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Designing and Implementation of the Blended Instructional Model Based on Reigeluth, Merrill, Keller and the Investigation of Its Effect on Students' Learning in Biology Course

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Abstract

Introduction: Instruction and learning play an important role in the twenty-first century which has been named the knowledge society and knowledge economy. The present research seeks to design and implement a blended instructional model based on the theories of Reigeluth, Merrill, and Keller and investigate its effect on students' learning in a biology course.

Methods: In this research, the pretest-posttest, quasi-experimental method with control was used. The population consisted of all second year high school students studying at Imam Khomeini high school in the 2013 - 2014 academic year. Using the random sampling method, the sample was selected and consisted of two classes, one of them as the control group and the other as the experimental group. Reliability of the research was calculated as 0.82 using the split-half method. Abundance, mean and standard deviation from descriptive statistics, and covariance methods were selected from inferential statistics, and SPSS version 20 was used to analyze data.

Results: The results revealed a meaningful and significant difference between the learning levels of the experimental group and the control group in a biology course ($F_{1, 37} = 23.808$; $P < 0.01$). The group which taught using the blended instructional design model based on the models of Reigeluth, Merrill, and Keller achieved a higher level of learning than the control group. Based on the results, it can be said that the research model has a good fit with real world data.

Conclusions: Use of the blended instructional design model based on Reigeluth, Merrill, and Keller's models in a biology course was more effective than conventional methods. The findings indicate that the blended instructional design model is an effective and efficient method for teaching a biology course.

Keywords: Design, Instruction, Learning, Students, Models, Biology

1. Introduction

From earliest days, human societies have tried to learn from nature, elders, and the communities of other cultures. It can be said that what has allowed today's man to survive in the face of nature and generally the globe is his capability of learning, which has had different forms over time. In the present age, the traditional way (conveyed from elders to the youth or in informal settings) is no longer considered by governments and education authorities. In fact, learning and training is considered an independent field of science. To achieve greater effectiveness and efficiency, scientific principles should be used to attain educational goals. Teaching is considered a science and an art. People expect a teacher to be proficient in teaching the topic and to know how to explain different ideas to students. Teaching, however, is much more than just explanations. Good teaching leads students' learning to higher levels and prepares them to explore the world around them.

In their study entitled "Factors affecting academic failure," Gasemi and Selsili reported that, among key components of curriculum, the most basic teaching-learning methods, a lack of proficient teachers, the use of traditional methods, memory-oriented and one-sided teaching, and inattention to providing appropriate learning opportunities have decisive and crucial impacts on academic failure (1).

Subsequently, other factors are somewhat effective in dropout, apathy towards study, and a lack of basic repeat lessons, such as curriculum goals lacking relevance to the needs and interests of students and the lack of appropriateness with priorities of the community. Inattention to the needs, talents, and individual differences of students and the lack of suitable methods of teaching and learning destroy students' interest and motivation to learn. This

lack of interest leads to negative results for students with different cultural, social, and economical backgrounds (2).

Common methods of teaching and learning in education are used which simply draw students' attention to the verbal indication instead of redirecting and developing their talents and potentiality to investigation, research, observation, analysis, and experimenting with surrounding phenomena. Ignoring these important issues and placing too much emphasis on passive methods destroy students' tastes, creativity, and initiative; it brings up individuals who are passive, inactive, and uninterested in studying, and the results of this appear in the form of academic failure (3). Meaningful learning, recall of learned contents, and increasing motivation are among the important components that educational systems and schools try to provide. Unfortunately, at a glance, it can be seen that the dominant method of teaching and learning in Iran is lecturing. In this method, students are considered as passive recipients of information and no attention is given to active learning with high motivation. Furthermore, the role of training sequence, training components, and models to motivate students is not seen. Lecture, a traditional education approach, is rooted in the fifth century BC. Many teachers still use this method to teach; they simply convey information to the learners. In fact, this method is considered a barrier to understanding science (4, 5). Information is conveyed directly from teacher to students, and students are passive. Students become bored, and the power of their creativity is not nurtured (6). Conversely, active learning improves student's learning. Findings of scientific research indicate that active learning can upgrade a student's understanding of science concepts, because active methods facilitate students' learning processes (5, 7). Active learning occurs when students are given more opportunities to establish interactive communication with the course subject and are encouraged to produce knowledge and apply it in their lives. In an active learning environment, teachers are learning facilitators rather than dictators.

