EFFECTS OF MOBILE LEARNING ON ACADEMIC ACHIEVEMENT: A META ANALYSIS

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Abstract

This study aims to collect experimental studies on mobile learning conducted between 2009-2014 in international area and determine their general effect size. "Meta-Analysis Method", which is one of the systematic synthesis methods, was used to this end. A total of 3,512 studies on the subject were found in EBSCOhost database and 10 studies were included in the study in accordance with the inclusion criteria and analyzed. Cohen's d was used as the effect size index of the study. As a result of the uniformity test, the model was changed from fixed effect model to random effect model. As a result of the analysis performed according to random effect model, it was found that mobile learning had a positive and high effect on academic success with an effect size of d=0.849. The critical p value obtained in the meta-analysis showed that mobile learning studies could be combined and mobile learning should be used more frequently.

Keywords: Mobil learning, meta-analysis, experimental research, effect size.

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MOBİL ÖĞRENMENİN ÖĞRENCİ BAŞARISINA ETKİSİ: BİR META ANALİZ ÇALIŞMASI

Öz

Bu çalışmada 2009-2014 yılları arasında uluslararası alanda daha önce mobil öğrenme ile ilgili yapılmış deneysel araştırmaların bir araya toplanıp, genel etki büyüklüğünün belirlenmesi amaçlanmıştır. Bu amaçla araştırmada, sistematik sentezleme yöntemlerinden biri olan "Meta-Analiz Yöntemi" kullanılmıştır. Konu ile ilgili EBSCOhost veri tabanında aratılan 3.512 makaleye ulaşılmış, çalışmanın kapsamı gereği belirlenen dâhil edilme ölçütleri dâhilinde 10 çalışma analiz edilmiştir. Araştırmada etki büyüklüğü indeksi olarak Cohen'nin d etki büyüklüğü kullanılmıştır. Yapılan homojenlik testi sonucunda, sabit etki modelinden rastgele etki modeline çevrilmiştir. Rastgele etki modeline göre yapılan analiz sonucunda, mobil öğrenmenin, akademik başarıya etkisi d=0.849 etki büyüklüğü pozitif yönde ve yüksek düzeyde bir etkiye sahip olduğu ortaya çıkmıştır. Yapılan meta-analizde elde edilen kritik p değeri, mobil öğrenme çalışmalarının birleştirilebileceğini ve eğitimde, mobil öğrenmenin daha fazla kullanılması gerektiği sonucunu vermektedir.

Anahtar Kelimeler: *Mobil öğrenme, meta-analiz, deneysel araştırma, etki büyüklüğü.*

1. INTRODUCTION

Learning, which is one of the basic characteristics of human beings, continuously develops with the help of education and experiences. Learning includes individual differences therefore individuals are not expected to display same levels of learning. However, when the teaching method is suitable to address individual differences, disparities between levels of learning decrease. Technology-aided learning supports innovative learning with technological tools and inspires educational sciences (Huang, Lin & Cheng, 2010; Looi & Wong, 2014).

This is the information and technology era. Technological advances are becoming more and more important in the field of education as in other areas.

While technological advances remove barriers that may originate in the classroom environment during learning, they generate new learning environments by utilizing computer-assisted education in order to adapt learning materials to students' individual levels of knowledge. It is easier now for students to access knowledge anywhere and anytime especially following the integration of the mobile devices with "smart teaching methods" (Sánchez & Olivares, 2011).

One of the most extensively used mobile devices to access knowledge is smart phones. While first generation cell phones could not go beyond call and message options, last generation smart phones provide different and extensive opportunities for students by presenting multimedia, location based learning materials, games that increase student satisfaction and motivating applications (Caudill, 2007).

Mobile technologies ensure access to information anywhere and anytime by supporting learning, performance, and open new channels for students. Mobile technologies have generated radical changes in education by transforming school education and traditional classroom practices to interactive classroom implementations to develop students' learning experiences (Scornavacca, Huff & Marshall, 2009).

With the help of mobile technologies, students have the ease to develop ideas and share them even when they are on the move (Looi, Wong, So, Seow, Toh, Chen, Zhang, Norris & Soloway, 2009). Rapid development of mobile technologies allows student performance and learning to take place both in and out of classroom. In addition, not only mobile technologies eliminate the pressure students feel in the classroom and improve the way students feel about themselves, they also allow students to discover their own learning content and learn at their own paces (Zhang, Song & Burston, 2011).

Mobile learning "(m-learning)" utilizes modern tools such as tablet PCs, laptop PCs, MP3 players, smart phones and pocket PCs (PDA) to support learning. Mobile learning refers to use of smart phones or devices with wireless internet connection for learning on the move. Generally, wireless internet connection is regarded as an indispensable part of mobile learning (Kukulska-Hulme & Traxler, 2005). M-learning means different things for different people. The following are some definitions of m-learning:

According to Quinn (2000), mobile learning is learning performed with mobile computing devices. Shepherd (2001) states that m-learning utilizes not only electronic devices, but also mobile devices. Colazzo, Ronchetti, Trifonova, and Molinari (2003) states that any learning and teaching activity is possible in mobile learning process with correct mobile devices or settings.

Mobile learning environment may increase learning performance of students and improve their creativity (Cavus and Uzunboylu, 2009). Several studies show that mobile learning tools help students as mobile guides in learning activities, increase their knowledge about environment and geography and enhance their motivation (Akkerman, Admiraal, and Huizenga 2009;. Chen Chang, Li and Li, 2008; Uzunboylu, Cavus, and Erçağ, 2009). However, the use of m-learning is not sufficient in the open education environment. This is because m-learning is a new educational tool and only helps students and teachers by showing them available options in the ever-expanding world of distant learning (Liaw, Hatala, & Huang, 2010). M-learning also brings strong portability feature instead of small Random Access Memory notes filled with books and the most appropriate learning content.

