Through Project-based Learning to Discuss the Relations of Knowledge Absorptive Capacity, Listening, and Multiple Intelligence Acquisition

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Abstract
This study aimed to investigate the relationships between knowledge absorptive capacity, listening, and multiple intelligences. Data were collected and analyzed from 79 students at Tainan First Boys' School and Anping Junior High School. An experimental design was implemented, dividing participants into two groups: a didactic instruction group and a project-based learning (PBL) group. The findings revealed that students in the PBL group demonstrated significantly higher levels of knowledge absorptive capacity, listening skills, and multiple intelligences compared to those in the didactic instruction group. Furthermore, regression analyses confirmed the following relationships:

1. Knowledge absorptive capacity positively influences multiple intelligence acquisition—students with greater absorptive capacity are more likely to develop multiple intelligences through PBL.
2. Knowledge absorptive capacity enhances listening skills—students with a higher ability to absorb knowledge tend to be more engaged listeners in the classroom.
3. Listening skills facilitate multiple intelligence acquisition—students who actively listen in class are better able to develop multiple intelligences through PBL.
4. Listening serves as a mediating factor between knowledge absorptive capacity and multiple intelligences, reinforcing its crucial role in the learning process.
   These findings provide empirical support for the effectiveness of PBL in fostering knowledge acquisition, active listening, and multiple intelligence development.

Keywords: knowledge absorptive capacity; listening; multiple intelligence; interdisciplinary curriculum; project -based learning

Introduction

Listening plays a crucial role in acquiring multiple intelligences, as it is fundamentally linked to knowledge absorptive capacity. However, in the cyber generation, where students are raised with mobile devices and an overwhelming amount of visual information, listening skills have been increasingly neglected. The dominance of audiovisual content not only fosters addiction to digital media but also diminishes students' natural ability to engage in active listening. Additionally, traditional spoon-feeding instruction (McKay & Kember, 1997) remains prevalent in Taiwan, where educators emphasize rote learning and repeated pen-and-paper tests to enhance students' exam performance. While this approach has been effective in improving test scores, it has simultaneously led to the gradual erosion of other essential competencies, particularly listening skills. Recent studies have shown that this teaching method is detrimental to meaningful learning (Gordon, Dehler, & Welsh, 2014). Neither the cyber learning environment nor conventional educational instruction places sufficient emphasis on developing students' listening abilities.

In response to these challenges, some scholars have advocated for the flipped classroom model, which has influenced many young educators to embrace student-centered learning. One of the most widely adopted student-centered pedagogies at the global level is Project-Based Learning (PBL). Designed to engage students in active learning, PBL encourages them to focus on completing projects through a combination of classroom study and teamwork. Barron et al. (1998) highlighted that PBL enables students to apply acquired knowledge to complete assigned tasks, thereby enhancing their practical skills and problem-solving abilities. The emergence of PBL (Barron et al., 1998) has provided valuable insights for students seeking real-world applications of their knowledge. Through project work, students not only enhance their listening skills and knowledge absorptive capacity but also develop multiple intelligences. Furthermore, PBL instruction facilitates the acquisition of practical knowledge by encouraging active engagement with real-world challenges (Edutopia, 2016).

Despite its benefits, PBL has its challenges, as team discussions often lead to conflicts and disagreements. To address these issues, this study incorporates Social Learning Theory and Promoter Theory. Social Learning Theory emphasizes how environmental and cognitive factors interact to shape learning and behavior, making it a useful framework for understanding team-based learning dynamics. Meanwhile, Promoter Theory suggests that heterogeneous expertise can be leveraged to drive innovation and overcome obstacles in the collaborative learning process.

In this study, PBL participants share their individual knowledge through absorptive capacity and apply listening skills to engage in team brainstorming and intensive discussions. These collaborative efforts enable them to develop feasible solutions for their assigned projects, demonstrating the practical benefits of PBL in fostering both cognitive and social competencies.

Literature Review

Theories

Project-Based Learning (PBL) is a student-centered pedagogy where students gain practical knowledge by actively exploring real-world challenges (Edutopia, 2016). According to Barron et al. (1998), PBL encourages students to complete assigned tasks by participating in specific activities or applying the knowledge they have acquired. This process aims to cultivate a variety of capabilities, including **designing, decision-making, autonomy, presentation skills**, and the ability to develop **real products** (Thomas, Mergendoller, & Michaelson, 1999). Blumenfeld et al. (1991) emphasized that the primary goal of PBL in schools is to help students acquire both intellectual knowledge and practical competencies during the process of completing assignments. In line with this, Maros, Korenkova, Fila, Levicky, and Schoberova (2023) confirmed the effectiveness of teaching **economics through Project-Based Learning**. The growing prevalence of PBL has sparked significant discussions about its role and impact on education (Almulla, 2020). While working in teams to complete projects, conflicts and disagreements are inevitable. To address these challenges, **Social Learning Theory** and **Promoter Theory** offer potential solutions. Social Learning Theory focuses on the continuous reciprocal interaction among **cognitive, behavioral, and environmental factors** and explores the connections between the **behaviors, attitudes, and emotional responses** of individuals (Bandura, 1977).

Promoter Theory consists of four types of promoters: **power promoters**, **expert promoters**, **process promoters**, and **relationship promoters**. **Power promoters** influence through hierarchical authority, while **expert promoters** contribute specialized knowledge (Witte, 1977). **Process promoters** focus on organizational expertise (Hauschildt, 1999), and **relationship promoters** engage in the integration of internal and external resources (Gemunden & Walter, 1995). In this research, **Project-Based Learning (PBL)** offers students increased opportunities to collaborate with peers. **Social Learning Theory** helps participants understand their teammates' **cognitive processes**, **attitudes**, and **emotional responses**. On the other hand, **Promoter Theory** supports team leaders in interdisciplinary teams by guiding them in recruiting the right mix of **heterogeneous specialists**. Through listening to diverse opinions and fostering close collaboration within teams, students not only enhance their **independent thinking** and **problem-solving skills** but also improve their **interpersonal abilities**.

In conclusion, the curricula that combine **Social Learning Theory**, **Promoter Theory**, and **PBL**, as proposed in this study, enable students to effectively improve their **knowledge absorptive capacity**, **listening skills**, and **multiple intelligences** through real-world practice, achieved by completing assigned projects.

