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The Effect of Multiple Intelligences-Based Instruction on Learning Motivation and Learning Achievement in Science Courses

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The purpose of this study was to understand the effect of implementing multiple intelligence (MI)-based instruction on the science learning motivation and learning achievement of 7th grade junior high students. This quasi-experimental research study utilized questionnaires and tests of science learning motivation and learning achievement, and examined collected data through use of the statistical package for the social sciences (SPSS). An analysis of covariance (ANCOVA) and a *t*-test were performed in order to explore the differences between the science learning motivations and learning achievements of the experimental group (N = 39), who were subjected to teaching based on MI theory, and the control group (N = 36), who were subjected to traditional lectures. The results of the study show that, after implementing MI-based instruction, the students in the experimental group significantly outperformed those in the control group in terms of science learning motivation, science learning value, and active learning strategies, while the students with low learning achievement showing an improvement in their learning attitude that allowed them to develop a positive learning attitude toward biology classes and raised their class participation and preference for biology classes.

Keywords: multiple intelligences (MI), learning motivation, learning achievement

Introduction

The multiple intelligences (MI) theory was proposed by Harvard University psychologist Howard Gardner (1983). He stated that intelligence is an ability that operates in multiple forms in life. And the human brain possesses a minimum of eight basic intelligences including: linguistic intelligence, logical-mathematical intelligence, spatial intelligence, bodily-kinesthetic intelligence, musical intelligence, interpersonal intelligence, intrapersonal intelligence, and naturalistic intelligence (Gardner, 2006). Education should provide opportunities to assist students in developing their strengths (Shearer, 2009). Gardner's proposal of the MI theory in 1983 had a huge impact on improving education in schools (White, 2008). Hanafin (2014) pointed out that the application of MI theory in the classroom could assist students in learning. MI theory describes the diversity of intelligence and emphasizes that all children can be educated most appropriately by discovering each child's strength and assisting him or her accordingly. This provides children with the opportunity for success and

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upholds the education principle of nurturing every child.

The application of Gardner's MI theory can strengthen an individual's learning process and inspire active learning in education (Hopper & Hurry, 2000). MI theory is an educational philosophy that advocates the different potentials of each individual to allow students to discover their own learning method (Saban, 2009). Instructors conducting MI learning activities must acknowledge that all types of intelligence are equally important. This is in stark contrast to traditional education perspectives that emphasize the development and application of linguistic and mathematical intelligence (Stewart, 2009). Traditional teaching activities are not advantageous to the development of individual learning activities, while MI theory is a learning channel that makes knowledge easily obtainable (Tracey, 2009). The application of MI in Taiwan's education system emphasizes that the focus of instructor attention should be on students' strengths in intelligence, while also encouraging students to develop their weaker intelligences. When MI theory is integrated into learning, students can apply the knowledge they learn in daily life and cultivate the ability to take their knowledge with them (Yang, 2015).

Literature Review

Pintrich, Marx, and Boyle (1993) emphasized that the learning goals, science learning value, and self-efficacy of students play a key role in students' construction or reconstruction of scientific concepts. Brophy (1998) and Pintrich and Schunk (1996) pointed out that self-efficacy, personal goal orientation, mission value, and the learning environment affect student learning motivation. Brophy (1998) and Pintrich and Schunk (1996) also pointed out that a given learning environment includes the instructor's teaching strategy, teaching activities, and teacher-student interactions that will impact student learning motivation. Brophy (1998) further pointed out that instructors create a learning environment to improve student confidence in learning, while also paying attention to the internal and external motives of students and inspiring their desire for learning in order to meet the needs of students; this is the strategy used to induce motivation. When inspiring learning motivation in students, instructors can select teaching activities that are suitable for the students, these activities must be related to the current experiences and needs of the students. Providing students with a choice in their learning method can improve their learning motivation (McLean, 2003). The perspective above complies with the spirit of Gardner's MI theory by emphasizing individual differences and maintaining that, through appropriate education and encouragement, along with the appropriate design and arrangement of learning activities, those differences become factors that can determine intelligence levels. Instructors should identify a learner's strengths in terms of intelligence and use diverse teaching methods to improve the weaker areas of his/her intelligence (Armstrong, 2017; Gardner, 1999, 2006).