In the twenty-first century, the creation of a knowledge-society perspective is considered desirable. In this society, teaching and learning are of paramount importance (8). Instructional design also serves teaching and learning in an effective and efficient way. It is also important to note that instructional design is wide-ranged. Performance improvement is one example of the new study area of instructional design. One feature and advantage that distinguishes human-kind from other creatures is the capacity of advanced learning. Learning is one of the most important fields of psychology. Experts have conducted numerous studies in this area and have theorized about learning, which is still one of the most difficult concepts to define. The best definition of learning has been given by Kimble. He said that learning had known as relatively permanent changes in behavior (potential behavior) that took place as a result of reinforced practice (9). All wonderful advances in today's world of humans were born from learning. Mankind acquires more skills through learning; by learning, they achieve intellectual growth, and through learning, they actualize their mental abilities. As before building, a plan is designed, it is crucial to have a plan for teaching and learning before implementation. Otherwise, the teaching process will continue without a specific plan, and predicting the efficiency or inefficiency of the process will be difficult. Instructional design as a not-so-new field of science and, at the same time, a field needing much work, attempts to rely on scientific and practical bases to make the efforts of educational authorities much more efficient and effective (10). With all due respect to teaching and learning in the process of training, instructional design has a special and privileged place in the educational process. If instructional design is not considered in educational efforts, effective learning and teaching will not occur and human and non-human resources will be wasted (11). Instructional design is a constitutional part of educational technology; whenever instructional design is talked about, in fact, one of the basic parts of educational technology is being discussed (12). Instructional design is based on both micro- and macro-levels. The micro-level consists of teaching methods related to a section of content, but the macro-level involves selecting, organizing, composing, and summarizing a great chain of content (like a course) (13).

Skilled instructional designers do not use design strategies mechanically or arbitrarily. High effectiveness not only depends on specific context (for example, high school students and training courses for companies) and the intended audience (e.g., pre-school children or senior financial managers), but also on reasonable and consistent scientific judgments that are based on educational and learning theories. Today, instructional designers prepare plans based on paradigm theories; each design has the best application (14). According to Reigeluth and Carr-Chellman, educational theories serve to determine how to help individuals learn better. They offer different methods of training as well as instructions for when and when not to use them (15). As the origin and development of instructional design models are based on learning theories, two approaches can be identified in this area: the independent approach and the blended approach.

With the independent approach, instructional designers offer their plan in the frame of a model based on a clear learning theory. In the blended approach, instructional design experts do not limit themselves in a particu-

lar theory; in fact, they attempt to take advantage of all the capabilities of different learning theories to provide programs in the form of a specific model (11). About the use of combined learning theories in the planning of educational systems according to the type of subject learning in educational environments or activities in industrial environments, Barker pointed out: Now our approach in providing computer-based learning resources and training is an approach based on optimal combination of all learning theories. Obviously, based on learning type and training activities in various situations, combinations will differ; the purpose of learning and activities can be very diverse. For example, some training may be done only to inform and attract the attention of individuals to a particular subject and in other situations, some training possible that provided to create specialized skills or an apprenticeship in a training environment or industry" (13). In general, Barker specified the main factors that follow as points that should be considered by instructional designers:

- Combining learning theories: individuals learn using different tools, techniques, and methods.

- Blended learning approach: Training programs can be used to provide information, tutoring, and remedial education, providing opportunities for thinking, experience, or consultation.

- Integrating the role of media: media can be tutor, mentor, guide, helper, book, tester, simulator, or database.

