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A Study on Jigsaw Model Application in Teaching and Learning Mathematics

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The current study investigated meaning of Jigsaw model application in teaching and learning mathematics based on the literature research and analysis of Jigsaw models. Through related literature, properties of the tasks of the expert sheets in mathematics are examined. Then the advantages of the application of Jigsaw in mathematics are discussed in terms of the realizing mathematical connections and promoting positive affective outcomes of Korean students in mathematics.

Keywords: cooperative learning, Jigsaw model, mathematical connections, affective characteristics.
MESC Classification: D10
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I. INTRODUCTION

According to the old teaching of Talmud, cooperative learning has been an integral part of human life for a long time and “students need a study buddy to learn.” In the 17th century, John Amos Comenius stated a student benefits from teaching or learning from another student (Johnson, Johnson & Smith, 1991). In the Eastern world, too, the importance of cooperative learning has been stressed regardless of the ages and countries.

In the 1930’s, competitive learning was the mainstream in the learning environment of the United States due to the influence of capitalism and social Darwinism but competitive

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learning caused a lot of problems. One of the serious problems was that the competitive learning focused on distinguishing winner and loser, instead of bringing out individual child's potential. To its opposition, Bloom's individualistic learning received attention as a mastery learning but it resulted in creating rugged individualism, which lacks sociality due to the absence of interaction with others. Cooperative learning is a new theory developed by Deutch in 1940's that redeems the shortcomings of competitive learning and individualistic learning based on the research findings of intellectual development of learner and social psychology about interaction among group members (Byeon & Kim, 1996; Jeong, 2006; Johnson & Johnson, 2009).

In Korea, it has been used as one way of practicing open education and open classroom movement during the education reform (Jeong, 1999).

In cooperative learning, there are various models including STAD, TGT, TAI, CIRC, Jigsaw, LT, GI, etc. (Johnson, Johnson & Stanne, 2000; Johnson & Johnson, 2009; Slavin, 1991), all of which promote cognitive development by maximizing positive interaction among the group members (Jeong, 2006). One of the model, the Jigsaw model, is created by Aronson and his students, who concluded that the hostility among groups become reasons for the competitive learning environment. Jigsaw model is designed to replace traditional competitive learning structure with cooperative learning structure (Jeong, 1995; Aronson, 2000).

In 1970's, racial discrimination was banned in Austin, Texas, which mingled diverse race and culture in each class. After several weeks, the doubt, fear and distrust between each group created problems in the affective characteristics such as hostility. Jigsaw was originally developed by Aronson in 1978 to make students possess positive affective characteristics as a primary goal (Jun, Choi, Lee, Ko & Lee, 2010). Also the expert sheet, which is generated to apply the Jigsaw model, can connect various aspects of mathematics by its nature.

Recently, the mathematics curriculum of Korea (Ministry of Education and Human Resources Development, 2011) stresses the importance of possessing positive affective characteristics of mathematics and mathematical communication. Mathematical connection is also emphasized because it can intrigue mathematical interest and raise awareness of mathematical values so that students can have positive affective characteristics in mathematics.

The current study examines various literatures to investigate properties of Jigsaw model as a type of cooperative learning and its characteristics shown through expert sheets. Then the influence of Jigsaw model in the teaching and learning of mathematics will be discussed in terms of affective aspect, mathematical connections and communication in mathematics.

The current study investigates importance and characteristics of the Jigsaw model and expert sheets as collaborative learning through various literatures and discovers verified effects of the Jigsaw model. Based on the findings, the Jigsaw model will be applied to develop several learning materials. Then the implications of the model and applicability of the Jigsaw model in teaching mathematics will be discussed.

II. COOPERATIVE LEARNING AND JIGSAW MODEL

Since Jigsaw model is a type of cooperative learning, in order to find out its features, the concept and features of cooperative learning are examined, along with other cooperative learning models before looking into the Jigsaw model in more depth.

