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A Model Proposal on ICT Integration for Effective Mathematics Instruction*

Etkili Matematik Öğretimi için BİT Entegrasyonu Model Önerisi

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ABSTRACT: The aim of this study is to present a model for an effective mathematics instruction with respect to how ICT integration is put into practice. The research was established on three bases as effective mathematics instruction, ICT integration and 5E learning cycle. A learning environment was created by grounding on these three elements. In this study, which was carried out in accordance with design-based research model, the participants were 47 preservice mathematics teachers. As data-collection tools, video-recordings, check-lists, and lesson plans were used. By the nature of design-based research model, data was collected during 12 weeks to enable the designs to be improved constantly, and it was analyzed instantly, consistently, retrospectively by means of frequency, percent and content analysis. As a result of the data analysis, it was revealed that the learning environment made a positive contribution to the process of preparing lesson plans aimed at providing ICT integration for effective mathematics instruction. When the realization process of ICT integration in prepared lesson plans has been investigated that 95 percent of 101 lesson plans of all weeks have been successful in terms of ICT integration. As a result, a model involving "Planning-Implementation-Evaluation" for implementing ICT integration was proposed.

Keywords: ICT integration, Effective mathematics instruction, Preservice teachers, Design based research, 5E learning cycle

ÖZ: Bu çalışmanın amacı etkili matematik öğretimi için BİT entegrasyonunun nasıl gerçekleştirilebileceğine ilişkin bir model önerisi ortaya koymaktır. Araştırma, etkili matematik öğretimi, BİT entegrasyonu ve 5E öğrenme döngüsü olmak üzere üç temel üzerine kurulmuştur. 12 hafta devam eden uygulama sürecinde bu üç öge temel alınarak bir öğrenme ortamı oluşturulmuştur. Tasarım tabanlı araştırma modeline uygun olarak yürütülen çalışmada katılımcılar, Bilgisayar Destekli Matematik Öğretimi dersini almakta olan 47 ilköğretim matematik öğretmen adayından oluşmuştur. Verilerin toplanmasında araştırmacılar tarafından geliştirilen kontrol listeleri, video kayıtları, öğrencilerin hazırladıkları ders planları, yansımalar ve anket kullanılmıştır. Tasarım Tabanlı araştırma modelinin doğası gereği, Tasarımların sürekli olarak iyileştirilebilmesi için 12 hafta boyunca veriler toplanmış ve her hafta toplanan veriler hemen, sürekli ve geriye dönük olarak frekans, yüzde ve içerik analizi yoluyla çözümlenmiştir. Verilerin analizi sonucunda, etkili matematik öğretimi, BİT entegrasyonu ve 5E öğrenme döngüsü olmak üzere üç temel üzerine kurulan öğrenme ortamının öğretmen adaylarının etkili matematik öğretimi için BİT entegrasyonunu sağlamaya yönelik ders planı hazırlama süreçlerine olumlu katkı sağladığı belirlenmiştir. Hazırlanan ders planlarında BİT entegrasyonunun gerçekleşme süreci incelendiğinde tüm haftalara ait 101 ders planından %95'inin BİTE açısından başarılı olduğu söylenebilir. Buradan yola çıkılarak etkili öğretim süreçleri gerçekleştirilebilmesi için BİT entegrasyonunun nasıl sağlanabileceğine ilişkin "Planlama-Uygulama-Değerlendirme" modeli ortaya konulmuştur.

Anahtar sözcükler: Etkili Matematik Öğretimi, Bilgi ve İletişim Teknolojileri, BİT Entegrasyonu, Öğretmen Adayı, Tasarım Temelli Araştırma

1. INTRODUCTION

It is stated that the use of Information and Communication Technologies (ICT) in learning and teaching mathematical concepts has made a positive contribution to students' learning and

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their motivation (Duru, Peker & Birgin 2012; Lin, 2008; Işıksal & Aşkar, 2005, Baki 2000). As is specified in “Technology Principle” which ranks among principles of school mathematics published by National Council of Teachers of Mathematics (NCTM) in 2000, how to use technology in classes and the yield of such use are bound to teachers.

Henceforth, it is expected that teachers will use ICT to enrich learning opportunities and enable its continuity. It can be said that this process will be decisive in effectiveness of both integration and teaching process. However, when the literature is examined, it has been seen that most of the teachers do not feel well-prepared while using technology and they need more knowledge and skills about the use of technology (Glazer, Hannafin & Song, 2005; Mumcu, 2011; Mumcu, Haslaman & Usluel, 2008). Studies have shown that preservice teachers’ competence in ICT-based instruction also increases thanks to their increasing knowledge and experience in the use of ICT (Hsu, 2010; Yurdakul, 2011). It has been set forth in studies that preservice teachers will learn ICT integration better and convey it to their teaching processes when they find an opportunity to integrate ICT with their observations and experience during their own learning processes (Glazer, Hannafin & Song, 2005; Mueller, Wood, Willoughby, Ross & Specht, 2008).

From this point of view, an ICT integration in mathematics instruction themed course was designed on the strength of principles of Effective Mathematics Instruction (EMI) and 5E Learning Cycle Model (5ELCM). With this course it’s aimed that prospective teachers to learn ICT integration for effective mathematics instruction and to observe the outputs.

1.1. Effective Mathematics Instruction (EMI)

When the literature is reviewed, it is ascertained that there are studies about EMI which examine the process and students’-teachers’ roles (Garnett 1992; Huang, Li & He, 2010; Kılıç 2010; Muschla, Muschla & Muschla 2010; Ontario Ministry of Education 2006; Smith & Geller 2004; Steedly, Dragoo, Afareh & Luke 2008; Trafton 1984). Yet, what is to be understood from EMI is not presented clearly.

In this research teaching principle of NCTM is handled as EMI. Teaching, which is one of the six principles of school mathematics determined by NCTM (2000) focuses on EMI. Therefore, what must be done in the process of EMI is emphasized rather than what is EMI.

According to this principle, it is emphasized that it is necessary to encourage and support students to point out and learn what they know and need to know for EMI in the best way. Moreover, the process of EMI was shaped according to principles put forward in A Guide to Effective Instruction in Mathematics.

