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Mode-Method Interaction: The Role of Teaching Methods on The Effect of Instructional Modes on Achievements, Science Process Skills, and Attitudes Towards Physics

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ABSTRACT
The purpose of this study is to explore the effects of instructional mode, methods, and interaction between them. In order to achieve this purpose, two two-level-independent variables were defined, teaching modes (blended vs. face-to-face) and teaching methods (expository vs. inquiry). Thus, a 2x2 factorial design was performed with four treatment groups of 314 students. Before and after the treatments, pre-tests and post-tests on achievement in electricity concepts, science process skills, and attitudes toward physics were administered. For the analysis of the data multivariate analysis of covariance were performed. It was found that the effect of blended mode is not dependent upon the teaching methods implemented. Related to the effects of instructional mode; blended instruction is more effective than face-to-face instruction in supporting students' achievement in electricity and science process skills. Additionally, it was found that the expository teaching method is as effective as the inquiry teaching method.

Keywords: blended learning, inquiry, high schools, physics education

INTRODUCTION

The advances and common use of web-based tools for instructional purposes led to a unique instructional mode generally referred as online learning. In the most general sense, online learning can be defined as learning activities conducted by use of computers and internet allowing learners to participate in activities regardless of time and distance. The major advantage of online learning is the flexible use of time and location, which may not be available in traditional face-to-face instructional settings (Dolan, Hancock, & Wareign, 2015). Although online learning is sometimes considered as an alternate to traditional face-to-face instruction, different instructional modes provide different learning opportunities for students. During face-to-face instruction, students can learn by listening to lectures, contributing to discussions, or participating in laboratory activities. On the other hand, during online learning, students can learn by reading texts, listening to audio materials, observing still or animated images, watching videos, interacting with virtual environments, or communicating via electronic tools (Yelon, 2006). Using the advantages of both online and face-to-face instruction seems to be a good idea for instructional practices. When a face-to-face instruction is blended with online learning, it provides learners with explanations combining text, voice, video, graphics, and simulations. Furthermore, teachers may provide individual guidance and use the class time more efficiently (Dollar, Steif, & Strader, 2007).

The intention of improving the quality face-to-face instruction with online learning opportunities is generally referred as "blended learning". Garrison and Kanuka (2004) defined blended learning as "…the thoughtful integration of classroom face-to-face learning experiences with online learning experiences" (p. 96). Blended learning mainly aims to use the advantages of both online and face-to-face learning. In the last decade, an enormous number of studies were conducted on blended learning and revealed that blended learning is superior to face-to-face or purely online learning. Several researchers also conducted meta-analysis to synthesize the findings in the related literature. For example, Means, Toyama, Murphy, Bakia and Jones (2009) conducted a meta-analysis on the

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Contribution of this paper to the literature

- This paper illustrates the possible effects of blended learning on high school students' physics achievements, science process skills, and attitudes towards physics.
- It highlights that the effect of blended instruction is not dependent upon the teaching methods implemented with.
- It also shows that expository teaching method is as effective as inquiry teaching method.

effect of blended and online learning. They found that the effect of blended learning on students' achievements is stronger than that of face-to-face instruction. Similar meta-analysis and synthesis studies conducted in different subject areas reported similar results (Bernard, Borokhovski, Schmid, Tamim, & Abrami, 2014; Cook, Levinson, Garside, Dupras, Erwin, & Montori, 2010; Tamim, Bernard, Borokhovski, Abrami, & Schmid, 2011).

The meta-analysis of Means et al. (2009) also allowed researchers to identify three moderator variables with a significant effect ($p < .05$) on the influence of blended learning on students' achievements. Effects were larger when a blended rather than a purely online condition was compared with face-to-face instruction; when the online pedagogy was expository or collaborative rather than independent in nature; and when the curricular materials and instruction varied between the online and face-to-face conditions. (p. 36)

Means et al. argued that the results of empirical studies should not be interpreted that blended learning is superior to others mode of learning under any circumstances. "Rather, it is the combination of elements in the treatment conditions, especially the inclusion of different kinds of learning activities that has proved effective across studies." (p. 36)

Although the meta-analyses give some signals about the possible role of learning activities on the effect of blended learning, one of the major issues in the empirical studies is that the nature of learning activities and instructional modes were entangled. This is why it is hard to identify the sole effect of blended learning. The purpose of the current study was to explore the role of learning activities on the effect of blended learning by making a distinction between instructional modes and learning activities. For this purpose, learning activities were operationalized by focusing on well-defined instructional methods proposed in the literature of science education. For this purpose two different instructional methods were selected to implement them with instructional modes (blended vs. face-to-face), one is expository teaching and the other one is inquiry.

