

The Implementation of Multiple Intelligence in (Science) Classroom: From Empirical Into Critical

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Abstract. Many educational researches have been done in the Multiple Intelligence (MI) perspective, both in quantitative and qualitative, and even action research. All of them offered a positive contribution to educational view. However, many researches have also found weaknesses that still need improvement both in terms of accuracy of the basic theory based on Gardner's theory, methodologies, instruments, as well as an understanding of MI theory itself. This study is part of the literature study with resources from some relevant references, authors' knowledge, observation results, and authors' experiences. Therefore, this paper describes how MI theory was used in the previous study, analyzed, and even criticized, as well as the perception of the authors. In bare, this paper analyzes some empirical studies in Multiple Intelligence, the interpretive perspective, MI in critical view, and the own-personal view about MI theory. In addition, the authors depict the lesson from implementation of the theory in school (Taiwan) in terms of compliance with the criteria of intelligence. The implementation MI theory in science domain is also exemplified.

Keywords: *Multiple Intelligences, empirical, critical, Taiwan, science classroom.*

Introduction

Previously, all psychologists assumed that scientific thought and the career of science represented the peak of human cognitive development because all of them used an egocentric thinking by Piaget and his colleagues. But, Howard Gardner aborted these

assumptions. He proposed Multiple Intelligences (MI) theory in 1983. According to him, an intelligence refers to a biopsychological potential of our species to process certain kinds of information in certain kinds of ways. The intelligence itself is not a content, but it is geared to specific contents and certain product (Gardner, 1983). Gardner also proposed the existence of seven distinct intelligences: linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, intrapersonal, and interpersonal.

Students may use their logical-mathematical intelligence to think through a situation; their visual-spatial intelligence to visualize it; their interpersonal intelligence to perform their emphatic; intra-personal to immerse themselves through an experiential learning process, the musical-rhythmic and verbal-linguistic intelligences may come into play as students use music to depict the tone of problem and discuss, write, listen, and read about related issues. In 1999, Gardner revised his model, combining intrapersonal and interpersonal into a single intelligence (personal intelligence) and adding another intelligence: naturalistic intelligence, the empathy for, and categorization of natural things. In addition, the students should also use their naturalist intelligence to classify and to organize objects in their natural surroundings. An additional intelligence, called existential intelligence, the ability to see oneself “with respect to the further reaches of the total immersion in a work of art” also proposed by Gardner (1999).

Five years later, Gardner (2004) proposed two additional intelligences, the “mental searchlight intelligence” and the “laser intelligence”. He claimed that people with high IQ test scores have a mental searchlight, which permits them to scan wide spaces in an efficient way, thus permitting them to run society smoothly, whereas specialists in the arts, sciences, and trades are more likely to have a laser intelligence that permits them to generate the advances of society. Gardner has not yet theorized a connection between laser, mental searchlight, and his eight other intelligences. If he did so, he will face the problem of reconciling the use of standard IQ scores as the basis for the mental searchlight intelligence while arguing that MI theory reveals the standard IQ measure to be a flawed concept (Gardner, 1983, 1999).

Gardner in light of three decades of research and reflection summarized the educational implications of MI theory quite sharply and called elevator speech. An educator believed of the relevance of MI theory should *individualize* and *pluralize* (Gardner, 2011). By individualizing, the educator should know as much as possible about the intelligences profile of each student for whom he/she has responsibility; and, to the extent possible, the educator should teach and assess in ways that bring out that child’s capacity. By pluralizing, the educator should decide on which topics, concepts, or ideas are of greatest importance, and should then present them in a variety of ways. Pluralization achieves two important goals: when a topic is taught in multiple ways, one reaches more students. In addition, the multiple modes of delivery convey what it means to understand something well. When one has a thorough understanding of a topic, one can typically think of it in several ways, thereby making use of one’s multiple intelligences. Conversely, if one

is restricted to a single mode of conceptualization and presentation, one's own understanding (whether teacher or student) is likely to be tenuous.

