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The effects of materials based on ARCS Model on motivation: A meta-analysis

Serkan Dinçer, *Çukurova University,* Turkey, *dincerserkan@cu.edu.tr* ORCID: 0000-0002-8373-7811

Abstract. This meta-analysis examined the relationship between motivation and materials which are designed based on ARCS Model. Twenty-six individual studies were included in the analysis and 28 effect size from these studies were calculated (N = 2140). The results showed positive effects of materials on motivation (g=0.57). Attention was found as the largest effect among the components of ARCS Model (g=0.55). Moreover, overall effect size was calculated 0.48 for relevance, 0.49 for confidence and 0.54 for satisfaction. Sample and duration were identified as two possible moderators. It was found that materials had rather effect on younger groups concerning sampling. As for duration, students' motivation grew as duration of material use increased. Based on the results in terms of duration moderator, it is thought that the results of experimental studies investigating motivation and use or design of materials in literature may not be reliable because they had short duration of implementation. For this reason, it is suggested that future experimental researches should be performed with long-period implementations.

Keywords: ARCS Model; motivation; multimedia learning environments; digital materials

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INTRODUCTION

Even though motivation has been primarily investigated in the field of psychology, a range of other disciplines such as human resources, economics, medicine and educational sciences have also examined motivation. In broadest sense, motivation means incitement and stimulating; however, the literature offers a variety of definitions regarding motivation. For instance, Watters and Ginns (2000) defined motivation as "the psychological presence which shows the effort spent to emerge a behavior" (p. 302). On the other hand, Keller (2010) considers motivation as "... the direction and magnitude of behavior" (p. 4), while it is defined as "organised patterning of an individual's goals, emotional arousal processes and personal agency beliefs" by Ford (1992, p. 5).

Based on the definitions stated above, motivation is a significant factor in generating a behavior and the pioneering factor that provides meaningful learning (Keller, 2010; Kriegbaum, Becker, & Spinath, 2018; Maslow, 1943; Paas, Tuovinen, van Merriënboer, & Darabi, 2005; Pintrich, 2003). For this reason, motivation is the leading variable widely used in educational sciences research. In the literature, the findings of the studies conducted on motivation argued that when individuals are motivated, they regulate their own behaviors, exhibit more appropriate behaviors in learning environments and become more successful in terms of academic achievement (Ahmed & Bruinsma, 2006; Keller, 1987a; 1999; 2010; Kutlu & Sözbilir, 2011; Pintrich & Maehr, 2004; Slavin, 2003).

Although many motivational design models were created, these models can be mainly divided into two: intrinsic and extrinsic motivation (Deci & Ryan 1985; Mottaz, 1985; Steers & Porter, 1991). Intrinsic motivation is defined to be self-motivation of an individual who regulates his/her behavior without any external control (Mottaz, 1985). Curiosity which an individual has towards learning and pleasure of success are also identified as intrinsic motivation in educational sciences (Deci & Ryan, 1985; Harter, 1981; Keller, 1983; 2010; Lepper, 1988). Intrinsic motivation involves some factors, such as being interesting, task involvement, responsibility, creativity and performance. As for extrinsic motivation, it represents the effort which an individual makes for being appreciated by other individuals and winning a reward from the others (Deci & Ryan, 1985; 2000; Newstrom & Davis, 2002). In brief, extrinsic motivation indicates the effects stemming from the individual's environment. External factors are crucial for enhancing motivation; however, without the factors which create intrinsic motivation, external factors mostly cannot provide the motivation required (Dinçer & Doğanay, 2017; Ersarı & Naktiyok, 2012; Keller, 2010). In addition, many studies revealed a positive relationship among intrinsic motivation, learning strategies and academic achievement (Chan, Wong & Lo, 2012; Gillet, Vallerand & Lafreniere, 2012; Niemiec & Ryan, 2009; Ryan & Deci, 2000; Schunk & Pajares, 2001).

Many researchers in the field, who focus on intrinsic motivation emphasize that an attention should be paid especially to the process of designing materials (Dalgety, Coll & Jones, 2003; Glynn, Taasoobshirazi & Brickman, 2007; Zusho, Pintrich & Coppola, 2003). This requirement can be basically explained by the relationship between the learner's interest and attention as well as incorporation of both motivational design and instructional design strategies without distinguishing between the two (Keller, 2010). Many studies stated that interest and attention have a very high effect on student academic achievement and success is increased if learners are taught with materials that raise interest and attention (Benware & Deci, 1984; Cordova & Lepper, 1996; Lazarides, Gaspard & Dicke, 2018; Marsh, Trautwein, Lüdtke, Köller & Baumert, 2005; Radel, Pelletier, Baxter, Fournier & Sarrazi, 2014; Renninger & Hidi, 2015; Siddiq, Hatlevik, Olsen, Throndsen & Scherer, 2016). Motivation theories indicate that teaching elements should also be relevant to increase academic achievement (Means, Jonassen, & Dwyer, 1997; McKeachie, Pintrich, & Lin, 1985).

In light of the above information, it is understood that intrinsic motivation should be increased in order to facilitate meaningful learning, and material design should be given importance in order to increase intrinsic motivation. Although there are many studies on the relationship between material design and motivation in the related literature, no study has been reached that addressed, in detail and with generalizable results, the effects of materials on motivation. The main reason for this is that the interpretation of individual study findings alone makes it difficult to achieve a definite result due to sample differences or the existence of moderator variables. Moreover, inconsistent findings of some studies in the literature also prevent a general conclusion.

In order to sustain motivation, which is a very important factor for meaningful learning and school success (Hattie, 2009), it is necessary to examine in detail the motivation factor in material design (Keller, 2010). This detailed examination can be easily done with meta-analysis method. It is possible to obtain more reliable results about material design and motivation level by comparing and combining (by employing moderator variables) the findings of previous individual studies with meta-analysis method. Examining all of these models in a meta-analysis study is very difficult due to the existence of many motivational models. Therefore, it is considered to be useful to obtain a general result and determine moderator variables by examining a motivational model focusing on material design. In summary, this study aims to determine, by meta-analysis, the effects of the materials designed using ARCS Model (Keller, 1987a) on the motivation of the learners and what the moderator variables might be.

ARCS Model

ARCS Model takes its name from its basic components, namely, attention, relevance, confidence and satisfaction. In 1979, Keller published the preliminary dimensions of the model and constituted the ARCS Model in 1987. Finally, Keller added the principles of volition and self-regulation to the model and formed the fifth dimension of the model (Cobb, 2013; Keller, 2008).

In the attention dimension of the model, it has been emphasized that if materials attract learners' attention, learners' curiosity and interest arise and accordingly their motivation increases. In order to attract learners' attention, the strategies which involve perceptual arousal, inquiry arousal and variability should be identified. Perceptual arousal is activated when the environments are changed (Cobb, 2013). Inquiry arousal includes encouraging learners to ask questions and solve problems in order to satisfy their curiosity. Variability is related to the maintenance of attention. Keller (2010) states that learners may lose attention before they get used to stimulants. Therefore, it is pointed out that after attracting attention, the variability strategy should be put into use in order to maintain learners' attention and not to lose learners' interest.

The second dimension of ARCS Model, namely, relevance, involves identifying learners' expectations and needs, and informing learners about the importance of learning outcomes. When a learner figures out the importance of learning outcomes, s/he will know about why s/he has to use these outcomes and s/he will be able to be motivated (Keller, 2010; Lau & Woods, 2009). Relevance embodies three sub-categories: familiarity, motive matching and goal orientation. Familiarity addresses associating learners' accumulation with the information provided which is concretized; goal orientation involves guiding learners to the objective which includes specifying the instruction goal, and the last sub-category motive matching embodies the strategies which are relevant to learners.

As the third dimension, confidence helps learners develop positive manner, thereby it enhances learners' success. Keller (2010) states that learners should feel capable of performing tasks that are given to them in order to succeed. For that reason, designing any instruction based on confidence will enhance motivation, and in turn, increase success. Similar to relevance dimension, confidence also embodies sub-categories such as, expectancy for success, challenge setting and attribution molding. Expectancy for success involves bringing in the ability to reach success; challenge setting embraces testing adaptation, which comprises providing appropriate opportunities, environments and facilities in order for students to attain success. The last sub-category attribution molding includes feedback patterns which stress the effort given and provide supportive feedback to learners.

Satisfaction, the fourth dimension, indicates the relationship between outcomes and learner expectations. When learners find out that they would not reach the outcomes which they expected to gain, they may be demotivated (Keller, 2008). Therefore, instructional designers should allow extrinsic reinforces relevantly, not higher than learners' expectations and they should be employed as required by the context in order to enhance and maintain learners' motivation. Thus, intrinsic motivation will remain in the required level and so satisfaction will be supplied (Keller, 2008; 2010; Keller & Kopp, 1987; Main, 1993). Volition and self-regulation, which Keller (2008) added to the model as the last dimension, involves learners' enhancing their motivation through regulating their own strategies (Cobb, 2013). Through that dimension, it is signified that persistency will come into existence.

In the implementation of ARCS Model, whose sub-dimensions are summarized above, the aim is not to design instruction and enhance academic success directly (Keller, 2008; Main, 1993). The primary objective of implementing ARCS Model is to enhance academic success in an indirect way by promoting motivation. The studies conducted in the light of this objective put forward that ARCS Model had a positive effect on academic achievement (Carey, Carey & Pearson, 1991; Keller & Suzuki, 1988, Main, 1993; Means et al., 1997; Song & Keller, 1999; Visser, Plomp, Amirault, & Kuiper, 2002). Although these studies state that ARCS Model enhances motivation and academic achievement, some studies reveal that motivation is not enhanced significantly (Huett, Moller, Young, Bray, & Huett, 2008; Moller & Russell, 1994; Song & Keller, 2001). Li and Keller (2018) associates this situation with the use of ARCS Model (teachers' not guiding learners adequately) and possibility of mismatch between ARCS strategies and every sampling (cultural-demographic differences) or learning environments.

Measurement of Motivation and IMMS

When the related literature is examined, it is conferred that motivation is generally evaluated with scales and the literature offers a number of these scales (Aydın, Yerdelen, Gürbüzoğlu-Yalmancı, & Göksu, 2014; Dede & Yaman, 2008; Eryılmaz, 2013; Keller, 2008; 2010, Tuan, Chin, & Shieh, 2005). While most of these scales measure motivation in a specific lesson / topic, some scales aim to measure motivation considering teaching materials and learners' interest towards lessons (Keller, 1987a; 2008; 2010). In all these scales, the data have been collected by using five point Likert Scale involving five ranges, from "definitely agree" to "definitely disagree", or from "definitely correct" to "definitely wrong", and interpretations were made based on these ranges. Instructional Materials Motivation Survey (IMMS) is one of these scales. It is seen that IMMS was firstly used in the literature in 1987 (Keller, 1987b). However, the original version of the scale, which is still used today, was applied to university students and published as Instructional Materials Motivation Scale by Keller (2006). Finally, the scale was published as book version without making any change by Keller (2010).