Mobile learning is used in many parts of the world by using mobile technologies for educational tasks such as registration, presenting syllabuses and presenting

changes in curriculums or for teaching the whole class via mobile technologies. Behera (2013) lists the advantages of using mobile learning tools as follows:

- Increased mobility: Learning is not restricted to fixed locations any more. Mobile devices allow learners to access learning content and learning interactions anywhere, such as factories, museums, hospitals, shopping malls, cafes and outdoor areas.

- Time-saving: People can now study when they are commuting and traveling.

- Environmental-friendly: It is amazing to find out how much information a mobile device can carry despite its light weight. Less printing is required.

- Interactive: Mobile technology enables students to closely link with their peers, teachers, distant partners, and even interest groups worldwide.

- Use of relatively inexpensive everyday technologies.

- Much better opportunities to obtain skills at one's own pace in such a way that may be missing if using shared computer sets or trusting somebody else's equipment.

- Good support for preferred modes of interaction, e.g. accessing audio content or participating in social networks on the move.

- Catering for interests beyond what is provided in class, through access to additional content such as podcasts or free learning materials (e.g. Open Learn).

- Handheld devices are often an everyday part of business, so learning can contribute directly to enhancing employability, life skills and work practices.

- Opportunities for learners to give immediate feedback on their learning experience.

- Better assessment and diagnosis of learning problems as they occur.

- Psychological support for those at risk of dropping out, through social networks or personal guidance from a mentor

- Learning materials can become accessible to a larger audience, through podcasts, mobile applications, blogs and e-books, which are seen by potential students.

Prensky (2001) notes that today's students think and process information fundamentally differently from their predecessors as a result of this wide-spread environment and the sheer volume of their interaction with it. Teachers and students can be reached via mobile devices and meaningful learning opportunities can be created (Ng and Nicholas, 2013). In a study conducted by Gertner (2011), it is noted that tablets provide more access to systems that contain the content compared to laptop PCs due to their high portability. In a study conducted by Henderson (2014), 30 undergraduate business administration students used tablet computers in classroom and extracurricular activities. It was observed that although students had a positive attitude toward the use of tablets, only the half of them had an increased performance.

In a study conducted by Chang, Chen, and Hsu (2011), learning performance of students in environmental education was assessed using different learning strategies. 103 students attending 6th grade were included in the study and divided into 3 groups. The traditional learning method was used in the first group, the traditional learning method and WebQuest were used for the second group and only WebQuest was used for the third group. As a result of the analysis, it was found that PDAs, tablet PCs and smart phones increased students' learning performance. These were also found to enhance creative thinking, perspective and learning.

Although studies that focus on informal learning activities by using mobile technologies are at their infancy, many studies show that use of mobile technologies is an effective teaching strategy. Prior studies in the field emphasize that students' post test scores significantly increase as a result of mobile learning (Chen & Huang, 2012) and positive results are observed in learning outcomes (Kukulska-Hulme & Shield, 2008; Wu, Hwang, Su, & Huang, 2012; Chang, Chen & Hsu, 2011; Chu, Hwang & Tsai, 2010; Burston, 2011). It is said that meta-analysis studies include published studies only and results of these studies are usually positive. However, unpublished studies should be included in meta-analysis as well (Stuebing, Barth, Molfese, Weiss, Fletcher, 2009). Typically, researchers tend to report statistically significant studies and ignore insignificant studies. Similar to this prejudice of reporting, editors of scientific journals tend to publish studies with statistically significant results and disregard studies with statistically insignificant results. This tendency points to prejudice of publishing of scientific journal editors. However, this problem is not exclusive to meta-analysis method and encountered in all qualitative or quantitative literature review methods. Only available data is collected and compiled.

Many of the previous studies focused on student feedback about learning regarding the use of mobile devices. However, it is also expressed that student acceptance of mobile technologies (Chen, Chang & Wang, 2008), students interest or attitudes towards mobile learning approaches (Chen, Kao, & Sheu, 2003) and methodologies of tools to develop learning achievement by using mobile technologies are still important and difficult topics to explore in the area (Chu, Hwang, & Tsai, 2010; Hwang, Kuo, Yin, & Chuang, 2010a).

According to American Society For Training and Development (ASTD, 2012), ratio of presenting training opportunities via mobile devices reached 1,4% in

2012 by increasing more than three times compared to the ratio of 0.4% in 2010. Studies also show that use of mobile learning increased to 39% in 2014 compared to 22% in 2013. These data point to rapid development of mobile learning use compared to other learning methods.

Although studies in the field present increases in achievement when mobile learning is used compared to traditional learning, new studies in the field are crucial. It is also clear that comprehensive studies generated by synthesizing individual studies in relation to effectiveness of mobile learning in an international scale to present the "big picture" which will allow generalizations are not available. Literature review about the topic in international scale points to very few meta-analysis studies on mobile learning (Wu, Chen, Kao, Lin & Huang, 2012). Wu (2012) systematically reviewed 164 studies conducted between 2003-2010 using meta-analysis. According to the results of this review, studies focused on effectiveness of mobile learning and the most commonly used research methods were questionnaires and experimental research methods. Also, it was found that PDAs and mobile phones were the most commonly used mobile learning devices. Wu (2012) used content analysis in this study, which is one of the sub-steps of meta-analysis. Our meta-analysis study aims to statistically determine general effect size of mobile learning on students' academic success. Therefore, it is an original and individual study. We were not able to find a meta-analysis study on mobile learning conducted in Turkey. For this reason, this study aims to collect experimental studies on mobile learning in international area (although limited to a certain region) and determine their general effect size.

