International Journal of Educational Media and Technology
2021, Vol. 15, No. 1 pp.90-104 .

Development of an Effective and Engaging Instructional Design and Technology Course

Kento NAKAMURA
Tokyo University of Science, Japan
1720515@ed.tus.ac.jp

Tadashi MISONO
Shimane University, Japan
misono@edu.shimane-u.ac.jp

Yuki WATANABE
Tokyo University of Science, Japan
wat@rs.tus.ac.jp

This paper aims to develop an effective and engaging instructional design technology (IDT) course. Pre-service teachers (PSTs) designed lesson plans and answered questionnaires before and after the IDT course. The result revealed that the IDT course was beneficial independent of the PSTs' specific subjects. The PSTs could design lessons in terms of Gagné's Nine Events of Instruction theory and the ARCS model. The allowance to view the checklists of ID theories can be considered to support the PSTs to design lessons in terms of the IDs. However, the PSTs do not seem to identify mathematics content or concept between advanced mathematics knowledge. A further direction will focus not only on the pedagogical aspect but also on content aspects.

Keywords: Instructional Design and Technology, Pre-Service Teacher-Training, Teacher Education

Introduction

Instructional Design and Technology in Japanese Teacher-Training Courses

The Central Council for Education (2016) in Japan considers the new curriculum guidelines, which are to take effect in junior high schools and high schools in 2021 and 2022, respectively, based on the following three pillars: (1) what students will be able to do, (2) what they will be able to learn, and (3) how they will be able to learn it. In particular, item (3) implies improvements in providing instructions from an active learning perspective.

In response to these needs, the Ministry of Education, Culture, Sports, Science and Technology (MEXT, 2017) summarized the skills required for the pre-service teacher-training courses of all Japanese universities in a document titled "A Core Curriculum of Pre-Service Teacher-Training Courses." In this core curriculum, pre-service teacher-training courses are divided into four categories. The categories of the curriculum and specific examples of the course at University A are presented in Table 1 below. For example, the "Instructional Design and Technology Course" falls under the category of "Teaching Method for Morals, Integrated Studies, Student Counseling, and Educational Consultation" at University A. The goal of these subjects was to understand the fundamental theories and practices of instructional design (ID). Specifically, pre-service teachers (PSTs) have the opportunity to design lesson plans. Therefore, there is a need to improve and gain an understanding of ID theories in lesson plans.

Table 1

Core Curriculum Categories and Specific Examples of the Course in University A (MEXT, 2017)

Category	Specific Examples of Course
• Specialization Subjects and Teaching Methods	• Teaching Methods of Mathematics Course • Teaching Methods of Science Course
• Basic Understanding of Education	• Foundation of Pedagogy • Introduction to the Teaching Profession
• Teaching Methods for Morals, Integrated Studies, Student Counseling, and Educational Consultation	• Instructional Design and Technology (IDT) • Extracurricular Activities and Career Guidance
• Educational Practice	• Preparation for Teaching Practice • Seminar in Teaching Profession

Japanese Students' Motivation in Secondary Education

The results of the Programme for International Student Assessment (OECD, 2018) revealed that Japanese high-school students have the highest level of mathematics literacy. However, according to the results of the Trends in International Mathematics and Science Study (TIMSS), Japanese junior high school students have low motivation for mathematics (TIMSS, 2015). Therefore, there is a problematic gap between high literacy and low motivation to learn.

To control students' mathematics motivation, we focused on the ARCS (Attention, Relevance, Confidence, and Satisfaction) model, which is a problem-solving approach to designing motivational aspects of learning environments that stimulate and sustain students' motivation to learn (Keller, 1987). Recently, some studies have focused on how attractive mathematics or science courses based on the ARCS model affect junior or high-school students' motivation (e.g., Feng and Tuan, 2005). However, few studies have focused on how mathematics or science teachers design motivational instruction in terms of the ARCS model.

Instructional Design in Lesson Plans

Suzuki (2005) explains ID as a model and research field that combines methods to increase the effectiveness, efficiency, and appeal of educational activities. For example, Gagné's Nine Events of Instruction and the ARCS model comprise an ID theory and model, respectively.

In the current study, the participants designed lesson plans, design documents that outline the type of lesson to be taught as well as its background, goals, and main contents (Ichikawa, 2019). In Japan, the lesson procedure traditionally comprises three parts: "Introduction," "Body," and "Summary." However, Gagné's theory is divided into nine events, from "Gaining attention" to "Enhancing retention and transfer." Considering these nine events, lesson planners may design lessons in more detail (Table 2).