Cronbach Alpha co-efficient of the scale was found as 0.96. In addition, the result of the analyses for scale components has put forward that Cronbach Alpha co-efficients were 0.89, 0.81, 0.90 and 0.92 (A, R, C, S) respectively. The original version of the scale was used in a range of studies and it was stated that coefficients of consistence were in appropriate levels to be used (Cobb, 2013; Huang, Huang, Diefes-Dux, & Imbrie, 2006; Li & Keller, 2018).

The Present Study

Although many variables in educational sciences literature are analyzed in the scope of meta-analysis, motivation oriented meta-analysis studies seem to be scarce. One of the reasons of this lack is that motivation is such a multidimensional concept which is dependent on a variety of factors. Some of these factors can be listed as teacher attitudes, regional factors and design of materials that are used. Using materials in instruction provides a lot of benefits, primarily in arresting learners' attention. One of these benefits may be supplying and enhancing motivation. However, it is considered very important to find out how important the benefit is and to what extent material designs affect motivation and determine, if any, moderator variables. In this respect, this study aimed to investigate the effect of material designs on motivation.

There are many models that focus on motivation in material design. It is very difficult to examine all of these models in a single meta-analysis study. Therefore, one of the motivation models was chosen in this study. In the study, it has been decided to use ARCS Motivation Model since it directly focuses on material. Besides, ARCS embodies an instrument which measures the contribution of material to motivation and it has been applied successfully for more than 40 years (Li & Keller, 2018). Thus, the study aimed to examine the effect of materials which are designed based on ARCS Model on motivation.

In summary, it is aimed to investigate the effects of materials which are designed based on ARCS Model on motivation. In addition, determining how moderator variables which affect motivation and this model influence results/findings was set as a subgoal. Hence, in this respect the following research questions were addressed:

1) What is the effect of the materials designed based on ARCS Model on students' motivation levels?
2) What is the effect of the materials designed based on ARCS Model on the components of ARCS in terms of motivation?
3) How do the materials designed based on ARCS affect the participants' motivation levels in terms of sample?
4) How do the materials designed based on ARCS affect the participants' motivation levels with respect to duration of implementation?

METHODS

Literature Search

One of the leading criticisms made against meta-analysis studies is combining different kinds of variables (apples and oranges) in order to calculate the overall effect (Borenstein, Hedges, Higgins, & Rothstein, 2009; Castro-Alonso, Ayres, & Paas, 2016). Another criticism is about the studies which compare individual studies using different measurement instruments (Card, 2012; Dinçer, 2014). Considering these criticisms, just one instrument (IMMS) has been chosen as reference among the instruments which evaluate ARCS Model (Keller, 2010). As mentioned in the introduction part, IMMS was published in more than one version by Keller. When the literature was reviewed for the first time, it was determined that the researchers gave two different names to a scale although they were using the same scale. In order not to miss any data, these two names ("Instructional Materials Motivation Survey" and "Instructional Materials

Motivation Scale") were searched in Google Scholar, Science Direct and Web of Science on March 15, 2018. With the key words "Instructional Materials Motivation Survey", 479 studies were reached and the key words "Instructional Materials Motivation Scale" 100 were found between the years 1990 and 2018. At the end of the searching phase, all the studies reached were listed, and, as 17 studies were found the same, 562 studies were involved in the first examination, by updating the list. Out of 562 studies, 158 studies were not involved in the analysis since 71 of them were inaccessible and 87 of them were not published in English. Finally, 404 studies were listed to be examined in terms of content.

Criteria for Including and Excluding Studies

Meta-analysis inclusion criteria are identified by researchers. In the study, the first criterion is that the studies, which will be involved in the analysis, must be published articles or proceedings. In the light of this criterion, 137 studies were excluded since some of them are books or theses.

The second criterion of the research is that the studies must have used IMMS with 36 items as the measurement instrument. In this respect, it has been found out that IMMS was not used in 138 studies. On the other hand, in 19 studies it was detected that the scale was readapted and there was item loss. Therefore, 294 studies in total were not included in the research.

The third criterion is the comparison of at least one material designed with ARCS with another one in individual studies. As part of the criterion, 23 studies were excluded since they investigated just one material and 37 studies were not involved since they did not examine the scale in terms of material. Finally, 24 studies were also excluded since the required data could not be reached (mean, standard deviation etc.). The findings which belong to the rest of the studies (*k*= 26) were involved to the meta-analysis (years between 2004 and 2017). Figure 1 presents the process regarding the selection of the studies.

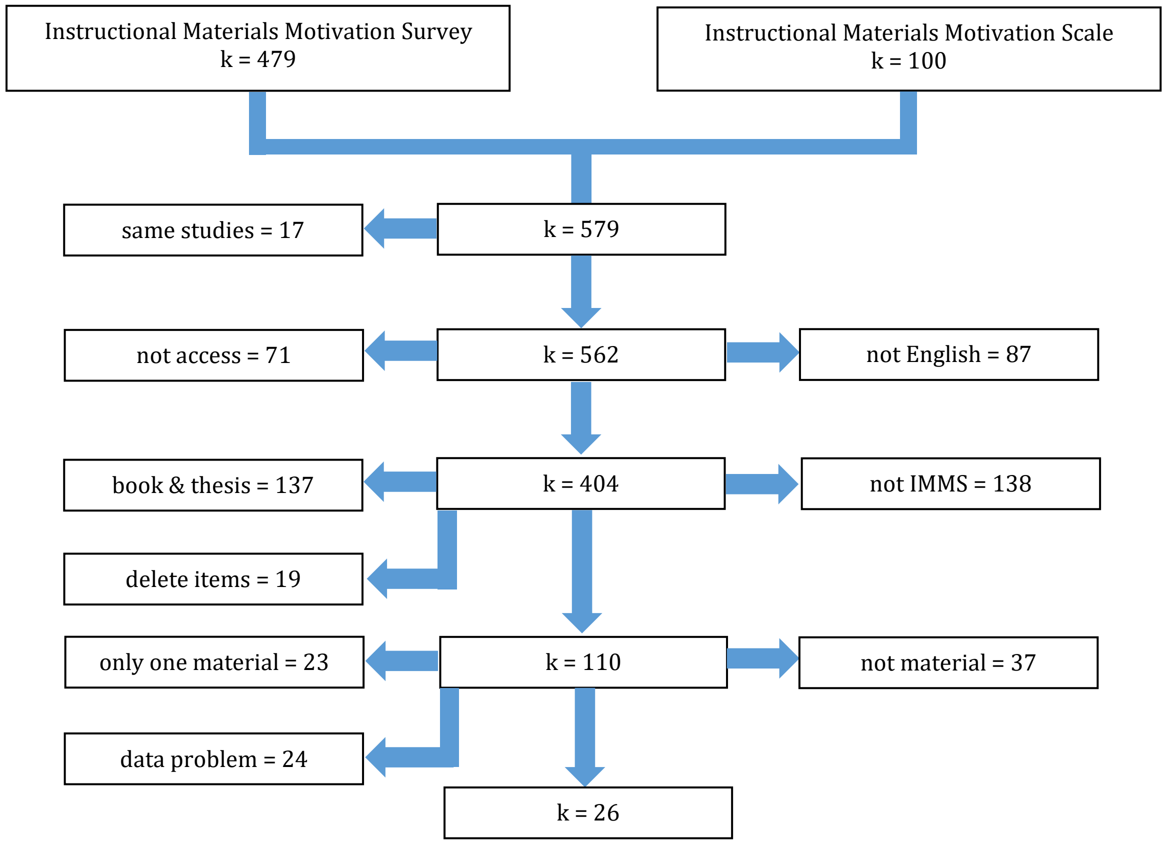


FIGURE. 1. *Literature search and selection procedure.*

Study Coding

As it is presented in Table 1, individual studies (*k*=26) were coded with the titles below: Publication Year, IMMS's components, group names, group definitions, materials used in groups, statistical findings regarding the material used in the group ($\bar{x}$*, sd, n* etc.), findings on academic achievement of groups ($\bar{x}$*, sd, n* etc.), sample, and duration.

These codings were set by two researchers individually. After coding, inter-rater agreement estimated with Cohen's Kappa was found suitable (Cohen's Kappa 0.89). The reason why the studies were coded differently (k=4) by the researchers was found out that there was a discrepancy about deciding whether the studies used materials in terms of ARCS or not. Codings regarding the studies were discussed by the researchers and they came to a common decision about different codings.

Statistical Analyses

In meta-analysis, the effect size (*Es*) in individual studies and overall effect size (*E++*) can be measured via various statistical programs as well as manual calculations. In these softwares, effect sizes are generally calculated based on Cohen *d*, Hedges' *g* or η^2. In this study, effect sizes were calculated based on Hedges' *g* through a statistics program. Except one study (Alhassan, 2014), all effect sizes were calculated through means, standard deviations and sample sizes. Since the effect size that belongs to this study is calculated with Cohen d, the effect size of the study was transformed from Cohen *d* into Hedges' *g.*

Overall effect size calculation was held with respect to both components (A-R-C-S) and total IMMS scores. Although the findings regarding components were presented in some studies, total IMMS points were not put forward. The total motivation effect size of these studies was calculated by combining components' effect sizes. In addition, the numbers of studies differed in overall effect size calculation since all of the components in some studies were not embraced.

In meta-analysis studies, overall effect size is calculated based on random effects model, fixed effect model and/or mixed effects model. The fixed-effect model starts with the assumption that all studies share a common effect size; on the other hand, the random-effect model allows that the true effect size may vary from one study to another (Borenstein, Hedges, Higgins, & Rothstein, 2010). Whereas some researchers (Chauhan, 2017; Cheung & Slavin, 2012) make model choices based on heterogeneity test, other researchers (Borenstein et al., 2009; 2010) disagree with that idea and suggest that the model should be selected in advance and strategies should be developed accordingly. In addition to these two approaches, some researchers (Field & Gillett, 2010; Richter, Scheiter, & Eitel, 2016) conclude that for social science data, the standard model applied should be conceptualized as a random-effect model. Apart from that, few researchers (Card, 2012; Dinçer, 2014) suggest that it is more convenient to compare effect sizes of individual studies respectively rather than estimating overall effect sizes in educational sciences research since sampling and instruments are different in educational sciences research and there is the possibility of failure stemming from sampling.