- Environmental factors: physical conditions in which learning occurs, such as home, work, open learning centers, classroom, and free conference.

- Control location: whether the control of the educational process is in the hands of the students, the responsibility of a computer, or exchanged between the two.

- Type of content: includes organizing the content, learning strategies implicit in the content and available resources regarding the content (13).

At the macro level, one noticeable pattern in the instructional design model is the Elaboration Theory, proposed by Reigeluth. Based on extensive research done at the micro and macro levels of instructional design by Reigeluth which were published in the article "Review of the educational arraignment strategies," the "Elaboration Theory" was announced. Reigeluth himself emphasized that his model was going to complete the work of Merrill on the macro level (16). The main purpose of this model is to help instructional designers select and organize content in a manner that optimizes the realization of the learning goals. The elaboration theory is based on cognitive psychology. Although this model can be used for teach complex cognitive subjects and simple psychomotor subjects, it is suitable for an affective domain. The main concepts of the model are sequence, composition, perspective, holistic, and elaboration. The elaboration theory contains three types of matter: conceptual, legal or theoretical, and procedures. Each of these types requires a specific sequence. To use the elaboration theory, first of all, a general perspective to educational materials should be taken. Then materials should be divided into different sections and each of them elaborated separately. Each section is divided into smaller parts, and these parts are also elaborated. Analyzing and elaboration will be continued until all required details are achieved. Instructional designers identify the type of educational content with respect to the organization principles and different strategies such as sequence, conceptual elaboration sequence, the sequence of theoretical elaboration, and simplifying conditions used by instructional designers (10). The component display theory suggested by Merrill is a model within the micro-level that was combined in this study with the elaboration theory. This model is in fact a description of the micro elements in education and is thus considered a micro-instructional design model (16) and conforms to the perspectives of Gagne & Briggs. From Merrill's point of view, all objects generally include two components: generalizations and instances. Merrill's component display theory is an example of an instructional design model on the micro level (10).

A third model used in this study is the motivational design of instruction proposed by Keller. Keller's motivational pattern not only focuses on what is taught, but also concentrates on teaching how to build meaningful learning. Keller pointed out that learning motivation consists of four factors: A) interests B) relevance C) expectancy D) satisfaction (16). Based on the survey and investigations conducted by researchers in terms of the research literature in Iran and abroad, no study was found to have investigated the same points the current study did. However, related studies showed a meaningful and effective impact of the instructional design model of Keller, Merrill, and Reigeluth on learning.

Seraji compared Merrill's instructional design model with traditional teaching methods in a primary school math class. The results showed that the overall academic achievement, learning, and duration of retention of students trained by Merrill's instructional design model were higher than that of students trained by the traditional method (17). In another study entitled "The Comparison between Merrill's Instructional Design Model with Advanced Organizer Model in Academic Achievement, Retention, and Academic Achievement Among Girls Students in First Grade Of Guidance School in Second Region of Tehran in Science Lesson" Baglu stated that the positive impact of Merrill's instructional design model in the areas of academic achievement and achievement motivation in the science course of elementary school is more than