1. Cooperative Learning

A. Concept and Features of Cooperative Learning

According to Johnson, Johnson & Holubec (2001), cooperative learning is a way of teaching that uses a small group to maximize each other's learning. This small group facilitates learning but sometimes distracts learning and creates disharmony and complaints in the classroom and can be divided into pseudo learning group, traditional learning group and cooperative learning group.

In a pseudo learning group, all students receive the task to be learned together but they do not get interested in learning together. Students believe that they will be evaluated in terms of individual performance so they superficially talk about the task but do not help each other because they consider each other to be their competitor. As a result, students perform better when they study individually.

In a group with traditional classroom setting, students recognize that they need to work together when they receive a task but in fact, the task requires almost no cooperative work structurally. Since they believe that they will be individually evaluated and rewarded for the performance, not as a group member, they seek for information from each other but do not have motivation to share and exchange information. Because mutual helping and sharing is minimized and some students just want to take from honest friends who put their effort into work, those students also do not want to put as much effort anymore. Even though the total sum is bigger than each member's potential, students who can study well on their own will produce better performance if they study individually.

In a cooperative learning group, students receive a task to be worked together and enjoy the process of learning together. They realize that their success depends on the effort of each group member. Such group exhibits five properties. First, the purpose of the group in maximizing learning of all of its members motivates students to proactively participate in learning. Second, all members of the group are aware that each of them is responsible to put the hard work to achieve the mutual success. Third, group members meet to learn together for the joint production. Fourth, all members learn social function and are expected to use them to harmonize each other's hard work. Fifth, the group analyzes effective means of achieving the purpose and cooperative learning method to consistently improve the quality of team work process. As a result, the sum of the total is greater than sum of parts and all students benefit more than when studying alone.

Thus, knowing the characteristics of group that can be present in the class will help which group is for the cooperative learning and will lead to effective use of cooperative learning.

B. Definition of Cooperative Learning

The definition of cooperative learning differs a little bit depending on the scholar who argues for it. Johnson & Johnson (1998) argued that the following five conditions are necessary for cooperative learning; clearly perceived positive interdependence, considerable promotive (face-to-face) interaction, clearly perceived individual accountability and personal responsibility to achieve the group's goals, frequent use of the relevant interpersonal and small-group skills, frequent and regular group processing of current functioning to improve the group's future effectiveness, whereas Slavin (1990) stated that an ability to learn together is the way of learning in small groups toward the same objective. Cohen (1994) argued that it is learning in a small group, where all learners participate in the collaborative learning task clearly assigned to them.

According to Jeong (2006), Park (1985) introduced cooperative learning for the first time in Korea and defined it as a learning strategy developed for the benefit for all of the members of the group an individual is part of. There are many other definitions but all are practically the same. In the current study, cooperative learning refers to a method of achieving the learning task or goal through collective work of each member of the small group (Byeon, Kim & Son, 2010).

C. Cooperative Learning Models

There are a variety of cooperative learning models including STAD, TGT, TAI, CIRC, Jigsaw, LT, GI, and etc. (Johnson, Johnson, & Stanne, 2000; Johnson, Johnson, 2009; Slavin, 1991). The current study will focus on Jigsaw model, which will be discussed in more detail in the following section. The features of the rest of the models are as follows.

First, the STAD (Student Teams-Achievement Division) model is differentiated from other models for its evaluation method and usage. Each student has a base score, which is an arithmetic mean of the pre-test. If the STAD is performed for the first time, then the base score can be set based on the previous test scores (Jeong, 2006).

The arithmetic mean of the improved score, compared to the original score from the individual evaluation, of group members after cooperative learning has been conducted becomes the group score. For the group score, group reward also exists. This process provides an opportunity for the successful learning of every group member (Jeong, 2006). Slavin (1980) created Jigsaw 2 model, which applies STAD evaluation method to Jigsaw model.