Taking these views into consideration, the random effects model and mixed effects model were used in order to calculate overall effects sizes in the study. Finally, Moderator Analysis, Homogeneity Test were used with the aid of relevant statistics program and Trim-and-Fill Analysis, Duval and Tweedie's Method and Egger Test were applied for publication bias with the aid of same program.

Table 1. *Studies included in the meta-analysis.*

Study	IMMS	Group1 Mean	Sd	n	Definition	Material	Ach. Mean	Ach. Sd	Group2 Mean	Sd	n	Definition	Material	Ach. Mean	Ach. Sd	g	Sample*	Duration
1. Alhassan (2014)	Total	113.80	1.41	32	project-based learning strategy	real-life examples	17.85	0.98	81.32	1.25	33	traditional teaching methods	computer	13.23	1.54	0.91	1	1 semester
2. All et al. (2017)	Total	4.21	0.48	34	digital-game based learning	computer-digital game	33.01	0.84	3.86	0.48	39	traditional teaching methods	PowerPoint-slide based lecture	28.50	0.91	0.72	4	3 course
3. Chen (2012)	A	4.06	1.16	39	experimental	PowerPoint with ARCS	60.83	16.08	3.78	1.28	37	control group	PowerPoint	50.78	14.89	0.23	3	2hx10w
	R	3.85	1.00						3.81	1.01						0.04		
	C	3.89	1.08						3.68	1.26						0.18		
	S	3.93	1.16						3.78	1.24						0.12		
	Total	-	-						-	-						0.14		
4.Chin et al. (2015)	A	3.67	0.45	25	experimental	U-learning material production system	31.20	8.07	3.56	0.16	23	control group	textbook etc.	26.30	8.01	0.32	2	n.a.
	R	3.96	0.24						3.62	0.20						1.51		
	C	3.76	0.32						3.41	0.31						1.09		
	S	3.94	0.42						3.53	0.27						1.13		
	Total	-	-						-	-						0.99		
5. Choi & Johnson (2005)	A	20.38	1.82	16	video-based instruction	video	n.a.	n.a.	17.44	4.00	16	traditional text-based instruction	textbook etc.	n.a.	n.a.	0.92	4	n.a.
	R	16.56	1.31						16.25	1.98						0.18		
	C	15.94	1.40						15.50	1.79						0.27		
	S	15.25	1.84						13.94	3.02						0.51		
	Total	-	-						-	-						0.47		
6.Cook (2009)	A	3.20	0.06	53	adaptive web based learning	computer-web	n.a.	n.a.	3.10	0.60	66	nonadoptive web based learning	computer-web	n.a.	n.a.	0.22	3	1 semester
	R	3.20	0.70						3.20	0.60						0.00		
	C	3.60	0.60						3.60	0.60						0.00		
	S	2.60	0.90						2.50	0.80						0.12		
	Total	3.20	0.60						3.10	0.50						0.18		
7. Di Serio et al. (2013)	A	3.76	0.72	55	based on augmented reality technology	AR	n.a.	n.a.	3.28	0.55	55	based on slides	PowerPoint	n.a.	n.a.	0.74	1	n.a.
	R	3.48	0.47						3.31	0.47						0.36		
	C	3.63	0.57						3.40	0.53						0.41		
	S	3.51	0.59						3.11	0.68						0.62		
	Total	3.62	0.50						3.29	0.46						0.68		
8. Gleixner et al. (2008)	A	3.25	0.64	43	experimental	with project based modules	n.a.	n.a.	2.99	0.67	43	traditional	without project based component	n.a.	n.a.	0.39	3	4 weeks
	R	3.28	0.61						3.10	0.64						0.29		
	C	3.02	0.70						3.03	0.62						-0.01		
	S	2.70	0.86						2.97	0.92						-0.30		
	Total	3.11	0.59						3.02	0.53						0.16		
9. Hu et al. (2016)	A	3.30	0.70	49	computer-aided instruction	computer 3D model	14.20	2.80	3.00	0.80	51	traditional	textbook etc.	13.90	3.40	0.40	3	30 minute
	R	3.30	0.70						3.10	0.90						0.25		
	C	3.20	0.70						3.00	0.90						0.25		
	S	2.70	1.00						2.50	1.00						0.20		
	Total	12.40	2.80						11.70	3.20						0.23		
10. Huett et al. (2008)	C	31.77	7.28	35	with ARCS	computer	93.40	5.43	28.70	7.36	37	without ARCS	computer	86.10	7.39	0.41	3	5.5 weeks
11. Hung & Young (2017)	A	4.24	0.50	51	experimental	tablet	n.a.	n.a.	4.01	0.57	67	traditional	textbook	n.a.	n.a.	0.42	3	n.a.
	R	4.28	0.47						4.13	0.48						0.31		
	C	4.10	0.54						3.89	0.57						0.37		
	S	4.24	0.50						4.01	0.57						0.42		
	Total	4.25	0.48						4.05	0.50						0.40		

* 1. middle school; 2. college; 3. university; 4. adult

Table 1. *Continue.*

		Group1						Group2								
Study	**IMMS**	**Mean**	**Sd**	**n Definition**	**Material**	**Ach. Mean-Sd**		**Mean**	**Sd**	**n Definition**	**Material**	**Ach. Mean-Sd**		**g**	**Sample***	**Duration**
12. Hung et al. (2017)	A	4.24	0.50	11 experimental 8	tablet	5.65	1.29	4.01	0.57	107 traditional	face to face live demonstration	5.34	1.39	0.43	3	n.a.
	R	4.28	0.47					4.13	0.48					0.31		
	C	4.10	0.54					3.89	0.57					0.38		
	S	4.24	0.50					4.01	0.57					0.43		
	Total	-	-					-	-					0.39		
13. Jing et al. (2017)	A	3.12	0.31	28 Variation Theory Based Strategy	textbook	47.57	13.32	2.70	0.44	28 experienced conventional teaching strategy	textbook	33.57	11.37	1.09	n.a.	6 weeks
	R	3.11	0.37					2.79	0.47					0.75		
	C	3.08	0.38					2.68	0.48					0.91		
	S	3.22	0.42					2.92	0.57					0.59		
	Total	-	-					-	-					0.84		
14. Juan et al. (2015)	A	4.00	0.69	36 game-based learning	game boards. cards. and tokens	n.a.	n.a.	3.25	0.94	36 traditional	textbook etc.	n.a.	n.a.	0.90	3	1.5 hours
	R	4.16	0.70					3.31	0.80					1.12		
	C	4.06	0.67					3.27	0.94					0.96		
	S	4.25	0.59					3.27	0.99					1.19		
	Total	-	-					-	-					1.05		
15. Katsa et al. (2016)	A	4.31	0.47	20 flipped classroom model	online classroom etc.	17.20	2.08	3.65	0.54	20 traditional	face to face . etc.	14.70	3.29	1.28	2	1 semester-8weeks
	R	4.27	0.48					3.50	0.64					1.33		
	C	4.32	0.43					3.76	0.53					1.14		
	S	4.37	0.34					3.71	0.55					1.41		
	Total	-	-					-	-					1.31		
16. Kostaris et al. (2017)	A	4.50	0.24	23 flipped classroom model	online classroom etc.	18.10	1.25	3.60	0.32	23 traditional	face to face . etc.	16.90	1.32	3.13	2	1 semester-8weeks
	R	4.25	0.32					3.50	0.28					2.45		
	C	4.40	0.24					3.69	0.35					2.33		
	S	4.47	0.32					3.62	0.42					2.24		
	Total	-	-					-	-					2.54		
17. Lee et al. (2016)	A	44.22	5.56	36 mobile-based video learning	video & mobile device	6.61	1.81	41.23	4.08	35 traditional	video	5.34	1.71	0.61	3	1 week
	R	32.56	3.75					30.71	3.03					0.54		
	C	28.78	5.00					25.77	3.42					0.69		
	S	20.72	3.57					19.17	2.13					0.52		
	Total	126.28	14.96					116.89	10.45					0.72		
18. Proske et al. (2014)	A	3.20	0.60	41 game-based	computer with game	68.10	16.70	3.10	0.60	41 traditional	writing-based	61.40	16.80	0.17	3	n.a.
	R	3.20	0.60					3.30	0.60					-0.17		
	C	3.70	0.70					3.50	0.60					0.30		
	S	3.00	0.90					2.70	0.80					0.35		
	Total	-	-					-	-					0.16		
	A	2.90	0.70	46 question-based	computer with app	69.20	17.30	3.10	0.60	41 traditional	writing-based	61.40	16.80	-0.30	3	n.a.
	R	3.20	0.60					3.30	0.60					-0.17		
	C	3.80	0.60					3.50	0.60					0.50		
	S	2.90	0.70					2.70	0.80					0.26		
	Total	-	-					-	-					0.07		
	A	3.00	0.70	47 model based	computer with app	71.60	15.00	3.10	0.60	41 traditional	writing-based	61.40	16.80	-0.15	3	n.a.
	R	3.30	0.60					3.30	0.60					0.00		
	C	3.50	0.60					3.50	0.60					0.00		
	S	2.60	0.80					2.70	0.80					-0.12		
	Total	-	-					-	-					-0.70		
19. Mumtaz et al. (2017)	A	3.75	0.89	23 lectures based on AR	mobile device AR tech	n.a.	n.a.	3.25	1.16	22 traditional	textbook etc.	n.a.	n.a.	0.48	3	n.a
	R	3.62	0.92					2.67	1.00					0.97		
	C	3.87	0.99					3.37	1.19					0.45		
	S	3.50	1.06					3.14	0.99					0.34		
	Total	136.26	18.45					114.32	19.03					0.54		