Multiple Intelligence Acquisition

Gardner (1999) defined intelligence as a bio-psychological potential to process information and solve problems. Sternberg and Detterman (1986) stated that some scholars are fond of reasoning ability but others prefer examining behavioral functions. Even though Herrnstein and Murray (1994) indicated that intelligence quotient scores are positively correlated with measures of societal socioeconomic success. However, Gardner and Hatch (1989) argued that IQ tests, which rely on paper-and-pen examinations, can only evaluate competences in linguistic and logical-mathematical areas but not the competences related to thinking and learning. Gardner (1987) also stated that the purpose of schooling is to help people reach appropriate vocational goals corresponding with their specific intelligences in verbal-linguistic, musical-rhythmic, logical-mathematical, visual-spatial, bodily-kinesthetic, intrapersonal, interpersonal, and naturalist areas. Barrington (2007) stated that the concept of multiple intelligences, a term originated in the 1980s, has been implemented in some elementary and secondary schools. In addition, the U.S. Department of Labor (1991) suggests that mathematics, reading, writing, speaking, and listening are essential for students to function effectively in the workplace as well as to improve their capabilities in critical thinking, effective communication, and problem solving. Therefore, McKenzie (2005) suggested learners should have multiple intelligences in the competitive cyber age. Currently, the theory of multiple intelligences has been widely adopted by the education communities (Greenberg, Zheng, & Maloy, 2020). Besides, recently educational

policies in Taiwan have drastically changed from score domination to heterogenous literacy cultivation. Thus, we posited here that multiple intelligence is a viable educational perspective. In this study, we borrowed measurements of competitive competence (Wagner, 2010) to assess multiple intelligence. In the following sects, we will have further discussions on listening competence and knowledge absorptive capacity.

Listening Competence

Murphy (2020) argued that listening via the processes of participating, understanding, and connecting with others will guide people to gain success. Listening is the primary communication mode (Barker, Edwards, Gaines, Gladney, & Holley, 1980; Wilt, 1950) and skill (Wolvin & Coakley, 2012) by which to create well-rounded learners (McAnally, 2007) and acts as a crucial element in academic success (Wolvin & Coakley, 2012) and better job performance (Bitterly, Brooks, & Schweitzer, 2017). Volioti and Williamon (2020) depicted that listen competence could support students' learning through trial and error, enhance creative insight, and strengthen self-efficacy. Ramsey and Sohi (1997) argued that listening is categorized into three dimensions: sensing, proceeding, and responding (Comer & Drollinger, 1999), which they suggested are the most important factors in listening. Sensing not only involves hearing the actual words of the speaker, but also includes receiving nonverbal signals like body language and facial expressions (Wolvin & Coakley, 2012). Proceeding includes four stages: understanding, interpreting, evaluating, and remembering messages (Brownell, 1985) and focuses on organizing and transforming information into meaningful messages through simultaneous sequential activities. Finally, responding refers to signals sent and received by both speakers and listeners (Wolvin & Coakley, 2012). When speakers are assured that listeners have received their messages, they will continue to engage in further dialogue. Therefore, sound listening competence has to build on sensing, proceeding and responding. Other studies also indicated that listening is not only serving a key factor in academic success (Zahra & Gerard, 2002) but also has positive connections with students' knowledge absorptive capacity and multiple intelligence acquisition (Wolvin & Coakley, 2012). Therefore, we may reason that students' listening competence may serve as critical element to acquire multiple intelligences.

Knowledge Absorptive Capacity

Knowledge absorptive capacity serves as an important element in the acquisition of multiple intelligences. Cohen and Levinthal (1990) stated that knowledge absorptive capacity is constructed by cognitive, assimilation, and exploitative capacities. Meanwhile, absorptive capacity is depicted as the processes involved in knowledge acquisition, transformation, and exploitation (Zahra & Gerard, 2002). Prior studies have proven that knowledge acquisition helps students expand their new skills and new ideas related to existing knowledge (Davis & Linn, 2000). Shulman (1987) argued that developing content knowledge, identifying concepts, and reshaping teaching approaches maximize comprehensibility for learners. Adenfelt and Lagerström (2006) found that people who exploit their domain knowledge exhibit better performance. Schilling (1998) advocated that people with great absorptive capacity help expand heterogeneous knowledge. Cohen and Levinthal (1990) indicated that absorptive capacity is the most important pillar among innovative capabilities. Zahra and Gerard (2002) suggested that knowledge absorptive capacity, which is accumulated through learning experiences, can be exploited to develop innovative approaches and achieve better performance. Other studies had verified that effect of absorptive capacity and co-creation on innovation performance (Dahlin, Moilanen, & Pesämaa, 2019; Popescu, Ceptureanu, & Alexandru, 2019). Hence, technical capability development strongly relies on knowledge absorptive capacity. A detailed literature review will be discussed in the following pages.

Knowledge acquisition: Knowledge acquisition, which is one aspect of knowledge management, occurs as a result of meeting existing needs as well as identifying and exploiting existing knowledge assets to develop new opportunities (Quinstas, Lefrere, & Jones, 1997). Grant (1996) indicated that knowledge acquisition is an individual activity that can occur in a variety of ways (Almeida, Dokko, & Rosenkopf, 2003) such as through informal or formal collaboration. Acquisition refers to the capability of identifying and acquiring external knowledge in terms of intensity, speed, and direction (Zahra & Gerard, 2002). Thus, knowledge acquisition and application (Huber, 1991) have been regarded as measures of innovation (Fiol, 1996).

Knowledge transformation: Transformation is defined as supplementation of the existing knowledge base (Desforges, 2000). The processes of transformation relies on interactions with heterogeneous experts to develop additional knowledge (Muller & Zenker, 2001). People internalized the gained heterogeneous knowledge from internal and external sources via intensive social interaction (Nonaka & Takeuchi, 1995) to develop collective knowledge (Zahra & Gerard, 2002).

Knowledge application: Knowledge application, which is built based on prior knowledge, involves collecting and making use of information (Bij, Song, & Weggeman, 2003). Arygris and Schon (1978) argued that knowledge application utilizing 'plan-do-check-act' processes improves existing knowledge or leads to the development of innovative concepts. Additionally, Zahra and Gerard (2002) indicated that applying and integrating heterogeneous knowledge may lead to the development of new learning approaches. Thus, new knowledge absorptive capacity

in the context of this study includes *knowledge acquisition, transformation, and knowledge application.* The terms listening and knowledge absorptive capacity (KAC) may serve important factors to gain multiple intelligences.
In this paper, we first intend to explore the connections among knowledge absorptive capacity, listening, and multiple intelligence acquisition through the innovative curricula. Besides, we also plan to examine whether knowledge absorptive capacity, listening, and multiple intelligence acquisition exist differences between project-based learning and spoon-feeding instruction. Accordingly, some research questions were developed as follows:

1. Does Knowledge absorptive capacity have connections with multiple intelligence acquisition?
2. Does Knowledge absorptive capacity have connections with listening?
3. Does listening have connections with multiple intelligence acquisition?
4. Does listening serve as mediating effect between knowledge absorptive capacity and multiple intelligence acquisition?
5. Does project-based learning on students' listening enhancement increase exist difference comparing to spoon-feeding education?
6. Does project-based learning on students' knowledge absorptive capacity increase exist difference comparing to spoon-feeding education?
7. Does project-based learning on students' multiple intelligence acquisition exist difference comparing to spoon-feeding education?