Second, the TGT (Teams-Games-Tournaments) model is similar to the STAD model in terms of the basic process but differs in that tournament is conducted in quiz format for evaluation. There is group reward and fair opportunity for success is promoted by having two people with similar abilities compete against each other in the quiz (Jeong, 2006).

Third, the TAI (Team Assisted Individualization) model, unlike the STAD and TGT, has different progress for each individual student (Jun, Choi, Lee, Ko & Lee, 2010). For this, each student receives individual diagnosis test, based on which they individually learn the chapter appropriate for their level. The evaluation is conducted after cooperative learning and the sum of the individual score becomes the group score. If the group score is above a certain level, the group gets the reward (Jeong, 2006).

Fourth, the CIRC (Cooperative Integrated Reading and Composition) is created for the language education, specialized in improving reading, reading comprehension and writing skills. It is composed of three parts, basic activity, direct teaching about reading comprehension, and integrated language and writing, and the evaluation is on the understanding level, composing a meaningful sentence using specific vocabulary, reading the presented word out loud and etc. There is also a group reward (Jun et al., 2010).

Fifth, in the LT (Learning Together) model, tasks are solved in teams but tests are taken individually. However, the score is based on the average score of the team and if the group average score is above a certain level, students get rewards as a group. It has good flexibility for application because it is comprehensive and generic (Jun et al., 2010).

Sixth, the GI (Group Investigation) model is an open cooperative learning model in which students take lead in the entire process from selection of the learning task to group reporting. Synthesizing the results of individual learning to complete the group learning, they present to other groups and offer them an opportunity to learn about what their group was taught (Jun et al., 2010).

2. Jigsaw

A. Characteristics and Class Procedure of Jigsaw Model

As stated earlier, Aronson and his students set forth the following two directions in order to replace the traditional, competitive learning structure with the cooperative learning structure. First, the traditional, competitive learning structure, which has one specialist (teacher) and many audience members (learners), is changed to a small group-based, cooperative learning structure. In this structure, 'individualistic competition' and 'success in learning' should not be able to co-exist and success achieved only through cooperation in the small group. Therefore, learners are more interested in the colleagues than in the teacher. Second, all of the members of the group need help from another member in cooperative learning. Each member of the group is responsible for a section of the entire lesson, requiring individuals to cooperate in order to achieve the lesson goal. Therefore, each individual can make a significant contribution to the success of group member. This creates a radical interdependent environment amongst colleagues. The Jigsaw model was developed to create two directions of learning structure (Jeong, 1995).

Including the variations of the Jigsaw, which will be discussed later, there are 4 basic steps of class procedure for the class that applies the Jigsaw model (Jeong, 2006; Jun, Choi, Lee, Ko & Lee, 2010; Clarke, 1994).

Step 1: Composition of Jigsaw groups or Home groups and Distribution of Expert sheet

After the Jigsaw groups are composed, members receive or select expert sheet. The number of members of the group should be same as the number of expert sheet to ensure fair opportunity for success and equality to all members.

Step 2: Cooperative Learning in Expert groups

Each member of the group forms expert group with the members of other groups that received the same expert sheet. In order to teach the material to the members of the home group, students exchange information about the learning material with the members of expert group, study and learn the material and become an expert in that area.

Step 3: Cooperative Learning in Jigsaw groups or Home groups

Students who are now experts return to the home group, teach the group members, and also learn about other areas from the members.

Step 4: Individual Evaluation

Each student is individually evaluated for the entire study material.

The following diagram (*Figure* 1) shows the entire process.

To help understand Steps 1 and, Davis-McGibony (2010) explained as follows.

30 students are divided into six home groups of five, called A, B, C, D, E and F. Each of the five members of the group receives an expert sheet that is numbered 1, 2, 3, 4 or 5. A student from group A, who received an expert sheet 1, is called 1A, and the other members of the group A will be called 2A, 3A, 4A and 5A, according to the number of expert sheet they received. Likewise, members of other groups, B, C, D and E, can be

named in a similar way. Expert group will be composed of students who received the same number of expert sheet, such as 1A, 1B, 1C, 1D, 1E and 1F.