* 1. middle school; 2. college; 3. university; 4. adult

Table 1. *Continue.*

		Group1								Group2								
Study	IMMS	Mean	Sd	n	Definition	Material	Ach. Mean-Sd		Mean	Sd	n	Definition	Material	Ach. Mean-Sd		g	Sample*	Duration
20. Podges & Kommers (2013)	A	3.83	0.55	13	problem-based learning	real life situation-using lab	n.a.	n.a.	3.34	0.58	16	traditional lecturing	textbook etc.	n.a.	n.a.	0.84	3	16 weeks
	R	3.64	0.55						3.06	0.92						0.72		
	S	3.92	0.75						3.06	0.56						1.29		
21. Rigby (2015)	Total	106.70	24.42	23	CAI	computer-based simulation	64.78	19.51	116.79	22.43	29	traditional	textbook etc.	63.44	14.95	-0.43	3	n.a.
22. Skromme et al. (2013)	A	3.44	0.49	17	CAI	software	86.40	22.10	2.84	0.80	16	traditional	Textbook	61.60	28.00	0.89	3	1 hour
	R	3.22	0.60						2.99	0.83						0.31		
	C	3.94	0.52						3.51	0.99						0.54		
	S	3.62	0.66						2.65	0.91						1.20		
	Total	3.54	0.40						3.01	0.77						0.85		
23. Stefaniak & Tracey (2015)	A	39.50	24.60	56	web-based learning modules	adaptive design	n.a.	n.a.	37.40	8.70	53	Web-based learning modules	nonadoptive design	n.a.	n.a.	0.11	3	1 semester
	R	36.20	10.30						32.30	6.30						0.45		
	C	35.80	6.20						34.60	5.20						0.21		
	S	23.10	5.60						21.00	5.50						0.38		
	Total	134.60	5.20						125.30	22.00						0.59		
24. Stepan et al. (2017)	A	3.15	0.62	33	virtual reality	computer	0.76	0.14	2.43	0.57	33	traditional	textbooks	0.75	0.16	1.19	3	8 weeks
	R	3.25	0.62						3.00	0.58						0.41		
	C	3.43	0.48						2.91	0.49						1.06		
	S	2.76	0.86						1.98	0.61						1.03		
	Total	12.60	2.12						10.32	1.86						1.13		
25. Yilmaz & Keser (2016)	Total	130.26	19.84	34	reflective thinking	podcast	n.a.	n.a.	120.71	17.73	34	not support reflective thinking	podcast	n.a.	n.a.	0.50	3	6 weeks
26. Yoon & Kim (2011)	A	2.57	0.48	31	CAI	computer app.	68.26	4.42	2.68	0.66	31	traditional	video	66.85	3.05	-0.19	3	1 hours
	R	2.67	0.63						2.44	0.62						0.36		
	C	2.83	0.53						2.85	0.68						-0.03		
	S	2.49	0.75						2.55	0.82						-0.08		
	Total	-	-						-	-						0.02		

* 1. middle school; 2. college; 3. university; 4. adult

RESULTS

In order to yield answers to the research questions, the findings of the analyses related to the components of IMMS, namely, A-R-C-S and total motivation (IMMS) scores were presented below for each research question.

Sample Analysis

Twenty six individual studies were involved in the research. However, one study was regarded as three different studies since it has three experimental groups. For this reason, 28 different effect sizes were analyzed in total. The findings of 21 individual studies were used to calculate the overall effect size of each component while the findings of 24 studies were employed to calculate the overall effect size of total motivation. The sample sizes varied from 29 to 235, and the overall sample size amounted to N = 2140.

The individual studies involved in the analyses were obtained from the researches which were published between 2004 and 2017. When the study groups were examined, it was found out that individual studies involved participants from middle school (k=2), college (k=4), university (k=17) and adults (k=2) (one of the studies did not give any information about the participants). When the research durations of the studies were looked into, it was detected that researches were conducted less than a week (k=3), between one and four weeks (k=3), four-eight weeks (k=4), and more than eight-week durations (k=8) (eight of the studies did not give any information about the durations).

It was identified that digital technologies, such as computer, tablet and so on were used in all the materials designed with ARCS Model whereas it was found out that traditional materials (presentations, books, etc.) were used in comparison groups except two studies.

Publication Bias Analysis

One of the biggest problems in the procedure of meta-analysis studies is publication bias (Duval & Tweedie, 2000; Rothstein, Sutton, & Borenstein, 2006). The concern that published studies generally reach similar findings or unpublished studies may obtain different findings may enable researchers question the reliability of the meta-analysis study. Therefore, determining the number of studies which may change the results of the study and testing the publication bias in meta-analysis is a very important issue. Although all of the publications in literature were tried to be accessed, unpublished studies, books and theses were not involved in the analysis and so, publication bias was decided to be tested. There exists a variety of methods for testing publication bias, the publication bias in the study was examined via the Classic Fail-Safe N (Rosenthal, 1991), Orwin's Fail-Safe N (Orwin, 1983), Egger's Regression Test (Egger, Davey Smith, Schneider, & Minder, 1997). Findings related to these methods are given for components and total motivation in Table 2,

As it is displayed in Table 2, it seems that publication bias exists according to Egger's Regression Test. However, it was decided to examine the other tests since Egger's Regression Test is a sensitive test. For the effect size to change, when the number of studies needed was analyzed through The Classic Fail-Safe N and Orwin's Fail-Safe N, it was put forward that the number of the studies was found considerably high in each test (between 468-1752 for The Classic Fail-Safe N; between 848-1146 for Orwin's Fail-Safe N). According to a guideline by Rosenthal (1991), the result of meta-analysis seems to be robust to the publication bias since The Classic Fail-Safe N exceeds 5k + 10 (125<606 for attention; 125<468 for relevance; 125<538 for confidence; 125<608 for satisfaction; 140<1752 for total motivation). In light of these findings, it was deduced that publication bias would not cause a fallacy for the findings. Due to the results of Egger's Regression Test, it was considered beneficial to examine the findings with Duval and Tweedie's Trim and Fill Method and Table 3 presents the findings.

Table 2. *Test of publication bias.*

	A	R	C	S	Total
The classic fail-safe N					
Z value for observed studies	10.24	9.05	9.67	10.26	16.20
p value for observed studies	0.00	0.00	0.00	0.00	0.00
Alpha	0.05	0.05	0.05	0.05	0.05
Tail	2.00	2.00	2.00	2.00	2.00
Z for alpha	1.96	1.96	1.96	1.96	1.96
Number of observed studies	23	23	23	23	26
Number of missing studies that would bring the *p* value to > alpha	606	468	538	608	1752
5 *k* + 10	125	125	125	125	140
Orwin's fail-safe N					
Hedge's *g* in observed studies	0.44	0.38	0.42	0.44	0.45
Criterion for a "trivial" Hedge's *g*	0.01	0.01	0.01	0.01	0.01
Mean Hedge's *g* in missing studies	0.00	0.00	0.00	0.00	0.00
Number of missing studies needed to bring Hedge's *g* to under 0.01	998	848	934	992	1146
Egger's regression					
Intercept	4.24	4.29	3.97	4.22	2.58
Standard Error	1.47	1.34	1.32	1.38	1.53
95% lower limit (2-tailed)	1.16	1.49	1.23	1.36	-0.57
95% upper limit (2-tailed)	7.29	7.08	6.72	7.09	5.73
t-value	2.89	3.20	3.02	3.06	1.69
Df	21	21	21	21	24
p-value (1-tailed)	0.00	0.00	0.00	0.00	0.04
p-value (2-tailed)	0.01	0.01	0.01	0.01	0.10

Table 3. *Results of trim and fill method*

		Fixed Effects				Random Effects			
		Studies Trimmed	Point Estimate	Lower Limit	Upper Limit	Point Estimate	Lower Limit	Upper Limit	Q-Value
A	Observed values		0.44	0.35	0.53	0.55	0.34	0.77	101.42
	Adjusted values	0	0.44	0.35	0.53	0.55	0.34	0.77	101.42
R	Observed values		0.37	0.28	0.47	0.48	0.29	0.67	88.03
	Adjusted values	2	0.46	0.37	0.54	0.55	0.35	0.77	117.84
C	Observed values		0.42	0.32	0.51	0.49	0.32	0.66	70.66
	Adjusted values	1	0.44	0.35	0.53	0.51	0.34	0.68	76.88
S	Observed values		0.44	0.35	0.53	0.54	0.35	0.74	90.99
	Adjusted values	0	0.44	0.35	0.53	0.54	0.35	0.74	90.99
Total	Observed values		0.46	0.40	0.51	0.59	0.39	0.79	274.91
	Adjusted values	6	0.69	0.64	0.74	0.76	0.53	0.98	560.67

In order to attain symmetry in funnel plot, Trim and Fill Method bases on trimming and filling studies from meta-analysis. As it is seen in Table 3 and Figure 2, although an exact symmetry could not be obtained, it was found out that the existent distribution was not extremely asymmetrical and it was also revealed that the effect size did not change much as a result of trimming. Based on these findings, it was concluded that the publication bias would not constitute a fallacy.