Expository and inquiry learning methods were deliberately chosen because they have different theoretical backgrounds related to how learners acquire knowledge. While expository teaching defines learners as passive receivers of knowledge, inquiry teaching defines learners as active cognitive processors who construct their own knowledge through inquiry. Consequently, the nature of the learning activities used during the implementation of these methods fundamentally differs during the instructions. For example, while expository teaching expects teachers to transmit their expert knowledge to students through lectures or demonstrations, inquiry expects students to construct their own knowledge through their own inquiries (Peşman & Özdemir, 2012). Inquiry learning is further specified for the current study by using a well-known inquiry oriented method in science education called as 5-E learning cycle. 5-E learning cycle is a sequence of instruction with well-defined instructional steps depicted by 5-E. These steps were, in the simplest form, "engaging" students in the subject to stimulate interest and curiosity before instruction, "exploring" the concepts through hands-on and mind-on activities, generating "explanations" based upon data, "elaborating" the explanations by linking them with other concepts, and finally "extending" the concepts by transferring them to different contexts.

In sum, to explore the possible interactions between instructional mode and method the instructional modes were set as blended and face-to-face instructions, while teaching methods were set as expository and 5-E learning cycle. The possible effects were searched on 9th grade students' physics achievements, science process skills, and attitudes towards physics. Consequently, the research questions of the study were formulated as follows:

1. What is the main effect of instructional modes (blended vs. face-to-face) on the population means of the combined dependent variables of 9th grade students' posttest achievement scores on "electricity", posttest science process skills, and posttest attitude scores towards physics when their pretest scores of achievements on "electricity", science process skills, and attitudes towards physics are controlled?
2. What is the main effect of teaching method (5E learning cycle vs. expository) on the population means of the combined dependent variables the 9th grade students' posttest achievement scores on "electricity", posttest science process skills, and posttest attitude scores towards physics when their pretest scores of achievements on "electricity", science process skills, and attitudes towards physics are controlled?
3. What is the interaction effect between teaching method and instructional modes on the population means of the combined dependent variables of the 9th grade students' posttest achievement scores on "electricity",

Table 1. Experimental Design

		Teaching Methods	
		Expository	Inquiry
Instructional Mode	Blended	B-EXPO	B-INQU
	Face-to-face	EXPO	INQU

Table 2. Number of Classrooms and Student Distribution in Selected Schools

	Number of Classrooms	Girls	Boys	TOTAL	Percentage
Private H.S.	5	38	51	89	28.35
Public H.S.	8	122	103	225	71.65
TOTAL	13	160	154	314	100

posttest science process skills, and posttest attitude scores towards physics when their pretest scores of achievements on "electricity", science process skills, and attitudes towards physics are controlled?

The major contribution of this study to the current literature is formulated by the third research question, which focuses on the interaction between teaching methods and instructional modes. More specifically, it is intended to understand the role of inquiry and expository teaching methods on the effect of blended and face-to-face instructions. Although there are extensive research on both inquiry oriented instructions (Lawson & Johson, 2002; Nwagbo, 2006; Sokolowski & Rackley, 2011; Yager & Akcay, 2010) and blended learning (Chandra & Watters, 2012; Delialioğlu & Yıldırım, 2007; Nellman, 2008) they seem to be independent research areas. Most of the research conducted on the effect of inquiry oriented instruction were conducted in face-to-face instructional settings and they have mostly revealed that inquiry oriented instructions are more effective than expository strategies on improving students' conceptual understanding (Minner, Levy, & Century, 2009). However, we could not locate any particular study seeking an answer to the question of whether the effect of inquiry oriented instruction differs when the setting was changed from face-to-face to blended learning. Similarly, in spite of extensive research on blended learning we could not locate any particular study seeking an answer to the question of whether the effect of blended learning depends on the instructional method used with blended learning environment. In the following sections, we explain the research design that allowed us to answer the questions that we raised so far.

METHODOLOGY

Research Design

A 2x2 factorial design with four treatment groups was used to explore the main and interaction effects of instructional modes and methods addressed by the research questions. The treatment groups were arranged as blended mode with inquiry teaching method (B-INQU), blended mode with expository teaching method (B-EXPO), face-to-face mode with inquiry teaching method (INQU), and face-to-face mode with expository teaching method (EXPO). The research design of the study is presented in **Table 1**.