pre-organized pattern (18). Mahdavi and Amirteimouri also investigated the effect of using Merrill's instructional design model on learning and achievement motivation in a biology lesson. Findings showed that the learning levels of students taught by Merrill's model were significantly higher than those of students trained traditionally. Moreover, they also reported that there was no meaningful difference between control and experimental groups in terms of academic achievement (19). The results of the study entitled "The Investigation of Effect of The Merrill's Instructional Design Model (Component Display Theory) on Learning and Retention in Biology Lesson of First Grade of High Schools" also showed that Merrill's instructional design model had a significant impact on the retention of learned material, and there were statistically significant differences in recall levels between the experimental group and the control group (20). Another study conducted by Kanani, "The Investigation of Effect Keler's Motivation Instructional Design on Learning and Retention in English Language," showed that this model also increased learning and retention rates in the areas of reading, writing, grammar, and vocabularies (21). Tagipoor's paper entitled "The Investigation of Effect of The Riegeluth's Instructional Design Model on Learning and Retention in 2 Grade Student's of Kaleibar in Science Lesson" reported that this model had a meaningful effect on learning and retention (22). The research "The Impact of Instructional Multimedia Based on Merrill's Model on Learning and Retention in Science Lesson" showed that multimedia based on this model increased the rate of learning and retention (23). Latifi's study "The Effectiveness of Instructional Design Model of Component Display Theory in Comparison of Traditional Instruction In Attaining to Goals of Comprehension in Remember and Application of Programming Lesson" indicated that achievement levels in recall level objectives were significantly higher in the group trained by Merrill's pattern compared with the control group. Moreover, greater achievement of objectives were attained by the group trained with Merrill's pattern than the control group in application level (24).

Fry and Reigeluth studied the impact of using sequence and composition factors to teach concepts and the structure of concepts. An interaction between the composition and sequence was found which indicated that providing the composition before the sequence is more effective than the opposite way (25, 26).

In the current research, two models on the macro level and one model on the micro level were used. The schematic in Figure 1 shows explicitly the three models.

Based on the research premise, the goal of the research is to blend the instructional design models of Reigeluth, Merrill, and Keller and investigate the effect of the new model on learning.

2. Methods

In this practical study a quasi-experimental research design was used. The population was all first year high school students attending Imam Khomeini public school in Shahr-e Ray during the 2013 - 2014 school year. Using simple random sampling, two classes were selected as study samples. By random assignment, 20 students were placed into the control group and another 20 students were placed into the experimental group. Research tools used to collect data were a researcher-made learning pretest (14 MCQs and 6 essay questions) and a researcher-made learning posttest (repetition of pretest questions), respectively. In measure the validity of the tests, lecturers were asked about the relevance, clarity, and understandability of the questions and whether the research questions were pertinent, and their opinions were used. Test validity was found to be desirable. The correlation method was used to evaluate the reliability of the test, and a desirable score of 0.82 was reported.

After the necessary coordination was made with the selected school and classes were randomly assigned as control and experimental groups, the pretest was administered to both groups. Then the ecology chapter of the biology course was taught to both groups. The same teacher taught both the control and the experimental group; the conventional method was used for the control group, and the experimental group was taught using the blended instructional model based on the theories of Reigeluth, Merrill, and Keller, designed by the researcher, and confirmed by experts in related fields. After the teaching process, the learning post-test was administered to both groups. Finally, data from the pre-tests and post-tests was analyzed using SPSS version 6 and descriptive statistics such as mean, standard deviation, frequency, and statistical test of covariance analysis. This study was conducted with the permission of the school principal after the duration and procedure of instructional intervention was explained. Participants were made aware of the purpose of this research; participation was not mandatory. The time of entering and leaving of the students and the researchers from the research was completely and clearly explained for the participants and after that, positive responses for participation taken from students. After the study, the results and some other detailed information was told to them.

3. Results

This study used descriptive statistics such as mean, standard deviation, and frequency. Analysis of covariance

was used to analyze the hypothesis to control the effect of students' pre-preparation and to adjust this variable in the pre-test as the control variable. For pretest and posttest with the control group, analysis of covariance was used. After adjusting the scores of the pre-test, post-test means were compared (27). In Table 1 the mean and standard deviation of the learning pre-test and post-test scores of the experimental and control groups are shown separately. Clearly, the mean scores of the experimental group on the learning post-test were increased significantly compared with the scores of the control group.