On its way from 1983 until today, MI theory has undergone many developments and even criticism. Broad implementation, including in the field of education and practical learning makes this theory be interesting to apply in practice learning. However, there also a lot of studies that explore and seek advantages and disadvantages of the theory both quantitative and qualitative review. Therefore, this paper describes and shows how this theory used in the study, analyzed, and even criticized, as well as the perception of the authors is described. In simple, this paper analyzes empirical study in Multiple Intelligence, the interpretive perspective of MI, MI in critical view, and authors' perspective about MI. Moreover, the authors analyze some papers related to a previous MI study and the implementation of the MI theory in the school in terms of compliance with the criteria of intelligence of Gardner. Finally, the implementation MI theory in science classrooms is illustrated.

Methodology

This study has been undertaken as a systematic literature review based on some evidences regarding previous MI' studies and following by the school and classroom observation in Binmao Elementary School and Binmao Junior High School in Taitung County, Taiwan. The review process comprises five phases: framing questions for a review, identifying relevant work, assessing the quality of studies, summarizing the evidence, and interpreting the findings (Khan et al., 2003). Then, the discussion is divided into three parts: empirical study of MI, MI in practice, and MI in critical reviews. Finally, the authors elaborate all the findings into authors' perception and create the final report.

Results and Discussion

Empirical Research in Multiple Intelligence Theory

Empirical research is a way of gaining knowledge by means of direct and indirect observation or experience. According to Gardner (1993), it is possible to do quantitative research on MI perspective. He said that there were eight criteria for an intelligence and two of them are: support from experimental psychological tasks and support from psychometric findings. It means we can conduct experimental research with the subject in people (teacher and student) as part of psychometric measurement. Table 1 describes some empirical research of MI perspective and complemented with an analysis of the author. Most studies were conducted using a quasi-experimental design and true experiments from various disciplines. Some of these studies also provide some evidences that strengthen the theory to be implemented in the classroom and the school.

Table 1
Some Empirical Studies about MI Theory

Subject	Results	Authors' Analysis
Mathematics (Isik & Kamuran, 2009)	Cooperative learning method supported by MI theory (CLMI) has been more effective than traditional methods. CLMI method increases academic achievement in its long-term use.	The authors suggested that MI can be applied in different subjects, i.e. mathematics and science and can be integrated into several learning methods: CL, PBL, reading strategies, learning style, etc.).
Science and Technology Book (Kılıç & Sert, 2015)	The book was suitable for verbal, logical and visual intelligence and wasn't sufficient according to interpersonal, intrapersonal, bodily kinesthetic and naturalistic intelligence. But no importance was given to musical intelligence.	Subjects should be prepared suitably for the intelligence level of the students. There should definitely be activities for musical intelligence as well as visual intelligence.
Junior high school (Bordei, 2014)	MI theory can be best implemented in schools within the extra-curricular activities or at primary school level (aged 10 to 14), with some obstacles: a big number of students, lack of school resources, overloaded curriculum, national standard of evaluations, parents' lack of education, teachers' lack of motivation.	MI theory is a way to approach the didactic activity with great advantages, for the students' level – by increasing their motivation and academic results and teachers' – by developing cooperation with parents' and contributing an authentic school community.
ESL (Ahanbor & Sadighi, 2014)	All male and female students had VL, LM, VS, BK, MR, Inter, and Intra as well as NAT intelligence. A significant difference was noticed between males and females with regard to Intra. Statistically significant relationship was observed between male and female students' learning styles and their MI.	The author proved the relationship between Multiple Intelligences, Learning Styles, and Gender
Media: Whiteboard (Chen, Chiang, & Lin, 2013)	The learning achievement of the students taught using interactive whiteboards was greater than that of the students taught using lectures. The interactive whiteboards achieved good learning effects, even for the students with weak LM intelligence.	The study showed the role of multimedia (whiteboard) from the MI perspective in improving learning achievement

Subject	Results	Authors' Analysis
Sport (Kutz, Dyer, & Campbell, 2013)	BK was significantly higher than the other intelligences. Intra intelligence was significantly higher than the remaining seven intelligences. VL intelligence was significantly lower than the other eight intelligences. The rank of intelligences is: BK, Intra, LM, Inter, VS, MR, EX, NAT, VL.	The author proved that BK as a dominant intelligence in sport view.
School leaders (Piaw, Ishak, Yaacob, Said, Pee, & Kadir, 2014)	VL, LM, and Inter were significantly predicted of motivation; Inter alone predicted of communication skill; Intra, NAT, MR, and VS were significantly predicted for creativity; LM, Inter, VL, Intra, and NAT were significantly predicted of curriculum management skill.	The component of MI theory support and predict work motivation, communication, creativity, and management skills of school leaders.