The past literature has shown that implementing MI theories in teaching natural sciences can improve the learning motivation, learning achievement, and learning attitude of junior high and elementary school students (Hsu, 2003; Tsai, 2002; Lin, 2001; Lei, 2001; Cutshall, 2003; Ozdemir, Guneysu, & Tekkaya, 2006; Abdi, Laee, & Ahmadyan, 2013; Pratiwi, Rochintaniawati, & Agustin, 2018), but that it results in no significant difference in learning achievement and attitude (Ma, 2002; Köksal & Yel, 2007). However, the subjects of MI theory studies in Taiwan were mostly elementary school students. There was little exploration of biology courses taken by junior high students who were facing greater academic pressures from the education system. The primary subjects of learning are students, and it is important to regain ownership of the theme of learning to increase their learning motivation and acquire knowledge. Therefore, this study explored the effect of MI theory in the biology education of junior high students in order to serve as a reference for education and further research.

Research Questions

Based on the purposes of this study, two research questions were proposed as follows:

1. Is there a significant difference between the effects of teaching based on MI and those of traditional lectures on the science learning motivation of junior high students?

2. Is there a significant difference between the effects of teaching based on MI and those of traditional lectures on the learning achievement of junior high students?

Method

The research participants of this quasi-experimental research study were 75 7th grade junior high students from two classes: 39 participants in the experimental group took part in a six-week biology course based on MI, while 36 participants in the control group took part in a traditional lecture-based course. Before and after their courses, both groups of students were given pre- and post- tests in the form of science learning motivation questionnaires and learning achievement tests. The research instruments that were used in this study included a science learning motivation questionnaire (students' motivation toward science learning [SMTSL]) and a learning achievement test. The SMTSL questionnaire was developed by Tuan, Chin, and Shieh (2005) with a sample size of 1,407 participants and Cronbach α of 0.89, and consists of five-point Likert scales for self-efficacy, active learning strategies, science learning value, performance goal, achievement goal, and learning environment stimulation. In this study, the SMTSL questionnaire showed a Cronbach α of 0.86 for the pre-test and a Cronbach α of 0.90 for the post-test. The learning achievement test included biology test scores from the first and second biology sectional exams, the contents were designed and reviewed by experts with master's degrees in science education and biology, and the first test was a pre-test that was administrated before the participants took the classes, so as to exclude instructor subjectivity. Therefore, the test scores were considered as a representation of learning achievement.

The experimental group of this study underwent education based on MI theory that utilized materials, such as "Understanding the Structures and Functions of Plants" and "Animal Digestion". The researchers referenced related literature (Lin, 2008; Armstrong, 2017; Gardner, 2006, 2011) to design the teaching materials based on MI theory, which were then given to experts with science education doctorates, science education master's degrees, master's degrees in biology, and other specialists for review. The materials were designed according to the following principles:

1. Student-centric course design where students are the protagonists of education while instructors provide assistance in learning;

2. Activities should utilize as many intelligences as possible to comply with the principle of respecting individual strengths of MI, so that students can come in broad contact with stimulants of all intelligences;

3. Design activities that are diverse and interesting to improve student learning motivation;

4. During the teaching process, instructors should provide many opportunities for students to learn in order to build their confidence and experience with success.

This study utilized MI theory as a teaching tool when dealing with course content. Multiple teaching methods were utilized to incorporate classroom methods to stimulate different intelligences, splitting students into groups for course activities and using teaching activities that incorporated stage performances, role playing, drawing, hands-on activity, study sheets, and other content to increase the range and number of stimulants in the learning environment, so that each student could select his/her advantageous intelligence and use his/her preferred method to participate in the course activities. This allowed them to integrate with the teaching scenarios, so that they were no longer passively listening to lectures. This approach was similar to Gardner's (1999) proposal of using MI theory to improve the learning results of students, so that they understand content and methods (Gardner, 2006). Table 1 is a MI activities chart for the structures and functions of plants topic, while Table 2 is a MI activities chart for the animal digestion topic. The control group listened to the traditional educational lectures, in which the instructor was the protagonist who relayed knowledge to students. The education of students was thus passive in nature.

Table 1

MI Activities Chart of Plant Structures and Functions Topic

Intelligence utilized	Activity
Linguistic	Discuss, report, or listen to the reports or descriptions of others.
Logical-mathematical	Categorize the types of plants.
Spatial	Look at images, observe, and draw plant structures.
Bodily-kinesthetic	Walk around campus, observe leaves, and demonstrate the characteristics of plants.
Interpersonal	Discuss with others, cooperate, and give reports.
Intrapersonal	Set goals and reflect on whether they have been achieved.
Naturalist	Walk around campus and observe leaves.