Table 2

Correspondence Table of a Lesson Procedure and Gagné's Instructional Events (Ichikawa, 2019)

Lesson Procedure	Instructional Event	
Introduction	1	Gaining attention
	2	Informing the learner of the objective
	3	Stimulating recall of prerequisite learned capabilities
Body	4	Presenting the stimulus material
	5	Providing learning guidance
	6	Eliciting performance
	7	Providing feedback about performance correctness
Summary	8	Assessing the performance
	9	Enhancing retention and transfer

Instructional Design and Technology Course

In pre-service teacher-training courses, many researchers have focused on the effectiveness of Information and Communication Technology use (e.g., Hicks and Bose, 2019). In addition, simply learning computer or instructional technology courses is not sufficient for PSTs to develop their understanding of Technological Pedagogical Content Knowledge (TPACK) and its application (Aktaş and Özmen, 2020). Therefore, we need to develop an instructional design and technology (IDT) course from the pedagogical aspect of the TPACK framework, such as ID theories.

In Japan, Nakamura, Misono, and Watanabe (2020a) surveyed how learning instructional design theories affect PSTs' ID. Through learning ID theories, the PSTs were able to design lesson plans from the perspective of "Attention" of the ARCS model. However, there is also room to incorporate other aspects of the ARCS model, that is, "Relevance," "Confidence," and "Satisfaction." Thus, the current IDT course must be revised.

Purpose

The purpose of this study was to develop an effective, engaging IDT course. To do so, we designed two studies (Study 1 and Study 2) and sub-goals: (1) surveying the qualitative change in PSTs' lesson plans, and (2) engagements toward ID. Specifically, the following research questions were explored:

1. Through the IDT course, how does the quality of PSTs' ID change from the perspective of Gagné's Nine Events of Instruction?
2. Through the IDT course, how does the quality of PSTs' ID change from the perspective of the ARCS model?
3. Through the IDT course, how do PSTs' teaching experience levels change?
4. Through the IDT course, how do PSTs' motivation toward ID change?

An Outline of the IDT Course at University A

University A has a pre-service teacher-training course for junior high and high schools, where students can obtain their teachers' licenses in mathematics, science, and information. At University A, the goals of the IDT course included learning ID theories and practical methods. The course contents are listed in Table 3 and include fundamental ID theories and models.

Table 3

Learning Content of the IDT Course

Title	Concrete Content
• Introduction	• Educational Technology, TPACK
• Design Instructions	• ID, Gagné's five types of learning outcome, Gagné's nine events of instruction
• Active Learning	• 21st-century skills, Active learning
• ID considering student motivation	• ADDIE model, ARCS model
• Learning Environment	• learning space, activity, and community
• The consistency of objective and assessment method	• teaching objective, method of assessment
• Instructional Media	• history of instructional media, practical use of ICT

Methods

Participants

The participants in this research comprised the PSTs at the Faculty of Science, Faculty of Industrial Science and Technology, University A. The number of PSTs in Studies 1 and 2 were 65 and 118, respectively. We did

not calculate the ratio of male to female PSTs due to the removal of the gender section. The PSTs specialized in one of the following subjects: mathematics, physics, chemistry, or biology; no one specialized in pedagogy. They were aged around 21 years because the IDT course was held for juniors. None of them had ever been to teaching practice, nor had they learned ID theories through other pre-service teacher-training courses. Therefore, the PSTs designed lesson plans for the first time based on ID theories.

Data Collection

Qualitative data were gathered from the two lesson plans that the PSTs had designed through the IDT course: a lesson plan after the first lesson (pre-lesson plan) and the last lesson (post-lesson plan).
Quantitative data were gathered from the two questionnaires that the PSTs had answered before and after the IDT course.

Lesson Plans

We set a learning unit for each specific subject. For example, mathematics PSTs have designed lessons in "Trigonometric Ratio" in "Mathematics 1." We also set information about high-school students to define the in-class context. In particular, the classroom situation has been set "The students understand the learning contents mostly based on what they learned in junior high school." The PSTs have been required to design lesson plans developed using the ID theories learned in the IDT course.

Questionnaires

We surveyed questionnaires from five perspectives as follows:

Instructional Design Motivation

We created 24 items of ID Motivation Scales for pre-service teacher-training course students with reference to a six-level definition of learning experience (Parrish and Wilson, 2008) using a 5-point Likert scale (1 = I don't think so; 5 = I think so). Each level has four items (e.g., "I am interested in the content of ID" for Level 1). We used the pre- and post-scores of Study 2 to understand the motivational change to ID.

Teacher Efficacy

We quoted 7 items related to subject instruction from the teacher efficacy scale for the Faculty of Education (Igarashi, Miyauchi, and Yamada, 2018) using a 5-point Likert scale (1 = I don't think so; 5 = I think so, e.g., "I can teach in a way that is easy to understand").

Change of Instructional Design Motivation (Study 1 only)

In the post-questionnaire, we asked whether students had changed their ID motivation using a 5-point Likert scale (1 = declined; 5 = increased). Subsequently, we asked why they had answered as they did both from the perspective of their own motivations and environmental causes.

We used these question items only in Study 1 to focus on understanding the effect of the IDT course on the PSTs' instructional design motivation changes.