Population and Sampling

The accessible population of the study consisted of all 9th grade high-school students in Çankaya, one of the central districts of Ankara, Turkey. The sample of the study was selected from the accessible population by purposive sampling. Technological availabilities and internet accessibilities of the schools were two important criteria for the selection of the sample because the students in blended groups needed to access internet and computers during the treatments. Two private and two public schools fulfilling these criteria were selected purposefully.

Five classrooms from two private high schools and eight classrooms from two public high schools were included in the study. 314 students (160 girls and 154 boys) in total participated in the study. The treatments were randomly assigned to the intact classes. Student distribution in these schools is shown in **Table 2**.

Outcome Variables

The purpose of the current study was to inquire about the possible effects of instructional modes, methods, and interaction between them. The experiment was conducted with 9th grade students during the instructions about electricity concepts. To measure the possible effects of instructions three outcome variables, achievement, science process skills, and attitude, were selected because they were three of the most frequently observed effects of instructional manipulations in the literature of science education. These variables were measured with i) Electricity Achievement Test (EAT), ii) Science Process Skills Test (SPST), and iii) Physics Attitude Scale (PAS).

EAT was used to measure 9th grade students' achievements in electricity prior to and just after the treatments. The test items were developed by the researchers according to 9th grade physics curriculum which includes the objectives related to electric current, resistance of a wire, Ohm's law, and connections of resistors. The test consisted of 30 multiple-choice items. The possible scores were ranged from 0 to 30. Before the administration of the test, a professor and three research assistants, majored in physics education, and a high school physics teacher examined the test with respect to the appropriateness of the test items in terms of content variation, difficulty, and grade level. Their recommendations were reflected in the test items. A pilot study was also conducted for item analysis and necessary changes were made according to the results. During the main study, pre-test and post-test reliabilities of the test were calculated as 0.78 and 0.89 respectively.

SPST was used to measure 9th grade students' science process skills prior to and just after the treatments. The SPST test used in this study was developed and validated by Temiz (2007). The test consists of 20 items including two essay types and eighteen multiple choice type items. The possible scores were ranged from 0 to 40. The reliabilities of the test scores (Cronbach's Alpha) according to pretest and posttest results were calculated as 0.85 and 0.91 respectively.

Students' level of attitudes towards physics was measured by physics attitude scale (PAS). The scale was originally developed by Taşlıdere (2002) and modified by Küçüker (2004). Five-point likert type scale was used for 24 items. The possible scores were ranged from 24 to 120. The reliabilities of the test scores (Cronbach's Alpha) according to pretest and posttest result were calculated as 0.94 and 0.93 respectively.

Treatments

According to 9th grade Turkish physics curriculum, there are four main objectives related to electricity as listed below:

Students should be able to:

1. Explain the role of potential difference in a simple electric circuit by remembering it as an indicator of energy difference that can create current between two edges of a conductor.
2. Explain the relationship between the current that passes through a conductor and the potential difference on it.
3. Explain the factors that affect the resistance of a conducting wire.
4. Explain the relation among current, resistance, and potential difference in serial and parallel circuits.

The treatments were basically designed to achieve the objectives. Nevertheless, each treatment was designed by using the combinations of specific instructional methods (inquiry vs. expository) and modes (blended vs. face-to face instruction) consistent with the purpose of the study. Detailed lesson plans were developed for each treatment conditions for the easiness of the teachers during the implementations of the treatments. Pretests and post-tests were applied at the same time to all groups so the duration of treatments were the same in each class. In the following sections, major characteristics of each treatment condition were explained.

Face-to-Face Expository Instruction

During the face-to-face expository instruction, the teacher was the center of instruction who intended to provide all the necessary information to students through lectures. The lectures basically included the definitions of the core concepts (e.g., current, potential difference, and resistance), relations among them, and related tables, figures, or graphs. The teacher also showed solutions of some exemplary problems, provided opportunities for students to work on different type of problems, and responded to the questions raised by students.