Synthesizing the results of studies on mobile learning and presenting the big picture for both practitioners and researchers will not only display the current

situation regarding these studies but will also contribute to identification of new directions strategically.

With this aim in mind, the study sought answers to the following question: "When international experimental studies that investigated the effectiveness of mobile learning practices on achievement compared to other methods- are combined, are significant differences observed between mobile learning and traditional learning in education between 2009 and 2014?"

2. METHODOLOGY

2.1. Research Model

This study utilized meta-analysis method, one of the literature review methods. Meta-analysis is the analysis of quantitative data on a specific topic obtained from individual studies with the help of statistical techniques, combining the results and reaching a common judgment (Petticrew & Roberts, 2006 p.194; Cumming, 2012 p.6 ; Ellis, 2012 p.5). According to researchers, steps of meta-analysis are as follows (Boslaugh, 2013; Chen and Peace, 2013):

- Defining the problem,
- Determining the criteria for including individual studies in meta-analysis,
- Reaching individual studies,
- Encoding each study according to related characteristics of meta-analysis,
- Combining findings of individual studies,
- Establishing the relationship between findings combined with characteristics of meta-analysis,
- Report the findings of the meta-analysis.

2.2. "Key Words" Used in the Review

Academic journals and articles submitted between 2009-2014 were included in the study using EBSCOhost and Google database. The following keywords were used: "Mobile Learning", "Mobile Technology", and "Mobile Education". A total of 3,512 international studies were found as a result of the search. In order to meet inclusion criteria identified for the study, classifiers such as "information technologies, "computer sciences", "biotechnology" and "education" were imposed on the data base and 197 articles found after this restriction were investigated.

2.3. Inclusion Criteria

Inclusion criteria used in the selection of studies for meta-analysis are cited below:

Criteria 1: Studies that were conducted until 04.04.2014 for the period between 2009-2014.

Criteria 2: Academic journals and electronic academic journals with or without peer reviews that are cited in "Sciences Citation Index"

Criteria 3: Research method: experimental studies with experimental and control groups in order to reach the standardized effect size in meta-analysis studies and F test results.

Criteria 4: Sufficient numerical data: sample size, average scores, standard deviation, frequency and F test values for experimental and control groups were included in the study.

28 articles that were written in English and that included experimental and control groups were selected as the data collection too for the study to obtain the standardized effect size in meta-analysis studies. However, only 10 studies that met all of the inclusion criteria and that had sufficient data were included in the meta-analysis study

2.4. Data Collection

10 articles on mobile learning previously published in international journals were used in the study as data sources.

2.5. Method of Coding

The characteristics that will be coded can be any characteristic in meta-analysis studies that can affect effect sizes in the studies. A coding method was used in the analysis to transform data from studies that fit the inclusion criteria to categorical variables in order to obtain the data to be used for comparison. Table 1 depicts the coding method used in the study.

The first part includes author or authors, year of the study, purpose, method, participants, mobile devices and disciplines courses, type of research and study.

The second part included mean scores for experimental and control groups, standard deviations, sample sizes and F test results.

2.6. Descriptive Statistics for the Studies Included In the Study

10 studies related to the effectiveness of mobile learning were included in Meta-Analysis and information about the studies is presented in Table 1.

Table 1. Information about Studies Included In the Meta-Analysis

Author (s)	Research purposes	Method	Participants	Mobile devices	Disciplines / courses	Effect Size
Chen, 2013	To evaluate the effectiveness of the mobile learning	Experimental design	High school students	PDA*	Interactive Learning Environments	1,237
Hwang, Wu, Zhuang & Huang, 2013	To evaluate the effectiveness of the mobile learning	Experimental design	6th-grade students of elementary school	PDA	Interactive Learning Environments	0,559
Hwang, & Chang, 2011	To evaluate the effectiveness of the mobile learning	Experimental design	5th-grade students of elementary school	PDA	Interactive learning environments	0,871
Hwang & Chen, 2013	To evaluate the effectiveness of the mobile learning	Experimental design	5th-grade students of elementary school	PDA	Computer Assisted Language Learning	1,418
Chang, Chen & Hsu, 2010	To evaluate the effectiveness of the mobile learning	Experimental design	6th grade students of elementary school	PDA	Technology, Pedagogy and Education	1,138
Chang, Chen & Hsu, 2011	To evaluate the effectiveness of the mobile learning	Experimental design	6th-grade students of elementary school	PDA	Teaching-learning strategies	1,176
Chu, Hwang, Tsai & Tseng, 2010	To evaluate the effectiveness of the mobile learning	Experimental design	5th-grade stundents of elementary school	PDA	Teaching-learning strategies	0,889
Huang, Lin & Chang, 2010	To evaluate the effectiveness of the mobile	Quasi Experimental design	11 years old elementary school srudents	PDA & MPLS**	Teaching-learning strategies	1,088

	learning				
Hwang, Wu & Ke, 2011	To evaluate the effectiveness of the mobile learning	Experimental design	10 years old elementart school students	PDA	Interactive learning environments	-0,298
Wu, Hwang, Tsai, Chan & Huang, 2011	To evaluate the effectiveness of the mobile learning with repotary grid approach	Quasi Experimental design	senior graders of the Nursing Department in University	PDA	Interactive learning environments	0,387

* PDA: Personal Digital Assistant
** MPLS: Mobile Plant Learning System

Examination of Table 1 shows that Hwang & Chen's (2013) study dated 2013 had the highest effect size. These studies included a total of 498 students; 247 students taught by mobile learning method and 251 students taught by traditional learning method. Most of the studies consisted of 5th and 6th graders. Positive sign (+) in the findings related to mobile learning pointed to higher effectiveness of mobile learning method compared to other learning methods whereas negative sign (-) pointed to lower effectiveness.