Teaching Experience Level (Study 2 only)

We created one item of Teaching Experience Level for pre-service teacher-training course students with reference to a six-level definition of Learning Experience (Kawamoto, Watanabe, and Hidaka, 2018) using a 6-point scale ranging from 1 for "I am not interested in this class. I do not think this class is useful" to 6 for "ID is important in life. I am happy to design instructions assuming the environment of education."

We used these question items only in Study 2 because we could not determine the absolute position of the PSTs' teaching experience level in the question, "change of instructional design motivation," asked in Study 1.

Procedure

Figure 1 illustrates the procedures used in the two studies. Study 1 was conducted between September and November of 2019. Study 2 was conducted from May to July of 2020. In both studies, the participants answered the questionnaires and designed lesson plans twice throughout the course.

In Study 1, the IDT course was held face-to-face in the active learning classroom of University A. The teacher of the IDT course used course slides on screens, as well as providing slide handouts of the course in each lesson.

In Study 2, the IDT course was held in an on-demand online style using a Moodle-based learning management system. The PSTs could access the course materials, except from 04:00 to 05:30. The course contains the video content and slide handouts and materials as pdf files. For example, the PSTs are allowed to view the checksheets of two ID theories that we developed to be described.

We developed lesson-planning version checksheets for the two ID perspectives. The first checksheet, "check sheet for Gagné's Nine Events of Instruction," comprises 36 items referring to Gagné's Nine Events of Instruction tips developed by Suzuki (1995). For example, items such as "Starting the class with something strange, unusual, or make a sudden change to open the learner's eyes wide" were mentioned from the first event of "Gaining attention." The second checksheet, "check sheet for the ARCS model," comprises 73 items referring to the motivational tactics checklist developed by Keller (1987), with Attention," "Relevance," "Confidence," and "Satisfaction" having 17, 22, 15, and 19 items, respectively. For example, items such as "Is there reference to specific people rather than mankind, people, or other such abstractions?" were mentioned from the perspective of "Attention."

After collecting data, we evaluated the PSTs' pre- and post-lesson plans using the checksheets. Each event or perspective of the forementioned ID theories has been evaluated "1" when at least one item satisfies the criterion item, or "0" otherwise. The lesson plan score is the sum of the score(s) of each event or perspective; that is, Gagné's Nine Events of Instruction ranged from 0 to 9, while the ARCS model ranged from 0 to 4.

We randomly selected 32 lesson plans (11% of all) following the guidelines for assessing and reporting intercoder reliability (Lombard, Snyder-Duch, and Bracken, 2010); The first and third authors double coded to calculate inter-rater reliability. According to Landis and Koch's (1977) criteria, we have got fair Gwet's (2014) agreement coefficient (AC_1), $M = .28$, $S.D. = 0.34$. The first author then evaluated the rest lesson plans.

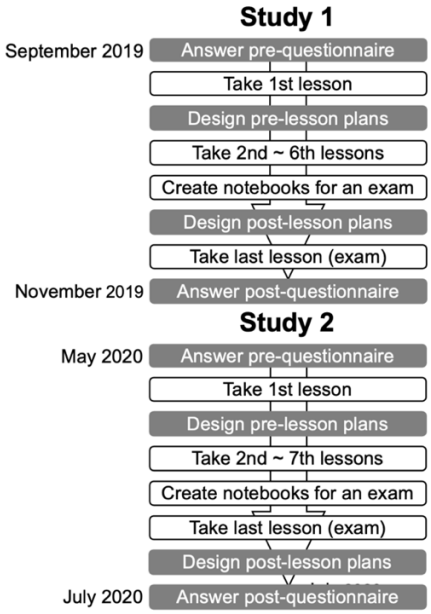

Figure 1. Research procedure

Guides to Analysis

To survey the effectiveness of the IDT course, we compared the scores of the PSTs' lesson plans evaluated by the first author using a three-way analysis of variance (ANOVA). Here, the variables are Study, Pre-Post, and Subject. We then conducted McNemar's test of the scores of PSTs' lesson plans to compare the pre- and post-scores from the perspective of Gagné's Nine Events of Instruction and the ARCS model to answer the first and second research questions, respectively.

To survey the engagement of the IDT course, we compared the PSTs' teaching experience level in Study 2 to answer the third research question. Here, we used Wilcoxon's signed-rank test to compare the pre- and post-teaching experience levels through the IDT course.

We also surveyed the PSTs' engagement in IDs using the pre- and post-data of Study 2 to answer the fourth research question. We used Wilcoxon's signed-rank test to compare improvements through the IDT course.

Results

In total, 141 participants answered both the pre- and post-questionnaires and designed pre- and post-lesson plans (Table 4). To accomplish our goals, we checked for qualitative changes in lesson plans and students' motivation.

Table 4

Number of Participants for Each Specific Course and Study

	Specific Course				
		Science			
Study	Math	Physics	Chemistry	Biology	Total
1	18	8	15	0	41
2	63	9	23	5	100
Total	81	17	38	5	141

Result of Lesson Plans

Gagné's Nine Events of Instruction

The descriptive statistics scores of Gagné's Nine Events of Instruction are reported in Table 5.