Face-to-Face Inquiry Instruction

Face-to-face inquiry instruction was conducted through the implementation of learning cycle. During the implementation, five phases of learning cycle, engage, explore, explain, elaborate, and evaluate were used. At the beginning of the instruction, the teacher presented interesting videos, photos, or questions related to the target concepts to stimulate students' curiosity and engage students to the instruction. During the explore phase, students generated questions through the guidance of the teacher (e.g., what is the effect of potential difference and resistance on the current in a simple circuit), conducted experiments, and collected data to respond to the questions. After the experiments, students were expected to generate explanations for the questions based upon their observations and the data. Next, the generated ideas during the exploration phase was elaborated by solving problems and extending the ideas to other contexts. The role of the teacher during the implementation of learning cycle was to guide students, facilitate the experiments, and encourage students to reveal their opinions.

Blended Expository Instruction

There were two environments for blended expository instruction (B-EXPO) group. One was web based expository learning environment (WELE) and the other was face-to-face expository learning environment. The implementation of B-EXPO started with WELE and continued in face-to-face classroom environment.

Students firstly used WELE in computer laboratory and then the same subject was reviewed in the classroom environment. WELE was constructed by using expository teaching method. The web site of WELE included explanations of basic concepts, related examples, tables, figures, and graphs; and solutions of some sample problems. Teacher did not directly control the students during the web hours. Nevertheless, in the face-to-face classroom environment, teachers dominated and directed the lessons by asking some questions, providing further explanations for the concepts, giving examples, solving problems similar to the ones on the web site, and responding to the questions raised by students.

Blended Inquiry Instruction

There were also two environments for blended inquiry (B-INQU) group. One was web-based inquiry learning environment (WILE) and the second one was face-to-face inquiry environment. The implementation of B-INQU started with WILE and continued in face-to-face classroom environment. The web environment of WILE was constructed according to 5E learning cycle. For each phase of 5E cycle, a new page was prepared in a sequence that started with engagement and ended with evaluation. The web page included engaging videos, interactive simulations, table and graphic tools, and forums.

Students firstly used WILE in computer laboratory and then the same subject was discussed in the classroom environment. The subject was taught according to 5E learning cycle in both web and classroom environment. In the web environment, students followed the activities on WILE such as watching videos, answering questions, performing experiments through simulations, filling tables and generating explanation on forums. Teachers did not directly control the students' activities during the web hours, they just participated in the forum discussions to give guidance to students' experimentations and explanations. In the classroom environment, teachers encouraged students for further explanations and elaborations.

Procedure and Validation Issues

Based on the 9th grade Turkish Physics Curriculum, four objectives related to electricity were determined as the focus of the treatments. The objectives formed the boundaries of EAT and lesson plans. WELE and WILE were developed according to the curriculum objectives and instructional methods chosen for the study. During the development of WELE and WILE, two professors, one is expert in physics education and the other one is expert in educational technologies, reviewed the web sites for their consistency with the curriculum objectives, instructional methods, and design principles. Their suggestions were included in the WELE and WILE until they were confirmed the consistency. The treatments were implemented in the second semester of 2009-2010 academic year for 4 weeks. Prior to and just after the treatments EAT, SPST, and PAS were used as pre-test and post-test. Before the treatments, teachers were trained about the implementation of instructions through the lesson plans developed by the researchers for each experimental group. During the treatments, the teachers and one of the researchers were also met every week and discussed about what and how to teach in each group in the following week.

Observation checklists were also developed for each treatment group and totally 22 hours of lessons (68% of the treatments) was observed by one of the researchers. According to the analysis of checklists filled by the researcher, 75 % of the treatments were consistent with the intended instructional methods and modes. The details on treatments, instruments, treatment fidelity and treatment verification can be reached from Çetin (2013).

Variables and Analysis

In the study, two two-level-independent variables, teaching methods (inquiry and expository) and instructional modes (blended and face-to-face) were used. The dependent variables were defined as post-test scores of EAT (posEAT), SPST (posSPST), and PAS (posPAS). Pre-test scores of EAT (preEAT), SPST (preSPST), and PAS (prePAS) were determined as covariates. As a result, two-way multivariate analysis of covariance (MANOVA) was used. In addition, follow-up ANCOVAs were performed separately for each dependent variable when needed.