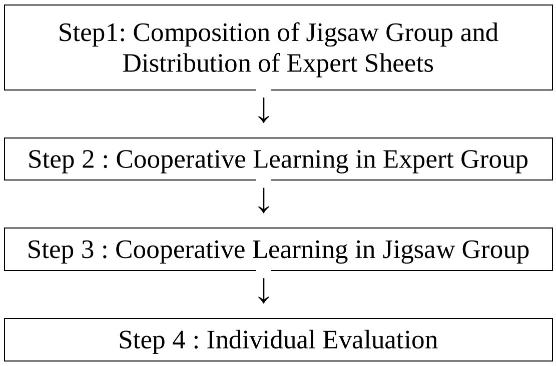

Figure 1. Four Basic Steps of Class Procedure in Jigsaw Model

The name Jigsaw refers to how students are divided into expert groups and come back to the home group, which is viewed as similar as the Jigsaw Puzzle (Jeong, 2006).

As each piece of the puzzle is important in a jigsaw puzzle, each member of the group is essential for the completion of the overall learning and effectiveness of the Jigsaw model (Aronson, 2000).

B. Types of Jigsaw Model

Since the creation of the Jigsaw model by Aronson, Jigsaw model has developed into Jigsaw 2, Jigsaw 3, Jigsaw 4, etc., which modify flaws of the previous model (Slavin, 1978; Steinbrink, & Stahl, 1994; Holliday, 2002). According to Doymus, Karacop & Simsek (2010), there are other models, including Reverse Jigsaw, Subject Jigsaw, etc., but this paper will only introduce Jigsaw, Jigsaw 2, Jigsaw 3 and Jigsaw 4.

1) Jigsaw 1

The primary objective of the Jigsaw model first developed by Aronson in 1978, as previously mentioned, was to promote students' positive affective characteristics(Jun et al, 2010).

In this model, the individual evaluation of Jigsaw affects individual score, but it does not affect the group score as in the STAD, meaning that the task dependence is high while reward dependence is low. Because they are not rewarded as a group, students do not have a formal group goal. However, since positive behavior of a member helps other group members to get rewarded, intrinsic dynamic exists in the cooperative reward structure (Slavin, 1980).

2) Jigsaw 2

In order to address shortcomings of Jigsaw model, the absence of group reward, Slavin (1980) applied the evaluation method of the STAD in the evaluation process of Jigsaw. In other words, he modified Jigsaw so that the individual evaluation will influence the group score and eventually the group reward. This means that there is a competition between groups (Doymus, Karacop & Simsek, 2010).

Jeong (2006) stated the following to be the difference between Jigsaw 2 and Jigsaw.

First, STAD evaluation method and group reward are used. STAD evaluation method plants a sense of group objective to the members to induce participation of all group members for the success of the group. For this, the basic score, improved score and group score are incorporated in the same way as in STAD.

Second, Jigsaw 2 does not assign a group leader, unlike in the original Jigsaw model, and eliminates organization and training steps of the group to stress autonomy of group members. This is also same as the evaluation method of STAD, where motivation for interaction within the group is in strong action.

3) Jigsaw 3

Steinbrink & Stahl (1994) raised a problem that students do not have enough time to prepare for the evaluation as they have to take the quiz immediately after coming back to the home group from learning in the expert group. In order to make up for this, Jigsaw 3 model added a grace period for the evaluation, as well as evaluation preparation time in the home group, between cooperative learning in the home group and individual evaluation.

4) Jigsaw 4

As a response to a question “How can we know that the answers of individuals and group for the cooperative learning of expert group and home group are correct?” Holliday (2002) developed Jigsaw 3 and Jigsaw 4.