Table 1. Learning Scores of Pre-Test and Post-Test, Mean and Standard Deviation for Experimental and Control Groups

	Group	Mean ± SD	N
Pre-test of Learning	Experimental	4.85 ± 2.412	20
	Control	5.20 ± 1.90	20
	Total	5.025 ± 2.15	40
Post-test of Learning	Experimental	16.45 ± 2.91	20
	Control	12.30 ± 2.43	20
	Total	14.37 ± 2.67	40

The research aimed to combine instructional design models based on Reigeluth, Merrill, and Keller's theories in order to investigate it's the effect of a blended model on students' learning in a biology lesson. The hypothesis was "Students taught based on the blended model learn significantly more than those taught by the traditional method." Analysis of covariance was used to test this hypothesis. Before covariance analysis was used to analyze the data, some assumptions had to be met. Each assumption is discussed in the following paragraphs.

Normality of data: One of the basic assumptions of the parametric statistical analysis is the normality of the dependent variable's scores. In Table 2 the Kolmogorov-Smirnov normal distribution of scores is given.

In Table 2 it is clear that all scores are normally distributed, because the size of the Kolmogorov-Smirnov test is not significant in any of the variables.

Consistency of variances error: consistency of variances error is one of the most important assumptions of covariance analysis. The Levin test is normally used to check this assumption. As seen in Table 3 the size of the Levin test is clearly not significant. This result indicates that the error of variance is equal, meaning that this assumption is also met.

Homogeneity of regression lines: This is the third assumption of the covariance analysis. There are varied ways to study this assumption. One technique is the lack of interaction meaning between the group and pre-test. In Table 4 it is clearly seen that the size of interaction between group and pretest is not significant.

Table 2. Kolmogorov-Smirnov Test for Studying the Data's Normality

Statistical Indicator		Pre-Test of Learning	Post-Test of Learning
N		40	40
Normal Parameters	Mean ± SD	5.02 ± 2.15	14.37 ± 3.37
Most Extreme Difference	Absolute	100	110
	Positive	83	109
	Negative	-100	-110
Kolmogorov-smirnov Z		630	694
Sig. (Two-Tailed)		0.822	0.722

All assumptions were met; therefore, using covariance analysis is appropriate for the current research.

The results of analysis of covariance are shown in Table 5. It is clear in this table that intergroup differences were significant at 1% in the size of the F-test. This result indicates that there was a significant difference between the experimental group and the control group after controlling the initial differences. In other words, students who participated in the experimental group received higher scores in learning than those in the control group. Thus, the mean score on the pre-test for the experimental group was 4.85, while the mean score on the post-test for the experimental group was 16.45. For the control group, the mean scores were 5.2 and 12.30 on the pre-test and post-test, respectively. Therefore, it was concluded that the hypothesis was confirmed ($P < 0.001$).

As seen in Table 5, it is understood that the effect size of the group was 39.0, which was considered as medium-high. This result pointed out that about 40% of the dependent variable (learning) changes was caused by the design and implementation of the blended educational model, based on Reigeluth, Merrill, and Keller's instructional design model.

4. Conclusions

Results indicate that after controlling the initial differences, there was a significant difference between the experimental group and the control group. In other words, students who participated in the experimental group received higher scores in learning than those in the control group, meaning that the hypothesis was confirmed. Studies done on this subject have shown the meaningful effect of these models on learning, recall, and achieve-

Table 3. Levin Test for Checking the Consistency of the Variances Error

	F	Df1	Df2	Sig.
Values	0.600	1	38	0.443

Table 4. Interaction Between the Group and Pre-Test to Check the Homogeneity of the Regression Lines

Source	Sum of Squares	df	Mean Square	F	Sig.
Intercept	1050.395	1	1050.395	142.021	< 0.001
Mutual Interaction of Group and Pre-test	6.892	2	3.446	0.466	0.631
Group	48.820	1	48.820	6.601	0.014
Error	266.258	36	7.396	-	-
Total	8711.00	40	-	-	-

Table 5. Covariance Analysis Test to Study Differences in Both Groups in Terms of Learning Scores