The principles for EMI in the book named as “A Guide to Effective Instruction in Mathematics” are ranged as follows:

- Foster Positive Mathematical Attitudes Focus on Conceptual Understanding
- Involve Students Actively in Their Learning
- Acknowledge and Utilize Students’ Prior Knowledge
- Provide Developmentally Appropriate Learning Tasks
- Respect How Each Student Learns
- Provide a Culture and Climate for Learning
- Recognize the Importance of Metacognition Focus on the Significant Mathematical Concepts (Big Ideas)

1.2. ICT Integration

ICT integration is a flexible, dynamic and changeable process. Therefore, it is seen that definition of the process has been handled differently (Mishra and Koehler 2006; ISTE, 2000; Lim, Teo, Wong, Khine, Chai & Divaharan, 2003; Lim & Ching, 2004; Roblyer 2006; Toledo, 2005; Tondeur, Hermans, van Braak & Valcke 2008; Vanderlinde & van Braak, 2010, Wang & Woo 2007). In this research, the process of ICT integration is accepted as “to contribute students’ learning-teaching processes with a suitable ICT and make it permanent and sustainable” (Usluel & Yıldız, 2012).

Different integration models were seen in literature (Haslaman, Kuskaya & Kocak 2008; Mishra & Koehler, 2006; Roblyer, 2006; Tondeur, Hermans, Van Braak & Valcke, 2008; Vanderlinde & van Braak, 2010; Wang 2008; Wang & Woo, 2007). These models approach to the process from different standpoints. It’s suggested that most of the models are dealing with only one dimension of the process. While some models focus on teachers or students, others give attention to the educational organizations or settings. Therefore, it can be clearly asserted that a model, which is practice-oriented and handles the process more holistically, is needed.

In this article, a four-step process to determine indicators of integration process was folllowed. Indicators of ICTintegration process were specified in this way.

- 48 articles obtained which aim to reveal regression analysis and the variables of the integration process. 40 articles found in the period from 2000 to 2010 (Kaya & Usluel 2011). Then 8 more articles were obtained by reviewing the literature for the studies having done after 2010.
- The indicators of The National Center for Education Statistics (NCES, 2002).
- The variables in integration models (Haslaman, Mumcu, Usluel, 2008; Mishra & Koehler, 2006; Roblyer, 2006; Tondeur, Hermans, Van Braak & Valcke, 2008; Vanderlinde & van Braak, 2010; Wang & Woo, 2007; Wang, 2008).
- Barriers of ICT integration and teacher competencies (Brush, Glazewski, Rutowski et. al, 2003; MEB, 2006; MEB, 2008).

1.3. 5E Learning Cycle Model (5ELCM)

5ELCM is a five stage cycle was developed by Bybee (1997) and accepted as one of the most suitable learning models for constructivist approach. It is manifest that model form its own concepts based on the principles of constructivist approach and attempts to make students involved in the process. (Trowbridge, Bybee & Powell, 2004). 5ELCM is explained briefly below:

Engage: Students are aware of the related topic, their prior knowledge and misconceptions are come to light.

Exploration: Students explore concepts taught with the help of appropriate activities.

Explanation: Students first express concepts with their own words and share others, and then these are presented formally by teachers.

Elaboration: New activities are presented to provide students with using the knowledge, skills and experience in new contexts which they gained beforehand.

Evaluation: Both learning-teaching processes and students’ products are evaluated. The data obtained is used for the next cycle to improve.

1.4. Research Questions

The aim of this study is to examine preservice teachers how to implement ICT integration according to 5ELCM for EMI in a learning environment within the frame of design-based research model. Within the scope of them, answers to the following questions have been sought:

- How is the implementation process of ICT integration in lesson plans that preservice teachers prepare according to 5ELCM?
- How is the implementation process of EMI in lesson plans that preservice teachers prepare according to 5ELCM?

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2. METHOD

The study seeks an answer to how to organize an instruction for ICT integration for an effective mathematics instruction. For this purpose, an instructional design was prepared and implemented weekly in an authentic environment. Every implementation of the design was evaluated weekly and needed-improvement studies based on these evaluations were performed. In this study researcher took an initiative in research as both researcher and designer. According to Wang & Hannafin (2005), these types of research actions are described as Design-Based Research (DBR). Therefore, the research was designed as Design-Based Research (DBR).

2.1. Design-Based Research

DBR is a cyclical and recursive process which is conducted in authentic environments for innovative learning settings to be developed, applied and information to be produced. It presents new learning opportunities and prevents gap between research and practice (Barab & Squire, 2004; Brown, 1992; Cobb, Confrey, diSessa, Lehrer & Schauble, 2003; Design-Based Research Collective, 2003; Jonassen, Cernusca & Ionas, 2007). Mckenney and Reeves (2012) define the information obtained during research and shared among other researchers and participants as “usable information”. Recursions display a spiral structure (Figure 1) and the data from every cycle has clues to improving the next cycle.

Every evaluation process produces the data that will be used for analysis and improvement of the next cycle. These cycles are handled as weekly lessons throughout implementation process and the data collected every week is used to enhance the application that will be performed one week later. Also, these cycles make possible the model to be tested (Cobb, 2001).

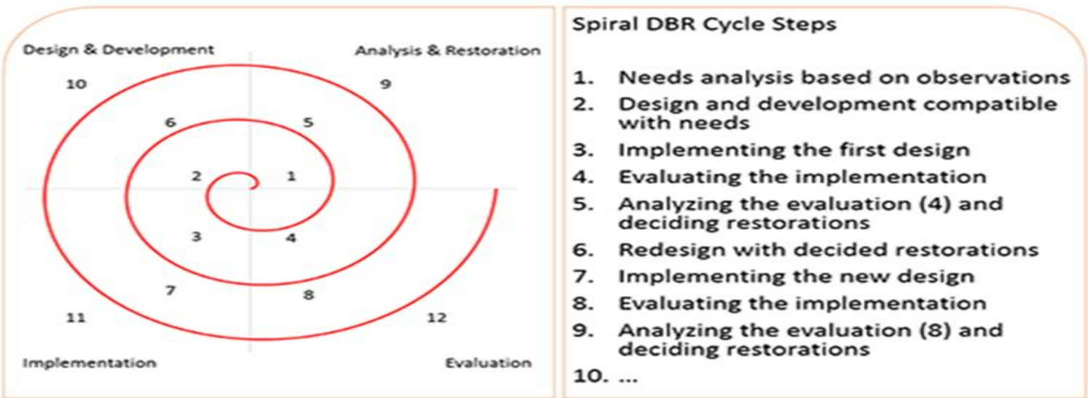

Figure 1: Spiral DBR Cycle (Adapted from Gay & Hembrooke (2004))