Unlike in Jigsaw 3, quizzes are given within the expert group to confirm the accuracy of the learned material as experts after the expert group’s cooperative learning in Jigsaw 4. Then another quiz to test accuracy will be given in the home group after members share learned material in their home groups. In this model, students may choose to have re-learning if majority of students did not do well in certain part of the evaluation (Holliday, 2002).

III. ANALYSIS OF PREVIOUS STUDIES

1. Importance and Characteristics of Expert Sheets in the Jigsaw Model.

As mentioned earlier, one distinctive feature of the Jigsaw model is the existence of home group, whose members each need to become an expert in and teach other members of the group for the part of the assignment that they are responsible. In other words, the group members are responsible for other members' learning. This makes a radical interdependent environment in the Jigsaw model, as compared to that of the other cooperative learning models.

Each member of the home group becomes expert by learning the materials on the expert sheets in expert group. This indicates that composition of expert sheet is key to the class that applies the Jigsaw model, which is also consistent with the argument of Vansickle (1994).Each member of the home group becomes expert through the process of problem solving in the expert sheet distributed by the teacher within the expert group. Hence composition of expert sheet is key for the formation of a lesson, to which Jigsaw model is applied. An expert sheet divides a part of a lesson and puts into a form that can be learned by students. In order to compose an expert sheet, division of assignment should come first, as an important draft for the lesson that applies the Jigsaw model.

How should, then, the assignments should be distributed to compose expert sheets, in terms of the method and features? In order to answer this question, previous domestic studies on the Jigsaw model were examined.

Shin (2007) and Yang (2003) applied the Jigsaw model to study the Pythagorean Theorem, which is in the curriculum for the third year in Middle School, and proposed various ways of proof as expert assignment. Kang (2005) also applied the Jigsaw model to the Pythagorean Theorem, in addition to triangular number, square number and irrational number, which are related to the Pythagorean Theorem. Lee (2010) applied the Jigsaw model to system of linear equation and proposed various cases of linear equations, such as distance, speed, concentration and age using method of addition and subtraction or elimination, as expert study task.

In addition to the above researches, there are papers written about teaching mathematics related to the Jigsaw model but there was insufficient number of papers on the way class was conducted using the Jigsaw model, especially in terms of the composition of expert sheets. Considering that there was not enough information or data to make conclusion about teaching mathematics, the scope of study was extended to previous studies and literature on other subject of study.

Studies conducted by Park & You (2001), Lee (2012), Lee & Kim (2015), Choi, Hong & Lee (1997), Mun & Lee (2011), Lee (2014), Kwon, Lee & Bae (2004), Moon & Kim

(2007), Han (2006) show practical examples of classes that applied the Jigsaw model. In the subject of science, Park & You (2001) composed four types of expert study tasks for measuring density of regular solid, irregular solid, liquid and vapor in the materials properties chapter. Lee (2012) composed an expert study task that allowed different approaches to the causes of altitude change of sun and climate change. This was also so that the students can experience various aspects and circumstances of related concepts for the achievement of a single goal for the class.

Analyzing the researches in mathematics and other subjects, it was found that there were some differences according to the nature of the subject. However, all of the expert study tasks were parallel in nature and were designed so that students can take various approaches for one subject on their own.

Thus it suggests that studying with expert sheets students have more chance to see mathematical connections among mathematical topics and relate mathematics to other subjects.

2. Affective effects of applying Jigsaw models

Analyzing the collected data of previous studies, affective effects of the Jigsaw model proved in other subjects were examined. In order to do so, the affective factors proven to be positive by collected data were put into a list to compare studies exhibiting similar or identical results. The results is as shown in the below table and the number of studies was counted with overlap.

Websites of Korea education and research information service' was used to search data. Among the Jigsaw related studies conducted between 1997 and now, 23 accredited journals of the Korea and the candidate journals for accredited journal of the Korea were used.