Table 3. Descriptive Statistics about pre-test and post-test scores of each group

	Face-to-face				Blended			
	EXPO		INQU		B-EXPO		B-INQU	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
N	41	41	79	79	50	50	83	83
EAT								
Mean	12.46	16.63	13.45	17.19	13.08	19.60	12.26	18.05
S.D.	4.35	4.62	4.01	4.18	3.66	3.63	4.44	5.33
SPST								
Mean	36.03	34.59	29.88	30.81	33.93	36.23	31.22	32.63
S.D.	3.19	5.16	9.88	8.49	5.29	3.77	8.45	7.64
PAS								
Mean	80.30	81.28	80.91	80.91	86.25	84.79	78.71	83.31
S.D.	20.84	21.24	14.21	15.88	15.70	16.41	16.98	15.90

Note. N: Number of Students; SD: Standard Deviation

RESULTS

Missing Data Analysis

During the missing data analysis, first of all, the students who did not complete one of the posttests were excluded from the study. The number of students in the study decreased to 261 after the exclusion. Secondly, the missing values of pretest scores were identified. Their percentage was less than 5 percent and thus there was no inconvenience for replacing the missing values with the series mean values (Tabachnick & Fidell, 2007, p.63). Finally, univariate and multivariate outliers were checked. The cases with z-scores that exceeded ±3 were determined as outliers (Tabachnick & Fidell, 2007, p.73). Eight outliers were found in the data. After they removed, 253 students' scores were left to be used in descriptive and inferential statistics. The gender distribution of the students included in the analyses was homogeneous with 130 female and 123 male students.

Descriptive Statistics

Descriptive statistics related to the number of students, mean values, standard deviations, skewness, and kurtosis values of each group for the pre-test and post-test scores of EAT, SPST, and PAS are presented in **Table 3**. According to Tabachnick and Fidell (2007, p79), skewness and kurtosis values should be around zero for a normal distribution and the values between -2 and +2 can be accepted as normal distribution (George & Mallery, 2003, pp. 98-99). The skewness and kurtosis values of all scores are around zero and the distributions were accepted as normal.

Students in all groups made progress in terms of achievement scores. The science process skills test scores of EXPO group seemed to decrease, while the other groups seemed to make progress. In terms of the physics attitude scale scores, B-EXPO group seemed to decrease while INQU group stayed almost the same between pre-test and post-test.

To make judgments about the practical significance of differences between mean scores of pre-tests and post-tests, gain scores and Cohen's d values were calculated as seen in **Table 4**. Cohen (1988) categorizes the effect sizes as small (d = 0.20), medium (d = 0.50), large (d = 0.80), and very large (d = 1.30). For achievement scores, all treatments had large or very large effect sizes. Blended mode with expository teaching method (B-EXPO) group seemed to make better progress with a very large effect size. When the groups were arranged for only teaching methods, expository groups (EXPO & B-EXPO) made better progress than inquiry groups (INQU & B-INQU). When the groups were arranged for only instructional mode, blended groups (B-EXPO & B-INQU) made better progress than face-to-face groups (EXPO & INQU). In terms of science process skills scores, blended mode with expository teaching method (B-EXPO) had medium effect size while face-to-face expository (EXPO) group seemed to drop back. The other treatments had small effect sizes. For physics attitude scales, blended mode with inquiry teaching method (B-INQU) had small effect size while the others had almost no effect size.

Table 4. Gain Scores and Effect sizes of each group

	N	EAT		SPST		PAS	
		Gain Score	Cohen's d	Gain Score	Cohen's d	Gain Score	Cohen's d
EXPO	41	4.17	0.93	-1.44	-0.34	0.98	0.05
INQU	79	3.74	0.91	0.93	0.10	0.00	0.00
B-EXPO	50	6.52	1.79	2.30	0.50	-1.46	-0.09
B-INQU	83	5.79	1.18	1.41	0.18	4.60	0.28
EXPO & B-EXPO	91	5.46	1.36	0.61	0.14	-0.36	-0.02
INQU & B-INQU	162	4.79	1.06	1.18	0.14	2.36	0.15
EXPO & INQU	120	3.89	0.92	0.12	0.02	0.33	0.02
B-EXPO & B-INQU	133	6.06	1.37	1.74	0.26	2.32	0.14

Table 5. Correlation Among Possible Covariates and the Dependent Variables

Variables	preEAT	preSPST	prePAS	postEAT	postSPST	postPAS
preEAT	1.00					
preSPST	**.402**	1.00				
prePAS	.118	.125	1.00			
postEAT	**.438**	**.304**	.095	1.00		
postSPST	**.456**	**.746**	.084	**.468**	1.00	
postPAS	.091	.102	**.650**	**.142**	.072	1.00

Inferential Statistics

To check the statistical significance of the results inferential statistics were conducted by using MANCOVA model. Three steps of analyses were conducted to respond to the research questions. First of all, covariates were determined, secondly MANCOVA was performed, and finally follow-up ANCOVA results were checked when needed.