In this paper, common features needed to be found in DBR are identified by reviewing the literature (Anderson & Shattuck, 2012; McKenney & Reeves, 2012; Van den Akker, Gravemeiger, McKenney & Nieveen, 2006; Wang & Hannafin, 2005). Those stand in line below:

- Conduct the study in authentic educational contexts which reflect daily life situations
- Provide co-operation among researchers, practitioners and participants
- Improve the designs continuously
- Analyse the data instantly, consistently and retrospectively
- Support the design by the help of the other researchers
- More specific qualities are represented for technology-based environments as well (Wang & Hannafin, 2005):
- It is necessary to integrate the known design principles and technological opportunities in complex problems.
- Reflective inquiry is to be done in order to test and improve innovative learning settings and reveal new design principles.

In literature DBR is applied in different ways such as “arrangement and improvement works of preservice teachers’ training done one-to-one (teacher-researcher and student)”, “studies conducted by teachers and cooperated with researchers relating to enhancing professional development” and “works of restructuring schools and school districts” (Akkoyunlu, 1991; Cobb & Steffe, 1983; Confrey, Bell & Carrejo, 2001; Güler, 2010; Haslaman, 2011; Lehrer & Schauble, 2000; Simon, 2000; Steffe & Thompson, 2000; Stein, Silver & Smith, 1998). This is a study carried out by within the context of “arrangement and improvement works of preservice teachers’ training done one-to-one (teacher-researcher and student)” (Güler, 2010; Simon, 2000). Details about implementation are mentioned in the section of implementation process.

2.2. Study Group

The research was conducted with nine male and 38 female, totally 47 preservice elementary mathematics teachers who took the course “Computer-Based Mathematics Instruction” in 2011-2012 academic year, 6th semester at Hacettepe University, Division of Elementary Mathematics Education. In this study that was performed in a design-based manner, active participation of preservice teachers into the process and high level of co-operation (Brown, 1992; Cobb et al., 2003) with all participants are required. Therefore, study group was determined with convenient sampling method.

The researcher was the instructor of “Computer-Based Mathematics Instruction” course and studying on ICT in mathematics education.

2.2.1. ICT profile of study group

Before computer based mathematics instruction course, preservice teachers took the courses whose contents are below:

Basic computer usage, operating systems and office applications, web design, basic animation applications, interactive whiteboard usage, Moodle learning management system usage and management, accessing, usage and evaluation of web-based virtual materials, Geogebra, Cabri II, Cabri 3D, Sketchup, Tinkerplots, Hot potatoes, Inspiration and Computer Algebra Systems.

2.3. Implementation Process

Implementation was maintained with preservice elementary mathematics teachers in the Computer-Based Mathematics Instruction course. The course was based on Elementary Mathematics Curriculum and the context was chosen from it. According to class levels, four objectives were picked from 6th and 7th grades and three from 7th grade.

When it comes to learning domains, 2 objectives were chosen from numbers, geometry, measurement and 3 ones from probability and statistics and algebra sub-learning domains. Thus, sample lesson plans were prepared for every learning domain and grades and it comprises 36.4 % of Ministry of National Education 6th to 8th grades elementary mathematics curriculum. Throughout the implementation, it was expected every week that preservice teachers would prepare lesson plans concerning different learning and sub-learning domains and objectives.

2.4. Implementation Setting

Implementation was applied at physical and online learning environment. It was strived in an environment of ICT integration underlying definition of integration adopted by researchers.

Physical Environment: Lessons were taught in a computer laboratory (Figure 2) which had wideband internet, projection and interactive whiteboard. Streaming video recordings of the lessons were available as well.

Online Environment: Moodle, which is a free web-based learning management system, was used in the research. It was used with a view to keeping activities and communication going on, providing learners with constantly taking part in the process and facilitating their access to contents and the other participants.

Weekly-implementations were carried out at three stages:

1. Before Lesson: This part includes preparations for the lesson. The items done here:

- Determining learning /sub-learning domains and objectives
- Preparing sample lesson plans
- Controlling class infrastructure and equipment and software requirements
- Choosing appropriate materials or developing the necessary ones
- Organizing the classroom environment

Expert opinions were taken and preparations were completed to carry out the first two stages.

Figure 2: Physical Environment

2. Lesson Process: Lesson process as theory and practice is comprised of two course hours.

First hour was designed to give feedback about previous lesson's homework, searching the new topic related to new lesson and learning/retrieving the subject. The student groups were formed. Objectives on which students would study were specified. Afterwards, groups work on eliciting students and teachers' prior knowledge, which requires them to owe on the purpose of teaching the subject, and possible misconceptions found in literature related to the subject. These information were expected to be used as a guide during lesson plan preparation. Groups completed the hour by determining ICT that they would use for the objectives at the engage stage of 5ELCM.

As to the second part, it was conducted in the manner of representing, reviewing and evaluating sample lesson plans. Sample lesson plan prepared for that week was taught elaborately and activities were conducted by preservice teachers. Afterwards, lesson plan and its practice were evaluated.

3. After Lesson: Preservice teachers also continued preparing their lesson plans in their extracurricular time. In this respect, group works went on with Moodle opportunities.

Reflections on lessons from preservice teachers were anticipated. In accordance with the nature of DBR, these weekly-received reflections were used in order to improve the next-week-lesson.

2.5. Data Collection Instruments

Questionnaire for Accessing and Using ICT: Questionnaire was comprised of six questions to determine participants' levels of accessing and using ICT and their demographic information.

5E Learning Cycle Checklist: Based on research on the subject of 5ELCM (Bybee, 1997; Campbell, 2000; Smerdan & Burkam 1999; Trowbridge, Bybee & Powell 2004), expected behaviors of teachers and students regarding the five stages are listed in tables (Yıldız, 2013). Indicators related to the process of 5ELCM were determined thanks to with the help of expert opinions. Checklists were formed by specifying them. Checklist items consisting of 44 ones in total were graded as 1 and 0. KR20 was calculated as ,71 in the reliability test.