Table 1. Affective factors verified in other subjects and the number of studies

The verified affective factors	Number of studies	The verified affective factors	Number of studies
active or positive learning attitude	9	sociability	2
interest	8	consideration for others	2
self-respect (self-efficacy)	7	motivation	2
self-learning ability	5	positive friend relations	2
communication ability (interaction)	3	spirit of team work	1
confidence	3	creativity	1
satisfaction	2	task commitment	1

This may be a mere enumeration but considering that there has not been many studies on the application of Jigsaw model in teaching mathematics in Korea, it was determined useful to first discover what has been verified in studies about other subjects.

As shown by the table above that proved efficacy of the Jigsaw model in other subjects, the lesson which applied the Jigsaw model was shown to be effective in affective characteristics including positive learning attitude, interest, self-respect, self-learning ability, confidence, task commitment, sociability, etc.

Hence, the result is expected to give more insight about application of Jigsaw model for mathematics.

IV. APPLICATION OF JIGSAW MODEL IN MATHEMATICS EDUCATION AND ITS IMPLICATION

Cooperative learning and the Jigsaw model were examined to understand the importance of expert sheets and their compositional characteristics. And the Effects of the Jigsaw model of other subjects were investigated in affective domain.

As previously examined in Chapter III, one of the most important factor in the Jigsaw model is the expert sheet, or divided task, and the composition of the expert sheet. Looking into an example of another subject revealed that the tasks divided to each student in the Jigsaw model are designed to enable various approaches by students. This feature remained the same when applied to mathematics; further leading to the statement that expert sheet should not have conceptual hierarchy. And teachers who intend to teach mathematics by applying the Jigsaw model will have to consider various aspects of the topic to come up with divided tasks, considering the nature of expert sheet composition.

When students take diverse approaches to investigate concepts and properties of mathematics and connect those concepts and properties to everyday life matters or other subjects, they are able to deepen their understanding of and recognize the usefulness of mathematics. Thus the analysis results of the Jigsaw model applied in mathematics and other subjects discussed thus far suggest that the Jigsaw model as cooperative learning enables better understanding of diversity of mathematics as well as the usefulness of mathematics.

Proved by many instances in international student assessments, Korean students usually show outstanding accomplishment in mathematics in terms of cognitive aspect but comparatively lower accomplishment in the affective aspect (Park, 2007; Korea Institute for Curriculum and Evaluation, 2013a & 2013b). To address this issue, the revised curriculum of 2007 set its goal of mathematics learning in improving the accomplishment level in the affective domain and increasing interest, confidence and positivity toward learning mathematics.

Cooperative learning in mathematics education shows positive effect in cognitive and affective social aspects by offering a chance for communication, providing an equal opportunity for success and teaching strategies for problem solving through interaction among groups (Jeon & Lee, 2002). Furthermore, cooperative learning focuses on the learning structure rather than learning contents and is the most effective structure, cognitively and affectively, by providing an opportunity to experience positive interdependence (Lee, 2006). And Jigsaw model studies in other subjects have found that the model helps facilitating affective development of the learner. Hence, as shown by the result of existing researches of other subjects as well as that of mathematics, the application of the Jigsaw model in teaching mathematics has a high chance of promoting the students' affective characteristics.

On the other hand, students in the Jigsaw model class are cultivated with the capacity for mathematical communication, which is highly regarded in Korea's curriculum, as they go through the process of becoming expert in the area that they are responsible for in the expert group, teaching other students when they return to the original home group, and learning from other expert colleagues.

Thus the application of the Jigsaw model in mathematics education can become a powerful alternative to enlighten the connection among mathematics, other subjects and daily life and enhance understanding of diversity of mathematics as well as the usefulness of mathematics. Furthermore, it will make students possess positive affective characteristics in mathematics education by building positive attitude, self-respect and confidence and by awakening interest.

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