Determination of Covariates

The basic statistical criterion for identifying covariates is that while the correlations among covariates should be low, the correlations between covariate and dependent variables should be high (Tabachnick & Fidell, 2007, pp. 211-212). The correlations between the variables were calculated as shown in **Table 5**.

As seen in **Table 5**, the correlations between pretests' scores are smaller than .80 and there are high correlations between pre-tests and post-tests. Therefore, pretests of EAT, SPST, and PAS were used as the covariates. Consequently, two-way MANCOVA was decided to be used with two independent variables, three covariates, and three independent variables. The assumptions of MANCOVA are defined as multivariate normality, linearity, outliers, homogeneity of variance-covariance matrices, homogeneity of regression, reliability of covariates, multicollinearity, and singularity. All these assumptions were checked as described in Pallant (2007, pp. 220-223,225), Stevens (2009, pp. 227-228 & pp. 300-308), and Tabachnick and Fidell (2007, pp. 202-203, p. 252 & pp. 281-284) and no serious violations were detected.

MANCOVA Results

Related to the research questions of the study the following hypotheses were tested with MANCOVA,

1. There is no significant main effect of instructional mode (blended vs. face-to-face) on the set of dependent variables, post-test scores on the EAT, SPST and PAS.
2. There is no significant main effect of teaching methods (5E learning cycle vs. expository) on the set of dependent variables, post-test scores on the EAT, SPST and PAS.
3. There is no significant interaction effect between the instructional mode (blended vs. face-to-face) and the teaching method (5E learning cycle vs. expository) on the set of dependent variables.

Mancova results are presented in **Table 6**. According to this table, when the main effect of instructional mode is checked, there is evidence that instructional mode makes a significant difference on the dependent variables (postEAT, postSPST, and postPAS). In other words, the effect of instructional mode is statistically significant ($F(3,244) = 6.697$, $p = 0.000$, Wilk's Lambda = 0.924, partial eta squared = 0.076 and observed power = 0.974) when students' pretest scores were controlled. Therefore, 1. null hypothesis was rejected. When the main effects of the method of teaching is checked, there is no evidence that the method of teaching make a significant difference on

Table 6. MANCOVA Results

	Wilks' Lambda	F	df	Sig.	Partial Eta-squared	Observed Power
Intercept	0.712	32.91	244	0.000	0.288	1.000
PreEAT	0.863	12.91	244	0.000	0.137	1.000
PreSPST	0.681	38.05	244	0.000	0.319	1.000
PrePAS	0.590	56.56	244	0.000	0.410	1.000
MOT	0.981	1.613	244	0.187	0.019	0.421
Mode	0.924	6.697	244	0.000	0.076	0.974
MOT By IM	0.984	1.314	244	0.270	0.016	0.349

Table 7. Univariate ANCOVA Results

Source	Dependent Variable	df	F	Sig.	Partial Eta Squared	Observed Power
Intercept	PostEAT	1	44.901	0.000	0.154	1.000
	PostSPST	1	42.999	0.000	0.149	1.000
	PostPAS	1	28.895	0.000	0.105	1.000
MOT	PostEAT	1	0.228	0.633	0.001	0.076
	PostSPST	1	4.288	0.039	0.017	0.541
	PostPAS	1	0.717	0.398	0.003	0.135
Mode	PostEAT	1	14.902	**0.000**	0.057	0.970
	PostSPST	1	8.440	**0.004**	0.033	0.825
	PostPAS	1	0.993	0.320	0.004	0.168
MOT by Mode	PostEAT	1	2.148	0.144	0.009	0.309
	PostSPST	1	0.558	0.456	0.002	0.115
	PostPAS	1	1.331	0.250	0.005	0.210

the dependent variables (postEAT, postSPST, and postPAS). In other words, the effect of methods of teaching is not statistically significant (F (3,244) = 1.613, p = 0.187, Wilk's Lambda = 0.924, partial eta squared = 0.019 and observed power = 0.421) when students' pre-test scores were controlled. Therefore, the null hypothesis was failed to reject.

When the interaction effect is checked, there is no evidence that there is an interaction between method of teaching (MOT) and instructional mode (Mode). The interaction is not statistically significant (F (3,244) = 1.314, p = 0.270, Wilk's Lambda = 0.984, partial eta squared = 0.016 and observed power = 0.349). In other words, there is no interaction between MOT and Mode, when the students' pre-test scores were controlled. Therefore, the null hypothesis was failed to reject.