Methodology

Case Introduction

Spoon-feeding education, a lateral teaching approach, focuses on instilling knowledge into students' blank mind. This instruction, which is lacked of opportunities to engage in communications and social interactions either with teachers or students, makes students feel bored in classroom learning. However, project-based learning grasps a great attention currently. It emphasizes learning by doing to complete assigned projects through teamwork. This study adopted project-based learning to teach students. The teacher in senior high school assigned his students to publish a book as their project; however, the other teacher in junior high school demanded her students to make microfilms instead. We expect that project-based learning make students feel comfortable and enjoyable in learning as well as improve their listening, knowledge absorptive capacity and multiple intelligences. The following sections will discuss research framework, operational definition, experimental procedures and samplings.

Curriculum design & teaching processes

The open interdisciplinary curriculum goal intends to support student to gain multiple intelligences as well as interpersonal skills through external resources (see figure 1). In order to achieve the curriculum goal of senior high school in this study, sub goals are required in the following four phases. At theme selection phase, students experienced the three different atmospheres in three types of shops and gave grades through the atmosphere for each shop. Then, choose the most favorable shops in the three different type ones as target shops for interview. At the icebreaker phase, through the process of persuading the participating owners to accept the interview invitations, it trained students to have skills of oral expression, icebreaker, and interpersonal communication. At the social interaction phase, it aims at improvements of listening skills, which includes sensing, proceeding, and responding. Through listening to the experiences of managing those shops, students had in-depth understandings from the owners' thoughts. Therefore, the interview results can be writing materials for the upcoming tour book. At the book writing and compiling phase, the focal points are organizing each article into a book, drawing skills, proofreading, and contacting with the publisher.

In order to finish assigned projects, students have not only to pay great attentions to listen advice from both teachers and teammates, but to complete outstanding contents as well. Students via listen have clear understanding of the gained knowledge. Then, they internalize the knowledge and transfer into individual knowledge. Through application of the existing knowledge on the assigned projects, students via learning by doing obtain practical multiple competencies in the real-world practice. In conclusions, this innovative curriculum is designed to help senior high school students not only enhance absorptive capacity and listening competence, but also gain multiple intelligences and interpersonal skills. The detailed information was shown in table 1.

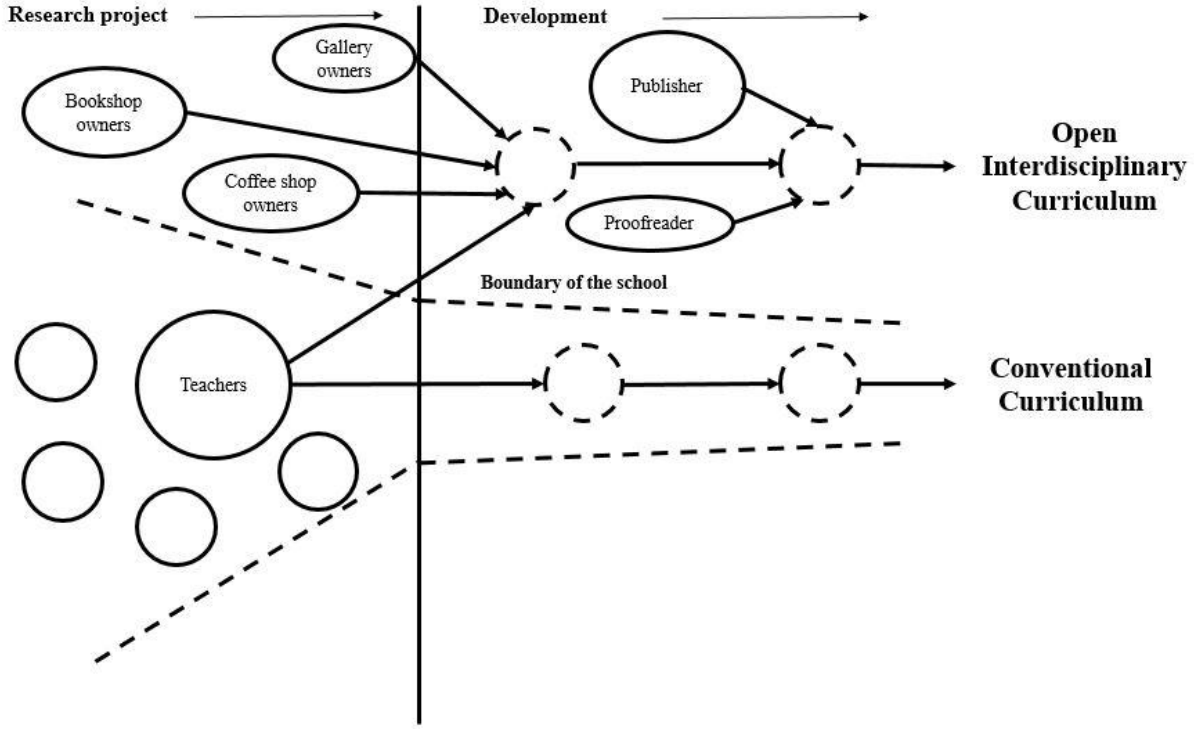

Figure 1. Open interdisciplinary curriculum design

Table 1. Curriculum & teaching design

Phases	**Curriculum goals/** *teaching approaches*
Tour study Phase	**Visiting galleries, bookstores, and coffee shops/** *writing materials* Team information searching Team critical thinking Team Knowledge absorptive capacity Team target shops selection through evaluations.
Icebreaker Phase	**Contacting with the owners of the target shops/** *Icebreaker* Oral expression skills Communication skills Interpersonal skills
Social interaction Phase	**Interviewing those owners/** *Question development &interview* Sensing skills Proceeding skills 0. Responding skills 1. Information analysis 2. Interpersonal skills
Book writing compiling Phase	**Completed a tour book/** *Book compiling* 3. Imagination 4. Cooperation 5. Writing skills 6. Adaptation 7. Problem-solving