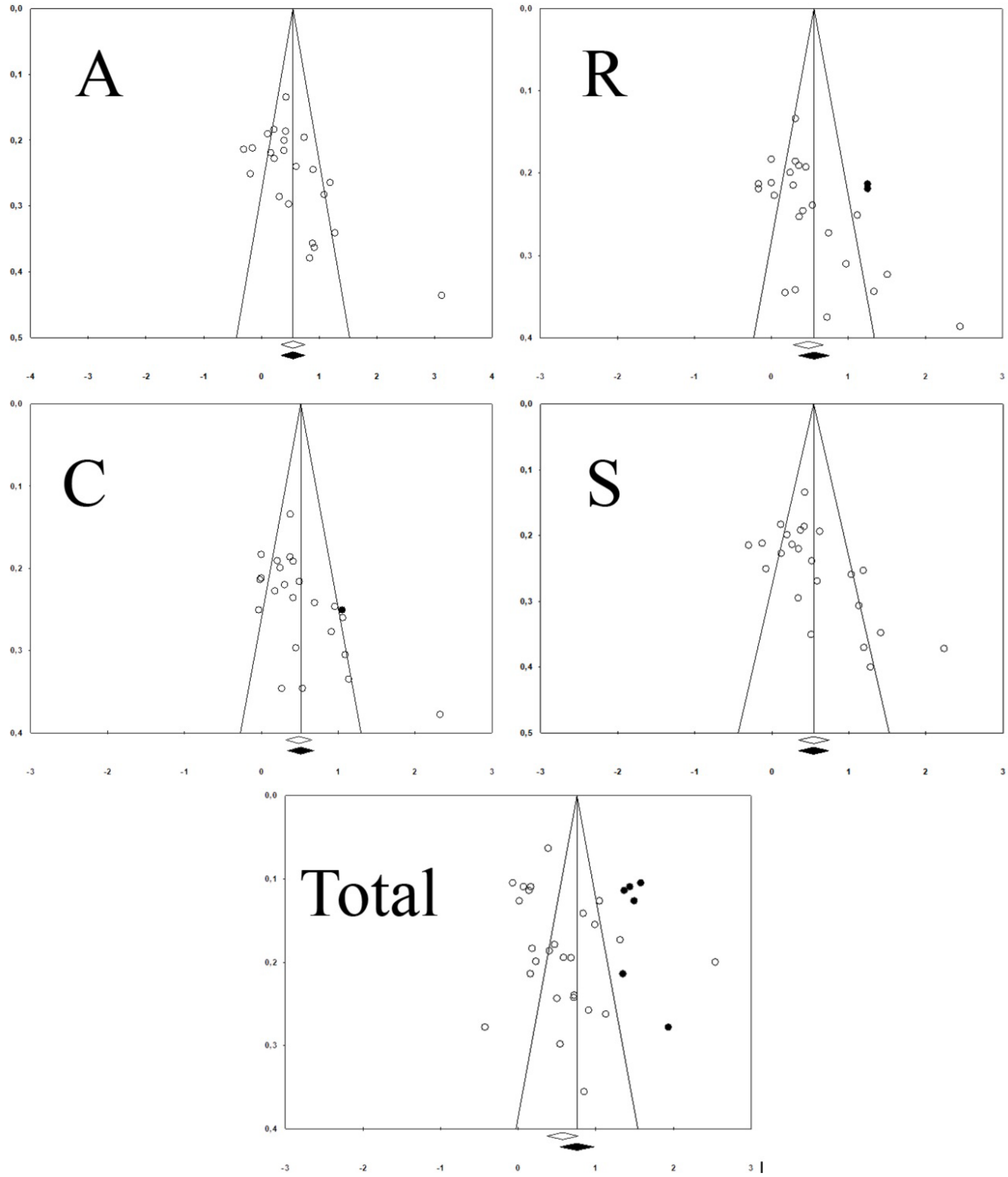


FIGURE. 2. *Funnel Plot of standard error by Hedges's g for all factors and total motivation score.*

The Overall Effect Sizes for All Components and Total Motivation

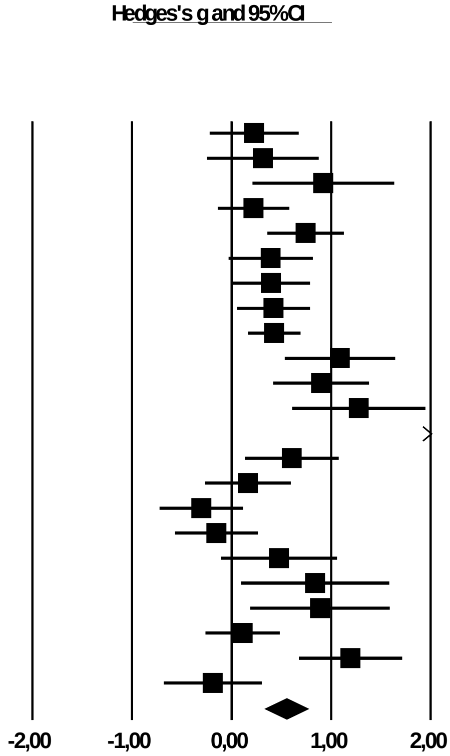
There were 23 effect sizes in the 21 articles for attention. A study conducted by Borenstein et al. (2009) suggests that in case there exists more than one effect size, those effect sizes in the study should be combined under one effect size and involved in analysis. However, in another study (Proske, Roscoe, & McNamara, 2014) every effect size was included in the analysis with regard to all attention components and total motivation scores respectively since the materials were considered from different aspects. Table 4 presents the descriptive statistics and effect sizes of attention.

Table 4 shows that 23 effect sizes found out in 21 articles vary from -0.30 to 3.13. When the overall effect size of attention in the studies was analyzed, it was found out that the material, which was designed based on ARCS Model, affected attention at medium-level (g=0.55). In addition, Q statistics revealed that the effect sizes in the analysis were heterogeneous

(Q_{total}=101.42, z =5.15, p = 0.00), which indicates that there were differences among the effect sizes that were attributable to sources other than subject-level sampling error.

Table 4. *Results of meta-analysis for attention factor*

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Chen (2012)	0,23	0,23	0,05	-0,22	0,67	1,00	0,32
Chin et al.(2015)	0,32	0,29	0,08	-0,25	0,88	1,10	0,27
Choi & Johnson(2005)	0,92	0,36	0,13	0,21	1,63	2,54	0,01
Cook et al.(2009)	0,22	0,18	0,03	-0,14	0,58	1,20	0,23
Di Serio et al.(2013)	0,74	0,20	0,04	0,36	1,13	3,80	0,00
Gleixner et al.(2008)	0,39	0,22	0,05	-0,03	0,82	1,82	0,07
Hu et al.(2016)	0,40	0,20	0,04	0,00	0,79	1,97	0,05
Hung & Yung (2017)	0,42	0,19	0,03	0,06	0,79	2,26	0,02
Hung et al. (2017)	0,43	0,13	0,02	0,17	0,69	3,19	0,00
Jing et al.(2016)	1,09	0,28	0,08	0,53	1,64	3,85	0,00
Juan & Chao (2015)	0,90	0,24	0,06	0,42	1,38	3,67	0,00
Katsa et al.(2016)	1,28	0,34	0,12	0,61	1,95	3,74	0,00
Kostaris et al.(2017)	3,13	0,44	0,19	2,27	3,98	7,17	0,00
Lee et al.(2016)	0,61	0,24	0,06	0,13	1,08	2,52	0,01
Proske et al.(2014)	0,17	0,22	0,05	-0,26	0,59	0,75	0,45
Proske et al.(2014)b	-0,30	0,21	0,05	-0,72	0,12	-1,41	0,16
Proske et al.(2014)c	-0,15	0,21	0,05	-0,57	0,26	-0,71	0,48
Mumtaz et al.(2017)	0,48	0,30	0,09	-0,11	1,06	1,60	0,11
Podges & Kommers (2013)	0,84	0,38	0,14	0,10	1,58	2,21	0,03
Skromme et al.(2013)	0,89	0,36	0,13	0,19	1,59	2,49	0,01
Stefaniak & Tracey (2015)	0,11	0,19	0,04	-0,26	0,49	0,59	0,56
Stepan et al.(2017)	1,19	0,26	0,07	0,68	1,71	4,52	0,00
Yoon & Kim (2011)	-0,19	0,25	0,06	-0,68	0,30	-0,75	0,45
	0,55	0,11	0,01	0,34	0,76	5,15	0,00



There were 23 effect sizes detected in 21 articles for relevance. The descriptive statistics and effect sizes of these articles are shown in Table 5 which demonstrates that 23 effect sizes in 21 articles vary from -0.17 to 2.45. When the overall effect size of relevance related to these studies was measured, it was figured out that the material designed based on ARCS Model, affected relevance at medium-level (g=0.48). Furthermore, Q statistics revealed that the effect sizes in the analysis were heterogeneous (Q_{total}=88.26, z =4.86, p = 0.00), which indicates that there were differences among the effect sizes that were attributable to sources other than subject-level sampling error.

The analysis showed that 23 effect sizes emerged in the 21 articles for confidence. Regarding these studies, the descriptive statistics and effect sizes are displayed in Table 6 below. According to the findings shown in Table 6, 23 effect sizes in 21 articles range from -0.03 to 2.33. The findings about the overall effect size regarding confidence showed that the material designed based on ARCS Model affected confidence at medium-level (g=0.49). Q statistics revealed that the effect sizes in the analysis were heterogeneous (Q_{total}=70.66, z =5.59, p = 0.00), which demonstrates that there were differences among the effect sizes that were attributable to sources other than subject-level sampling error.

For satisfaction, there were also 23 effect sizes detected in the 21 articles and Table 7 presents the descriptive statistics and effect sizes which are related to those studies involved in the analysis. In Table 7, it is seen that 23 effects sizes in 21 articles vary from -0.03 to 2.24. The analysis of the overall effect size for satisfaction signified that the material designed based on ARCS Model had a medium effect on satisfaction (g=0.54). Besides, Q statistics put forward that the effect sizes in the analysis were heterogeneous (Q_{total}=90.99, z =5.40, p= 0.00), which shows that there were differences among the effect sizes that were attributable to sources other than subject-level sampling error.

Table 5. *Results of meta-analysis for relevance factor*

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Chen (2012)	0,04	0,23	0,05	-0,41	0,48	0,17	0,86
Chin et al.(2015)	1,51	0,32	0,10	0,87	2,14	4,67	0,00
Choi & Johnson(2005)	0,18	0,35	0,12	-0,50	0,86	0,52	0,60
Cook et al.(2009)	0,00	0,18	0,03	-0,36	0,36	0,00	1,00
Di Serio et al.(2013)	0,36	0,19	0,04	-0,01	0,73	1,88	0,06
Gleixner et al.(2008)	0,29	0,21	0,05	-0,14	0,71	1,33	0,18
Hu et al.(2016)	0,25	0,20	0,04	-0,14	0,64	1,23	0,22
Hung & Yung (2017)	0,31	0,19	0,03	-0,05	0,68	1,69	0,09
Hung et al. (2017)	0,31	0,13	0,02	0,05	0,58	2,35	0,02
Jing et al.(2016)	0,75	0,27	0,07	0,21	1,28	2,73	0,01
Juan & Chao (2015)	1,12	0,25	0,06	0,63	1,61	4,45	0,00
Katsa et al.(2016)	1,33	0,34	0,12	0,66	2,01	3,88	0,00
Kostaris et al.(2017)	2,45	0,39	0,15	1,69	3,21	6,34	0,00
Lee et al.(2016)	0,54	0,24	0,06	0,07	1,00	2,24	0,02
Mumtaz et al.(2017)	0,97	0,31	0,10	0,36	1,58	3,13	0,00
Podges & Kommers (2013)	0,72	0,38	0,14	-0,01	1,46	1,93	0,05
Proske et al.(2014)	-0,17	0,22	0,05	-0,59	0,26	-0,75	0,45
Proske et al.(2014)b	-0,17	0,21	0,05	-0,58	0,25	-0,77	0,44
Proske et al.(2014)c	0,00	0,21	0,04	-0,42	0,42	0,00	1,00
Skromme et al.(2013)	0,31	0,34	0,12	-0,36	0,98	0,91	0,36
Stefaniak & Tracey (2015)	0,45	0,19	0,04	0,07	0,83	2,34	0,02
Stepan et al.(2017)	0,41	0,25	0,06	-0,07	0,89	1,67	0,09
Yoon & Kim (2011)	0,36	0,25	0,06	-0,13	0,86	1,44	0,15
	0,48	0,10	0,01	0,29	0,67	4,86	0,00

