac{True\ SA}{Total\ SA}$$

The accuracy approach considers only percentage of number of true SA in number of total SA. By assessing the number of true and false SA in the Total SA, the number of times the piece is correctly assembled, and the number of times the piece is incorrectly assembled, can be identified. By using the accuracy approach, students who solve the jigsaw-puzzle on their first attempt may receive a result of one, where as students who move the pieces more often may receive a lower result.

In this paper, a combined approach for integrating the naive approach and accuracy approach is suggested.

Combined approach

$$s_k^{comb.} = \frac{\alpha}{last(SSA_k) - start_time_k} * \frac{True\ SA}{Total\ SA}$$

We proposed a combined approach for measuring the spatial intelligence.

The combined approach integrates the method for assessing the time spent solving a given problem with the method for valuating how accurately the pieces are assembled. The existing method considers only the time - and not the number of times the puzzle pieces are moved - and consequently it is difficult to accurately evaluate the students. The suggested method evaluates the number of puzzle pieces moved by the student to solve the jigsaw puzzle, along with the time spent solving the puzzle. Thus, the suggested method provides a more comprehensive evaluation than the existing evaluation method, which uses only the time.

3. Implementation

We implemented this map jigsaw-puzzle application on the android platform for convenient and easy usage in educational purposes. So, this application is runnable in android smart phones and tablets. This geographic puzzle application is usable for educating and evaluating children's location and spatial knowledge. Table 1 shows the environment used to implement the jigsaw-puzzle application. For hardware, a tablet commonly used in current educational environments was selected.

3.1 Implementation of the Jigsaw-Puzzle

Figure 3(a) depicts the screen for selecting a map when beginning a jigsaw puzzle. The map is stored in the tablet in the form of a typical JPEG file, and the stored map can be used to create a jigsaw-puzzle automatically. Figure 3(b) depicts the screen for running the jigsaw-puzzle application on the tablet. The jigsaw-puzzle to be solved is located in the screen on the right, and a solution to the problem can be attempted by touching it to move the puzzle into the answer screen on the left. Furthermore, the time spent solving the problem is displayed above the answer screen so that students are aware of the time that has elapsed.

3.2 Student Evaluation

Figure 4 depicts a screen wherein the student is evaluated by considering only the time - that is, without using the suggested technique - and Figure 5 depicts a screen wherein the student is evaluated using the suggested technique. According to these two screens, Student #2 received a score of 89 in Figure 4, where as the student scored 82 in Figure 5. Moreover, Student #4 scored 87

Table 1. Implementation Environment

SW	Android 4.3
Hardware	Samsung Galaxy 10.1 Tablets
Language	Java, XML

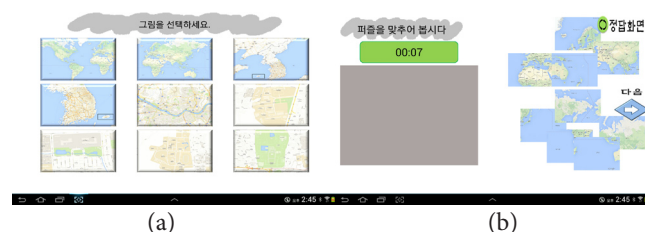


Figure 3. Running the Puzzle App in a Tablet.

Puzzle			
Naive		Accuracy	Combine
Rank	Student No.	Name	Score
1	2	김지윤	89
2	4	노민지	87
3	11	박민재	80
4	12	백은서	74
5	14	송민	72
6	15	신도윤	69
7	19	이예솔	60
8	22	조명재	54
9	4	김형석	48

Figure 4. Naive Score.

Puzzle			
Naive		Accuracy	Combine
Rank	Student No.	Name	Score
1	4	노민지	84
2	2	김지윤	82
3	11	박민재	77
4	12	백은서	70
5	15	신도윤	68
6	14	송민	67
7	19	이예솔	57
8	22	조명재	50
9	4	김형석	42

Figure 5. Combined Score.

according to the naive method and received a score of 82 with the combined method. Although Student #2 spent less time solving the puzzle, the pieces were moved 15 times; Student #4, on the other hand, consumed more time than Student #2, but moved the pieces only 11 times - that is, fewer times than Student #2. Thus, Student #4 received a higher score according to the combined method.

4. Conclusion

In this paper, a new method for evaluating the spatial-cognitive ability of students by using a jigsaw-puzzle was suggested. Furthermore, a jigsaw-puzzle application implementing the suggested technique was applied. The suggested method expands the notion of accuracy by considering the time spent completing the puzzle along with the number of times the puzzle pieces are moved. The suggested technique is expected to provide more accurate information than the existing method for valuating students.

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6. References

1. Newcombe NS and Frick A. Early Education for spatial intelligence: why, what, and how. *Mind, Brain and Education*. 2010; 4(3):102–11.
2. Levine SC, Ratiff KR, Huttenlocher J, Cannon J, Early puzzle play: a predictor of preschoolers' spatial transformation skill. *Dev Psychol*. 2012; 48(2):530–42.
3. Shim SH. Learning place location using map puzzles in primary geography. *Journal of Korea Association of Geographic and Environmental Education*. 2011; 19(2):1–17.
4. Carmel MD, James JW. Identifying and Supporting Spatial Intelligence in Young Children. *Contemp Issues Early Child*. 2000; 1(3):299–313.
5. Hall JK. Field Dependence-Independence and Computer-based Instruction in Geography. Doctoral Dissertation. Virginia Polytechnic Institute and State University; 2000.