Table 2

MI Activities Chart of Animal Digestion Topic

Intelligence utilized	Activity
Linguistic	Discuss, report, or listen to the reports or descriptions of others.
Logical-mathematical	Think about problems.
Spatial	Look at images and videos, observe, and draw the structures of digestive organs.
Bodily-kinesthetic	Arrange digestive organs into their correct positions.
Interpersonal	Discuss with others, cooperate, and give reports.
Intrapersonal	Set goals and reflect on whether they have been achieved.
Naturalist	Observe and identify digestive structures.

The quantitative data in this study are processed and analyzed by using the statistical package for social science (SPSS). An analysis of covariance (ANCOVA) was performed to analyze the science learning motivation questionnaire results, while a t-test was performed to analyze the learning achievement test results, with the level of significance being set to $\alpha = 0.05$, in order to analyze the effects on the science learning motivation and learning achievement of the two groups after learning. This study conducted analysis, induction, and integration of qualitative data including student study sheets.

Results

The Effect of Different Types of Education Instructions on Science Learning Motivation

Tables 3 and 4 show the results of the science learning motivation questionnaire analysis. After the MI-based instructions was implemented, the experimental group showed superior active learning strategies compared to the control group, with the difference being significant ($p = 0.00 < 0.05$). The science learning value of the experimental group were also superior to those of the control group, with the difference being significant ($p = 0.04 < 0.05$). The science learning motivation of the experimental group was also stronger than that of the control group, with the difference being statistically significant ($p = 0.02 < 0.05$). In addition, the self-efficacy, active learning strategies, science learning value, achievement goal, learning environment stimulation, and total scale scores of the experimental group all showed greater improvement than those for the control group, signifying that there was a positive increase for most of the learning motivations.

Table 3

Summary of the ANCOVA for the Experimental and Control Groups' Science Learning Motivation

Title of subscale	Source of variation	SS	*df*	MS	*F*	*P*	η^2
Self-efficacy	Group	18.89	1	18.89	1.12	0.29	0.015
	Error	1,211.81	72	16.83			
Active learning strategies	Group	81.93	1	81.93	3.59*	0.00	0.15
	Error	1,447.08	72	20.38			
Science learning value	Group	18.74	1	18.74	4.00*	0.04	0.053
	Error	332.39	72	4.62			
Performance goal	Group	27.82	1	27.82	3.07	0.08	0.041
	Error	652.19	72	9.06			
Achievement goal	Group	10.24	1	10.24	1.63	0.21	0.022
	Error	453.01	72	6.29			
Learning environment stimulation	Group	37.67	1	37.67	2.40	0.13	0.032
	Error	1,131.81	72	15.72			
Total scale	Group	734.19	1	734.19	4.94*	0.02	0.068
	Error	10,561.77	72	148.76			

Note. * $p < 0.05$.

Table 4

Mean (M), Standard Deviation (SD), and Adjusted Mean (AdjM) Results for the Experimental and Control Groups' Science Learning Motivations

Title of subscale	The experimental group ($N = 39$)			The control group ($N = 36$)		
	M	*SD*	*AdjM*	*M*	*SD*	*AdjM*
Self-efficacy	28.31	4.24	28.07	26.81	5.83	27.06
Active learning strategies	34.16	3.08	34.06	31.97	3.18	31.96
Science learning value	21.51	2.25	21.61	20.72	3.03	20.61
Performance goal	14.92	3.83	14.91	16.11	3.21	16.12
Achievement goal	19.41	2.51	19.48	18.80	2.71	18.73
Learning environment stimulation	23.21	3.58	23.55	22.47	4.99	22.10
Total scale	141.88	12.89	141.85	136.40	13.02	136.41

When the researchers analyzed the reason for the positive increases in the science learning motivation of the experimental group students, the students made statements, such as "The teacher made biology more vibrant and interesting", "The teacher had confidence in me", "The teacher kept encouraging us", "Biology class is fun and interesting", and "We were able to perform on stage in the biology class".

S02: Biology is a fun subject, plus the class was interesting and we performed on stage, while I did well on each test, so I like biology. (This student scored 100 on the test and is a high achieving student.)

S04: I only studied biology, because the teacher had confidence in me and the class was more fun. (This student showed a 15-point improvement on the test and is a low achieving student.)

S20: The biology teacher in the class was more interesting and fun, so I started paying more attention in class, so that I only wanted to study biology. (This student showed a 19-point improvement on the test and is a low achieving student.)

S29: The teacher helped us like biology by making the deep material more vibrant and interesting. The biology teacher also kept encouraging us, so I enjoyed the subject. (This student is a low achieving student.)