2.7. Coding Reliability

All collected studies were coded to Meta-Analysis Coding Form by the researcher and two other coders. In order to ensure reliability, the consistency of coding performed by the researcher and coders was examined. In cases of different coding, a consensus was reached and codes were corrected. The collected studies were assessed in accordance with the inclusion criteria and appropriate studies were included in the meta-analysis.

2.8. Data Analysis

"Treatment effectiveness" meta-analysis was used in data analysis. In cases when arithmetic mean values for independent variables (academic achievement) are not collected from the same sample in the study, standardized arithmetic mean differences effect size method is used.

It is necessary to convert data to a common unit of measure in order to combine independent studies statistically and to arrive at a common judgment. This unit of measurement is called effect size. Concept of effect size, introduced by Cohen in 1988, is the foundation of meta-analysis and explained as the frequency of a phenomenon in society. Standard effect size is used to correct the bias generated by effete size (Hedges, 1989).

Current study utilized Cohen's (1992) effect size classification and was interpreted accordingly.

According to Cohen (1992); if the effect size value;

- is between 0,20 and 0.50, it has small amount of effect,
- is between 0,50 and 0,80, it as medium effect,
- is between 0,80 and higher; it has large effect.

Statistical Package Program CMA Ver. 2.0 Comprehensive Meta-Analysis (Borenstein, Hedges, Higgins & Rothstein, 2009) was used to compare effect sizes and variances and groups. Level of significance was accepted as 0,05 for all analyses.

6 of the 10 studies were analyzed based on Means and SD in each group while the other four were analyzed based on F for diff change.

3. RESULTS

This section presents descriptive statistics followed by publication bias for studies, unoptimized findings for effect sizes and forest plot, optimized findings based on fixed effects model and results of homogeneity test, optimized findings based on random effects model and results of moderator analysis.

3.1. Descriptive Data for the Studies that Investigated the Effects of Mobile Learning on Achievement

Table 1 presents information 10 studies on the effectiveness of mobile learning included in the meta-analysis. Table 2 displays frequencies and percentage statistics for studies per year.

Table 2. Frequencies and Percentage Statistics per Year in Studies That Investigated Effectiveness of Mobile Learning on Achievement

Year of the Study	Frequency(f)	Percentage (%)
2010	3	30,0
2011	4	40,0
2013	3	30,0
Total	10	100,0

When studies that investigated academic achievement gained through mobile learning method were examined by year, year 2011 stands out as the year with the highest number of studies with 40%.

Table 3. Frequencies and Percentage Statistics for Teaching Levels per Year in Studies That Investigated Effectiveness of Mobile Learning on Achievement

Teaching Level	Frequency (f)	Percentage (%)
Primary School	8	80,0
High School	1	10,0
University	1	10,0
Total	10	100,0

It is observed that studies that investigated academic achievement were mostly focused on primary schools with a rate of 80%.

Table 4. Frequencies and Percentage Statistics for Subject Matter in Studies That Investigated Effectiveness of Mobile Learning on Achievement

Teaching Level	Frequency (f)	Percentage (%)
History	1	10,0
Social Science	1	10,0
Local Culture	1	10,0
English	1	10,0
Natural Science	4	40,0
Botany	1	10,0
Nursing	1	10,0
Total	10	100,0

It is observed that studies that investigated academic achievement were mostly implemented on Natural Science classes with a rate of 40%.

Table 5. Frequencies and Percentage Statistics for Sample Size in Studies That Investigated Effectiveness of Mobile Learning on Achievement
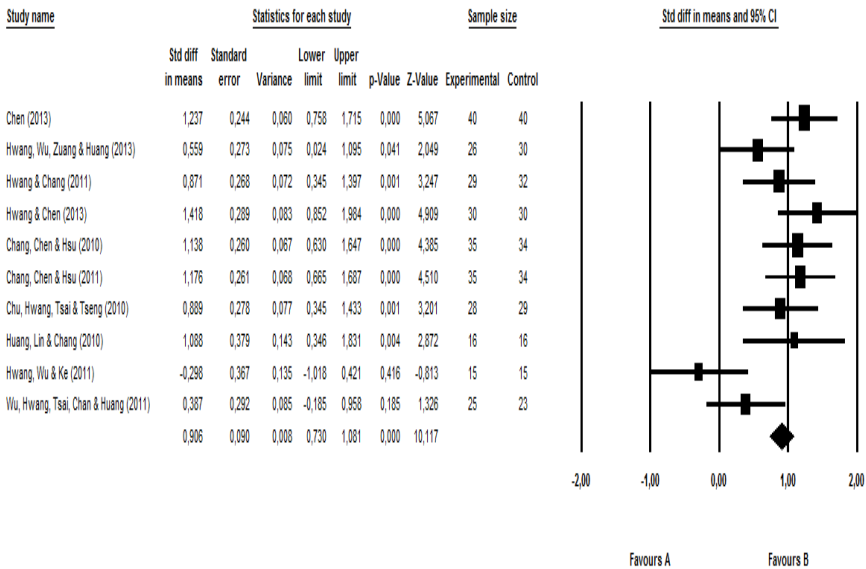
Sample Size	Frequency (f)	Percentage (%)
Ö<35	2	20,0
35<Ö<65	5	50,0
65<Ö	3	30,0
Total	10	100,0

Sample size of studies (experimental + control group) points to the total number of students on which the meta study is conducted. The 10 studies that investigated the effects of mobile learning on achievement that were included in meta-analysis consist of a total of 562 students; 279 students taught with mobile learning and 283 students taught with traditional methods. In two of these studies, sample sizes are below 35. In five of the studies, sample sizes are

between 35 and 65. In three studies, total sample sizes are larger than 65. In general, total sample size shows a distribution between 35 and 65.