Note: MI = Multiple Intelligences, VL = Verbal-linguistic, LM = logical-mathematical, Inter = interpersonal, Intra = intra-personal, NAT = naturalistic, MR = musical-rhythmic, VS = visual-spatial, BK = bodily-kinesthetic, EX = existential

The Limitation of Empirical Study of MI Theory

Based on the writer's analysis of some papers that discussed, there are at least five limitations of educational research in the perspective of MI Theory, as follows:

- 1) The problem with the instruments, especially questionnaire and inventory, even though the reliability of the instrument is high (i.e. *Cronbach's* α). Ahanbor & Sadighi (2014) gained 0.873 and 0.80 on their instrument, however, this result didn't contribute to answer the research questions. In contrast, Tirri & Nokelainen (2008) succeed to test the internal consistency of the MIPQ III.
- 2) Some researchers in quantitative research used experimental design, but some of them seem difficult to control everything, so the impression is a highly gap between the experimental and the control group. In other words, the contribution of treatment in the experimental group to be biased by a variable that is difficult to control. Some others found it difficult to control everything in both groups, see Tai (2014).
- 3) Several papers used standardized inventory, but the authors didn't consider the condition of instrument after performing the translation. For instance, Teele Inventory for Multiple Intelligence (TIMI) is an instrument in English version, so if we want to use this instrument, then we must consider that the new version in a different language has the same reliability and validity, see Ahanbor & Sadighi (2014).
- 4) Some papers indicated the intelligence means the total intelligences in quantitative research, (i.e. Ahanbor & Sadighi, 2014). It is completely differs to the theory, which

is Gardner set eight criteria for an intelligence to be identified and to stand-alone (Gardner, 1993).

- 5) The results of an empirical study sometime depend on the discipline studied. For example, research on ESL is predictable that the linguistic become the dominant intelligence. On the other hand, if the research is in science and sport, then the dominant intelligence is logical-mathematics and bodily-kinesthetics respectively. It means there are no significant new findings from empirical studies.

The Interpretive Perspective of MI

MI in Practices

Interpretative analysis is an approach to psychological qualitative research that gives more priority to understanding of phenomenon, in a given context, and makes sense of a given phenomenon. Turning to interpretive perspective, MI theory must be understood has the specific criteria for an intelligence. Gardner (1993) set eight criteria of multiple intelligence:

“(a) An identifiable core operations; (b) evolutionary history and plausibility; (c) recognizable end-states and distinctive developmental trajectory; (d) existence of savants, prodigies and other individuals distinguished by presence or absence of specific abilities; (e) potential isolation by brain damage; (f) supported from experimental psychological tasks; (g) support from psychometric finding; and (h) susceptibility to encoding in a symbol system”.

When employed in the teaching-learning process, MI theory can not be separated from the three-dimensional learning pedagogy, as shown in Figure 1. The components of the teaching learning process consist of objective, learning process, and assessment.

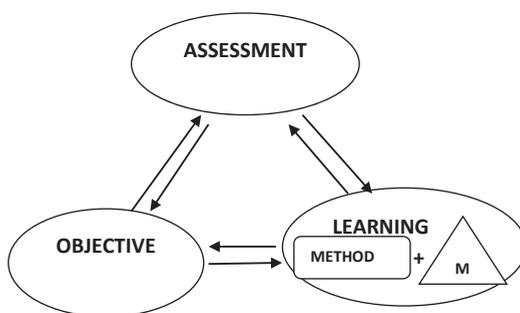


Fig. 1. Implementation of MI theory in teaching-learning process

In terms of learning process, we can combine or integrate MI by various technical and procedural with another method, strategy, or model of learning. For instance, cooperative learning method (Isik & Kamuran, 2009), problem based learning (Fogarty, 1997) can combine and integrate together with MI theory. In addition, the information about

how to assess and why we assess of MI student were very technical described by Hoerr (2001). Assessments show how a problem was solved and the points of progress along the learning-route and provide the student with information about personal achievement. For students, assessment provides feedback on their performance and increase their personal intelligence. For student's parents, assessment provide information on how their children are progressing. For educators, assessment helps us know what a student has mastered and what still needs more attention. For the larger community, assessment generates confidence that students are prepared to succeed in society. For the largest educational institution, assessments indicate their responsibilities and ensure confidence in student's learning and preparation for higher learning.