Table 5

Descriptive Statistics Scores (M, SD) of the Score of Gagné's Nine Events of Instruction

	Study 1 (n = 41)		**Study 2 (n = 100)**	
	pre	**post**	**pre**	**post**
Math	2.78 (1.00)	3.11 (0.90)	2.25 (1.05)	3.25 (1.47)
Science	2.52 (0.90)	3.09 (1.20)	1.76 (0.80)	3.30 (1.45)
Total	2.63 (0.94)	3.10 (1.07)	2.07 (0.99)	3.27 (1.46)

In Study 1, n_{Math} = 18, $n_{Science}$ = 23. In Study 2, n_{Math} = 63, $n_{Science}$ = 37

The results of a three-way ANOVA of Gagné's Nine Events of Instruction are presented in Table 6. The three factors in this analysis are "Study (Study 1, Study 2)," "Pre-Post (Pre, Post)," and "Course (Mathematics, Science)."
The results revealed no significant main effect or interaction with the Course factor, which means that there is no difference in the scores of either mathematics or science PSTs. Therefore, we used the data of mathematics and science PSTs together for later analyses.

The results revealed that there was a significant Study × Pre-Post interaction. Therefore, we conducted Bonferroni's multiple comparison of the scores and found four significant differences: $pre_2 < post_1$, t (274) = 4.29, p <.001, d = 0.29, $pre_1 < post_2$, t (274) = 2.82, p <.050, d = 0.17, $pre_2 < pre_1$, t (274) = 2.90, p <.050, d = 0.17, and $pre_2 < post_2$, t (274) = 7.36, p <.001, d = 0.44 (figure 2).

Table 6

Results of Three-way ANOVA of the Score of Gagné's Nine Events of Instruction

Factors	***SS***	***df***	***MS***	***F***	η^2
Study	3.08	1.00	3.08	2.22	0.01
Pre-Post	41.67	1.00	41.67	29.97**	0.09
Course	1.90	1.00	1.90	1.37	0.00
Study × Pre-Post	9.50	1.00	9.50	6.83**	0.02
Study × Course	0.11	1.00	0.11	0.08	0.00
Pre-Post × Course	2.10	1.00	2.10	1.51	0.00
Study × Pre-Post × Course	0.34	1.00	0.34	0.24	0.00
Residuals	380.87	274.00	1.39		

n = 141, *SS:* Sum of Squares, *MS:* Mean Square ** p < .010, *** p < .001

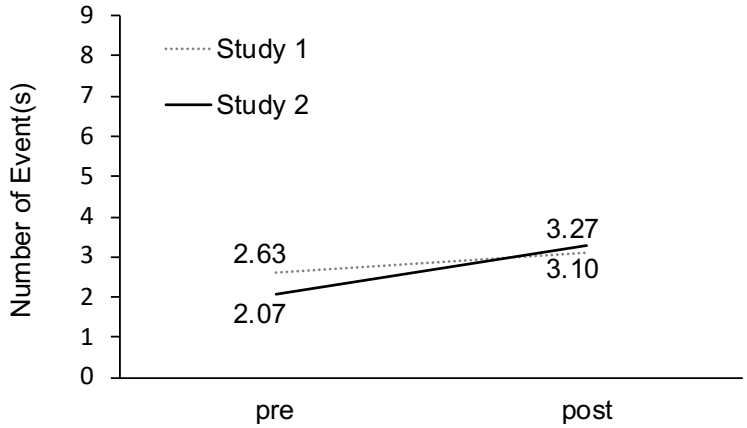

Figure 2. Mean Scores of PSTs Number of Gagné's Nine Events of Instruction in Their Lesson Plans

This result means that although the pre-score of Study 2 was lower than that of Study 1, the post-score of Study 2 was higher than that of Study 1. That is, the IDT course in Study 2 seemed to be effective.

We then conducted McNemar's test for the score of Gagné's Nine Events of Instruction in Study 2 (Table 7). As a result, the number of PSTs who designed lesson plans developed with the following events significantly increased: "1. Gaining attention," "2. Informing the learner of the objective," "3. Stimulating recall of prerequisite learned capabilities," "5. Providing learning guidance," "6. Eliciting performance," "8. Assessing performance," and "9. Enhancing retention and transfer." However, only approximately 10% of PSTs could design the summary part.

Table 7

Accomplishment of Gagné's Nine Events of Instruction

Event		n_{pre}	n_{post}	$\chi^2(1)$
1	Gaining attention	14	37	23.00***
2	Informing the learner of the objective	40	64	24.00***
3	Stimulating recall of prerequisite learned capabilities	24	49	23.15***
4	Presenting the stimulus material	84	86	0.50
5	Providing learning guidance	1	9	8.00***
6	Eliciting performance	42	57	10.71***
7	Providing feedback about performance correctness	0	3	–
8	Assessing the performance	1	13	12.00***
9	Enhancing retention and transfer	1	9	6.40*

$n = 100$ * $p < .050$, *** $p < .001$

ARCS Model

The descriptive statistics scores of the ARCS model are reported in Table 8.