3.2. Unoptimized Findings of Effect Size Analysis for the Effects of Mobile Learning on Achievement and Forest Plot

Graphic 2 presents effect sizes regarding the effects of mobile learning on achievement, standard error for effect sizes higher than low effect size value and lower and upper limits based on 95% confidence interval.

Study name	Std diff in means	Standard error	Variance	Lower limit	Upper limit	p-Value	Z-Value	Experimental	Control
Chen (2013)	1,237	0,244	0,060	0,758	1,715	0,000	5,067	40	40
Hwang, Wu, Zuang & Huang (2013)	0,559	0,273	0,075	0,024	1,095	0,041	2,049	26	30
Hwang & Chang (2011)	0,871	0,268	0,072	0,345	1,397	0,001	3,247	29	32
Hwang & Chen (2013)	1,418	0,289	0,083	0,852	1,984	0,000	4,909	30	30
Chang, Chen & Hsu (2010)	1,138	0,260	0,067	0,630	1,647	0,000	4,385	35	34
Chang, Chen & Hsu (2011)	1,176	0,261	0,068	0,665	1,687	0,000	4,510	35	34
Chu, Hwang, Tsai & Tseng (2010)	0,889	0,278	0,077	0,345	1,433	0,001	3,201	28	29
Huang, Lin & Chang (2010)	1,088	0,379	0,143	0,346	1,831	0,004	2,872	16	16
Hwang, Wu & Ke (2011)	-0,298	0,367	0,135	-1,018	0,421	0,416	-0,813	15	15
Wu, Hwang, Tsai, Chan & Huang (2011)	0,387	0,292	0,085	-0,185	0,958	0,185	1,326	25	23
	0,906	0,090	0,008	0,730	1,081	0,000	10,117		

Graphic 2. Effect Sizes Forest Plot

According to Garphic 2, standardized mean differences (d) in 10 studies based on mobile learning changes between -0.298 in favor of traditional learning and 1.418 in favor of mobile learning. While statistical significance difference was found to be (p <.05) in 8 studies, no meaningful differences were detected in 2

studies. Confidence interval for 10 studies was found to be between -1,018 and 1,984.

Graphic 2 presents that the majority of the results in studies that included data about teaching methods were in favor of mobile learning.

3.3. Homogeneity Test, Q and I2 Statistics

Statistical significance was calculated to be Z=10,117 based on Z test. This result is significant with p=0.007. While 2 of the 10 studies included in the study based on mobile learning variable (Hwang, 2010; Chu, 2010) obtained closer values to effect size by keeping in the limits between to upper and lower limits of average effect size, rest of the studies (8) stayed either below or higher than those limits. Table 7 provides the results for homogeneity test for effect size distribution.

Table 7. Homogeneity Test Results for Effect Size Distribution Regarding Mobile Learning

Q-Value	df(Q)	P- value	I-squared
22,640	9	0,007	60,248

In fixed effects model, homogeneity is investigated with several statistics such as Q statistics and I2-statistics. According to homogeneity or Q statistics (Q=22,64 with df= 9 and p=0,07), in fixed effects model, null hypothesis, i.e. the hypothesis that universe effect size does not change in the studies included in the analysis, is rejected. In other words, it is confirmed that studies included in the analysis have different universes, there are differences between studies on mobile learning and there is heterogeneity among studies.

I2 statistics, developed as a supplement to Q statistics, provides clearer results for heterogeneity (Petticrew & Roberts, 2006). I2 shows the rate of total variance for effect size. Contrary to Q statistics, I2 statistics is not affected from number of studies. 25% points to low heterogeneity, 50% to medium level heterogeneity and 75% to high heterogeneity in interpreting I2 statistics (Cooper et. al., 2009).

Results of effect size heterogeneity among studies change according to the teaching level, sample size, subject matter and demographic characteristics of the target group of the individual studies that were included in the meta-analysis.

Since I2 value for average effect size was calculated to be 60,248 % for mobile learning variable according to fixed effects model, the model was changed to random effects model because to obtained value pointed to medium level heterogeneity.

3.4. Findings of Effect Size Meta-Analysis Regarding Mobile learning for Random Effects Model

In random effects model, it is assumed that universe effect sizes change from study to study. Therefore, universe effect sizes of all studies are regarded to be different from zero (Ellis, 2010). Table 8 presents effect sizes regarding the effects of mobile learning on achievement, standard error for effect sizes higher than low effect size value and lower and upper limits based on 95% confidence interval.