Lessons learned from MI school program in the US

One of the familiar school with MI program is *the Key Learning Community* in Indianapolis, US. The school was the first school in the world to base its approach to the theory of MI by coming up on Frames of Mind was opened in 1987 whom Christine Kunkel was the key's principal (Kunkel, 2007). The implementation of MI in someschools in the US gives a positive impact to student achievement. The most important things can we catch from MI school program in US can be summarized as shown as Figure 2.

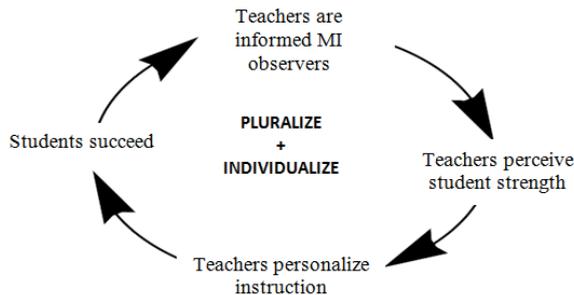


Fig. 2. A cycle of success of the US Elementary School (modified from Campbell & Campbell, 1999).

Lesson From Several Schools in Taiwan

In this part, we describe the lesson from the two schools in Taiwan: Binmao Elementary School and Binmao Junior High School in Taitung County, which implemented MI theory in their school. Both of the two schools have integrated the theories of MI in their learning process. For instance, we can check from Table 2 and Table 3 that give an example how MI theory has been implemented.

Based on Table 2 and Table 3, the implementation of learning process be held both inside and outside the classroom by applying MI theory. By individualizing, teachers know as much as possible about the intelligences profile of each student for whom they have responsibility for each individual is unique in each of his or her processing skills

Table 2

One of The School Activities as an Implementation of MI Theory in Binmao Elementary School

Activities	Kind of Intelligences				
	Logical-Mathematics	Musical	Linguistic	Intra-personal	Naturalist
Conducting a specific ceremony, namely: Pakikazala, every Sept 28 th in order to how to respect to the teacher.	Some science and mathematics games held at this event	The activity is accompanied by special music from the indigenous	The activity encourages students' abilities in communication skill	Through this activity, the students will also grow in self-esteem, self-concept, and self-confidence to dare to appear	Some students use material taken directly from nature, e. g. dance accessories

Table 3

One of The School Activities as an Implementation of MI Theory in Binmao Junior High School

Activities	Kind of Intelligences				
	Linguistic	Bodily-kinesthetic	Spatial	Interpersonal	Naturalist
Outdoor activity in order to close students with local culture, the atmosphere is related to the story of tribes, and also nature activities like mountain hiking	The story of tribes makes the students learn to be-rose, literacy, essays, and stories of the past	Student performance requires body work and maneuvers part of a bodily-kinesthetic	Students will be sensitive into space and time	Students interacting with each other by doing scouting, help each other and complement in the task	Since the outdoor activity so many students learn about the nature around

(Teele, 2000). In addition, by pluralizing, teachers succeed to decide on which topics, concepts, or ideas are of greatest importance and then presenting them in a variety ways in school. The principals have to equip students to be independent, how they will live in the community, and how later when they study it further in the level. In addition, it takes careful planning curriculum in applying MI in the classroom and outside the classroom, as was done by both schools. In this part, different teaching methods are required to encourage students to learn from their dominant ways of processing and to build on previous successful experiences (Teele, 2000).

The Implementation of Multiple Intelligence in Science Classroom

The implementation of MI theory in science classroom can be reviewed from formal and informal science education. In formal terms, the activities of science classroom can be analyzed into the types of intelligence. However, informal science is related to science centers, museums, cultural centers, zoos, and national science park (Suprpto & Pai, 2015). Specifically, the implementation of MI theory in relating to formal and informal science learning process from both schools (Binmao Elementary School and Binmao Junior High School, Taiwan) can be described as follows.

Observing the nature

- a) Logical-mathematical: students learn life science, science, treeage, leaf diameter, flowers, cambium, pollination, and and the various dimensions of the tree.
- b) Bodily-kinesthetic: students illustrate how aboriginal people carry out something to the mountain.
- c) Intra-personal: this intelligence will appear on the students' self-awareness that the universe was created by God and we should be grateful.
- d) Naturalist: students make some observations about the oldest trees in the mountain.