Sample Items:

Stage	**Sample Item**
Engage	: puts forward the problem
Explore	: interacts with learners only as a facilitator; provides them resources and feedback.
Explanation	: wants proof and explanations from learners.
Elaboration	: recalls learners alternative explanations and directs them forward.
Evaluation	: evaluates learners' knowledge and skills.

ICT Integration Checklist: ICT Integration Checklist developed by Usluel and Yıldız (Usluel & Yıldız, 2012) was applied in order to assess the suitability of lesson plans to ICT integration. Checklist items consisting of 42 ones in total were graded as 1 and 0. KR20 was calculated as ,825 in the reliability test.

Sample Items:

- ICT is to be accessed easily by everyone (teachers and learners)
- Selected ICT is appropriate for technological infrastructure.
- Selected ICT is appropriate for objectives.
- Selected ICT is appropriate for grade levels.
- ICT-enhanced environment was provided for teachers and learners in classrooms.

- ICT was used to give/collect homework/duties/activities.

Effective Mathematics Instruction Checklist: Based on the studies related to this field in literature, teachers' expected roles during EMI implementation were specified by the researchers. By getting expert opinions they were accepted as indicators of EMI implementation. A 28-item checklist was formed with these indicators. These items were graded as 1 and 0. KR20 was calculated as .65 in the reliability test.

Sample Items:

- The objectives were put forward.
- Misconceptions were determined regarding concepts.
- Students' prior knowledge was linked strongly to new concepts.
- Multiple representations were used.
- Different evaluation methods were suggested, and both the process and learning objectives were assessed with them.
- Students could gain experience in problem solving.

Preservice Teachers' Weekly Reflections: Weekly reflections were taken by 7 open-ended questions to receive preservice teachers' opinions about 5ELCM, physical environment and lesson plans which they developed during ICT integration process. These reflections were utilized to improve the next lesson.

Video Records: Implementation process was recorded by video camera. These records were used to monitor shortcomings of the implementation and to improve the next-week implementation accordingly, to analyse retrospectively and diversify data, make a validity study on suitability of sample lessons to 5ELCM, ICT Integration and EMI.

2.6. Validity of the Study

Expert opinions were received to specify whether weekly-lessons were taught suitably according to 5ELCM, ICT Integration and EMI during the implementation process. Lesson plans prepared before the lessons were evaluated via checklists by 3 experts. In accordance with expert suggestions, lesson plans were improved according to 5ELCM, ICT Integration and EMI.

In the process of lesson plans' implementation, experts were not in the classroom; they evaluated iteratively whether the lesson was taught according to the elements of 5ELCM, ICT Integration and EMI via checklists by watching video recordings per week. Evaluation results were added weekly to the process in order to enhance the next-week-implementation.

The lesson plans prepared by students were evaluated based on the checklists by instructors. To provide validity and reliability of the lesson plans' evaluation period, 3 lesson plans per week were selected randomly and 30 lesson plans were evaluated by 2 experts in addition to the researcher. Cohen's Kappa was calculated to provide interrater validity. Coherence between Kappa points and observers or raters is calculated in percent (Gwet, 2008; Landis & Koch, 1977), the lowest point was .839 and almost perfect according to Kappa scale (Landis & Koch, 1977).

Furthermore, triangulation and participant control (Yıldırım & Şimşek, 2005) were used to provide the validity.

Triangulation: In addition to products taken from the participants, reflections, observations and video recordings were used.

Participant Control: It was requested preservice teachers to evaluate by taking into consideration the lesson plan and all checklists. Thus, the fact that participants would involve in the process and the credibility was provided.

2.7. Data Analysis

Data was collected through lesson plans prepared by preservice teachers, participations in online environment, observations and video recordings. Lesson plans were graded and evaluated with three checklists by taking the participants' reflections and learning domains into consideration. Points of each lesson plan were transformed into percentages on both sub-components and total point because the maximum point of each checklist was different. 60 was set as the pass mark. Accordingly, lesson plans were evaluated with their sub-components and total point.

Components of 5ELCM, ICT Integration and EMI which underline this study are comprised of many checklist items. In addition, they separate into two groups: 1- Items that ones who prepare lesson plans and implement them have chance to intervene. 2- Items that are required but ones who prepare lesson plans and implement them do not have chance to intervene. The main reason for this separation is to exclude main components such as infrastructure, technical support, curriculum, etc. from evaluation. Point scoring was done with the suppose that they were in every lesson plan at the beginning. However, the study was based on evaluating the items that participants could make changes, contribute and take part in with regard to the process. The number of variables in evaluation process is 25. These items are in Appendix 1.

101 lesson plans in total were prepared. Both a point for every sub-component and total point were obtained by evaluating these lesson plans for the elements of 5ELCM, ICT Integration and EMI.

3. FINDINGS

As a result of data analysis, it was seen that average points of week 2, week 4 and week 10 lesson plans unexpectedly decreased in comparison to the previous and following weeks. The possible reasons of it were set forth as a result of the analysis of students' reflections. Accordingly, it was ascertained that the situations of their encountering the process for the first time in week 2:

"…We had difficulty in preparing lesson plans for the first time …"

Preservice teachers' obliging to preparing lesson plans without examining samples in week 4:

"…We were hard put to generate ideas due to the difficulty of the subject to some extent…"

"… We could not look at the sample lesson plans in this lesson…"

Their lack of basic material and content knowledge in week 10:

> *"To my surprise, I had not known the word meanings of identities and letter expressions, but thanks to this lesson, I thought I learned them."*
>
> *"If I had known how to make identities with algebra tiles, it would be better."*

caused the points to lower in relevant weeks. Yet, these reasons lie beyond the scope of the study, and they are other courses' issues.

The fundamental aim of the study modelled by DBR is to evaluate the process of lesson plan preparation every week and lesson plans, to overcome shortcomings of the implementation with design-based research and to improve the next one thereby maximizing the level of the process of lesson plan preparation and lesson plans. Consequently, lesson plans concerning relevant weeks were examined within the reflections and selected subjects. It was suggested that the fall in week 2, 4 and 10 stemmed from lack of experience and readiness. Hence, data of these three weeks were removed from the analysis.

Except week 2, 4 and 10, it is seen that there was an increase varying between 0.6 and 0.8 in their weekly average points the students took from the lesson plans related to 5ELCM, ICT Integration and EMI. In the diagram (Figure 3) it is understood that points given to lesson plans were at least in the first week, but students got much higher points in later weeks (Because there was no class in week 7, it is not in the chart).