Research framework, experimental procedures & samplings

Research framework: We adopted many measurements to examine the research framework. Song, Bij, and Weggeman (2005) developed knowledge application. Additionally, knowledge transferring and acquisition (Lane, Koka, & Pathak, 2006) were modified and developed. Furthermore, we took listening (Comer & Drollinger, 1999) as another measurement. Moreover, multiple intelligence adopted the items in competitive competence (Wagner, 2010) as measurements in this study. Consequently, we combined knowledge acquisition, transformation and application to develop knowledge absorptive capacity construct. Therefore, the entire framework was developed and shown on figure 2. Table 2 lists operational definition with detailed items of questionnaire *Samplings:* The selective sampling were students from Tainan first boy senior high school and Anping junior high school. Twenty-

five students are from Tainan first boy school and fifty-four students are from Anping junior high school. The sample size is seventy-nine students. *Experimental procedures:* Questionnaires were held to measure the changes in each construct in two different time phases and groups and to examine framework. Figure 3 is the pictures of the students participating in different activities through PBL.

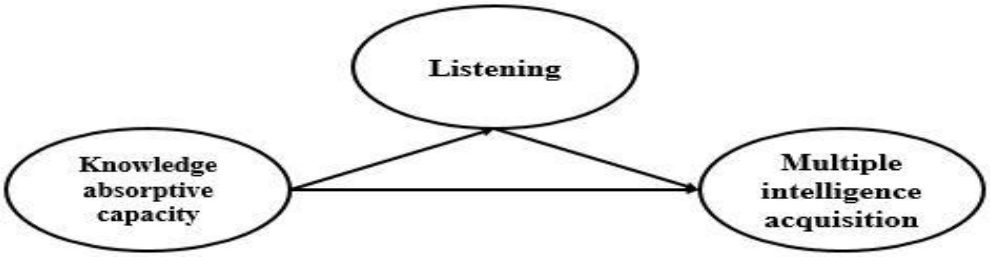

Figure 2. Research framework

Table 2. Operational Definitions of Constructs

Operational Definitions
Sensing: Sources: Comer & Drollinger (2005), seven-point Likert scale
EN 1. I am aware of what my teacher (teammates) imply but do not say.
EN 2. I sense how my teacher (teammates) feels.
EN 3. I listen for more than just the spoken words.
EN 4. I am aware of my teachers' (teammates') unique concerns
EN 5. I sense why my teachers (teammates) feel the way they do.
Processing: Sources: Comer & Drollinger (2005), seven-point Likert scale
RO 1. I assure teachers (teammates) that I will remember what they say by taking notes when appropriate.
RO 2. I keep track of points my teachers (teammates) make.
RO 3. I summarize points of agreement and disagreement when appropriate.
RO 4. I remember important details of previous conversations with my teachers (teammates).
RO 5. When I am not certain of the meaning of my teachers' (teammates') statements, I ask for clarification.
Responding: Sources: Comer & Drollinger (2005)), seven-point Likert scale
ES 1. I assure my teachers (teammates) that I am receptive to their ideas.
ES 2. I show my interest by asking questions or using probes to gain more information and to clarify points.
ES 3. I ask questions that show my understanding of my teachers' (teammates') positions.
ES 4. I show my teachers (teammates) that I am listening by my body language.
Knowledge acquisition: Sources: Lane et al., (2006), seven-point Likert scale
A 1. I gain knowledge easily from classroom lecturing.
A 2. I gain skills in a limited time.
A 3. I gain knowledge through community resources.
Knowledge transformation: Sources: Lane et al., (2006), seven-point Likert scale
T 1. I classify the learned knowledge.
KT 2. I improve my competence of knowledge absorption through constant practices.
T 3. I have the ability to modify the learned knowledge.
Knowledge application.: Sources: Song et al., (2005), seven-point Likert scale
AP 1. I will apply the learned knowledge to the assigned projects.
AP 2. I will use the learned knowledge to solve problems.
AP 3. As soon as I learned new knowledge, I will try to use it to the assigned projects.
AP 4. I review the learned knowledge and make sure it is applied to the assigned projects.
Multiple intelligence acquisition: Sources: Wagner (2010), seven-point Likert scale
II 1. Independent thinking & problem solving.
II 2. Cooperation.
II 3. Environmental adaptation.
II 4. Creativity.
II 5. Oral expression and writing skills.
II 6. Playing the digital orchid game can be an interface leading to interactions among people.
II 7. Information collection and analysis.

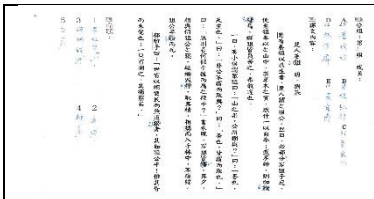	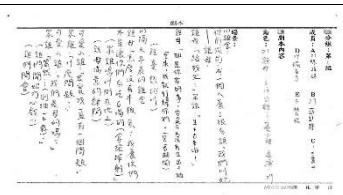	
Group study in reading	Team playwriting	Team brainstorming
		
Narrating	Role play	Film
		
Gallery	Department store	bookstore
		
Tainan Leisure map	A picture of authors	Autograph session

Figure 3. Pictures of the students participating in different activities through PBL

Results and Analysis

Validity and Reliability (EFA)

Some criteria for validity and reliability are given as follows: KMO >0.5, communality >0.5, eigenvalue >1, factor loading >0.6, Cronbach's alpha > 0.7, and item-total correlation >0.6. The six items measuring multiple intelligence have factor loadings of 0.89, 0.93, 0.89, 0.83, 0.88 and 0.90 (α=0.94). Listening comprising sensing, proceeding, and responding is determined based on the literature. The three items assessing sensing have factor loadings of 0.88, 0.89 and 0.89 (α=0.87). The five items measuring proceeding have factor loadings of 0.85, 0.89, 0.91, 0.88 and 0.77 (α=0.90). The four items assessing responding have factor loadings of 0.91, 0.91, 0.90 and 0.88 (α=0.92).

Knowledge absorptive capacity comprised knowledge transformation, acquisition and application. The three items assessing knowledge transformation have factor loadings of 0.93, 0.94, and 0.92 (α=0.92). The three items measuring knowledge acquisition with factor loadings of 0.89, 0.84 and 0.79 (α=0.79). The four items assessing knowledge application with factor loadings of 0.81, 0.85, 0.89 and 0.80 (α=0.86).

