Developing Technological Competence of Pre-service Teachers through Multiple-Representation Lesson Study

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Abstract

The effects of the Multiple-Representation Lesson Study (MRLS) on pre-service Physics teachers' technological competence were investigated by employing a pretest-posttest control group quasi-experimental design. The research was participated in by 18 randomly-chosen Physical Science majors of the Bachelor of Secondary Education program in a Philippine state university. Specifically, the Technological Knowledge and the competence in the production of instructional materials of the research participants were measured using the Technological Knowledge Test and the Scoring Rubric for Instructional Material Assessment. Results showed that the experimental group incurred a significantly higher mean score both in the written test and in the instructional material assessment than the control group. Findings suggest a higher technological competence of the pre-service teachers exposed to the MRLS than those exposed to the Traditional Instructional Planning Approach (TIPA). The integration of the Lesson Study framework and the utilization of multiple representations in the teacher education curriculum were recommended.

Keywords: lesson study (LS), multiple representations, pre-service teachers, science teaching, technological competence, technological knowledge

1. Introduction

The notion that technology has a pervading influence in the educational domain is irrefutable. In fact, the Technological Pedagogical Knowledge (TPCK) framework established by Mishra and Koehler (2006) is presently the overarching paradigm on instructional competence that lucidly embraces the crucial role technology plays in the didactic processes.

With the overwhelming success of the TPCK framework in underpinning educational constructs, much attention has been afforded to the development of the TPCK among pre-service and in-service teachers (Chang, Tsai, & Jang, 2014; Chew & Lim, 2013; Ervin, 2014). Conversely, little consideration has been provided to explore technological competence as a distinct domain. Understanding this construct necessitates understanding of technology and technological knowledge. However, there has been a confusion among teachers in distinguishing theoretical from practical knowledge of technology (Norstrom, 2013).

Norstrom (2014) has contended that there is an expansive sphere of viewing technological knowledge. For adult learners, the sources of this knowledge may come from practically everything that interacts with them (Knowles, 1984; Laal & Laal, 2012). Collaborative learning engagements like the Lesson Study, incorporated with technology-driven multiple representations, may potentially offer valuable learning outcomes (Fernandez, 2002; Laal & Laal, 2012).

This paper aims to elucidate technological competence in terms of conceptual and practical technological knowledge in the context of a group-based instructional planning approach.

1.1. Technological Knowledge and Competence

Technological knowledge encompasses a wide-ranging perspective (Norstrom, 2014), hence, technological competence denotes multi-faceted dimensions which demands various assessment methods. In the TPCK context, Technological Knowledge is defined as the recognition of the products, use, and function of the various technologies in the teaching-learning process (Koehler, Mishra, Akcaoglu, & Rosenberg 2013; Koehler, Mishra, & Cain, 2013).

Almerich, Orellana, Suárez-Rodríguez, & Díaz-García (2016) have asserted that teachers' ICT competence affects technological knowledge and technological competence. This knowledge and competence may be enhanced through high digital competence (Krumsvik, 2008), modeling from teachers, pervasive technology integration in learning activities, and peer collaboration (Tondeur et al., 2012).

Academicians and scholars have presented varied methods in assessing technological knowledge and competence. The most popular of which is the use of quantitative self-survey instruments (e.g. Chew & Lim, 2013). Few researchers, however, employed qualitative techniques (e.g. Cavin, 2007).

Literature provides a firm foundation of technology integration in education. However, there is paucity of data illuminating the technological competence as a distinct construct. Further, very few or no study has been devoted to probe the effects of the Multiple-Representation Lesson Study (MRLS) on pre-service Physics teachers' technological competence using a content-oriented test and an assessment of outputs or artefacts.

1.2. Lesson Study

Majority of the Teacher Education Institutions (TEIs) in the Philippines adhere to the Traditional Instructional Planning Approach (TIPA) where pre-service and in-service teachers do all instructional functions by themselves. The Japanese teachers do things differently; they collaboratively plan, design, and implement their lessons to investigate *how* their pupils learn the topics taught to them. This exceptional instructional practice is called *jugyokenkyu* or Lesson Study (Cerbin & Kopp, 2006; Fernandez, 2002).