Education with meaning requires analysis of student interactions with new information to aggressively construct educational content with individual meaning. The new information interpreted by the individual is then integrated into existing knowledge that has been understood (Raffini, 1996). Pintrich and Schunk (1996) pointed out that if students feel the value and meaning of learning goals, they actively participate in learning missions and use active learning strategies to integrate previous experiences and new experiences. Raffini (1996) pointed out that providing students with the choice to use any method to complete their work inspires student to participate actively in learning and encourages student achievement, this can improve their learning motivation. Therefore, the implementation of MI-based instruction can improve science learning motivation and also improve the learning attitudes of low achieving students, including the participation in and preferences of students towards biology courses.

The Effect of Different Types of Education Instructions on Learning Achievement

Table 5 shows the results of the learning achievement analysis. The implementation of MI-based instruction did not lead to a significant difference in learning achievement results between the experimental and control groups (p = 0.06 > 0.05). However, Table 6 shows a school-wide ranking of biology learning achievements and that the experimental group improved from 5th place to 1st in the school.

Table 5

The t-Test for the Learning Achievement of the Experimental and Control Groups

Tests	Groups	*M*	*SD*	*t*	*P*	*d*
First science sectional exam	The experimental group	75.59	17.86	0.49	0.48	0.13
	The control group	71.50	18.23			
Second science sectional exam	The experimental group	79.21	19.50	3.48	0.06	0.81
	The control group	78.00	15.11			

Note. $^{*}p < 0.05$.

Table 6

School-Wide Ranking of the Biology Learning Achievement of the Experimental and Control Groups

Test	The experimental group ranking	The control group ranking
First sectional exam	5	7
Second sectional exam (after MI-based instruction implemented with experimental group)	1	3
Total of 7th grade classes in the school	15	15

The researchers analyzed the reason for the learning achievement improvements of the students in the experimental group, and out of all the tested subjects (language, English, math, social studies, and biology), only the subject of biology received praise from the students: “I am highly interested in biology”, “I like taking biology classes", "Biology is fun, joyful, and interesting", and "It feels nice to take biology classes".

> S10: Because biology is fun and I enjoy the class, I only like biology. (This student showed a 20-point improvement on the test and is a mid-achieving student.)
>
> S27: I only want to study biology, because I understand what the teacher is talking about. (This student showed a 14-point improvement on the test and is a low achieving student.)
>
> S36: I like taking biology, because the teacher's class is special and interesting, so I focus very hard in the biology class.
>
> S38: The teacher's class is pretty fun so I enjoy it very much, which is why I only want to study biology. (This student showed a 14-point improvement on the test and is a low achieving student.)
>
> S39: I only want to study biology, because I think the subject is very fun. (This student showed a 33-point improvement on the test and is a low achieving student.)

When the MI-based instruction was implemented, the students were able to select their intelligence strengths to learn and participate in the course content according to their own preferences. They obtained a sense of achievement in the learning process and felt that the class was fun, the subject was easier to study, they displayed interest in the subject, and they only wanted to take biology, because they understood the course content. This improved their learning achievement, indicating that learning motivation is the factor that impacts learning achievement (Brophy, 1998) to give students a positive learning attitude towards biology class.

Conclusions and Recommendations

This study investigated 7th grade junior high students and their learning of biology. The results of the study show that, after implementing multiple intelligences-based teaching, the students in the experimental group significantly outperformed those in the control group in terms of science learning motivation, science learning value, and active learning strategies; the self-efficacy, active learning strategies, science learning value, achievement goal, learning environment stimulation, and total scale scores of the experimental group all improved. These results show that there was a positive increase for most learning motivations; the learning attitudes of students with low learning achievement were improved, so that they had positive learning attitudes toward biology and improved student participation in and preference for biology courses.

MI theory emphasizes individual differences and the search for suitable methods to help students learn. The following were key points in designing and implementing the teaching activities of the researchers:

1. Design student-centric courses. Students are the protagonists in education while instructors are there to assist them;

2. Activities should include as many intelligences as possible to comply with the MI theory principle of respecting individual differences. Give each student a sense of participation and broad contact with stimulants of all types of intelligence;

3. Design activities that are diverse and interesting to promote learning motivation in students;

4. During the learning process, instructors should give students the opportunity to learn by caring for the students and encouraging them with a gentle tone. Giving students confidence and experience of success can build good teacher-student interactions and increase science learning motivation in students.

The utilization of MI-based instruction in the biology education of 7th grade junior high students in this study had positive effects and can serve as a reference in future education and research efforts.

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