Finally, the three items assessing listening have factor of loadings of 0.89, 0.91 and 0.89 (α=0.88). The three items measuring knowledge absorptive capacity have factor loadings of 0.90, 0.88 and 0.87 (α=0.86). The detailed figures show on table 3.

Table 4 shows the detail information of validity and reliability. The values of convergent validity were 0.92, 0.91 and 0.95, while those of AVE were 0.80 0.78 and 0.78. These are all higher than the criteria for composite reliability and average variance, which are 0.6 and 0.5 (Fornell, 1981), respectively. Hair argued that the square root of AVE

should be at least 75% higher than the correlation coefficients among the constructs (Hair, Anderson, Tatham, & Black, 1998). The square roots of AVE values were 0.89, 0.88 and 0.88, and thus met the criterion, as shown on Table 3, and so the constructs showed good discriminant validity.

Table 3. Validity and Reliability

Construct	Items	Factor Loading	α	CR	AVE
Listening	LS1. Sensing.	0.89	0.88	0.92	0.80
	LS2. Proceeding.	0.91			
	LS3. Responding.	0.89			
Knowledge Absorptive capacity	KM1. Knowledge acquisition.	0.90	0.86	0.91	0.78
	KM2. Knowledge transformation.	0.88			
	KM3. Knowledge application.	0.87			
Multiple intelligence	MI1. Independent thinking & problem solving.	0.89	0.94	0.95	0.78
	MI2. Cooperation.	0.93			
	MI3. Environmental adaptation	0.89			
	MI4. Creativity.	0.83			
	MI5. Oral expression and writing skills.	0.88			
	MI6. Information collection and analysis	0.90			

Table 4. Discriminant validity

	Listening	Knowledge absorptive capacity	Multiple intelligence
Listening	(0.89)		
Knowledge absorptive capacity	0.72***	(0.88)	
Multiple intelligence	0.76***	0.69***	(0.88)

Analysis of Listening

Table 5 shows the descriptive statistics and results of the independent samples t test for the learners' listening in class. The mean values in the questionnaire were 5.49 and 6.64 respectively for the adopting project-based learning, and 4.52 and 5.64 for the students adopting spoon-feeding education. The results of the independent samples t test show that significant effects are found for listening ($t=4.26$, $p<0.001$) and ($t=2.81$, $p<0.01$). This suggests that project-based learning could help the students to enhance listening more than spoon-feeding education is able to.

Table 5. Descriptive Data and T Test Results of listening in two different school students

Experiment design (junior high)	N	Mean	SD	Std. error	t
Spoon-feeding education	54	4.52	0.98	0.13	4.26***
Project-based learning	54	5.49	0.84	0.16	
Experiment design (senior high)					
Spoon-feeding education	25	5.64	1.36	0.34	2.81**
Project-based learning	25	6.64	0.38	0.096	

Analysis of knowledge absorptive capacity

Table 6 shows the descriptive statistics and results of the independent samples t test for the learners' knowledge absorptive capacity. The mean values in the questionnaire were 6.57 and 5.50 respectively for the adopting project-based learning, and 5.90 and 4.73 for the students adopting spoon-feeding education. The results of the independent samples t test show that significant effects are found for listening ($t=2.05$, $p<0.05$) and ($t=3.54$, $p<0.001$). This suggests that project-based learning could help the students to increase knowledge absorptive capacity more than spoon-feeding education is able to.

Table 6. Descriptive Data and T Test Results for knowledge absorptive capacity in two different school students

Experiment design (junior high)	N	Mean	SD	Std. error	t
Spoon-feeding education	54	5.90	1.17	0.29	2.05*
Project-based learning	54	6.57	0.56	0.14	
Experiment design (senior high)					
Spoon-feeding education	25	4.73	0.94	0.12	3.54**
Project-based learning	25	5.50	0.80	0.16	

Analysis of multiple intelligences

Table 7 shows the descriptive statistics and results of the independent samples t test for the learners' multiple intelligence acquisition. The mean values in the questionnaire were 6.81 and 5.87 respectively for the adopting project-based learning, and 5.29 and 5.00 for the students adopting spoon-feeding education. The results of the independent samples t test show that significant effects are found for listening (t=5.49, p<0.001) and (t=3.86, p<0.001). This suggests that project-based learning could help the students to acquire multiple intelligences more than spoon-feeding education is able to.

Table 7. Descriptive Data and T Test Results for multiple intelligence in two different school students

Experiment design (junior high)	N	Mean	SD	Std. error	t
Spoon-feeding education	54	5.29	1.05	0.26	5.49***
Project-based learning	54	6.81	0.34	0.08	
Experiment design (senior high)					
Spoon-feeding education	25	5.00	0.98	0.13	3.86***
Project-based learning	25	5.87	0.83	0.16	

Results and Research Model

The criteria for the good model fit of structural equation models are as follows: CMIN/DF=2.03, NFI= 0.88, RFI= 0.85, IFI=0.93, TLI=0.91 and CFI=0.93. The VIF values of the model were below 10, which show there were no issues related to multicollinearity. With regard to the hierarchical regression, we first examined the relationship between knowledge absorptive capacity and multiple intelligences. The results show that the more knowledge absorptive capacity students possess, the easier they will acquire multiple intelligence (β=0.14，p>0.05). Second, we examined the relationship between knowledge absorptive capacity and listening. The results showed that the more knowledge absorptive capacity students need, the greater listening they have to possess while teachers are lecturing (β=0.86，p＜0.001). Third, we examined the relationship between listening and multiple intelligences. The results demonstrated that the greater listening students possess in class, the easier for them to acquire multiple intelligence (β=0.66，p＜0.001). The resulting framework is shown in Figure 4.

Finally, we also examined the mediation effect of knowledge absorptive capacity, listening and multiple intelligences. First, the results show that knowledge absorptive capacity has a positive influence on the multiple intelligence (β=0.70, p＜0.001). Second, knowledge absorptive capacity when supported by listening has a positive influence on the multiple intelligence acquisition (β=0.32, p＜0.01), (β=0.54, p＜0.001) as shown in Table 8. Third, knowledge absorptive capacity has a positive influence on listening (β=0.72, p＜0.001) as shown in Table 9. These values meet the requirements of partial mediation (Baron & Kenny, 1986). Thus, the results indicate that listening acts as a role of mediator between knowledge absorptive capacity and multiple intelligence acquisition.