Table 8

Descriptive Statistics Scores (M, SD) of the Score of ARCS model

	Study 1 (n = 41)		Study 2 (n = 100)	
	pre	**post**	**pre**	**post**
Math	0.56 (0.62)	0.67 (0.59)	0.40 (0.66)	1.10 (1.09)
Science	0.61 (0.50)	0.78 (0.60)	0.59 (0.64)	1.30 (0.97)
Total	0.59 (0.55)	0.73 (0.59)	0.47 (0.66)	1.17 (1.04)

In Study 1, n_{Math} = 18, $n_{Science}$ = 23. In Study 2, n_{Math} = 63, $n_{Science}$ = 37

The results of a three-way ANOVA of the ARCS model are presented in Table 9. The three factors in this analysis are "Study (Study 1, Study 2)," "Pre-Post (Pre, Post)," and "Course (Mathematics, Science)."

The results revealed no significant main effect or interaction with the Course factor, which means that there is no difference in the scores of either mathematics or science PSTs. Therefore, we used the data of mathematics and science PSTs together for the later analyses.

The results revealed that there was a significant Study × Pre-Post interaction. Therefore, we conducted Bonferroni's multiple comparison of the scores, as a result of which there were four significant differences: $pre_1 < post_2$, t (274) = 4.08, $p < .001$, d = 0.24, $post_1 < post_2$, t (274) = 3.13, $p < .050$, d = 0.19, and $pre_2 < post_2$, t (274) = 5.99, $p < .001$, d = 0.36 (Figure 3).

Table 9

A Three-Way ANOVA of the Score of ARCS Model

Factors	***SS***	***df***	***MS***	***F***	η^2
Study	2.09	1.00	2.09	3.27	0.01
Pre-Post	10.02	1.00	10.02	15.68***	0.05
Course	1.14	1.00	1.14	1.79	0.01
Study × Pre-Post	4.39	1.00	4.39	6.87**	0.02
Study × Course	0.19	1.00	0.19	0.29	0.00
Pre-Post × Course	0.02	1.00	0.02	0.02	0.00
Study × Pre-Post × Course	0.01	1.00	0.01	0.02	0.00
Residuals	174.99	274.00	0.64		

** $p < .010$, *** $p < .001$

n = 141, *SS:* Sum of Squares, *MS:* Mean Square

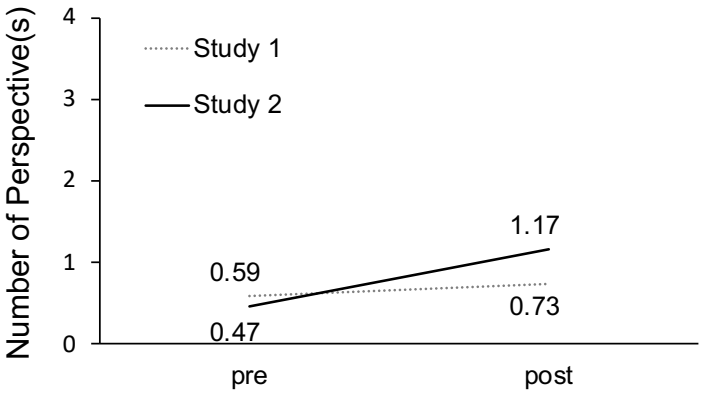

Figure 3. Mean Scores of PSTs' Number of ARCS Models in Their Lesson Plans

In particular, students were better able to use the ARCS model for their specific course through the learning style of Study 2 than that of Study 1.

We then conducted McNemar's test for the score of the ARCS model in Study 2 (Table 10). As a result, all perspectives of the ARCS model improved. However, less than 50% of the PSTs designed the components of the ARCS model.

Table 10

Number of Accomplishment of the ARCS Model

Perspective of the ARCS Model	n_{pre}	n_{post}	$\chi^2(1)$
Attention	29	46	15.21***
Relevance	6	20	12.25***
Confidence	11	34	23.00***
Satisfaction	1	17	14.22***
$n = 100$			*** $p < .001$

Result of Questionnaires

Teaching Experience Level

The results of the pre-and post-scores of Teaching Experience Level in Study 2 are presented in Table 11. More students reported Level 4 than any other level. According to the results of Wilcoxon's signed-rank test, the PSTs' teaching experience level did not change through the IDT course, $M_{pre} = 3.50$, $M_{post} = 3.58$, $W = 495.50$, *n.s.*, $r = 0.12$.

Table 11

Number of Teaching Experience Level

Level	1	2	3	4	5	6	Total
n_{pre}	1	9	39	43	6	2	100

n_{post}	0	7	40	43	8	2	100

Instructional Design Motivation

The results of Wilcoxon's signed-rank test for the pre- and post-scores of ID motivation in Study 2 are presented in Table 12. The results show that the PSTs could design instructions by considering the learning content. However, their specific courses, such as mathematics, were less useful for designing instructions.