A regular Lesson Study process involves the following steps: collaborative (1) goal-setting, (b) lesson planning, (c) designing the study, (d) implementing the lesson plan, (e) discussing the lesson implementation, (f) revising the lesson plan, and (f)documenting the entire study (Cavin, 2007; Cerbin & Kopp, 2006; Chew & Lim, 2013; Fernandez, 2002).

The integration of Lesson Study in many institutions around the globe have manifested various remarkable effects on pre-service teachers' instructional competence (Elipane, 2012; Gurl, 2009; McDowell, 2010) and student learning (Barrett, Riggs, & Ray, 2013; Kanellopoulou, E.M., Darra, M., 2018; Lucenario, Yangco, Punzalan, & Espinosa, 2016; Quilario, 2014; Teele, Maynard, & Marcoulides, 2015). Apparently, there is dearth in literature incorporating technology-driven and conventional representations in the Lesson Study framework. Moreover, no study cited the effects of the Multiple-Representation Lesson Study on the technological competence of pre-service Physics teachers.

This study aims to address the aforementioned gaps in knowledge. Likewise, it aims to cast light upon a relatively new educational paradigm which is founded on collaboration, group effort, and team spirit.

2. Methodology

The study employed a pretest-posttest control group quasi-experimental design. A total of 18 pre-service Physics teachers in a Teacher Education Institution (TEI) participated in the study. The experimental and the control groups were randomly selected through a fishbowl technique from the fourth year students of the Bachelor of Secondary Education (BSED) major in Physical Science in the academic year 2016-2017. Nine pre-service Physics teachers from the experimental group were exposed to the Multiple-Representation Lesson Study (MRLS). Meanwhile, nine participants from the control group carried out the Traditional Instructional Planning Approach (TIPA).

The study was conducted from June 2016 - August 2016 which was completed in six weeks during the Practice Teaching of the research participants. The two instructional approaches were implemented in the 12 Grade 8 classes of a public high school in Tacloban City, which, eventually, were divided into four groups. The Traditional Instructional Planning Approach (TIPA) was implemented in one group while the three MRLS versions were applied in the other three groups of classes. These were the first version technology-driven MRLS, the second version technology-driven MRLS, and the conventional version MRLS. Each class handled by the pre-service teachers was consisted of approximately 50 students.

2.1. The Sample

The study was participated in by 18 BSED-Physical Science students who qualified for Practice Teaching in the first semester of the academic year 2016-2017. They were equally divided into two groups by random assignment through a simple fishbowl technique. The profile of the research participants is exhibited in Table 1.

The mean age of the TIPA group participants was 19.56 years, with a range of 19 to 21 years. Conversely, the mean age of the MRLS group was 19.00 years, with age range of 18 to 20 years.

There were three male (33.3%) and six female (66.7%) participants in both the TIPA and the MRLS group. Eight (88.9%) from the TIPA group were products of public elementary schools while one (11.1%) was a product of a private elementary school. On the other hand, nine (100%) MRLS participants came from public elementary schools. Both the MRLS group and the TIPA group had seven (77.8%) members who graduated from public high schools and two (22.8%) members who graduated from private high schools.

Table 1: Profile of the Research Participants

Parameters	TIPA (*n* = 9)	MRLS (*n* = 9)
Age Range	19-21	18-20
Average Age	19.56	19.00
Sex		
Male	3 (33.3%)	3 (33.3%)
Female	6 (66.7%)	6 (66.7%)
Elementary		
Public	8 (88.9%)	9 (100%)
Private	1 (11.1%)	0
High School		
Public	7 (77.8%)	7 (77.8%)
Private	2 (22.2%)	2 (22.2%)
Mean Rating in Science	1.91 (2.4-1.5)	1.89 (2.3-1.6)
Mean Rating in Math	1.72 (2.3-1.1)	1.77 (2.5-1.1)

Note: Mean Ratings in Science and Math were derived from participants' ratings in 19 Science and two Math subjects that they have taken prior to the experiment. The highest possible rating or grade is 1.0 while the lowest passing grade is 3.0.