Table 8. Regressions of knowledge absorptive capacity and listening with regard to multiple intelligences

		Multiple intelligence
Intercept	***	
Knowledge absorptive capacity	0.70***	0.32**
Mediator		
Listening		0.54***
Adjusted R^2	0.48	0.61
R2 Change	0.48***	0.62***

Note: *p＜0.05, **p＜0.01, ***p＜0.001

Table 9. Regressions of knowledge absorptive capacity on listening

	Listening
Intercept	***
Knowledge absorptive capacity	0.72***
Adjusted R^2	0.52
R^2 Change	0.52***

Note: *p＜0.05，**p＜0.01，***p＜0.001

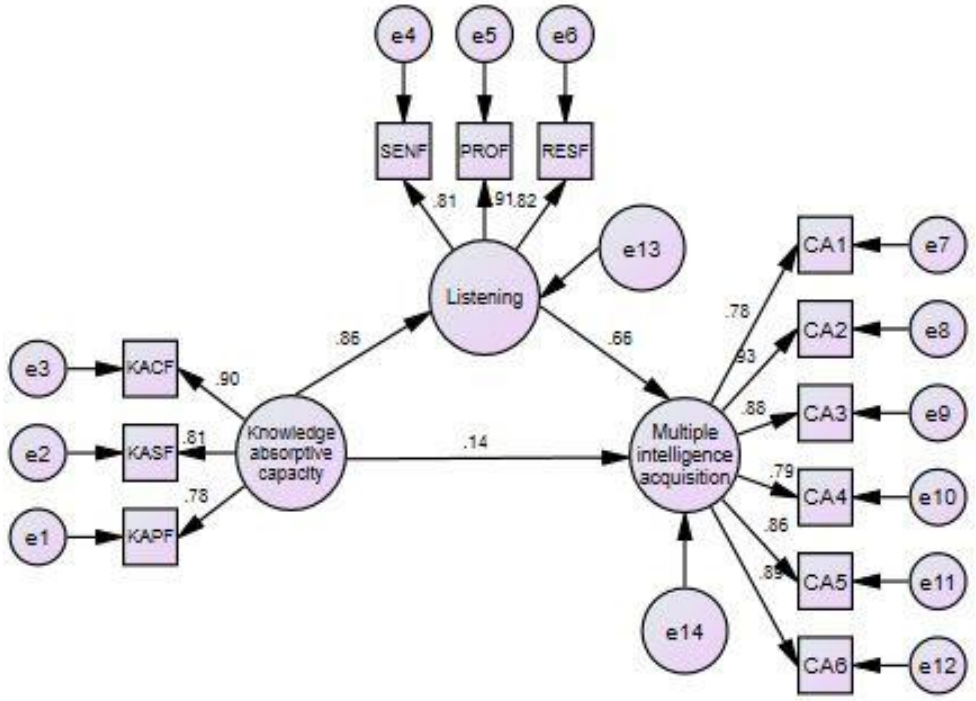

Figure 4. Research framework

Conclusions and Discussions

This research identifies two key contributions. First, it develops interactive curricula that integrate project-based learning, drawing upon the principles of social learning theory and the role of a facilitator. The curricula include two case studies: one designed for junior high school students and the other for senior high school students. In the junior high curriculum, the teacher presents an ancient Chinese story about bullying and then assigns students, working in teams, to write scripts and produce microfilms as their final projects. For senior high school students, the curriculum involves collaborative writing, where participants co-author a tourist guidebook. The ultimate goal of this project is to publish the **Tainan Leisure Map**. Second, the curricula have positively influenced students' attitudes and behaviors. Specifically, they have enhanced students' listening skills, improved their ability to absorb and retain knowledge, and fostered the development of multiple intelligences.

The influence of listening on Project-based learning

A project-based learning (PBL) approach, in which students complete assigned projects, has been shown to enhance their attention to classroom instruction and engagement in discussions with peers. The process of completing assigned projects requires active listening, which is essential for effective learning. Listening in this context consists of three stages: sensing, processing, and responding. From the sensing perspective, students must interpret meanings, emotions, and body language through continuous communication with their teachers. In the processing stage, students need to confirm, comprehend, adapt, and retain key concepts introduced in class. Additionally, teammates must share their individual knowledge and integrate it into structured, modular knowledge. Finally, in the responding stage, students must propose feasible solutions to their assigned projects and complete them. The case study involving senior high school students illustrates the role of listening at each stage of project-based learning. The process begins with team formation and task division. Next, team members engage in information gathering relevant to their assigned tasks. They then share findings and engage in discussions, which may involve developing interview questions, drafting written materials, creating illustrations, and refining the layout of their project. Following this, students compile the final product and seek feedback from their advisor. Lastly, they publish the book and engage in marketing efforts at bookstores. The detailed process is illustrated in Figure 5. To navigate challenges at each stage, participants must become skilled listeners. In conclusions, we argue that the structured process of sensing, processing, and responding fosters students' listening competence. Understanding people's emotions, habits, and motivations requires extensive listening, making it the most effective and efficient tool for comprehending interpersonal interactions, individual motivation, and decision-making tendencies. Thus, listening plays a crucial role in project-based learning. These findings align with previous research (Blumenfeld et al., 1991; Comer & Drollinger, 1999; Gardner, 1983). Table 10 illustrates the acquisition of diverse competencies through the processes of sensing, processing, and responding.