As a result, one hypothesis was rejected while the other two hypotheses were failed to reject. For the rejected hypothesis, follow-up ANCOVA was constructed to understand the dependent variables causing the significant difference.

Follow-up ANCOVA Results

Table 7 shows the univariate ANCOVA results. The new alpha level for ANCOVA analysis was set at 0,017 because a Bonferroni type adjustment was required for the inflated Type I error for separate univariate tests instead of a single multivariate test. The new alpha level was calculated by dividing the current alpha value (0.05) by the number of dependent variables, 3, as described in Tabachnick and Fidell (2007, p. 270).

According to **Table 7**, the main effect of instructional mode is on the dependent variables of achievement (postEAT) and science process skills (postSPST). Blended instruction and face-to-face instruction significantly differ on the achievement with a medium effect size (F(1,246) = 14.902, p=0,000; partial eta squared = 0.057, observed power = 0.970). The postEAT mean scores of blended and face-to-face groups are 18.63 and 17.00 respectively. The postEAT mean scores of the blended groups are higher than the face-to-face groups. As a result, the significant difference between blended and face-to-face groups in achievement (postEAT) scores is in favor of the blended groups.

According to science process skills (postSPST), blended instruction and face-to-face instruction significantly differ with a small to medium effect size (F(1,246) = 8.440, p=0,004; partial eta squared = 0.033, observed power = 0.825). The postSPST mean scores of blended and face-to-face groups are 33.98 and 32.10 respectively. The postSPST mean scores of the blended groups are significantly higher than the face-to-face groups in favor of the blended groups.

Summing up the Results

1. There is a statistically significant difference with a medium effect size between mean combined scores of electricity achievement, science process skills, and attitudes towards physics in blended and face-to-face instructional groups. According to follow-up ANCOVA results, blended and face-to-face groups significantly differ in the achievement and science process skills scores with a medium effect size in favor of blended instruction. There is no statistically significant difference in students' attitudes towards physics.
2. There is no statistically significant difference between inquiry (5E learning cycle) and expository teaching methods on the combined dependent variables of the 9th grade students' achievement, science process skills, and attitude towards physics.
3. There is no statistically significant interaction effect between teaching method and instructional mode on the combined dependent variables of the 9th grade students' achievement, science process skills, and attitude towards physics.

DISCUSSION & CONCLUSION

Blended learning is designed to integrate the strengths of face-to-face learning experiences with those of web-based learning (Garrison & Kanuka, 2004). Several studies reported that blended learning affects students' achievements positively (Chandra & Watters, 2012; Delialioğlu & Yıldırım, 2007; Nellman, 2008). Based upon the review of empirical studies Larsen (2012) also concluded that blended learning improves achievement. The argument that blended learning enhances students' achievements was supported with the results of the current study. The current study also revealed that blended instructional mode affect students' science process skills as well as achievements. Nevertheless, this study did not detect any evidence that instructional modes can make a difference on students' attitudes towards physics. This result is similar to that of Bilal and Erol (2009) but contradicts with others' (Chandra & Watters, 2012; Sun, Lin & Yu, 2008; Şengel, 2005). A positive effect of blended mode of instruction on students' achievement and science process skills observed probably because students instructed in blended mode can access the course content and have a chance to review it, practice and actively engage in the activities, solve extra problems, and share their opinions and questions with their teachers any time they needed.

Two teaching methods, inquiry and expository, were selected to test the possible effects of teaching methods. The analysis of data could not detect a significant difference between the effects of teaching methods on students' possible gains. Actually, there is no conclusive evidence in the literature about the superiority of inquiry oriented instructional methods on students' achievements. While some studies (Lawson & Johson, 2002; Nwagbo, 2006; Sokolowski & Rackley, 2011; Yager & Akcay, 2010) conclude that inquiry learning provides better understanding when it is compared to expository learning, some others (Sweak, Jong, & Joolingen, 2004) present contradictory evidence that expository teaching provides better understanding. This is probably because achievement is a multifaceted construct and the effect of a specific instruction depends on what sort of achievement is intended. In this study, the achievement test included different types of items formats but the problem situations were limited to well-defined problems. Although the result that inquiry did not make a difference compared to expository instruction on students' achievements can be understandable from this perspective, the result that inquiry did not make a difference on students' science process skills is a little odd. One of the unique qualities of inquiry-based teaching is its potential to stimulate science process skills. Students need to actively use and consequently improve science process skills during an inquiry-based instruction. Quite a number of studies have also showed that inquiry-based teaching methods improve students' science process skills (Campbell, Zharg & Neilson, 2011; Ergül, Şimşekli, Çalış, Özdilek, Gökmençelebi, & Şanlı, 2011; Şimşek & Kabapınar, 2010). In this study, when the students' science process skill scores are checked, gain score of inquiry groups (0.93) is higher than those of expository groups (-1.44). However, this difference is not statistically significant. This is probably because improving students' science process skills needs much more time than the time spent in this study.