Prior to the conduct of this research, the academic performance of the research participants was determined by obtaining their mean ratings in Science and Mathematics. Data were derived from the 13 Science courses and two Mathematics courses that they have taken before their participation in the study. Table 2 provides the group-data and the statistical analysis on academic performance.

Table 2: Mann-Whitney *U* Test for Academic Performance

Subject/Group	***N***	***Mean Rating***	***Mean Rank***	***Mann-Whitney U***	***p***
Science					
MRLS	9	1.89	9.67	39.0	.894
TIPA	9	1.91	9.33		
Math					
MRLS	9	1.77	10.00	36.0	.690
TIPA	9	1.72	9.00		

It can be shown in the table that there was no significant difference between the group ratings in Science of the MRLS group and the TIPA group (p = .894). In the same manner, it was found that the two groups did not have significantly different mean rating in Mathematics (p=.690). These suggest that TIPA participants are comparable to MRLS participants in terms of academic performance in Science and Mathematics before their participation in the study.

2.2. The Instruments

A. The Technological Knowledge Test

The Technological Knowledge Test was a 15-item researcher-made written instrument aimed at assessing pre-service teachers' knowledge of the existence, functions, and appropriate uses of the different educational technologies. Each question contained three options with corresponding number of points. The correct option was equivalent to three points, the partially correct option was scored two points, while the least probable option was worth one point. A maximum of 45 points and a minimum of 15 points may be obtained from the Technological Knowledge Test.

Three experts from the University of the Philippines validated the instrument. They were composed of researchers, book authors, and trainers in the field of Science and Mathematics Education. The instrument was pre-tested and then pilot-tested to 77 pre-service teachers of the BSED-Physical Science program from two state universities in the Eastern Visayas Region, Philippines. The pre-testing resulted to a Cronbach's alpha of .703 for the entire instrument.

B. The Scoring Rubric for Assessing Instructional Materials (IMs)

This instrument consisted of four items with a five-point scoring method of three corresponding descriptions - Novice (1), Intermediate (2-3 points), and Advanced (4-5 points). Each research participant can get a maximum score of 20 points and a minimum score of 4 points when assessed using this instrument. The overall intraclass correlation (ICC) coefficient of this rubric was .946. The coefficients for the four items – Relevance, Functionality, Aesthetics, and Workmanship - ranged from .934 to .975.

C. Interview Protocols

To substantiate the Technological Knowledge of the pre-service Physics teachers, interviews were done aside from the written assessment. The questions revolved on the choices of instructional technologies adapted in their teaching. Follow-up questions were also asked to emphasize their knowledge on the functions and uses of the technologies that they mentioned. The interviews were scheduled on August 18-19, 2016, after the intervention.

D. Journals

Data were also derived from the daily experiences of the research participants with the implementation of their respective lessons utilizing the specific instructional approach assigned to them. These experiences were written on a notebook with specific dates and entries. The term "journal" was used to call the instrument.

The participants were oriented to emphasize in their journal entries the challenges and successes that they have experienced, as well as the coping mechanisms that they have carried out. The journals were collected after the interview, the last day of data-gathering.

2.3. Data Collection Procedure

The researcher asked permission from the university president and other academic administrators to commence the data-gathering procedure during the first stage of Student Practice Teaching, School Year (SY) 2016-2017. A letter was signed by the researcher and the adviser which were then approved by the university officials on March 17, 2016. On April 11, 2016, the research participants were oriented on the entire process of the study. Later in the afternoon, they were asked to sign the Informed Consent Form after all the procedures were explained and all their queries were answered.