Source	Sum of Squares	df	Mean Square	F	Sig.
Intercept	1152.811	1	1152.811	157.458	< 0.001
Pre-test of Learning	2.259	1	2.259	0.309	0.582
Group	174.309	1	174.309	23.808	< 0.001
Error	270.891	37	7.321	-	-
Total	8711.000	40	-	-	-

ment motivation, separately. For example, Mahdavi and Amirteimouryresearched the effect of Merrill's instructional design model on learning and achievement motivation in a biology lesson (19). They reported that the rate of learning of students taught by the instructional design model of Merrill was higher than that of students taught using the traditional method. The findings of the current research are in line with the mentioned study. The reason why the results of the present study are in line with those of Mahdavi and Amirteimoury could be the common definitions and appropriate examples with regards to the content and secondary elaboration which exists in Merrill's model. In his dissertation entitled "Effectiveness of Merrill's instructional design model compared to traditional education in the achievement of objectives of recall and application level in a programming course", Latifi reported that the learning rate of the experimental group in the recall level as well as the application level was higher than that of the control group. Moreover, Alipour in his study came to the conclusion that educational multimedia based on Merrill's instructional design had a positive impact on the learning and retention of elementary students in Tehran's Region 2 (23). This finding is also in line with the results of the current research. The reason for this alignment could be that the content was designed at the micro level in Merrill's model. Varied examples, secondary elaboration, and questions are used in Merrill's model; by using these educational activities, learning and teaching becomes more efficient and effective. Kanaani conducted a study entitled "The study of the effect of using Keller's motivational instructional design model on learning and the retention of English language lesson" and showed that this model increased the levels of learning and retention in the areas of reading, writing, grammar, and vocabulary (21). The findings of Kanani's study were also in line with the present research. This alignment may be due to common factors of the current study and the above-named studies such as relevance, interest, anticipation, and satisfaction. In another research conducted by Taghipour entitled "The effect of Reigeluth's instructional design model on learning and retention in second year science class of Kaleybar city," the results indicated that this model had a meaningful effect on learning and retention (22). The findings of Taghipour study were also in line with those of the present research. In the current study, analysis of covariance was used, so other covariates disappeared. It was concluded that the use of the model based on the integration of Reigeluth, Merrill, and Keller's theories was positively effective in students' learning in the biology course. By merging the Reigeluth, Merrill, and Keller's models, the researchers

in the current study were able to take advantage of three models in the frame of a blended model which led to effective educational product, teaching, and learning. The lesson plan used in this study was designed based on the three mentioned models; thus, advantage was taken of all three models. By taking this measure, the researchers could see a more meaningful and significant learning compared with the traditional method that occurred because of such components as variety of definitions and examples, questions, descriptions, expansions, perspectives, respect for learning prerequisites, syntax summaries, allegory, learning strategies, communication principles, interests, expectations. and satisfaction, which were achieved through the use of the blended approach. Blended approach is considered a new approach in the field of instructional design. Based on this approach, a blended instructional design model can take advantage of different instructional models; however, it should not be forgotten that some consideration must be given to how to blend the models. In conclusion, it can be said that designing and implementing the blended instructional model based on Reigeluth, Merrill, and Keller had a positive effect on students' learning in a biology course.

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Footnotes

Authors' Contribution: The most important contribution of this research was in blending the three important and invaluable models in the science instructional design. We strongly believe that this research will be useful and scientific contribution to the field of instructional design and technology.

Conflict of Interest: To prevent the information on potential conflict of interest for authors from being overlooked or misplaced, mention this information in the cover letter. Authors must identify any potential financial conflicts of interest before the review process begins. Declared conflict of interest will not automatically result in rejection of paper but the editors reserve the right to publish any declared conflict of interest alongside accepted. The following would generally be regarded as potential conflicts of interest: 1. direct financial payment to an author for the research or manuscript production by the sponsor of a product or service evaluated in an article. 2. ownership of shares by an author in the company sponsoring a product service evaluated in an article (or in a company sponsoring a competing product). 3. Personal consultant for companies or other organizations with a financial interest in the promotion of particular health care products and services.

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