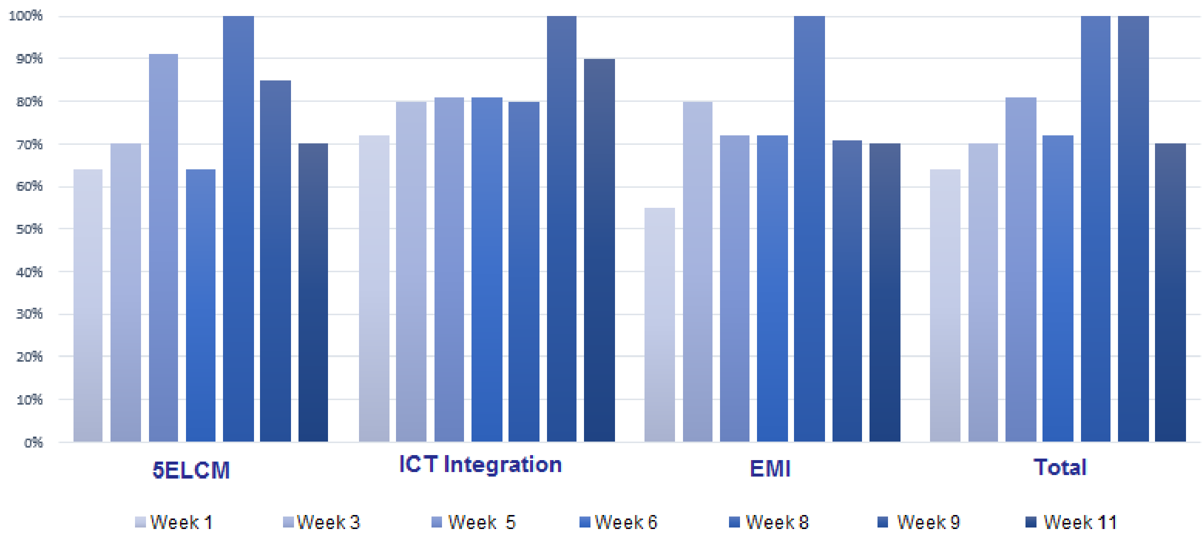

Figure 3: Distribution of the points that students got from weekly lesson plans according to 5ELCM, ICT Integration and EMI

3.1. Preservice Teachers' Implementation Process of ICT Integration in Their Lesson Plans According to 5E Learning Cycle Model

The number of lesson plans which were evaluated is 71. Two of them got under 60. The remaining 69 lesson plans getting 60 point and above were considered as successful. Hereunder, it was observed that 97% of them passed 60 point when 42 items in ICT Integration checklist on total score were evaluated. Suitability points to ICT Integration process was given in Table 1.

In Table 1, the lowest point, 39, is seen in the item of uncovering prior knowledge of learners with ICT. The item of "Use of ICT to engage students' attention to the subject" and "Use of ICT in engage stage of 5ELCM" come with 45 point. Use of ICT in Engage stage includes uncovering of prior knowledge and engaging learners' attention. Subsequently, the item of "Use of ICT in Evaluation stage" with 46 point and "Use of ICT in Explanation stage" with 53 point follow.

Table 1: Suitability points to ICT Integration process of lesson plans prepared according to 5ELCM

Control items that students can have roles in the process of integration of ICT	Av. Point
1 - Use of ICT in Engage stage of 5E learning cycle	45
2 - Use of ICT in Explore stage of 5E learning cycle	72
3 - Use of ICT in Explanation stage of 5E learning cycle	53
4 - Use of ICT in Elaboration stage of 5E learning cycle	90
5 - Use of ICT in Evaluation stage of 5E learning cycle	46
6 - Attention of learners with ICT is engaged to the subject.	45
7 - Prior knowledge of learners with ICT is uncovered.	39
8 - ICT presents different learning opportunities by taking learners' different learning styles and difficulties.	75
9 - Transfer of samples related to concepts are provided by ICT.	95
10 - ICT is used for connection between concepts and prior knowledge.	84

As is seen, it is understood that 5ELCM becomes a problem for use of ICT in the stages of Engage, Explanation and Evaluation. Stage of Engage is vital where students' attention will be aroused and their prior knowledge will be uncovered. It involves a lot of variables such as students' and teachers' prior knowledge, misconceptions, the command of subject etc. Participants stated in their reflections that they had difficulty in finding an engagement activity which would be done with ICT. Participant reflections on these difficulties are seen below:

> *"While preparing engagement activity, an idea immediately comes to my mind... but sometimes even in one hour, it does not do that."*

> *"The story in the stage of engage shows that it is well-considered in terms of its creating a problem for children and leading them to think."*

> *"We could not find an active engage activity while doing our own plans."*

In the stage of Explanation, the main objective is firstly to enable learners to express what they got with own words, then to give formal information to them. This was implemented with academic words in the plans by transfer of descriptions and rules without any interaction. In this process, they did not get positive points for ICT integration because there was a transfer of only descriptions and rules via projectioners.

Likewise, it is seen that there are lacks of effective use of ICT in Evaluation stage. The fact that reflecting of open-ended and multiple choice questions via projection while grading were commented as "ICT is not used at Evaluation stage for similar cases."

Lastly, it was observed that high grades were got where transfer of concepts (95 point) and use of ICT to connect concepts with prior knowledge in this process (84 point). It was assessed that these were the ones which the participants felt most comfortable, focused on something most easily and took part in activities most actively in these control items. It is not an unexpected finding that preservice teachers who learned with a more traditional learning approach close to behaviorism and felt comfortable themselves during the stage of content transfer and connection of their prior knowledge with new concepts.

Even though preservice teachers bring novelty to their teaching process via ICT, the stages that they use bear traces of traditional approach.

As a result, it might be said that ICT integration was carried out in lesson plans prepared according to 5ELCM.

4. DISCUSSION and RESULTS

The research prepared according to DBR model was run with a cyclical and recursive structure. The aim in this process was to improve the next cycle thanks to data collected after the evaluation of every cycle. Despite decreases to some extent, it is seen that there was an increase in points got from lesson plans that were prepared in all weeks. Implementation process of this study was handled holistically to be set as a model. Variables affecting and contributing to the process or must be in the process were assessed. Variables throughout process of DBR formed components of Model Proposal. The relationships with each other were put forward in three stages as Planning-Implementation-Evaluation (PIE) model (Figure 4).