Table 8. Effect Sizes Regarding the Effects of Mobile Learning on Achievement

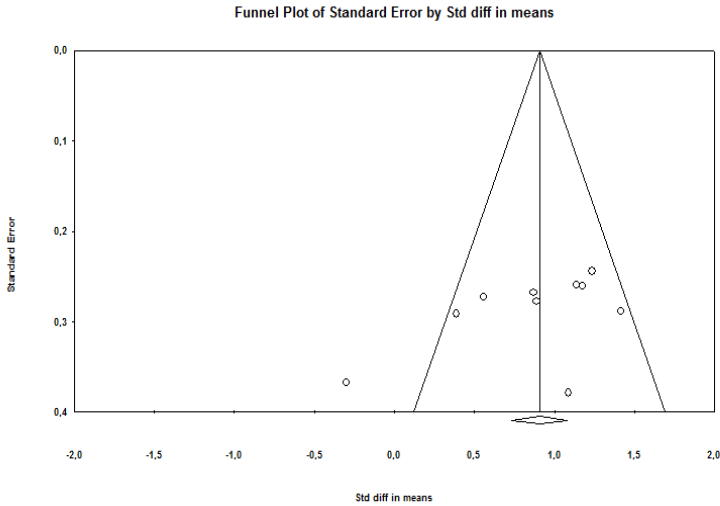| Model	Point Estimate	Standard Error	Variance	Lower Limit	Upper Limit	Z-Value	P-Value
Random Effects Model	0,874	0,143	0,021	0,592	1,155	6,090	0,000

Table 8 displays that based on random effects model, data in the 10 studies that were included in meta-analysis pointed to 0.143 standard error, upper and lower limits for 95% confidence interval were 1,155 and 0,592 respectively and effect size value was found to be d=0.874. It was observed that effects of mobile learning on achievement were higher compared to those of traditional learning. Since effect size value was higher than 0.80, it was calculated to have a high level effect based on Cone's classification (Cohen, 1988). When statistical significance was calculated according to z-test it was found to be Z=6,90. It was identified that the obtained result had statistical significance with p=0.00.

3.5. Publication Bias

Publication bias shows that studies that report higher effect size are more probable to be published compared to studies with lower effect size. When publication bias is above a certain level, it may change the average that will be calculated and may present it to be higher than it normally is. Two methods were used in the current study to identify publication bias.

Funnel Plot is a simple scatter graphic and its results are provided in Graphic 1. Horizontal (X) axis presents the effect size of the study while the vertical (Y) axis shows standard error value. Studies with smaller standard error are collected towards the upper parts of the funnel closer to average effect size. Studies with larger standard error are collected towards the bottom of the figure because

there is more sample variance for effect size estimation in studies with smaller sample size (Borenstein et. al., 2009).

Graphic 1. Funnel Plot for Studies on Mobile Learning that Include Effect Size Data

As can be seen in Graphic 1, 10 studies included in the study are scattered symmetrically to both sides of the effect size vertical axis and are located very close to optimized effect size. When publication bias is not present, studies are expected to scatter symmetrically to both sides of the vertical axis that presents the effect size (Borenstein et. al., 2009).

The fact that 10 studies included in the study to determine optimized effect size based on subject matter were scattered symmetrically in the upper and middle parts shows no publication bias (Borenstein et. al., 2009). This funnel plot graphic is one of the indicators that points to no publication bias in the studies included in the meta-analysis.

Classic Fail-Safe N was also calculated to test publication bias. Classic Fail-Safe N calculates the number of studies that may be missing from the meta-analysis (Borenstein et. al., 2009). Fail-Safe N calculates p value and effect size of each study separately and combines these values.

z value for data in the 10 studies included in this meta-analysis was 9,72 (p=0,0000). Classic Fail-Safe N was calculated to be 237. It is necessary to have 237 extra studies that are insignificant to invalidate the results of the current meta-analysis. This result means that 10 international studies that are included in the meta-analysis point to the total amount of studies that can be reached based on the inclusion criteria (qualitative, quantitative, theoretical etc.). Since it is not possible to access 237 extra studies in addition to these studies, the result is accepted as an indication of the nonexistence of publication bias.

As a result of Egger's Regression Intercept test, the intercept value was found to be (B0)-1.18129, 95% confidence interval (-7.37392, 5.01134) with t=0.43989 and df=8. 1-tailed p-value was calculated to be 0.33583 and 2-tailed p-value was 0.67166. According to these results, it can be said that statistically there was no publication bias since B0 value did not significantly differ from 0.

4. DISCUSSION AND CONCLUSIONS

This section includes results that were obtained based on research findings and their interpretations and provides the suggestions that were developed according to these results.

When significance of each study's effect size was examined individually, it was seen that 8 out of 10 studies were significant and 2 studies were insignificant. With 95% confidence interval, the lowest lower limit among studies was -0.298 (Hwang, 2011) and the highest upper limit was 1.18 (Hwang, 2013). In terms of

effect direction, 9 studies were positive and 1 study was negative. According to studies, it can be said that the use of mobile learning positively affects students' academic success. When effect size was examined according to Cohen's classification, the effect size group with the highest frequency was the large effect size group with 7 studies. 1 study had a medium effect size and 2 studies had a small effect size. As a result of the Fail Safe N analysis performed with 10 studies included in the study, it was found that obtained findings would be invalid in case 237 contrasting values were found in the literature.

According to data obtained from the 10 international studies regarding the effects of mobile learning on achievement effect size was calculated to be d=0,874 based on random effects model. This result points to positive and high level effect in favor of mobile learning regarding achievement compared to traditional learning methods. According to this result, it can be argued that mobile learning applications improve achievement. Results point to the fact that mobile learning practices that make learning and teaching processes more productive and efficient will gain more importance and play a role to develop productivity in teaching. It is possible to claim that mobile learning applications are becoming more and more attractive and used more effectively and widely synchronously with advances in technology and with the increases in faster internet options and use of mobile devices. The cost of mobile learning may still be high today but it is decreasing day by day. This study may be replicated in the future by including attitude, motivation and permanency in addition to academic achievement. These studies may contain sub group analyses based on subject matter, age and gender.