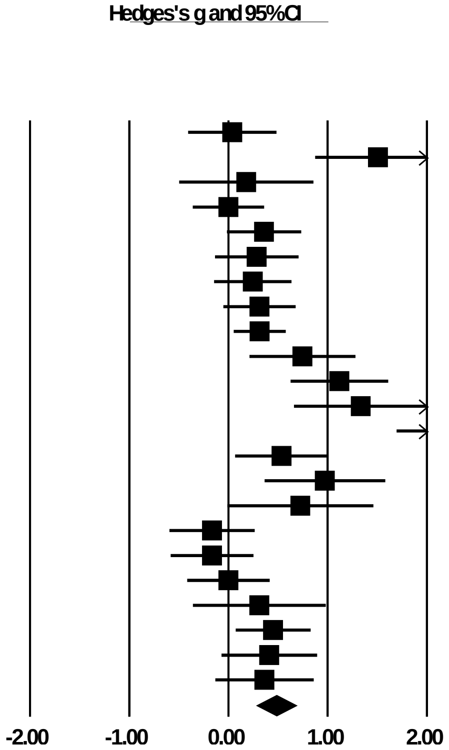


Table 6. *Results of meta-analysis for confidence factor.*

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Chen (2012)	0,18	0,23	0,05	-0,27	0,62	0,78	0,44
Chin et al.(2015)	1,09	0,31	0,09	0,49	1,69	3,58	0,00
Choi & Johnson(2005)	0,27	0,35	0,12	-0,41	0,95	0,77	0,44
Cook et al.(2009)	0,00	0,18	0,03	-0,36	0,36	0,00	1,00
Di Serio et al.(2013)	0,41	0,19	0,04	0,04	0,79	2,17	0,03
Gleixner et al.(2008)	-0,01	0,21	0,05	-0,43	0,40	-0,07	0,94
Hu et al.(2016)	0,25	0,20	0,04	-0,14	0,64	1,23	0,22
Huett et al.(2008)	0,41	0,24	0,06	-0,05	0,88	1,76	0,08
Hung & Yung (2017)	0,37	0,19	0,03	0,01	0,74	2,01	0,04
Hung et al. (2017)	0,38	0,13	0,02	0,11	0,64	2,81	0,00
Jing et al.(2016)	0,91	0,28	0,08	0,37	1,45	3,29	0,00
Juan & Chao (2015)	0,96	0,25	0,06	0,47	1,44	3,89	0,00
Katsa et al.(2016)	1,14	0,34	0,11	0,48	1,79	3,39	0,00
Kostaris et al.(2017)	2,33	0,38	0,14	1,58	3,07	6,15	0,00
Lee et al.(2016)	0,69	0,24	0,06	0,22	1,17	2,87	0,00
Proske et al.(2014)	0,30	0,22	0,05	-0,13	0,74	1,38	0,17
Proske et al.(2014)b	0,50	0,22	0,05	0,07	0,92	2,29	0,02
Proske et al.(2014)c	0,00	0,21	0,04	-0,42	0,42	0,00	1,00
Mumtaz et al.(2017)	0,45	0,30	0,09	-0,13	1,03	1,52	0,13
Skromme et al.(2013)	0,54	0,35	0,12	-0,14	1,21	1,55	0,12
Stefaniak & Tracey (2015)	0,21	0,19	0,04	-0,17	0,58	1,09	0,28
Stepan et al.(2017)	1,06	0,26	0,07	0,55	1,57	4,07	0,00
Yoon & Kim (2011)	-0,03	0,25	0,06	-0,52	0,46	-0,13	0,90
	0,49	0,09	0,01	0,32	0,66	5,59	0,00

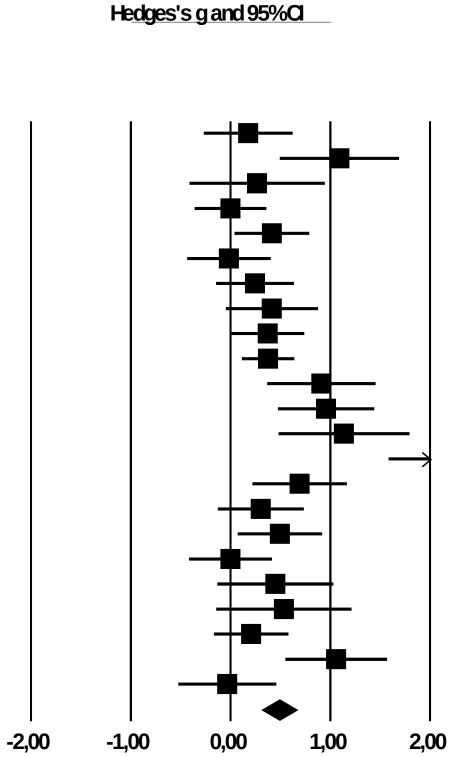


Table 7. *Results of meta-analysis for satisfaction factor*

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Statistics for each study						
Chen (2012)	0,12	0,23	0,05	-0,32	0,57	0,54	0,59
Chin et al.(2015)	1,13	0,31	0,09	0,53	1,73	3,69	0,00
Choi & Johnson(2005)	0,51	0,35	0,12	-0,18	1,20	1,46	0,15
Cook et al.(2009)	0,12	0,18	0,03	-0,24	0,48	0,64	0,52
Di Serio et al.(2013)	0,62	0,19	0,04	0,24	1,00	3,22	0,00
Gleixner et al.(2008)	-0,30	0,21	0,05	-0,72	0,12	-1,40	0,16
Hu et al.(2016)	0,20	0,20	0,04	-0,19	0,59	1,00	0,32
Hung & Yung (2017)	0,42	0,19	0,03	0,06	0,79	2,26	0,02
Hung et al. (2017)	0,43	0,13	0,02	0,17	0,69	3,19	0,00
Jing et al.(2016)	0,59	0,27	0,07	0,06	1,12	2,19	0,03
Juan & Chao (2015)	1,19	0,25	0,06	0,69	1,69	4,70	0,00
Katsa et al.(2016)	1,41	0,35	0,12	0,73	2,10	4,07	0,00
Kostaris et al.(2017)	2,24	0,37	0,14	1,51	2,97	6,01	0,00
Lee et al.(2016)	0,52	0,24	0,06	0,05	0,99	2,18	0,03
Proske et al.(2014)	0,35	0,22	0,05	-0,08	0,78	1,58	0,11
Proske et al.(2014)b	0,26	0,21	0,05	-0,15	0,68	1,24	0,22
Proske et al.(2014)c	-0,12	0,21	0,04	-0,54	0,29	-0,58	0,56
Mumtaz et al.(2017)	0,34	0,30	0,09	-0,23	0,92	1,17	0,24
Podges & Kommers (2013)	1,28	0,40	0,16	0,50	2,07	3,21	0,00
Skromme et al.(2013)	1,20	0,37	0,14	0,47	1,92	3,23	0,00
Stefaniak & Tracey (2015)	0,38	0,19	0,04	-0,00	0,75	1,96	0,05
Stepan et al.(2017)	1,03	0,26	0,07	0,53	1,54	3,99	0,00
Yoon & Kim (2011)	-0,08	0,25	0,06	-0,57	0,42	-0,30	0,76
	0,54	0,10	0,01	0,35	0,74	5,40	0,00

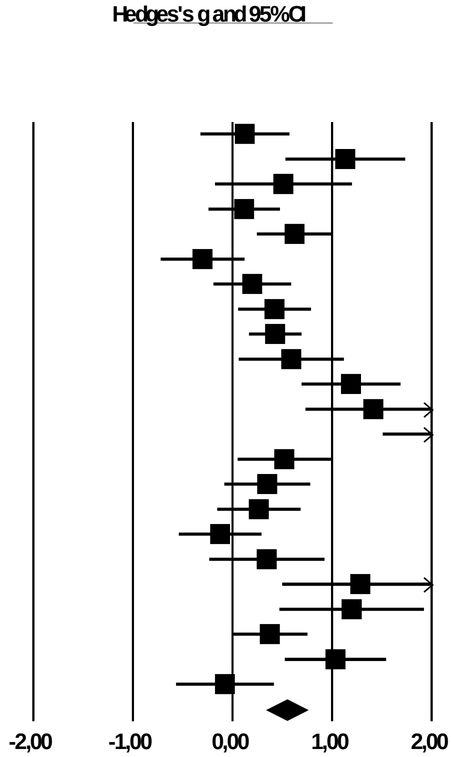
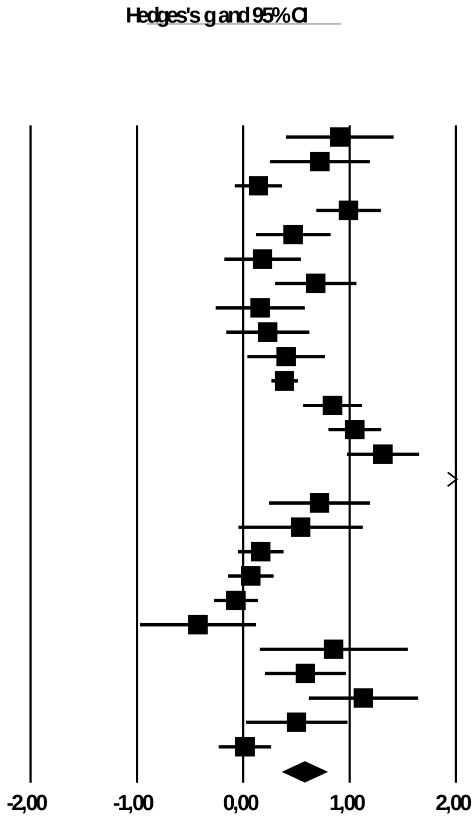