There are some requirements in order to mention about integration process. These can be listed as infrastructure, administrative support, technical support, curriculum support and ICT skills (Roblyer, 2006; Tondeur, Hermans, Van Braak & Valcke, 2008; Vanderlinde & van Braak 2010). In this study, ICT process was planned for the cases where the preliminary requirements were supplied, and these elements were approved as if they had been implemented.

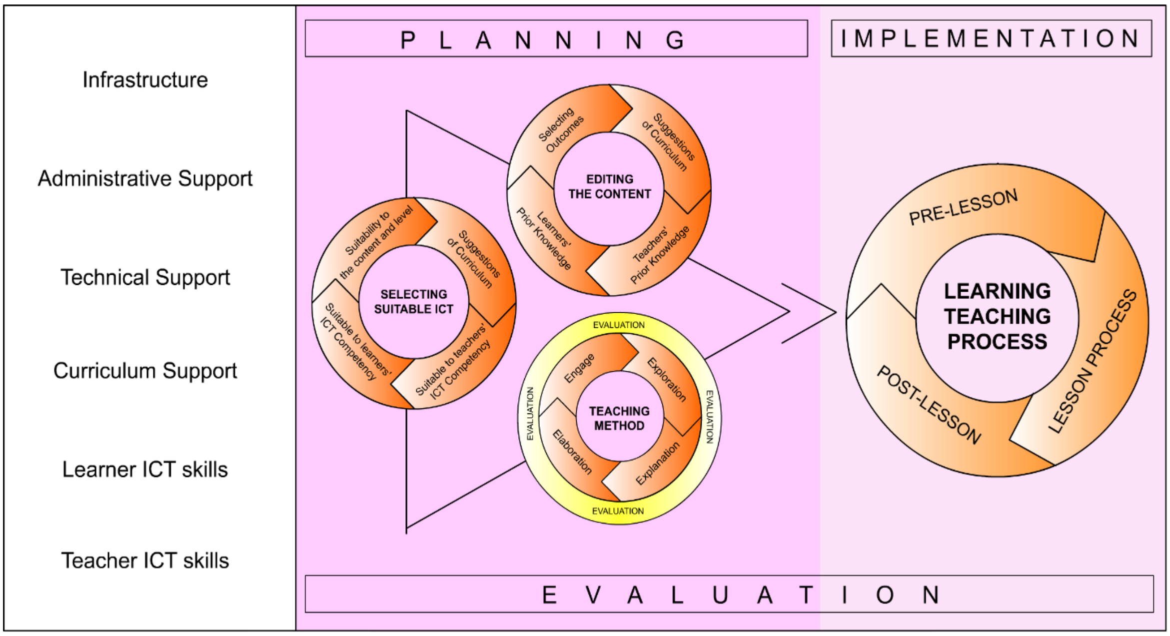

Figure 4: Planning-Implementation-Evaluation (PIE) model for ICT Integration (Yıldız, 2013)

Planning Stage: Basically, it is the planning in accordance with the aims of context and learning-teaching process. 3 elements put in an appearance here. They were explained respectively below:

- *Editing the content:* structuring content knowledge taken from elementary mathematics curriculum according to learners' level. It is targeted to enhance what they can learn by organizing the content, learners' prior knowledge, misconceptions about the subject according to the objective and level and by paying attention to suggestions in mathematics instruction curriculum.
- *Teaching Method:* 5ELCM was chosen for the study. Main reason for selecting this model is that it has a recursive structure in itself. Therefore, the features of suitability to constructivism, being open to making headway and in rapport with DBR method used in the implementation of this study highlight 5ELCM. Nevertheless, model is open to different teaching methods to be used.

- *Selecting Appropriate ICT:* The selection of appropriate ICT and use of it effectively in integration process are of essentially importance. Suitable selection of ICT covers three sub-components:
    - Access: ICT must be suitable to infrastructure, hardware and software, and should be accessible by everyone.
    - Skill: ICT should be chosen for both learners' and teachers' skills. If a new ICT is used, doing a pre-study for developing skills about the use of ICT. Thus, students took courses related to ICT skills.
    - Suitability to the content and level: ICT should be appropriate for the content and class level. For this reason, subject areas in the curriculum, objectives and advices must be paid attention.

Planning stage is a theoretical process. The objectives determined by curriculum and set according to levels must be taken into consideration. Moreover, enriching this theoretical process with experience will make huge contributions. So, experts had better take part in planning stage.

Implementation Process: It is the implementation of organized context during learning and teaching process in three different stages.

- *Before lesson:* It is expected in this phase that teachers inform preparations for the lesson and what students do before the class.
- *Lesson Process:* It is the period in the classroom in compliance with selected teaching method. Activities prepared according to ICT selected teaching method and should be presented to students.
- *After Lesson:* It is the formation stage of homework, reflections, or online/offline discussion environments for students via Moodle LMS to continue the relationship between students and content after the lesson. Post-lesson is the period which happens after face-to-face lesson. Until the next lesson, activities must be conducted so that students will not disassociate themselves from the lesson. This process is too significant for the extra-curricular communication.

Evaluation Stage: It is comprised of evaluating both planning and implementation processes.

Evaluation is accepted as indispensable for every process. All decisions such as how the process is run and where intervention and correction require can be made with evaluation process. Evaluation is conducted interactively and holistically in both planning and implementation processes. Data from evaluations should be used to improve the next stage.

To increase reliability of evaluation, it is necessary that the data be varied. Henceforth, during both the process and product evaluations, different evaluation approaches can be used. For instance, while getting students' reflections, peer evaluations might be used. Students can evaluate themselves thanks to portfolio assessment, as well.

The model consisting of planning, implementation and evaluation stages aims at providing ICT integration to learning-teaching processes. It can be suggested that this can be used for different areas, although designed specifically for EMI. Despite the fact that elements in these models are together as complementary components of themselves, results obtained with each element are given below in detail:

4.1. Results Concerning Implementation Process of ICT Integration

When the implementation process of ICT integration in lesson plans has been analysed, students got 60 point and above from 95% of 101 lesson plans of all weeks. It may be said that these are effective on this results follows:

- Access to numerous computer-based plays, activities and materials related to concepts and subjects of 6th-8th grades,
- Provision of the elements such as technical and administrative support, infrastructure and curriculum support,
- Preservice teachers' naming the lesson as "computer lesson" in the scope of study and their acceptance the computer use as one of the first aims.