Table 12

Change to PSTs' Instructional Design Motivation and Result of Wilcoxon's Signed-Rank Test

		pre		post		M_{post}-M_{pre}	W	r
		M_{pre}	SD_{pre}	M_{post}	SD_{post}			
1	I gain something through ID.	3.91	0.82	4.24	0.73	0.33	318.50**	0.50
2	I am interested in the ID contents.	3.77	0.69	3.74	0.85	-0.03	570.50	-0.06
3	I interact with other students when designing instructions.	3.08	1.21	3.04	1.33	-0.04	1316.50	-0.06
4	ID is not a single task.	3.83	0.83	3.98	0.93	0.15	567.00	-0.24
5	Designing instructions is not boring because it is not a mindless routine.	3.58	0.73	3.67	0.94	0.09	855.00	0.10
6	I know why I design instructions.	3.61	0.84	3.95	0.78	0.34	332.50***	0.54
7	I grow through ID.	3.56	0.83	3.95	0.83	0.39	247.00***	0.60
8	I want to design instructions again if possible.	3.67	0.89	3.77	1.05	0.10	582.00	0.16
9	I prioritize the preparation for design instructions even when I am busy with other class activities.	2.79	0.84	2.80	1.10	0.01	972.50	0.00
10	The other specific courses I take are useful to design instructions.	3.76	0.92	3.46	1.10	-0.30	1583.00*	-0.27
11	The other teacher-training courses I take are useful to design instructions.	3.82	0.80	4.05	0.80	0.23	460.50*	0.36
12	The other specific subject courses I take are useful to design instructions.	3.84	0.71	3.87	0.93	0.03	775.00	0.09
13	I spend a lot of time designing instructions in my school life.	2.82	0.90	3.19	1.09	0.37	526.50**	0.42
14	I try to look for the subjects and topics that attract students' attention.	3.86	0.77	4.05	0.80	0.19	648.00	0.27
15	Designing instructions is interesting.	3.65	0.82	3.91	0.90	0.26	760.50*	0.31
16	ID is essential when I become a teacher.	4.46	0.69	4.61	0.58	0.15	417.50	0.26
17	I try to look for books and materials apart from the lecture materials.	2.99	1.10	3.10	1.11	0.11	982.00	0.11
18	I try to adopt various teaching methods when I design instructions.	3.41	0.82	3.68	0.84	0.27	591.00*	0.33
19	I change my teaching methods depending on the learning contents.	3.30	0.77	3.56	1.01	0.26	889.00*	0.28
20	I try to ask others to review my ID to design better.	3.07	0.83	2.89	1.17	-0.18	1480.50	-0.19

		pre		post		M_{post}-M_{pre}	W	r
		M_{pre}	SD_{pre}	M_{post}	SD_{post}			
21	I go to societies, study groups, or academic conferences for ID.	2.01	1.23	1.80	1.18	-0.21	715.50	-0.27
22	Through ID, I sometimes feel happy that I am a PST.	2.87	0.84	2.94	0.94	0.07	439.50	0.15
23	Through ID, I want to be a teacher soon and be active in the environment for education.	3.45	1.08	3.43	1.03	-0.02	889.00	-0.04
24	I forget the time when I devote myself to design instructions.	3.05	0.87	2.83	1.21	-0.22	1334.00	-0.21

$n = 100$, $\alpha_{pre} = .88$, $\alpha_{post} = .87$, 5-point Likert scale $^{*}p < .050$, $^{**}p < .010$, $^{***}p < .001$

Discussion

Discussion on Lesson Plans

From the two ID theories' perspectives, there were no significant interactions between "Course" and "Study" or "Course" and "Pre-Post." That is, there is no difference between pre-service mathematics and science teachers in terms of the quality of lesson plans from the perspective of ID theories. This result suggests that, through the IDT course, PSTs acquired knowledge related to pedagogical knowledge in the TPACK framework regardless of their specific subject (Alrwaished, Alkandari, and Alhashem, 2017).

From the perspective of Gagné's Nine Events of Instruction, the post-lesson plan scores were high in Study 2, although the pre-lesson plan scores were lower than those of Study 1. The reason why the PSTs' post-lesson plans in Study 1 marked a low score is that the PSTs might have had difficulties designing lesson plans from the perspective of ID theories without having ID theory checksheets. Therefore, in Study 2, we allowed the PSTs to view the checklists of ID theories, which could be considered to have made the PSTs design lesson plans effectively from the perspective of ID theories compared to the PSTs in Study 1. That is, providing the checksheets of ID theories can trigger PSTs to design instructions better from the perspective of Gagné's Nine Events of Instruction.

However, the number of students who designed lesson plans considering "4. Presenting the stimulus material" and "7. Providing feedback about performance correctness" showed no significant difference between the pre- and post-scores. The reason for this lack of increase is that the number of students who designed the former event was already at 84%, and there may, therefore, have been no room to increase. Moreover, only 3% of the PSTs could design lesson plans considering the latter event. The PSTs may have had no idea how to design the summary part of a lesson, as Choi (2020) reports that few mathematics PSTs have reconstructed lesson plans in terms of teaching and learning methods in the summary part. This may be attributed to the lack of opportunities for PSTs to design and perform instructions in a real classroom environment. Further IDT courses should consider actual classroom environments, such as micro-teaching, considering ID theories.