Similarly, permission was sought from the Tacloban City Schools Division Superintendent, School Principal, and Science teachers to conduct the study in the public high school where the pre-service teachers were fielded for Practice Teaching. The letters were signed and approved by the Schools Division Superintendent and by the School Principal on June 28, 2016, and July 1, 2016, respectively.

An orientation with the Science Cooperating Teacher Coordinators (CTEs) was conducted on July 4, 2016. They were the public high school Science teachers who were tasked to monitor and assess the progress of the pre-service teachers. The researcher asked permission to conduct regular observation of classes, to record the lesson implementations through a video camera, and to use some student records for research purposes. The researcher discussed the flow of the study, the role of the CTEs, the schedule of activities, and the data needed for the analyses. Likewise, the risks and benefits of the study were explained.

A. Multiple-Representation Lesson Study (MRLS) in Practice Teaching

The nine members of the MRLS group were divided further into three sub-groups. Each sub-group worked collaboratively in writing the lesson plans and in constructing the instructional materials for all the Physics topics assigned to them. For each lesson implementation, one of the sub-group members delivered the lesson while the other two members scrutinized students' behavior and reaction towards the lesson. They recorded their observations with emphasis on *how* the students learn the topic through their interactions with the teacher and with the learning activities.

The MRLS group handled three Science classes where the three versions of the instructional plans were implemented. – the first version of the technology-based lesson plan, the conventional version, and the second version of the technology-based lesson plan. Two or more digital representations (i.e. verbal, pictorial, graphical, mathematical, or/and multimedia systems) were utilized on the technology-based versions. Similarly, two or more traditional representations were used for the conventional version.

After every implementation of the first version of the technology-based lesson plan, the sub-group members discussed all their observations with or without the presence of the CTE and the researcher. The suggestions and comments that arose from the post-lesson discussion were integrated in the revision of the lesson plan, hence, the second version of the technology-based lesson plan. This version was implemented in the fourth-period class which was followed by another post-lesson discussion. The results were then used to write the final lesson plan and observation reports, and to create the final instructional materials.

C. Traditional Instructional Planning Approach (TIPA) in Practice Teaching

The Traditional Instructional Planning Approach (TIPA) is the prevailing practice in the university where the research was conducted. Pre-service teachers are trained to write instructional plans, construct instructional materials (IMs), and implement the lesson plans on their own. Contrary to the collaborative nature of the MRLS, the TIPA is individualistic in nature.

During the intervention, the TIPA group members individually prepared the lesson plans, fabricated the instructional technologies, and implemented the instructional plans. An individualized post-lesson discussion was done by the CTE, with or without the researcher, every after lesson implementation. Revisions were made based on the comments and recommendations of the CTE and / or the researcher.

The members of the TIPA group were free to utilize traditional or digital instructional materials. However, majority of them (seven out of nine) favored the traditional IMs due to some limitations such as the lack of laptop or computer unit. Some of them preferred the traditional preparation of visual aids in order to master the content as concepts were retained while they wrote them on the Manila paper and cartolina.

Over one hundred ninety videos of lesson implementations of all the research participants were recorded and analyzed by the researcher, the CTEs, and an external expert. Emphasis was placed on the type of educational technologies used and how they were used in the lesson. Table 3 shows the summary of the entire study.

Table 3: Summary of the Study

MRLS Group	TIPA Group
• Technological Knowledge Pretest	• Technological Knowledge Pretest
• Orientation of the Research Procedure	• Orientation of the Research Procedure
• Practice Teaching through MRLS ▪ Collaborative lesson planning ▪ Collaborative construction of IMS ▪ Collaborative lesson implementations (Tech-based 1st and 2nd Versions, Conventional) ▪ Group-based post-lesson discussions	• Practice Teaching through TIPA ▪ Individual lesson planning ▪ Individual construction of IMS ▪ Individual lesson implementations ▪ Individualized feedback
• Technological Knowledge Posttest	• Technological Knowledge Posttest

2.4. Data Analysis Procedure

Data derived from the Technological Knowledge Test and IMs assessment were analyzed using quantitative measures through the SPSS program, Version 23. Specifically, the statistical difference between the scores of the MRLS group and the TIPA group was determined using the Mann-Whitney *U* test at a .05 significance level.