Besides, the first one of the researchers is a lecturer of the lesson at the same time, his positive relationships with the participants, his experience in use of ICT in mathematics instruction, his belief in advantages of ICT integration to learning-teaching processes, his sharing participatory activities about the contents for students with the classroom may make a positive contribution to high marks taken.

4.2. Results Concerning the Implementation Process of Effective Mathematics Instruction (EMI)

When the implementation process of ICT integration in lesson plans has been analysed, it is seen that students got 60 point and above in terms of EMI checklist from 67% of 101 lesson plans of all weeks. There is about 28% difference between the implementation processes of EMI and ICT integration. This can be commented that preservice teachers found suitable ICT in the lesson plans they prepared, but they did not use them efficiently in terms of mathematics instruction. When checklist items were analysed, preservice teachers avoided mathematical processes, which they encountered and were relatively challenging and demanding to apply, such as "hypothesizing, collecting data, analysing…" etc. That's why, it was noticed that they got low marks. This result shows that it is a must for preservice teachers to gain more experience in their careers about mathematical processes.

Another important factor for EMI is to determine misconceptions. It is considered that determining possible misconceptions at the beginning of each lesson and their use as a guide during the preparation of sample activities and lesson plans will make contributions to the process. Yet, it was observed that preservice teachers could not determine and using them efficiently. It is set forth that preservice teachers had these misconceptions in some weeks and this case stemmed from the lack of experience of misconceptions and removing them. Therefore, misconceptions should be dwelt on in lessons much more.

Accordingly, prior knowledge and content were tried to be linked to each other, and ICT was used in this respect. However, strong connections could not made sufficiently at this stage. It is considered that some part of the difference between ICT integration and EMI points brings about because of this. Use of ICT integration in lesson plans got a positive point from ICT integration checklist when ICT was compatible with the stages of "selecting suitable ICT". How efficiently ICT was used for EMI is controlled in EMI checklist. Establishing strong connections are in parallel with the power of conceptual learning. Hence, lacks of learning affect directly the success of method or technique used.

Ultimately, it can be said that this model proposal is usable in order to provide ICT integration for EMI. This study succeeded in combining ICT and learning-teaching processes effectively. Also, preservice teachers as participants gained experience regarding ICT integration process. Although the model of planning-implementation-evaluation (PIE) was set forth as a model based on effective mathematics instruction, it can be tested for different areas, learning-teaching methods and class levels. Furthermore, when this study's participants started their professions, getting feedback from them by searching what they did for ICT integration in order to conduct EMI may contribute to both the development of the model and implementation process.

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Uzun Özet

Günümüzde Bilgi ve İletişim Teknolojileri (BİT) kullanıldığı her alana farklı açılardan pek çok yenilik ve olumlu etki katmaktadır. Bu yaygın kullanımı eğitimde de önemli bir yer edinmeye başlamıştır ve eğitsel alandaki çalışmalar incelendiğinde BİT kullanımının öğrenci öğrenmesine ve motivasyonuna olumlu katkılar sağladığı görülmektedir. Matematik eğitiminde başlıca başvuru kaynaklarından birisi sayılan NCTM tarafından yayınlanan Prensipler ve Standartlar dökümanında da "Teknoloji Prensibi"ne özel bir yer verilmektedir. Bu prensibe göre teknolojinin sınıfta nasıl kullanılacağı ve bu kullanımın verimi öğretmene bağlıdır. Bu nedenle öğretmenlerin öğrenme fırsatlarını zengişletirecek şekilde BİT kullanması ve sürekliliği sağlamaları beklenmektedir. Bu sürecin de hem entegrasyon hem de öğretim süreçlerinin etkililiğinde belirleyici olacağı ileri sürülebilir. Ancak alanyazın incelendiğinde öğretmenlerin çoğunun öğretim sırasında teknoloji kullanırken kendilerini iyi hazırlanmış olarak hissetmedikleri, teknoloji kullanımı hakkında daha fazla bilgi ve beceriye gereksinimleri olduğu ifade edilmektedir.

Yapılan çalışmalar öğretmen adaylarının BİT kullanım bilgi ve deneyimlerinin artması ile BİT destekli eğitim yapma yeterliklerinin de arttığını göstermektedir. Yeterliklerin nasıl artırılabileceğine ilişkin olarak, araştırmalarda öğretmen adaylarının BİT'i kendi öğrenme süreçlerinde gözlem ve deneyimleri ile birleştirme fırsatı buldukları durumlarda BİT entegrasyonunu daha iyi öğreneceklerini ve kendi öğretme süreçlerine taşıyabilecekleri ortaya konulmuştur. Bu noktadan hareketle bu çalışmada, BİT'in öğrenme öğretme süreçlerine entegrasyonunun sağlanmış olduğu bir ortamda öğrencilere "Matematik öğretiminde BİT Entegrasyonu" konulu bir ders verilerek hem etkili bir matematik öğretimi için BİT entegrasyonunn öğrenilmesi hem de BİT entegrasyonu sürecinde uygulamanın ve çıktıların gözlemlenebilmesi sağlanmaya çalışılmıştır. Dersin tasarlanması aşamasında etkili matematik öğretimi ilkeleri ve 5E öğrenme döngüsü modeli kullanılmıştır.