From the perspective of the ARCS model, the post-lesson plan scores were high in Study 2. Specifically, the number of students who design lesson plans considering all the components of the ARCS model, "Attention," "Relevance," "Confidence," and "Satisfaction," significantly increased from the pre-lesson plans. For example, some students could introduce topics problematically to inquire about arousing inquisitiveness. However, in the post-lesson plans, less than 50% of the PSTs designed the components of the ARCS model (e.g., 20% for "Relevance"). This means that even though the PSTs have completed the IDT course, only half of them can design lessons considering the ARCS model. This implies that PSTs have trouble adapting the ARCS model to their specific subjects. To adapt the ARCS model, a solution may be for PSTs to design lesson plans with other PSTs, such as peer-reviewing lesson plans.

Discussion on PSTs' Engagements

We compared the pre- and post-data of PSTs' teaching experience levels and ID motivation using a questionnaire. As a result, more students reported Level 4 than any other level. However, there was no change in the teachers' teaching experience level through the IDT course. This result means that the PSTs did not lose their teaching experience level; however, the PSTs' teaching experience level also did not increase through the IDT course. Future research should discuss when to increase PSTs' teaching experience level, focusing not only on the IDT course, but also throughout the teacher training course.

Moreover, the PSTs' motivation toward ID increased significantly overall. For example, by designing instructions, the PSTs come to find something, know why they design instructions, and feel they have grown. That is, students' engagement with ID increased through the IDT course of Study 2.

However, through the IDT course, the PSTs feel that their other specific college courses, such as geometry, are less useful in designing instructions. This means that they do not design lesson plans considering their specific courses, such as mathematics, at a higher education level. Unfortunately, the contents of the PSTs' lesson plans seem to remain at the secondary education level. They do not seem to identify mathematics content or concept connections between advanced mathematics knowledge (acquired during undergraduate studies) and mathematics taught in secondary schools, as Zazkis and Leikin (2010) suggest that few mathematics PSTs provide content-specific examples of PSTs' advanced mathematics knowledge. A further direction of this study will focus not only on the pedagogical knowledge aspect of PSTs, but also on content knowledge aspects such as mathematics content knowledge and pedagogical content knowledge for mathematics teachers.

Conclusion

In this study, we developed an effective and engaging IDT course. ID theories such as Gagné's Nine Events of Instruction were taught to affect PSTs in designing lessons based on such theories. Specifically, from the perspective of the aforementioned theory, students can design lessons that gain attention, informing the learner of the objective, stimulating recall of prerequisite learned capabilities, providing learning guidance, eliciting performance, assessing performance, and enhancing retention and transfer. From the perspective of the ARCS model, students can design lesson plans that focus on and find the relevance of learning content, make learners confident, and satisfy learners. In addition, the IDT course of Study 2 was meaningful and understandable due to the increase in students' motivation regarding ID; the PSTs' teaching experience level did not decrease. Therefore, this research can serve as a case study of an IDT course as an online asynchronous course.

However, this study had several limitations. Despite the PSTs' lesson plans improving from the perspective of Gagné's Nine Events of Instruction and the ARCS model, some students were unable to design lesson plans considering ID theories or models. As a future task, there may be a need to determine what makes these PSTs design lesson plans that do not consider these aspects. In addition, the relationship between the PSTs' teaching experience level and their ID engagement remains unknown.

Moreover, in this study, the PSTs designed lesson plans rather than an entire lesson. Therefore, whether PSTs can instruct actual lessons is not the focus. Furthermore, from the perspective of ID theory, this IDT course concerns effectiveness and appeal (engagement), but there is no focus on efficiency. In future tasks, researchers may consider how long PSTs spend designing lesson plans.

Acknowledgments

This study was supported by JSPS Grant-in-Aid for Scientific Research Grant Number JP19K03119.

Postscript

This study expands and orgamizes the results of a study presented by Nakamura, Misono, and Watanabe (2020b) and Nakamura, Misono, and Watanabe (2020c).

References

Aktaş, İ., & Özmen, H. (2020). Investigating the impact of TPACK development course on pre-service science teachers' performances. *Asia Pacific Education Review*, *21*(4), 667-682.

Alrwaished, N., Alkandari, A., & Alhashem, F. (2017). Exploring in- and pre-service science and mathematics teachers' technology, pedagogy, and content knowledge (TPACK): What next? *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(9), 6113–6131.