The conceptual content analysis was utilized to analyze the interview responses and journal entries. Data were coded until categories and themes were generated.

3. Results and Discussions

Figure 2 presents the group mean scores in the Technological Knowledge Test. It can be shown that the MRLS group (*Mn*= 41.00, 91.11%) obtained a slightly higher mean score than the TIPA group (*Mn*= 40.56, 90.13%) in the pretest. However, the Mann-Whitney *U* test analysis showed a non-significant difference (*p*=.928) in the group mean scores. This suggests that the MRLS participants were comparable to the TIPA participants in terms of Technological Knowledge prior to the conduct of the study.

The posttest results, on the other, revealed that the MRLS group obtained a significantly higher mean score (*Mn*= 41.90, 93.10%; *p*=.002) than the TIPA group (*Mn*= 38.80, 86.20%). This indicates a higher level of Technological Knowledge of the MRLS group than the TIPA group after the intervention.

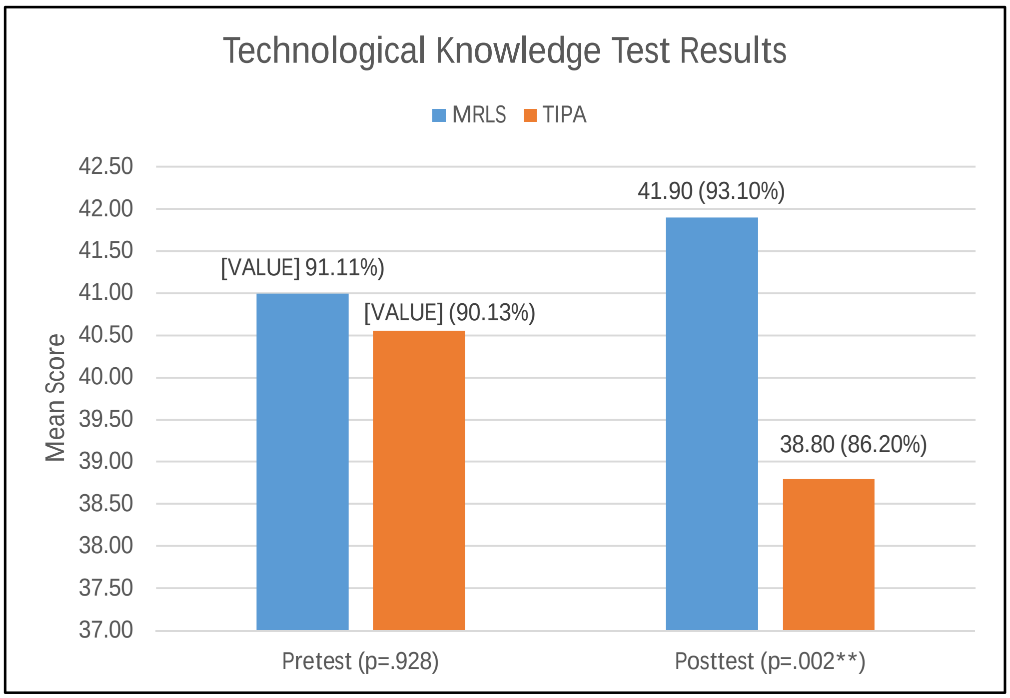

Figure 2. Technological Knowledge Test Mean Scores

The Technological Knowledge of the pre-service teachers were further measured through the instructional materials that they have developed and utilized. It must be noted that the mean scores of the research participants were obtained from the scores given by the three evaluators – the CTE, the researcher, and the external expert. It can be culled from Table 4 and Table 5 that the MRLS (*Mn*=4.04) group significantly outperformed the TIPA group (*Mn*=3.48; *p*=.012) with a large effect size (*r*=.593).