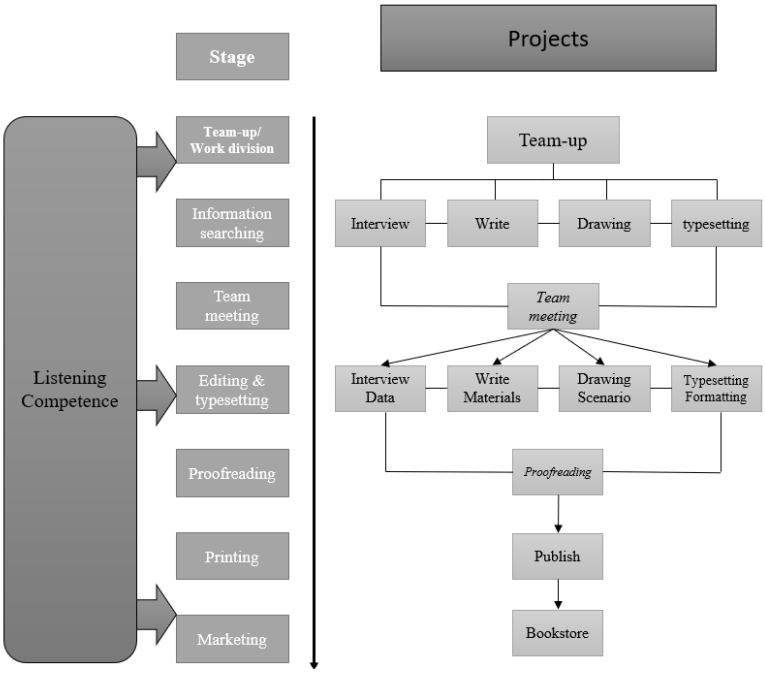

Figure 5. The processes of writing a book named Tainan leisure map

Knowledge absorptive capacity & multiple intelligence acquisition

The innovative curriculum has been validated as an effective approach for enhancing students' knowledge absorptive capacity and fostering the development of multiple intelligences. From the perspective of knowledge absorptive capacity, participating students acquire fundamental knowledge—such as interviewing techniques, writing skills, and artistic concepts—through formal classroom instruction. Additionally, they deepen their domain-specific knowledge through informal activities, engaging in intensive interactions with their peers. Through team brainstorming, students internalize existing knowledge and generate new insights, such as refining written materials and improving image editing techniques. They then integrate individual contributions into modular knowledge, applying these insights to complete a tourism guidebook. Finally, students negotiate with publishers to print the book and organize an autograph session. Completing this project significantly enhances students' ability to acquire, transform, and apply knowledge, thereby improving their overall absorptive capacity. Figure 6 presents detailed information on this process.

From the perspective of multiple intelligence acquisition, developing practical competencies depends on the processes of knowledge acquisition, transformation, and application in real-world contexts. In the case of the senior high school project, students demonstrate a willingness to listen to their teammates' ideas, reinforcing their ability to collaborate effectively. Additionally, Promoter Theory enables team members to leverage their strengths in different roles, including expertise, leadership, relationship-building, and process management. Furthermore, the implementation of the PDCA (Plan-Do-Check-Act) cycle allows students to iteratively refine their project, including outlining and structuring content, formulating interview questions, improving writing and photography skills, designing page layouts, and coordinating with printers to publish the Tainan Leisure Map. Figure 7 illustrates the relationship between multiple intelligence acquisition, knowledge absorptive capacity, and the listening process, while Table 11 compares the stages of sensing, processing, and responding in two different schools. The innovative curriculum fosters students' functional competencies, including independent thinking, problem-solving, adaptability, creativity, oral communication, writing proficiency, and information collection and analysis. Additionally, teamwork processes enhance students' interpersonal skills, such as cross-disciplinary communication, cooperation, and collaboration. The results are presented in Tables 12 and 13. These findings align with prior research (Wagner, 2010; Zahra & Gerard, 2002).

In conclusions, this study provides empirical evidence that project-based learning (PBL), when integrated with social learning theory, is more effective than traditional lecture-based (spoon-feeding) education in enhancing students' knowledge absorptive capacity, listening skills, and multiple intelligence acquisition at both the junior and senior high school levels.

Three key contributions emerge from this research:

1. Effectiveness of PBL: PBL has been demonstrated as an efficient teaching approach for fostering students' practical skills and multiple intelligences.
2. Development of π-Shaped Talents: PBL not only improves students' knowledge absorptive capacity and listening competence but also cultivates learners into π-shaped talents—individuals with both deep expertise in specific areas and broad interdisciplinary knowledge.
3. Moderating Role of Listening: Listening serves as a crucial moderating factor in the learning process, facilitating knowledge acquisition and application.

Limitation

This study acknowledges two primary limitations: sample size and the inherent challenges of Project-Based Learning (PBL). First, the sample size consists of only seventy-nine students from two different schools. To enhance the generalizability of the findings, we plan to expand the study by inviting additional schools to participate in future research. Second, while PBL is an effective and engaging teaching method, it presents several challenges. The following are five common limitations:

1. **Time-Consuming**: Implementing PBL requires substantial time for planning, execution, and reflection, making it difficult to integrate into tightly structured curricula.
2. **Resource-Intensive**: Successful PBL often necessitates a variety of resources, including materials, technology, and specialized tools, which may not be readily available in all educational settings.
3. **Challenges for Certain Learners**: Some students, particularly those who require additional support, may experience confusion or anxiety in a PBL environment, making it difficult for them to thrive.
4. **Teacher Training Requirements**: Educators may need specialized training and ongoing support to effectively implement PBL, which can be a barrier to its widespread adoption.
5. **Group Work Challenges**: PBL frequently involves collaborative learning, which may lead to conflicts among students or issues related to unequal participation, such as free-riding.

Despite these challenges, experienced educators who effectively design and implement PBL can foster active student engagement and enhance learning outcomes.

Future research

Future studies should focus on increasing the sample size and addressing the shortcomings of Project-Based Learning (PBL). First, experimental education schools in Taiwan have been rapidly expanding. In 2016, only sixty schools adopted experimental education; however, by the end of 2024, this number has grown to 250. Principals and teachers in these schools are highly supportive of project-based learning, as it enables students to apply classroom knowledge to real-world competencies through hands-on projects. Common themes explored in these projects include environmental protection, marine ecosystems, local culture, technology, and food and agriculture. To further our research, we plan to collaborate with faculty members in these schools to gain a deeper understanding of their programs. Through their participation, we anticipate achieving a larger sample size in future studies. Second, to address the challenges associated with PBL, we propose several improvements. These include designing new PBL curricula that can be implemented within limited timeframes, preparing teaching materials in advance, providing additional support for slow learners, encouraging teachers to participate in professional development training, and establishing peer assessment mechanisms to enhance collaborative learning.