Central Council for Education. (2016). Youchien, shou gakkou, chu gakkou, koutou gakkou oyobi tokubetsu shien gakkou no gakusyu shidou youryou tou no kaizen oyobi hitsuyou na housaku tou ni tsuite [Improvement of the courses of study in kindergartens, elementary schools, junior high schools, high schools, and special support schools, and the measures needed to be taken]. https://www.mext.go.jp/b_menu/shingi/chukyo/chukyo0/toushin/1380731.htm (in Japanese)

Choi, H. (2020). Exploration of Instructional Design Changes of Pre-service Mathematics Teachers by Restructuring the Lesson Plan. *Journal of the Korean School Mathematics*, *23*(1), 159–177. (in Korean) https://doi.org/10.30807/ksms.2020.23.1.008

Feng, S., & Tuan, H. (2005). Using ARCS Model to Promote 11th Graders' Motivation and Achievement in Learning about Acids and Bases. *International Journal of Science and Mathematics Education*, *3*, 463–484. https://doi.org/https://doi.org/10.1007/s10763-004-6828-7

Gwet, K. L. (2014). *Handbook of Inter-Rater Reliability, 4th Edition: The Definitive Guide to Measuring The Extent of Agreement Among Raters*. Advanced Analytics.

Hicks, S., & Bose, D. (2019). Designing Teacher Preparation Courses: Integrating Mobile Technology, Program Standards, and Course Outcomes. *TechTrends*, *63*(6), 734-740.

Ichikawa, H. (2019) Jugyou wo tsukuru to iukoto [Designing a lesson]. In T. Inagaki (Ed.), *Kyoiku no houhou to gijutsu* [*Methods and Techniques of Teaching*] (pp.27-41). Tokyo: Kitaohji shobo. (in Japanese)

Igarashi, R., Miyauchi, T. & Yamada, H. (2018) Changes in teacher-efficacy and anxiety towards practice-teaching of student teachers through practice-teaching and preparatory-training. *Journal of The Human Development Research*, *8*, 67-78. (in Japanese)

Kawamoto, H., Watanabe, Y. & Hidaka, K. (2018). Primary Factors that Influence Learning Experience in Higher Education. *Japan Society for Educational Technology*, *41*(4), 363-374. (in Japanese)

Keller, J. M. (1987). Development and use of the ARCS model of instructional design. *Journal of Instructional Development*, *10*(2), 2–10. https://doi.org/10.1007/BF02905780

Landis, J. R., & Koch, G. G. (1977). The Measurement of Observer Agreement for Categorical Data. *Biometrics*, *33*(1), 159–174. https://doi.org/10.2307/2529310

Lombard, M., Snyder-Duch, J., & Bracken, C. C. (2010). *Practical resources for assessing and reporting intercoder reliability in content analysis research projects*. Retrieved from http://matthewlombard.com/reliability/index_print.html

Ministry of Education, Culture, Sports, Science and Technology. (2017). *Koyusyoku katei koa karikyuramu* [*A core curriculum of pre-service teacher-training course*]. Retrieved from https://www.mext.go.jp/b_menu/shingi/chousa/shotou/126/houkoku/1398442.htm (in Japanese)

Nakamura,K., Misono, T. & Watanabe, Y. (2020a) How Does Learning Instructional Design Theories Affect Instructional Designs of Pre-Service Teacher-Training Students? *Proceedings of the 36th Annual Conference of JSET,* 285-286. (in Japanese)

Nakamura, K., Misono, T., & Watanabe, Y. (2020b). How Does Learning Instructional Design Theories Affect Instructional Designs of Pre-Service Teacher-Training Students? *43rd Annual AECT Proceedings*, 249–258.

Nakamura, K., Misono, T., & Watanabe, Y. (2020c). A Study on Development of An Instructional Design and Technology Class and Instructional Designs of Pre-Service Teacher-Training Students. *International Conference for Media in Education 2020 Conference Program and Proceedings*, 546–551.

Organisation for Economic Co-operation and Development (2010). PISA 2018 Results Combined Executive Summaries. Paris: *OECD Publishing*. Retrieved from https://www.oecd.org/pisa/Combined_Executive_Summaries_PISA_2018.pdf

Parrish, P. and Wilson, B. G (2008). A design and research framework for learning experience. *A paper presented at the 31st Annual Convention of the AECT,* Orlando, FL.

Suzuki, K. (1995). Housou Riyou karano Jugyou Dezeina- Nyumon [Introduction to Instructional Designers from Broadcast Use]. Nippon Housou Kyouiku Kyoukai. Tokyo, Japan. (in Japanese)

Suzuki, K. (2005). Instructional Design for e-Learning Practices. *Japan Society for Educational Technology*, *29*(3), 197-205. (in Japanese)

Thomson, S., Wernert, N., O'Grady, E., & Rodrigues, S. (2017). TIMSS 2015: Reporting Australia's Results. Camberwell, Victoria: *Australian Council for Educational Research Ltd.* Retrieved from https://research.acer.edu.au/timss_2015/2/

Zazkis, R., & Leikin, R. (2010). Advanced mathematical knowledge in teaching practice: Perceptions of secondary mathematics teachers. *Mathematical Thinking and Learning*, *12*(4), 263–281. https://doi.org/10.1080/10986061003786349