Table 4. Technological Knowledge through Instructional Material Assessment

Group	*N*	*Mn* (*Max.=5.00*)	*SD*	*(SD)²*	*η*	*η²*
MRLS	9	4.04	.245	.060		
TIPA	9	3.48	.431	.186	.641	.412
Total	18	3.76	.444	.197		

Note: *Mn*=mean; *SD*=standard deviation; *(SD)²*=variance; and *η and η²=measures of association*

Results of the study suggest that the MRLS can effectively develop the theoretical and practical technological knowledge of pre-service Physics teachers. Further, these imply that a holistic view of the Technological knowledge may not be sufficiently provided by a single measure.

Table 5. Mann-Whitney *U* Test for the Instructional Material Assessment

Group	*N*	*Mean Rank*	*Mann-Whitney U*	*Z*	*p*	*r (ES)*
MRLS	9	12.7	12.0	-2.518	.012*	.593
TIPA	9	6.33				

Note: **p<.05*

The results of this study support the findings of other scholars. Chew & Lim (2013) and Ceppi-Busmann (2006) expressed a positive effect of the Lesson Study on the technological knowledge of pre-service and in-service teachers. This may have been prompted by the extended interaction of the MRLS participants with the educational technologies and with their peers as they engaged in the collaborative instructional activities. As mature learners, social interaction may have developed their cognitive faculties that created a web of learning systems concerning knowledge of educational technologies (Laal & Laal, 2012; Knowles, 1984). The conceptual knowledge acquired by the learner through their interaction with peers and through their actual experience with technologies is easily transformed into practical knowledge as evidenced by tangible products like the instructional materials.

The utilization of digital tools and multiple representations by the MRLS group may also have instigated an improved Technological Knowledge (Ainsworth, 2006; Mayer, n.d.). A technology-infused classroom environment offers unlimited possibilities for learning, may it be conceptual or procedural (Ainsworth, 2006; Almerich et al., 2016; Chai, Koh, & Tsai, 2010; Terpstra, 2009). A variety of digital representations or multimedia systems may be created and utilized for instruction by discovering existing application softwares (Krumsvik, 2008).

Results of this research draw certain implications to teaching and learning. First, a collaborative instructional practice fosters a significant impact on the theoretical and practical Technological Knowledge of pre-service teachers. Providing an expansive cooperative learning experiences in the undergraduate teacher education curriculum is vital in the development of prospective teachers' Technological Knowledge. Second, an extensive conceptual and pragmatic Technological Knowledge may be promoted by setting learning experiences supported with multiple representations, particularly the technology-generated representations. Pre-service teachers may be trained to effectively use varied digital and conventional representations prior to and during practice teaching to scaffold their technological competence. Lastly, the use of multiple methods in assessing student learning may be promoted in all stages of the teacher education curriculum. Assessing learning products can appreciably substantiate the teachers' understanding on the learner's performance.

4. Conclusion and Recommendations

It has been shown that the pre-service Physics teachers exposed to the Multiple-Representation Lesson Study (MRLS) scored significantly higher than those exposed to the Traditional Instructional Planning Approach (TIPA) in the Technological Knowledge Test. Moreover, the MRLS group scored significantly higher than the TIPA group in the instructional material assessment. These suggest that the MRLS is an effective instructional approach in developing the technological competence of pre-service teachers. Specifically, it can effectively enhance preservice teachers' theoretical and practical Technological Knowledge.

Consequently, it is recommended that the Lesson Study framework be integrated in the teacher education curriculum and in the in-service teacher development programs. This collaborative instructional approach offers wide-ranging potentials in the instructional competence development. Furthermore, the use of multiple representations in any instructional engagement is highly recommended. The technology-generated and conventional multiple representations pose various learning endeavors that stimulate learners' intellectual faculties. Finally, multiple-assessment methods are strongly recommended to comprehensively assess student learning. A simple written test may not provide an exhaustive information of students' academic performance.

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