Table 8. *Results of meta-analysis for total motivation*

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Statistics for each study						
Alhassan (2004)	0,91	0,26	0,07	0,40	1,41	3,53	0,00
Ali et al.(2017)	0,72	0,24	0,06	0,25	1,19	3,01	0,00
Chen (2012)	0,14	0,11	0,01	-0,08	0,37	1,25	0,21
Chin et al.(2015)	0,99	0,15	0,02	0,69	1,29	6,39	0,00
Choi & Johnson(2005)	0,47	0,18	0,03	0,12	0,82	2,63	0,01
Cook et al.(2009)	0,18	0,18	0,03	-0,18	0,54	0,99	0,32
Di Serio et al.(2013)	0,68	0,19	0,04	0,30	1,06	3,50	0,00
Gleixner et al.(2008)	0,16	0,21	0,05	-0,26	0,58	0,74	0,46
Hu et al.(2016)	0,23	0,20	0,04	-0,16	0,62	1,16	0,25
Hung & Yung (2017)	0,40	0,19	0,03	0,04	0,77	2,17	0,03
Hung et al. (2017)	0,39	0,06	0,00	0,26	0,51	6,13	0,00
Jing et al.(2016)	0,84	0,14	0,02	0,56	1,12	5,93	0,00
Juan & Chao (2015)	1,05	0,13	0,02	0,80	1,30	8,29	0,00
Katsa et al.(2016)	1,31	0,17	0,03	0,97	1,65	7,59	0,00
Kostaris et al.(2017)	2,54	0,20	0,04	2,15	2,93	12,69	0,00
Lee et al.(2016)	0,72	0,24	0,06	0,24	1,19	2,96	0,00
Mumtaz et al.(2017)	0,54	0,30	0,09	-0,04	1,13	1,81	0,07
Proske et al.(2014)	0,16	0,11	0,01	-0,05	0,38	1,50	0,13
Proske et al.(2014)b	0,07	0,11	0,01	-0,14	0,29	0,65	0,52
Proske et al.(2014)c	-0,07	0,10	0,01	-0,27	0,14	-0,66	0,51
Rigby (2015)	-0,43	0,28	0,08	-0,97	0,12	-1,53	0,13
Skromme et al.(2013)	0,85	0,36	0,13	0,15	1,55	2,39	0,02
Stefaniak & Tracey (2015)	0,59	0,19	0,04	0,20	0,97	3,01	0,00
Stepan et al.(2017)	1,13	0,26	0,07	0,62	1,64	4,31	0,00
Yilmaz & Keser (2016)	0,50	0,24	0,06	0,02	0,98	2,06	0,04
Yoon & Kim (2011)	0,02	0,13	0,02	-0,23	0,26	0,13	0,90
	0,57	0,10	0,01	0,37	0,77	5,63	0,00



With the aim to examine the effect of the material based on ARCS Model on total motivation, the results of IMMS total scores were involved in the analysis and 26 effect sizes in the 24 articles, which were examined in the study, were computed. The effect sizes of these studies whose descriptive statistics and effect sizes are given in Table 8 range from -0.43 to

2.24. When the overall effect size of total motivation regarding these studies was assessed, the material designed based on ARCS Model had a medium effect on motivation (g=0.54). In addition, Q statistics revealed that the effect sizes in the analysis were heterogeneous (Q_{total}=270.16, z =5.63, p = 0.00), which reveals that there were differences among the effect sizes that were attributable to sources other than subject-level sampling error.

Due to the unusual effect size of a study (Kostaris et al., 2017) examined in the meta-analysis study, it is thought to be useful to exclude this study from the analysis and to examine the overall effect again (Lipsey & Wilson, 2001). When the study conducted by Kostaris et al. (2017) was excluded, changes regarding the effect sizes for attention (g =0.46), relevance (g =0.40), confidence (g =0.42), satisfaction (g =0.47), and total motivation score (g =0.49) were found out. However, in the final phase this study was not excluded from the analysis since there was no significant change in the overall effect sizes and in order to prevent any possible publication bias.

Due to the fact that the effects sizes regarding both components and overall motivation were found heterogeneous in the meta-analysis, it was decided to carry out moderator analysis. In coding, two variables (sample and study duration) were specified as moderator and moderator analysis was realized by these variables. The findings of the analysis are presented in Table 9. As Table 9 displays, it was found out that the material designed based on ARCS Model enhanced the most the motivation of college students. Besides, the analysis of components in terms of sampling revealed that the materials designed based on ARCS Model affected the motivation of teenagers (middle & college) much higher in terms of all components, and total scores of teenagers.

When the motivation levels were analyzed with regard to duration, as the second moderator, it was revealed that the duration of material use increased all components and total motivation scores. In other terms, it was found out that more than an eight-week use of material had a significant effect on motivation (g=0.97). However, this effect was not found out in direct proportion to relevance and satisfaction.

DISCUSSION and CONCLUSION

Teaching materials play a crucial role in teaching practices. The design and the implementation of materials influence academic success in addition to many other variables (Blumenfeld et al., 1991; Sun, Tsai, Finger, Chen, & Yeh, 2008). Motivation is among the variables that are critical in learning process (Pintrich, 2003; Schiefele, 1991). Therefore, any attempt to increase academic success should involve efforts to increase student motivation. However, the issue at this point is usually determining how to increase student motivation (Weiner, 1990). Keller (2010) postulates that ARCS Model with four components enhances student motivation, and thus designing teaching practices and materials based on this model could elevate student motivation. However, although extremely important, it was not clearly stated that which of these components affected the general motivation more and whether there were differences in terms of moderator variables. The present meta-analysis study investigated the teaching materials designed with ARCS Model in relation with student motivation.

When the effect of materials designed according to ARCS Model on motivation was analyzed, it was found that these types of materials affected student motivation moderately (g=0.57). The main reason for this impact was found to be attention which had higher impact compared to the other components. That is, materials used in studies increased attention and effected motivation positively. This assumption is supported by many studies in the related literature (Dinçer & Doğanay, 2017; Hawlitschek & Joeckel, 2017; Keller, 2008; Sun & Yeh, 2017). Attention will be discussed in detail in the following sections.

Table 9. *Moderator analyses for sample and duration*

Moderator		Number of comparisons k	Effect size g+	95% CI for g+
Sample*				
A	Middle	1	0.74	[0.36 ; 1.13]
	College	4	1.24	[0.18 . 2.35]
	University	16	0.35	[0.17 . 0.53]
	Adult	1	0.92	[0.21 ; 1.64]
R	Middle	1	0.36	[-0.02 . 0.73]
	Collage	4	1.54	[0.96 . 2.12]
	University	16	0.27	[0.12 . 0.42]
	Adult	1	0.18	[-0.50 . 0.86]
C	Middle	1	0.42	[-0.04 . 0.79]
	Collage	4	1.23	[0.50 . 1.95]
	University	16	0.34	[0.19 . 0.49]
	Adult	1	0.27	[-0.41 . 0.95]
S	Middle	1	0.62	[0.24 . 1.00]
	Collage	4	1.26	[0.50 . 2.02]
	University	16	0.39	[0.19 . 0.58]
	Adult	1	0.51	[-0.18 . 1.20]
T	Middle	2	0.77	[0.46 . 1.07]
	Collage	4	1.36	[0.59 . 2.13]
	University	17	0.33	[0.17 . 0.50]
	Adult	2	0.56	[0.28 . 0.84]
Duration**				
A	<1 week	4	0.48	[-0.01 . 0.97]
	1 week<	1	0.61	[0.13 . 1.08]
	4 week<	2	0.72	[0.04 . 1.40]
	8 week<	7	0.93	[0.34 . 1.53]
R	<1 week	4	0.51	[0.10 . 0.93]
	1 week<	1	0.54	[0.07 . 1.00]
	4 week<	2	0.49	[0.04 . 0.93]
	8 week<	7	0.71	[0.20 . 1.22]
C	<1 week	4	0.42	[-0.01 . 0.84]
	1 week<	1	0.69	[0.22 . 1.17]
	4 week<	3	0.41	[-0.10 . 0.93]
	8 week<	6	0.76	[0.18 . 1.34]
S	<1 week	4	0.60	[-0.03 . 1.23]
	1 week<	1	0.52	[0.05 . 0.99]
	4 week<	2	0.13	[-0.74 . 1.00]
	8 week<	7	0.88	[0.36 . 1.40]
T	<1 week	4	0.52	[-0.07 . 1.11]
	1 week<	2	0.72	[0.39 . 1.05]
	4 week<	3	0.52	[0.10 . 0.95]
	8 week<	7	0.97	[0.33 . 1.61]

* Q= 7.19; df =3 ; p= 0.07 for A; Q= 17.33; df =3 ; p= 0.00 for R; Q= 5.70; df =3 ; p= 0.13 for C; Q= 5.51; df =3 ; p= 0.14 for S; Q= 11.59; df =3 ; p= 0.00 for Total motivation

** Q= 1.42; df =3 ; p= 0.70 for <A; Q= 0.50; df =3 ; p= 0.92 for R; Q= 1.52; df =3 ; p= 0.68 for C; Q= 2.36; df =3 ; p= 0.50 for S; Q= 1.61; df =3 ; p= 0.66 for Total motivation

It was found that the effect sizes of studies by Kostaris et al. (2017) and Rigby (2015) were quite different from those of other studies. The difference of the study by Kostaris et al. (2017) was that it had higher effect sizes than other studies. They explained this high level of motivation with the interest of the students in ICT and supported their explication with the findings of other researches in the field (Davies, Dean, & Ball, 2013; Sureka, Gupta, Sarkar, & Chaudhary, 2013). Although similar results were reached in a similar study conducted by Katsa, Sergis, and Sampson (2016), any high effect size could not been obtained and the reason of this non-obtention could not been clearly explained in this meta-analysis. However, we think that different courses or teachers can be thought as possible reason for this. When it comes to the difference of the study by Rigby (2015), it had lower and negative effect sizes than other studies.

The researcher did not bring a clear explanation why this result was obtained. When discussion made by the researcher was analyzed, we could reach the conclusion that materials could not have same effect for each student. As stated by Li and Keller (2018) and Keller (2010), materials could have varying impacts for different student groups. In this context, designers should focus not only on age, gender, education level, etc. but also on variables such as culture and teachers who are supposed to use these materials. In parallel with this consideration, Li and Keller (2018) linked to these variables the fact that they gathered negative or insignificant results regarding motivation in the studies they reviewed. Although target samples, methods, and materials were similar in these two individual studies, it is thought that the differences in the effect sizes calculated were obtained because courses and teachers who used the materials and guided students were different. This comment is supported by many studies in literature (Dinçer & Doğanay, 2017; Keller, 1987; Şimşek, 2014).