Limitations

This study was limited to domestic and foreign studies on the effect of mobile learning on academic success conducted between 2009-2014, accessible in electronic environment. For this reason, studies conducted outside this period and inaccessible in electronic environment were not included in the study. Similarly, only individual studies utilizing the experimental pattern were included, whereas relational studies were excluded. It is believed that taking these limitations into account performing meta-analysis studies on mobile learning in future will contribute to the literature by revealing a complete picture.

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GENİŞ ÖZET

Giriş

Mobil teknoloji kullanılarak gerçekleştirilen informal öğrenme etkinlikleri ile ilgili yapılan araştırmalar sadece başlangıç aşamasında olsa da, birçok çalışma mobil teknoloji kullanımının etkili bir öğretim stratejisi olduğunu göstermektedir. Bu konu ile ilişkin daha önce yapılan araştırmalarda, mobil öğrenme sonucu, öğrencilerin aldığı son test puanlarında önemli derecede artış gözlendiği ve öğrenme çıktılarında pozitif yönlü sonuçlar ortaya çıktığı vurgulanmaktadır. Daha önceki çalışmaların çoğunda, öğrenme başta olmak üzere mobil cihazların kullanımı ile ilgili öğrencilerden geri bildirim almaya odaklanılmıştır. Ancak bununla birlikte öğrenciler tarafından mobil teknolojinin kabulü, öğrencilerin ilgi ya da mobil öğrenme yaklaşımına yönelik tutumları ve metodolojileri ya da öğrencilerin öğrenme başarılarını geliştirmek için araçlar sağlanması konuları önemli ve zor konu olmaya devam ettiği belirtilmektedir.

Bu konu ile ilişkin araştırmalar göz önüne alındığında, mobil öğrenmenin, geleneksel öğrenmeye göre yapılan çalışmalarda başarıyı artırdığı görülse de, yeni yapılacak çalışmalara ihtiyaç vardır. Dahası, mobil öğrenmenin etkinliği konusunda, uluslararasında yapılmış, bireysel çalışmaların bir araya getirilip sentezlenmesiyle oluşmuş ve bilimsel genellemeler yapılabilmesini sağlayan, geniş kapsamlı çalışmaların henüz yapılmadığı da ortadadır.

Bu konu ile ilişkili daha önce yapılmış olan çalışmalara ilişkin uluslararası literatür incelendiğinde; mobil öğrenme ile ilgili yapılan meta analiz araştırmalarına oldukça az sayıda rastlanmıştır (Wu, W.-H., Wu, Y-C J., Chen, Kao, Lin & Huang, 2012; Arrigo, Kukulska-Hulme, Arnedillo-Sa´nchez & Kismihok, 2013). Ülkemizde ise, hiç rastlanmamıştır. Bu nedenle, bu çalışmada uluslararası alanda daha önce mobil öğrenme ile ilgili yapılmış deneysel araştırmaların bir

araya toplanıp etki büyüklüklerinin belirlenmesi amaçlanmıştır. Bu amaç doğrultusunda çalışmada, öğrenme değişkeni açısından etki büyülüğünün ve birincil araştırmalarda göz ardı edilen bazı değişkenler açısından etki büyükleri arasında bir farklılığın olup olmadığının belirlenmesi hedeflenmiştir.

Yöntem

Bu araştırmada sistematik sentezleme yöntemlerinden biri olan "Meta-Analiz Yöntemi" kullanılmıştır. Çalışma, "Sciences Citiation Index"te hakemli ve hakemsiz dergilerde 2009-2014 yılları arasında yayınlanmış, deney ve kontrol grubuna sahip olan ve bu gruplar için örneklem büyüklüğü, ortalama puan, standart sapma ve frekans değerleri bulunan uluslararası makaleler üzerinde yürütülmüştür.

Araştırmalara ulaşmak için EBSCOhost veri tabanında aratılan anahtar sözcüler: "Mobile Learning", "Mobile Technology" ve "Mobile Education" dur. Aratılan anahtar sözcükler sonucunda, toplam 3.512 uluslararası makaleye ulaşılmıştır. Çalışma kapsamında belirlenen dâhil edilme ölçütlerini karşılayan çalışmalara ulaşmak için, veri tabanında sınırlayıcılar uygulanmış ve "Bilgi teknolojileri", "Bilgisayar bilimleri", "biyoteknoloji" ve "eğitim" disiplerinin seçilmesinin ardından kalan 197 çalışma incelenmeye alınmıştır. İncelenen 197 çalışma içerisinde, yazım dili İngilizce olan ve meta-analiz çalışmalarında standartlaştırılmış etki büyüklüğüne ulaşabilmek için, deney ve kontrol grubuna sahip olan 28 deneysel çalışma, araştırmanın veri toplama aracını oluşturmuştur. Fakat araştırmanın meta-analiz uygulamasına; dâhil edilme ölçütlerinin tamamını karşılayan ve yeterli veri içeriğine sahip olan yalnızca 10 çalışma dâhil edilmiştir.

Verilerin analizinde, grup karşılaştırma meta-analizi türlerinden "Grup Farklılığı" yöntemi kullanılmıştır. Çalışmadaki bağımsız değişkene (akademik başarı) ait

aritmetik ortalama değeri aynı ölçeklerden alınmadığı durumlarda standartlaştırılmış aritmetik ortalamalar farkı etki büyüklüğü yöntemi kullanılır. "Cohen d" istatistiği standartlaştırılmış aritmetik ortalamalar arası farkları tanımlayan etki büyüklüğü olup ortalamaların birbirinden kaç standart sapma uzaklaştığını gösterir. Çalışmaya ait etki büyüklükleri ile varyansları ve grupların karşılaştırmaları Meta-Analiz için İstatistiksel Paket Programı CMA Ver. 2.0 Comprehensive Meta Analysis (Borenstein, Hedges, Higgins & Rothstein, 2009) kullanılarak hesaplanmıştır. Araştırmaya dâhil edilen 10 çalışmadan 6 tanesi Means, SD in each group'a göre, 4 tanesi F for diff change'e göre analiz edilmiştir.