Developing a science library

- a) Logical-Mathematical: the program raises students' achievement and the abilities of math and science.
- b) Linguistic: the program allows students to love reading and cultural literacy for school supply.

Triggering potential sports: basketball, baseball, and gymnastics

- a) Logical Mathematics: students learn how to calculate the the points of the game (basketball and softball), how many points to throw two digits, three digits, and so on. It also studied the logic of how a strategy to defeat an opponent in a match.
- b) Bodily kinesthetic: the activities familiarize students in healthy living through exercises and scored a formidable athlete.
- c) Intra-personal: the school plan creates student become a national athlete, so improves their confidence when participate in some tournaments, events, and contests.
- d) Visual: this activity also trains students insight into the space-related field or stadium, for example: the size of the field, running track, length, etc.

The school conducts an art-craft course, collaborating with an expert

- a) Spatial: in art-crafts, in art-crafts, creative students use their spatial intelligence to form an artistic artwork.
- b) Bodily Kinesthetics: students use the power of their hands and foot muscles to produce work through activities carve or weld.

- c) Intra-personal: students will be aware of themselves to develop their skills and their imagination in designing a work of art.

In fact, the implementation of multiple intelligence in the science classroom integrates the existence of science, technology and/or engineering, mathematics (STEM), and arts. The technology develops very quickly in the creative society and the new technological solutions are increasingly adapted in practice activities (Pečiuliauskienė & Dagys, 2016). On the other hand, society is undergoing constant change of generations. This, new generation is currently learning at school. In-lined with Suprpto (2016) who stated that there is a close relationship between the dimensions of STEM education (especially in junior high) as the whole domain in science education. Moreover, the program allows students to love reading, cultural literacy, and science communication skills for school supply. Therefore, the role of teachers for applying communication skills is important for transferring the skills (Suprpto & Ku, 2016).

Multiple Intelligence in Critical View

In critical perspective, the researchers or the teachers need to develop a systematic understanding of the conditions which shape, limit, and determine action so that these constraints can be taken into account. It might also be described as 'action research'. Action research was the goal of critical theory in education. In terms of method, a self-reflective spiral of cycles of planning, acting, observing and reflecting is central to the action research approach (Carr & Kemmis, 1986). So, from the critical perspective, we can give analysis about the pros and the cons a theory.

The Pros and Cons of MI Theory

Considering the pros of MI theory, the authors summarized into 5 points: (1) MI theory able to present the possibility of integration implemented by the method or specific learning strategies, for instance: CL, PBL, reading strategies, learning style, etc.; (2) there are many kinds of MI toolbox (see Lazear, 1999); (3) MI can be applied in different subjects (science, language, social studies, music, etc.) as described in Table 1 above; (4) the closeness between 'biopsychology' in term of 'Multiple Intelligences' with the educational theory in practices; and (5) the schools that implemented MI theory perform in student with the highest score in achieving. It means there is a positive correlation between this theory with learning outcomes.

Turning to the cons of MI theory also summarized into several points. *First*, some critical reviewers of MI theory argued that there was little empirical evidence to support it. There have been no published studies that offer evidence of the validity of the multiple intelligences. MI theory has no empirical validating data (Sternberg, 1994; Waterhouse, 2006). *Second*, the same review presented evidence to demonstrate that cognitive neuroscience research did not support the theory of multiple intelligences. *Third*, because Gardner claimed that the intelligences are innate potentialities related to a general con-

tent area, MI theory lacks a rationale for the phylogenetic emerging of the intelligences. *Four*, the MI theory has often been confused with learning styles. Gardner has denied that multiple intelligences are learning styles and agrees that the idea of learning styles is incoherent and lacking in empirical evidence.

Some Commentaries about MI Theory

Even though, Gardner & Connell (2000) conceded that there was “little hard evidence for MI theory”, the other researchers give their defense of this theory. Chen (2004) argued that a theory is not necessarily valuable because it is supported by the result of empirical tests, with 5 arguments: (1) Empirical evidence for MI is not necessary, (2) Intelligence is not a tangible object, (3) MI are novel constructs requiring new measures, (4) MI theory has been validated by its classroom applications, and (5) MI theory profiles cognitive skills better than do IQ subtest.