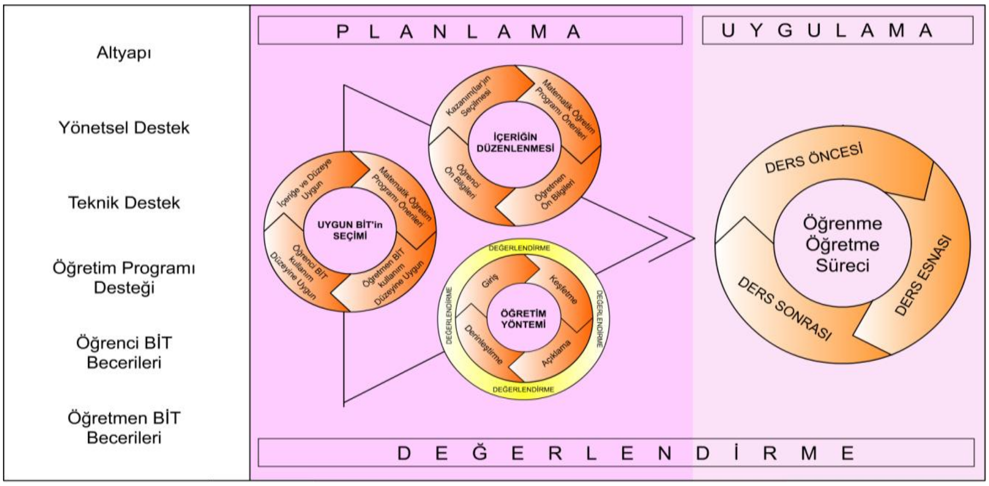
Tasarım tabanlı araştırma çerçevesinde planlanan çalışmada etkili bir matematik öğretimi için BİT entegrasyonu sağlamaya yönelik bir eğitimin nasıl düzenlenebileceği sorusuna yanıt aranmıştır. Çalışma Bilgisayar Destekli Matematik Öğretimi dersini almakta olan 9 erkek 38 kız olmak üzere toplam 47 ilköğretim matematik öğretmen adayı ile gerçekleştirilmiştir. Verilerin toplanmasında; ders planlarının değerlendirilmesi için, araştırmacılar tarafından geliştirilen Etkili Matematik Öğretimi, BİT Entegrasyonu ve 5E Öğrenme Döngüsü Modeli kontrol listeleri kullanılmıştır. Sınıfta işlenen derslerin BİT entegrasyonu ve 5E Öğrenme Döngüsü Modeline uygun olup olmadığının kontrol edilebilmesi için de sınıfta gözlemci bulunamadığı için dersler video ile kaydedilerek uzmanlar tarafından yine BİT entegrasyonu ve 5E Öğrenme Döngüsü Modeli kontrol listeleri ile değerlendirmeleri sağlanmıştır. Ek olarak haftalık olarak öğrencilerden yansımalar alınmıştır. Son olarak öğrencilerin demografik bilgileri ve BİT erişim durumlarının ortaya konulabilmesi amacıyla bir anket kullanılmıştır.

Uygulama 12 hafta sürmüştür ve temel olarak 3 adımdan oluşmaktadır:

- *Ders Öncesi:* Bu aşamada derse hazırlık sürecini içermektedir. Dersten önce içeriğin ve sınıfın fiziksel ortamının derse hazır hale getirilmesi aşamalarını içermektedir.
- *Ders Süreci:* Teorik ve uygulama olarak ortak yürütülen ders süreci iki ders saatinden oluşmaktadır. Önceki dersin değerlendirilmesi ve yeni konuya ilişkin dersin işlenmesi olarak iki aşamadan oluşmaktadır.
- *Ders Sonrası:* Sınıfta işlenen dersin ardından ders dışında gruplar ders planlarını hazırlamaya devam etmişlerdir. Ek olarak öğretmen adayları işlenmiş olan ders hakkında yansımalarını da bu aşamada iletmektedirler.

Uygulama sürecinde ders içi ve ders dışı yapılan çalışmaların birlikte yürütülebilmesi, tüm verilerin her zaman ulaşılabilir olması ve tek bir merkezde toplanabilmesi için çevrimiçi bir ortam hazırlanmıştır. Çevrimiçi ortam için MOODLE öğrenme yönetim sistemi kullanılmıştır. Tasarım Tabanlı araştırma modelinin doğası gereği, Tasarımların sürekli olarak iyileştirilebilmesi için 12 hafta boyunca veriler toplanmış ve her hafta toplanan veriler hemen, sürekli ve geriye dönük olarak frekans, yüzde ve içerik analizi yoluyla çözümlenmiştir. Ders planlarının değerlendirilmesi temel olarak araştırmacılar tarafından geliştirilen Etkili Matematik Öğretimi, BİT Entegrasyonu ve 5E Öğrenme Döngüsü Modeli kontrol listeleri ile gerçekleştirilmiştir. Kontrol listelerinden alınan puanlar ders planının ilgili konudaki başarısını gösterdiği kabul edilmiştir.

Verilerin analizi sonucunda, etkili matematik öğretimi, BİT entegrasyonu ve 5E öğrenme döngüsü olmak üzere üç temel üzerine kurulan öğrenme ortamının öğretmen adaylarının etkili matematik öğretimi için BİT entegrasyonunu sağlamaya yönelik ders planı hazırlama süreçlerine olumlu katkı sağladığı belirlenmiştir. Hazırlanan ders planlarında BİT entegrasyonunun gerçekleşme süreci incelendiğinde tüm haftalara ait 101 ders planından %95'inin BİT entegrasyonu açısından başarılı olduğu söylenebilir. Buradan yola çıkılarak etkili öğretim süreçleri gerçekleştirilebilmesi için BİT entegrasyonunun nasıl sağlanabileceğine ilişkin "Planlama-Uygulama-Değerlendirme" modeli ortaya konulmuştur.



APPENDIX 1

10 Control Items of ICT Integration

- ICT was used in Engage stage of 5ELCM.
- ICT was used in Exploration stage of 5ELCM.
- ICT was used in Explanation stage of 5ELCM.
- ICT was used in Elaboration stage of 5ELCM.
- ICT was used in Evaluation stage of 5ELCM.
- Attention of learners with ICT is engaged to the subject.
- Prior knowledge of learners is uncovered.
- ICT presents different learning opportunities by taking learners' different learning styles and difficulties.
- Transfer of samples related to concepts are provided by ICT.
- ICT is used for connection between concepts and prior knowledge.

15 Control Items of EMI

- Tasks/problems that would connect the concepts and prior knowledge were prepared.
- Students' prior knowledge was linked strongly to new concepts.
- Challenging but solvable/doable problems/tasks about concepts were created.
- Significant mathematical concepts were emphasized while tasks were designed.
- Confirmative and encouraging feedback was given on all occasions.
- Multiple representations were used.
- Examples were presented for misconceptions about the concept/subject.
- Different evaluation methods were
    - suggested.
    - used the process to be assessed.

    - used the outcomes to be evaluated.
- It was maintained that students could get experience in
    - problem solving process.
    - reasoning process.
    - process of sensory development.
    - process of mathematical thinking skills.
    - processes of hypothesis, data collection, analysis, evaluation and exploration.