Bulgular

Branş değişkenine göre hesaplanan birleştirilmiş etki büyüklüğünü belirlemek üzere araştırmaya dâhil edilen 10 çalışmanın simetrik bir şekilde üst ve orta bölgede dağılıyor olması yayın yanlılığının olmadığını göstermektedir.

10 çalışmanın mobil öğrenmeye göre standartlaştırılmış ortalamaların fark(d) büyüklüğü -0.298 değer ile geleneksel öğrenmenin lehine, 1.418 değer ile mobil öğrenmenin lehine değişmektedir. 8 çalışmada istatistiksel anlamlı farklılık (p <.05) bulunurken 2 çalışmada anlamlı bir farklılık belirlenmemiştir. 10 çalışmanın güven aralığı ise -0.185 ile 2.306 arasında değişmektedir.

Hesaplamalar doğrultusunda meta analize dâhil edilen 10 çalışmadaki veriler sabit etkiler modeline göre mobil öğrenmenin lehine başarının geleneksel öğrenmeden daha olumlu olduğu bulunmuştur. Ayrıca etki büyüklüğü değeri 0.80'den büyük olduğu için Cohen'in sınıflandırmasına göre yüksek düzeyde bir etkiye sahip olduğu belirlenmiştir (Cohen, 1988).

Meta analize dâhil edilen 10 çalışmadaki veriler rastgele etkiler modeline göre; 0.148 standart hata ve % 95'lik güven aralığının üst sınırı 1.139 ve alt sınırı -0.559 ile etki büyüklüğü değeri ES=0.849 mobil öğrenmenin lehine başarının geleneksel öğrenmeden daha olumlu olduğu bulunmuştur. Ayrıca etki büyüklüğü değeri 0.80'den büyük olduğu için Cohen'in sınıflandırmasına göre yüksek düzeyde bir etkiye sahip olduğu belirlenmiştir (Cohen, 1988). Thalheimer ve Cook (2002)'a ait sınıflandırmaya göre de yüksek düzeyde (0.75 – 1.10) bir etki büyüklüğüne sahiptir. İstatistik anlamlılık z-testine göre hesaplandığında Z=5.739 olarak bulunmuştur. Ulaşılan sonucun p=0.00 ile istatistiksel anlamlılığa sahip olduğu belirlenmiştir.

Sonuç ve Tartışma

Mobil öğrenmenin başarıya etkisini hesaplamak için bu meta analiz çalışmasına uluslararası alanda yapılan ve araştırmaya dâhil edilen 10 çalışmadan elde edilen verilere göre, mobil öğrenmenin, öğrencilerin akademik başarısına etkisi hesaplanan etki büyüklüğü. 0.849'luk (%95 GA 0.559–1.139) aralığındadır. Bu durum mobil öğrenmenin, diğer yöntemlere göre akademik başarı üzerinde olumlu ve yüksek düzeyde bir etkisinin olduğunun göstergesidir. Bu sonuca göre, mobil öğrenme uygulamalarının akademik başarıyı artırdığı söylenebilir. Bu bulgu, Wen-Wu (2008)'nun çalışma bulgularıyla benzerlik göstermektedir.

Meta-analiz normal dağılım grafiği, ilgili veri kümesinin toplam etki büyüklüğü hesaplaması için yeterli ve uygun olduğu sonucunu göstermektedir.

Yapılan meta-analizde elde edilen kritik p değeri, mobil öğrenme çalışmalarının birleştirilebileceğini ve yöntemin daha fazla tercih edilmesi sonucunu vermektedir. Mobil öğrenmenin sınıf içi ve sınıf dışında da öğrencilerin etkin olmasını sağlamakla birlikte, eğitim uygulamalarının hızla artması beklenmektedir.

Günümüzde gelişen teknoloji ile birlikte giderek mobil öğrenmenin önemi ve buna yönelik çalışmalar artmaktadır. Mobil öğrenmeyle birlikte artık her zaman öğrenme mümkün hale gelmiştir. Mobil öğrenmeyle ilgili ileriki yıllarda yeni çalışma bulguları eklenerek tekrarlanabilir ve karşılaştırma yapılabilir. Sonuçların etki büyüklüğünün artması ya da azalmasının sonuçları tartışılabilir.

Araştırmaya tamamlayıcı olarak, yeni yapılacak çalışmalarda sadece ön-son deneysel çalışmalar değil, farklı desenlerden oluşan çalışmalarda dâhil edilebilir. Yeni araştırmalarda sadece akademik başarı değil, tutum, motivasyon, kalıcılık gibi etkenlerin hesaplanması araştırmaya dahil edilip yeniden yapılabilir. Yapılan çalışmalarda ders, yaş, cinsiyete göre alt grup analizleri yapılabilir.

Araştırmanın sınırlılığı Zaman aralığı: 2009-2014 yılları arasında yapılmış olan çalışmalar ve "Sciences Citiation Index'de" aratılan hakemli ve hakemsiz akademik dergiler, elektronik akademik dergiler olarak sınırlandırılmıştır. Farklı akademik dergilerden araştırma yapılarak daha fazla yayın bulunarak meta analize dâhil edilebilir.