None of Chen’s five arguments can serve to exempt MI theory from the need for validating empirical data. MI theories should not be tested by experimental methods because they are intangible theorized constructs, but, if their components are specified, they can be tested. MI may require new measures, but new measures depend on clearly defined components for the intelligences, and Gardner stated that he will not define such components (Gardner, 2004). It means MI theory cannot be validated through applied research because such research assumes the validity of the intelligences.

Authors’ Perspective

Personally, we believe in MI Theory. If we use interpretive paradigm, then MI theory gives us opportunity to understand about the profile of a human being in term of their ability in eight-abilities: linguistic, musical, logical-mathematics, spatial, interpersonal, intrapersonal, bodily-kinesthetic, and naturalistic. In contrast, some of the researchers who only use positivism approach, they doubt about MI theory. They claim that it has lack of evidence so maybe this theory is the lack of a scientific theory. But, nowadays a lot of researchers are conducting the research by integrating MI theory in practice. For instance, the integrating of MI and Cooperative Learning (CLMI), MI with Problem Based Learning (PBLMI), MI with learning style (LSMI), and so on. The results of those researches are very overjoy.

Learning method works supported by the multiple intelligence theory are one of the significant steps of meaningful learning. And also, MI theory can effective to increase student achievement. Consequently, some of the se claims can be deciduous and indisputable. Moreover, the positivist paradigm is not one of all, the others are interpretive and critical approach. The last two paradigms support for the existence of MI theory. In addition, many criticisms provide a portion of the balance between the pros and the cons of MI. It means attention to MI increasingly and signify support for this theory. In fact, lately, many journals that focus on research on MI theory either quantitative,

qualitative, or mixed-methods. According to the reason above, we strongly support the existence of MI theory.

Conclusions

The authors depict the lesson from implementation of the theory in school (Taiwan) in terms of compliance with the criteria of intelligence by Howard Gardner. The implementation of MI theory in science classrooms is also exemplified. Some empirical researches provide some evidences that strengthen this theory to be implemented in the class associated with teachers and students directly and the school itself. The limitation of empirical study, including: problem with the instruments, the difficulties to control everything, several papers used standardized inventory, but the authors did not consider whether the condition of instrument after performing translation, some of papers indicated the intelligence mean the total intelligences, the results of an empirical study sometime depend on the discipline was studied. In terms of MI in interpretive perspective, the components of the teaching-learning process consists of objective, learning process, and assessment must be noticed. In critical paradigm, as well as others theory, MI theory has the plus and the minus. However, based on our point of view, we agree with MI theory.

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Daugialypio intelekto teorijos taikymas (tikslųjų mokslų) pamokose: nuo empirinio iki kritinio požiūrio

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Santrauka

Remiantis daugialypio intelekto (DI) teorija, yra atlikta daug edukacinių, tiek kiekybinių, tiek kokybinių, tyrimų, taip pat ir veiklos tyrimų. Šie tyrimai yra reikalingi pedagogikos mokslui plėtoti. Tyrimai padėjo nustatyti tobulintinas metodologijas, tyrimo priemonių, taip pat ir pačios daugialypio intelekto teorijos supratimo sritis, pasiremiant Gardnerio teorija. Šiuo straipsniu pristatoma dalis antrinio tyrimo, kuriame remiamasi kitų autorių šaltiniais, pačių straipsnio autorių žiniomis, stebėjimo rezultatais ir patirtimi. Straipsnyje aprašoma, kaip daugialypio intelekto teorija buvo taikoma ankstesniame tyrime, pateikiama jos kritinė analizė ir autorių nuomonė. Apibendrinus, šis straipsnis analizuoja empirinius DI tyrimus, pateikia interpretacinį požiūrį, kritinį požiūrį į DI ir mūsų asmeninį požiūrį į DI teoriją. Be to, straipsnyje autoriai aprašo teorijos įgyvendinimo Taivano mokykloje pamoką, atsižvelgiant į intelekto kriterijų atitiktį. Taip pat yra pateiktas DI teorijos įgyvendinimo pavyzdys tikslųjų mokslų srityje.

Esminiai žodžiai: *daugialypis intelektas, empirinis, kritinis, Taivanas, tikslųjų mokslų pamoka.*

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