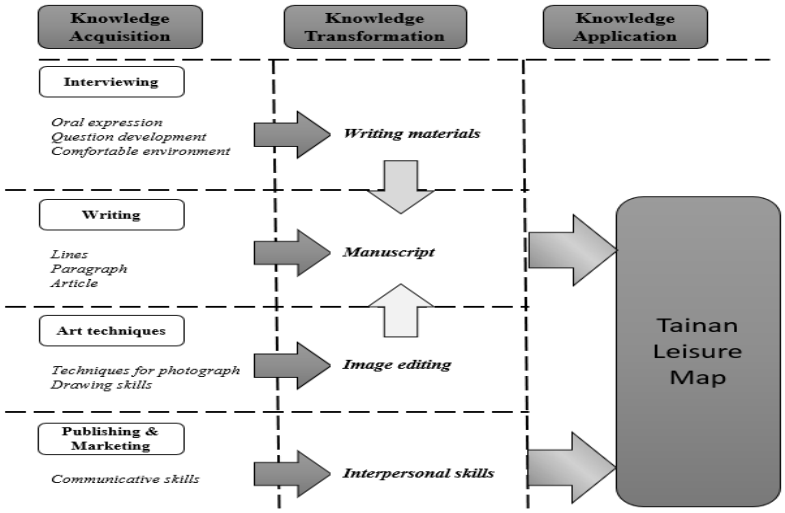

Figure 6. The processes of completing a book, Tainan Leisure Map, via knowledge absorptive capacity

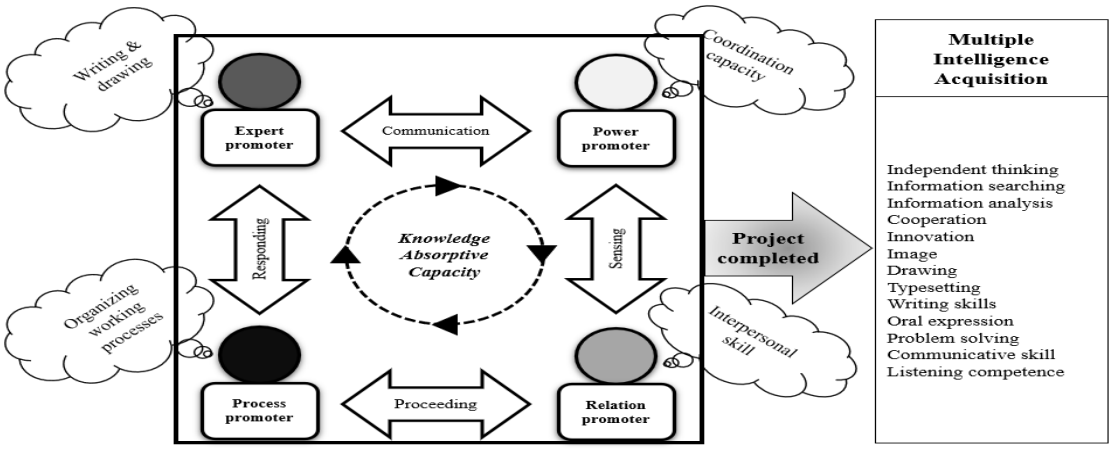

Figure 7. Connections of knowledge absorptive capacity, listening, and intelligence acquisition

Table 10. The process of sensing, proceeding and responding in two different schools

Listening Competence Training in Project-based Learning				
Curricula	**Goal**	**Sensing**	**Proceeding**	**Responding**
Chinese Class **Junior High school** **High School**	**Make micro-films** **Publish a book**	***Competence*** ● Self-awareness ● Perspective taking ● Emotional regulation ● Affective response ● Empathetic attitude	***Approaches*** ● Taking notes ● Refresh the important ideas ● Agreement and disagreement summary ● Memorizing the previous conversations ● Keeping asking questions	***Feedback:*** ● Receiving other ideas ● Probe information ● Emotional expressions ● Body language

Table 11. The process of knowledge absorptive capacity in two different schools

Knowledge Absorptive Capacity Training in Project-based Learning				
Curricula	**Goal**	**Knowledge Acquisition**	**Knowledge Transformation**	**Knowledge Application**
Chinese Class in Junior High School	***Make micro-films***	***Single knowledge*** ● Listening ● Bullying stories ● Image ● Independent thinking ● Oral expression ● Writing skills ● Use shooting software ● Virtual platform	***Module knowledge*** ● Write a short story ● Acting ● Film editing ● Oral presentation ● Interpersonal skills ● Managing Facebook	***System knowledge:*** *(Completing projects):* ● **Make Bullying films**
Chinese Class In Senior High School	***Publish a book***	***Single knowledge*** ● Listening ● Understand owners' expertise ● communicative skill ● Interview draft ● Independent thinking ● Problem solving ● Oral expression ● Writing skills ● Oral expression ● Information collection & analysis ● Virtual platform	***Module knowledge*** ● Interdisciplinary knowledge ● Diverse life experiences ● Interpersonal skills ● Creativity ● Writing skills ● Oral presentation ● Autograph session ● Managing Facebook	***System knowledge:*** *(Completing projects):* ● **Tainan leisure map (a book)**

Table 12. Results of multiple intelligence acquisition for senior high students

Multiple Intelligence	Tainan Leisure Map	Remarks
Independent thinking	● How to start writing ● content integral	*The plot of Tainan leisure map*
Problem solving	● Communicative & collaborative skills ● Competence in knowledge integration ● Interdisciplinary competence Acquisition	*Proofread* *Contact with bookstores & printers* *Publish Tainan leisure map*
Cross-field cooperation	● Booksellers ● Printers ● Tainan Education Bureau ● Primary schools in Tainan city ● Bookstores, Art Exhibition and Coffee & tea shop owners	*Collaboration with the supply chain*
Environmental adaptation	● Trends of Leisure tourism	*Aware of environmental changes*
Creativity	● Literary writing ● Interdisciplinary learning ● Modularization	*Observation from different angles*
Oral expression	● Final presentation ● Autograph session ● Forum ● Writing experience sharing	*Communicative skills* *Knowledge & experience sharing*
Writing skills	● Written report ● Tainan leisure map	*Polishing writing skills*
Information collection & analysis	● Interview owners ● Experience the philosophy of life ● Draw a downshifting Tainan map	*Understand where to find the information*

Table 13. Results of multiple intelligence acquisition for junior high students

Multiple intelligence	Making Micro films		Remarks
Independent thinking	Story planning Showing the short films Film editing skill	Scenario development Film shooting Uploading the film -loading	*Showing the short film*
Problem solving	Peer communication and collaboration Knowledge sharing and integration	Acting Film shooting and editing	*Completed short film*
Cross-field cooperation	Story writing Film shooting and editing	Acting skills Up-loading to YouTube	*External resource cooperation*
Environmental adaptation	Acute environmental observation Follow the latest editing software	Film editing Popular platform	*New generation preference*
Creativity	Directing plays based on literature Team work project	Training the imagination Interdisciplinary learning	*Innovative teaching approach*
Oral expression	Final exam presentation Personal expressions	Teamwork Communication Acting	*Fluent and logical oral presentation*
Writing abilities	Rough draft Pictures, stories, books	Assignment (film shooting) Report writing	*Text polishing abilities*
Information collection & analysis	Reading other classical literature Sharing life experiences with peers	Teacher instructions Film shooting and editing	*Expert, book, and online world knowledge*

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