Table 10. *Summary of overall effect sizes*

		k	ES	SE	Variance	Lower	Upper	Z-value	p-value	Q-value	df	p-value	I^2
A	Fixed	23	0.44	0.05	0.00	0.35	0.53	9.15	0.00	101.42	22	0.00	78.31
	Random	23	0.55	0.11	0.01	0.34	0.76	5.15	0.00				
R	Fixed	23	0.38	0.05	0.00	0.29	0.48	7.94	0.00	88.03	22	0.00	75.000.
	Random	23	0.48	0.10	0.01	0.29	0.67	4.86	0.00				
C	Fixed	23	0.42	0.05	0.00	0.32	0.51	8.82	0.00	70.66	22	0.00	68.87
	Random	23	0.49	0.09	0.00	0.32	0.67	5.59	0.00				
S	Fixed	23	0.44	0.05	0.00	0.35	0.54	9.20	0.00	90.99	22	0.00	75.82
	Random	23	0.54	0.10	0.01	0.35	0.74	5.40	0.00				
Total	Fixed	26	0.45	0.03	0.00	0.39	0.51	15.35	0.00	270.16	25	0.00	90.75
	Random	26	0.57	0.10	0.01	0.37	0.79	5.63	0.00				

The results of the present meta-analysis indicated that materials designed with ARCS Model affect attention in student motivation at medium level (g=0.55). Attention was found the most affected component by materials and as attention was increased, total motivation was also accrued. Based on the results of this meta-analysis concerning attention and as attention is placed in the first step of many teaching models, it is advised to give special consideration to attention when designing teaching materials. In line with this claim, research in the field reported that student motivation is not provided when attention is not obtained (Mor & Winquist, 2002; Vallerand, & Blssonnette, 1992; Vancouver, & Kendall, 2006). Malone (1981), for example, emphasizes that motivation levels are increased when curiosity is triggered and learning environment becomes more entertaining. Many other studies also point out that materials that attract students' attention enhance student motivation (Alessi & Trollip; 2001; Lowe & Schnotz, 2008). While some studies concluded that interest increases motivation (Fryer, 1931; Hidi, 2006; Izard & Ackerman, 2000), feelings and attention are the main components of interest (Berlyne, 1949); and therefore, the present meta-analysis study considered attention as the most important part of motivation. In other words, it is thought that being attention-grabbing is the most important characteristic of a teaching material and materials would mostly be ineffective in increasing student motivation when they lack the feature of drawing attention. In many studies, it is emphasized that not only getting students' attention at first sight but also maintaining their attention were required in order to maintain motivation (Dinçer, 2017; 2018; Hayden, Lorch, Almasi, & Milich, 2017; Keller, 2010; Li & Keller, 2018).

Finally, when individual studies were analyzed in respect to attention, it was determined that the effect sizes were almost in normal distribution. However, it is remarkable that the results showed an extremely high effect size in the study by Kostaris et al. (2017) whereas studies conducted by Proske et al. (2014) and Yoon and Kim (2011) indicated negative effect. When the studies by Proske et al. (2014) and Yoon and Kim (2011) were closely analyzed, it was found that they used the materials which were familiar to the participants from previous courses. It is understood that materials had no effect on motivation in the multi-dimensional study conducted by Proske et al. (2014) because, even though technology-integrated, these materials were similar with those already used by students. Based on these results, it was commented that the effect of innovation must also be employed during the design process in order that materials increase attention.

The results of this meta-analysis showed that materials moderately affect motivation regarding relevance (g=0.48). Relevance component in ARCS Model refers to training students to establish connections among their expectations, interests and needs and to inform them on the importance of learning outcomes. Teachers or guidance in the use of materials is very important in this component and previous knowledge, relevance level, etc. should be determined elements in the process of material design (Keller, 2010; Li & Keller, 2018). However, no information about prior knowledge and relevance was found in the studies reviewed, so the reasons could not be discussed. Similar to attention, extreme values in calculated effect size from the findings of Kostaris et al. (2017) and Proske et al. (2014) lead to various interpretations. As stated above, the studies by Kostaris et al. (2017) and Katsa et al. (2016) were similarly designed but did not provide similar findings. It is thought that different courses and teachers can be the reasons of different results. In other words, the difference between these studies may be explained by the fact that students received comparatively less guidance and made fewer connections between the materials and their real life expectations in the study of Katsa et al. (2016). Therefore, guidance of the teachers who present and use the materials is crucial in this component. In several studies, this importance was also given to play a critical role in motivation (Hidi, Berndorff, & Ainley 2002; Roscoe, Brandon, Snow, & McNamara, 2013).

It has been found that materials designed with ARCS Model affected confidence component in students' motivation at medium level (g=0.49). It should be noted that students' expectations of achievement and personal traits are important in this component. Besides, the difficulty level of questions is also one of the components which affect expectation of achievement. Confidence is the combined effect of fear of failure and desire for achievement. Students should believe that they could be successful. However, findings which would enable to comment the effect of confidence could not be reached in reviewed studies. For example, although Hu, Shewokis, Ting, and Fung (2016) pointed out that online materials were ineffective in creating confidence since they lack face-to-face human interaction, their study did not postulate any findings to support this assumption. Many other studies, on the other hand, suggest that confidence levels could be increased by the help of feedback, etc. (Cameron & Dwyer, 2005; Ricci, Salas, & Cannon-Bowers, 1996; Rieber, 1996; Schunk & Swartz, 1993; Zimmerman & Risemberg, 1997).

The findings indicated that materials had medium effect on satisfaction in motivation (g=0.54) and it was the second highest effect following attention component. Satisfaction component refers to the consistency between students' expectations and the efforts they display to realize these expectations. When there is no consistency between these two variables, motivation levels are expected to decrease. Students need to be satisfied or rewarded following their learning experiences. It is understood that academic achievement score was regarded as reward in most of the reviewed studies. This assumption is supported by the fact that students with lower achievement displayed lower values for this component than the other group. In the study by Gleixner, Douglas and Graeve (2008), it was pointed out that materials with project-based modules gave effective results for attention, relevance and total motivation while they affected satisfaction negatively. In this reviewed study, negative effect of confidence (another factor related to success) leaded to comment that success and success expectancy were related to motivation.

Two moderator variables were selected for the present study and the relevant analyses were presented separately in terms of all components and total motivation. When the findings were analyzed in terms of sampling, as the first moderator variable, it was found that materials designed with ARCS Model were especially effective in increasing motivation in younger groups. Considering the effect of attention, this was an expected result because the effect of innovation appears easily in younger groups and they consequently pay greater attention to new materials (Cheung, & Slavin, 2012; Dweck, 1986; Dinçer & Doğanay, 2017; Zepeda, Richey, Ronevich, &

Nokes-Malach, 2015). This comment can be criticized since the group coded as middle showed lower effect than the group coded as college. Although this seems to be true to an extent, two answers can be given to this criticism. Firstly, the number of individual studies coded as Middle was small. Secondly, the measurement tool IMMS was designed with university students. The tool was adapted for middle school students previously by Dinçer and Doğanay (2017). Researchers indicated that they transformed items with negative statements into positive ones and they excluded three items from the study because the students could not understand negative items. In the summary, we think that any findings which would justify this criticism would not be obtained if the number of reviewed studies was increased or IMMS was developed for each sample type.

When duration, as another moderator variable, was analyzed, it was found that motivation increased as the duration of the implementation was longer. The literature presents studies in support of this finding (Chauhan, 2017) as well as findings that report the reverse (Dinçer, 2017; 2018). Even though attention component is expected to decrease as duration increases, the continuous increase in the effect was thought to be related to the presence of features that could maintain attention in the design. The studies conducted by Sun and Yeh (2017) also support this conclusion. They stated that new features or new designs could help maintain attention, which directly increases motivation. Satisfaction component is another feature in duration moderator. As stated previously, the fact that students' motivation increases when they are rewarded or their efforts are acknowledged is more clearly supported by the findings of this moderator. It is thought that students could not make full efforts or could have fewer expectations of rewards because medium level effect was observed in short-period implementations. However, student satisfaction and motivation could increase in longer-period implementations as students would receive rewards, feedback, or high grades as a result of their efforts. Therefore, students should be informed that their efforts will be praised during implementations.

Motivation must be taken into account when designing instruction and materials (Gagne, Wager, Golas & Keller; 2005; Keller, 2010). For example, Gagne, et al. (2005) emphasized this importance by "one characteristic that should be taken into consideration when designing instruction is learner motivation" (p.114). However, in most of reviewed studies, it was not possible to find out whether researchers designed these materials, whether they paid attention to ARCS Model while designing materials. In most of the studies reviewed, it is thought that the lack of this information during the description of the material design process is a serious deficiency. For this reason, there is not detailed comment on the design of materials in this meta-analysis study.

In conclusion, it was revealed that materials designed with ARCS Model affected student motivation moderately and this effect mostly through attention attraction. Therefore, it is advised that the attention component should be taken into consideration and materials should involve elements that would help maintain student attention. Although research on ARCS Model was conducted especially with university students, it has been stated that ARCS Model was effective with young learners. Furthermore, it is also found that motivation increases as the duration of the implementation is longer. It is thought that the results of the experimental studies investigating motivation and use or design of materials in literature may not be reliable because they had short duration of implementation. For this reason, it is suggested that experimental researches should be performed with long-period implementations.

Limitations and Future Research

A criticism of the meta-analysis is that it tries to calculate general effect by combining different variables. However, this weakness is thought to be minimized as the criteria of inclusion in the present study involved focusing on materials designed with ARCS Model and same measurement tools.

On the other hand, the inclusion of the studies in which measurement tools are modified for several reasons (exclusion of items in the process of scale adaptations or of data analysis) could be regarded as a limitation of this meta-analysis study.

However, as Li and Keller (2018) state that there are varied data collection tools used to determine motivation levels for ARCS Model in literature, choosing only IMMS in the present study is another limitation.

On the other hand, the non-inclusion of the studies in which measurement tools were modified for several reasons could also be regarded as a limitation of this meta-analysis study. Considering these two limitations, it can be suggested for future research to remake the analysis by reaching all individual studies, to calculate the effect sizes of the studies using different measurement tools and compare them with the results obtained from IMMS, to reanalyze the study with different moderators, and finally to repeat the study with different models of motivation and compare them with ARCS Model.

Implications for Research and Practice

Motivation is one of the most important variables that should be considered when predicting students' success (Kriegbaum et al., 2018; Schrader, Reichelt, & Zander, 2018). Therefore, it is recommended to examine this variable with different dimensions in educational researches. Based on the fact that the two moderator variables determined in the study changed the results, it is suggested to use these variables in researches.

As materials had a medium effect on motivation, it is suggested to researchers to focus on the material design. In order to attract attention constantly, it is recommended to make designs that would allow new add-ons / features to be produced as the material is used.

It was understood that material designs should be done within the framework of a design model. In fact, this comment is stated by many other researchers (Dick, Carey, & Carey, 2005; Keller, 2010). However, in this study, although the relationship between ARCS model and material was indicated as a selection criterion, there was not sufficient information about material design.

IMMS was developed to measure the impact of material on motivation. However, it is recommended to pay attention to the measurement tools in such educational research as it was determined that IMMS was used for different variables in 37 articles that were excluded from the coding during the determination of the studies to be included in the meta-analysis.

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