The research design of the study had an advantage of seeing the effects of each instructional mode for two different teaching methods and each teaching method on two different instructional modes; consequently, the interaction between teaching method and instructional mode was tested. However, no evidence was detected about the interactions. It is worth to notice that the methods of this study are limited to expository and inquiry and it is still possible to detect an interaction effect between instructional method and mode when some other methods like modeling, problem based, or project based learning are implemented. In the same way, other type of instructional modes can also create an interaction. Blended and face-to-face modes were used in the current study. Only web based learning mode or other arrangements of web and face-to-face instructional modes can still make a difference in terms of interactions between instructional methods and modes.

In the current study, there were two independent variables, instructional modes and methods of teaching, and three dependent variables, achievement, science process skills and attitudes. However, some other independent variables such as gender, school, or school types can also be used during the analysis. For example, when instructional mode and gender were used as fixed factors; without methods of teaching, gender was found significant for PAS scores. It seems that the attitudes of females towards physics changed positively with blended instruction more than those of males and it is statistically significant. Similarly, when school types (public vs. private) and instructional modes were used as fixed factors, there appears an interaction between the independent variables on students' achievement scores; the achievement of students in public high schools was increasing with blended learning while it was decreasing in private high schools.

In addition to the extra analyses with the data, future studies can also consider some other variables than the current study did not mention. Some other dependent variables like problem solving skills and attitudes towards internet or computers can be searched. Also blended learning with some other teaching methods or strategies like problem or project based learning or modeling instruction can be used in the future studies.

This study has some inherent limitations. We have already discussed the methodological limitations of the research such as using specific instructional methods and modes while analyzing the interactions between them, and limiting the achievement test to well-defined problems. There were also limitations on the development of web-based tools for blended learning environments. We used freely available resources for web-based materials especially for interactive simulations. Unfortunately, there are only a limited number of simulations for particular subject areas and these simulations are highly structured and hardy provide flexibilities for students' own inquiries. This nature of simulations provides only limited opportunities for students to develop science process skills. In terms of instructional implications, the results of the study obviously reveal that blended learning is more powerful than face-to-face learning. Blending face-to-face instructions with online learning is definitely a good idea to improve students' success on both achievement and science process skills. However, improving students' science process skills seems to be much more difficult than improving their achievement. Although inquiry oriented instructions seem to have potentials for improvement of science process skills there are also some challenges about teaching through inquiry in science teaching. The major issue seems to be related to the beliefs about the nature of teaching and learning because teachers usually focus on teaching the content of science and believe that the best way to do that is transmitting the expert knowledge to their students through lecture. For example Roehrig and Luft (2004) identified several challenges that science teachers experience while implementing inquiry oriented instructions; such as understanding of the nature of science and scientific inquiry, content knowledge, pedagogical content knowledge, and teaching beliefs. Although we did our best while developing instructional plans and monitoring the implementation of instructions for each treatment group as described in the methodology section we could not control either the teacher's or the students' true perceptions and beliefs about the inquiry oriented activities which may affect the outcomes of activities. As argued by several researchers, teachers' need time, effort, and support while they were becoming an inquiry-oriented teachers (Jones & Eick, 2007).

As a final remark, it has to be noted that we begin this study with the argument that the success of blended learning reported in the literature has some shortcomings because the instructional methods used with blended learning was not clearly defined or controlled in the research design. Consequently, instructional method and mode was entangled in way that it was hard to identify whether the result of an experiment is due to the manipulation of instructional mode or method. This is why we hypothesized that if we include both instructional mode and method in the experimental design as independent variables we may detect an interaction between them. However, we failed to detect such an interaction when the instructional methods were set as face-to-face and blended learning; and instructional methods as inquiry and expository learning. This failure could be due to chosen methods, types of blending, or the outcome variables; or simply there is no interaction between them. Nevertheless, to be sure, in the long run we strongly recommend to test the same hypothesis with other instructional methods and outcome variables.

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