Adaptation of interaction in web environments with educational content

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Abstract

This study, which aims to determine the design principles of interaction adaptation in adaptive online learning environments, was based on a mixed and comparative type of relational screening model. Modified online Delphi method was employed in order to develop the principles and determine the relative importance. Ninety experts participated in the study. Arithmetic mean, first quartile deviation, standard deviation and intraclass coefficient of correlation were utilised to determine the levels of agreement of the experts on the principles. Two hundred and seventy studies which included parameters utilised during the design of interaction were analysed by using content analysis and the robustness of the findings was categorically evaluated, and it was found that experts had almost full agreement on all the 10 principles. Furthermore, the agreement on principles between the observers (intraclass correlation coefficient = 0.903) was found perfect. The obtained principles that indicate the common inclinations both in the literature and of the domain experts should be employed.

Keywords: Adaptive learning, adaptive learning environments, interaction adaptation, modified online Delphi method.

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1. Introduction

Developing technology has made information more accessible and has necessitated the delivery of the increasing quantities of information in accord with individual's learning needs. Besides this, the development of adaptive systems to form structures that are shaped in time with the needs of individuals has gained speed. The notion of 'one size fits all' has been abandoned (Brusilovsky, 1999; 2003; Brusilovsky & Peylo, 2003) and the notion of 'one size does not fit all' (Reigeluth, 1996) has gained acceptance instead (Somyurek, 2008). During the recent years, adaptive online environments and adaptive information systems have developed rapidly and new terms, models, methodologies and systems have appeared (Knutov, De Bra & Pechenizkiy, 2009). These systems can adapt themselves their structures, functions or interface according to the needs of the users that change in time (Benyon & Murray, 1993). When the adaptive systems are employed in the design of online learning environments and the individual differences are taken into consideration, learning environments that support constructivist–collaborative approaches could be provided (Cetinkaya, 2013; Cetinkaya & Keser, 2018).

Adaptive educational hyper environment systems offer a learning environment which shape according to learners' preferences and needs (Brusilovsky & Peylo, 2003). There are plenty of studies in the literature which indicate that these personalised environments affect learners' performances positively, facilitate learning process and increase learner satisfaction (Guyer & Cebi, 2015). One of the most important components of these popular online learning systems is to review behaviours, give the interests and learner preferences prominence to offer personalised services (Chen, 2009). Since the user in adaptive learning systems is the learner at the same time, main approach is focused on how the learner characteristics will be determined and how they will be adapted to learning environment (Brusilovsky, 1998; Jameson, 2003; Somyurek, 2009). Since these systems have been used for the learners that have different abilities on different networks, one of the most important features is their personalised nature (Brusilovsky, 2001; Brusilovsky & Peylo, 2003; Weber, Kuhl & Weibelzahl, 2001). However, individuals learn in different ways and hence their learning needs may vary. Instead of providing the same opportunities to all learners, the development of adaptive environments which observe individual differences has become compulsory and has necessitated the design of the interaction components among all the stakeholders effectively. The effective design of the learner's interaction process will affect the formation of learner model dynamically which is the major component of the learner systems and act centrally. Adaptive educational hyper environment systems have capacity to take interaction decisions and support learners without any instructions (Papanikolaou, Grigoriadou, Kornilakis & Magoulas, 2003). Interaction plays an important role in all distance education practices between learner, instructor and the content (Bernard et al., 2009). Accordingly, in many good research studies on adaptive interactive educational environments (Chen, Chang & Wang, 2008; Johnson & Johnson, 2006; Kinshuk et al., 2009; Triantafillou, Pomportsis & Demetriadis, 2004; Xu & Wang, 2006), the researchers have stated that adaptive and intelligent tutoring systems model each learner's aim, preference and knowledge; hence, meet the needs of learners via interaction and become more adaptive.

Focusing on the learners' individual learning processes does not require the learners to be isolated from social context (Zimmerman & Schunk, 2001). On the contrary, people working in the fields of instructional technology and distance education often state that interaction is an important variable in learning (Bannan-Ritland, 2002). A well designed interactive online education could be more prolific and effective than the traditional class experience (Seabury, 2005). The expectation of their success should be based on their development in accordance with their sustainability (Dennis, Wixom & Roth, 2006; Kavanagh & Thite, 2009; Sommerville, 2007). The advantages of adaptive learning systems emphasise their role in education and bring up the question of identification of variables that are needed for their development (Guyer & Cebi, 2015). Since the development of such systems require an interdisciplinary approach, most of the time they end up with the studies which are not adaptable with method and evaluation and most of all, neglect the employment of pedagogical approaches. In order to avoid this and make different systems function together, meeting on a common ground is

necessary (Cetinkaya, 2013; Cetinkaya & Keser, 2018). It is of great importance to gain interaction components, which are quite effective in shaping the meaning, a structure which is dynamic and adaptable to the learner. Accordingly, this study aimed to develop a set of principles for the formation of a common language in the design of adaptation of interaction in learning environments.

2. Method

2.1. Research model

This study, which aims to determine the design principles of interaction components in terms of adaptation in online learning environments, was based on a mixed and comparative type of relational screening model. In the mixed method model, which is defined as using the quantitative and qualitative methods together (Creswell, 2003), the data obtained from each method can be used to compare or support each other (Snyder, 2006). The data of both methods were analysed together and integrated to increase the validity and reliability of the findings.

2.2. Study group

As the participants of the study need to have information and interest about the topics (Alexander & Serfass, 1999), purposeful sampling was used for the selection of the study group. In purposeful sampling, the main aim is to collect information on the person, phenomenon or case that is the subject of the research (Maxwell, 1996). Criterion sampling, which is a form of purposeful sampling, was utilised to determine the online Delphi expert group participants. The study group consisted of experts who have doctorate degrees and;

• giving lectures on web design, instructional design, interactive distance education technologies, multimedia design, adaptive learning environments, artificial intelligence and instructional practices,
• having made research studies on web and multimedia design.

The study group consisted of 92 (93.9%) online experts throughout Turkey. During the analysis of the results of the second (one expert) and third (one expert) phases of the Likert Type Delphi, the responses of the two experts who marked the same choice throughout the research and had response time records below the first quarter (25%) value were not included in the study and in the statistical analysis. Ninety (90%) experts' responses were considered valid and the data were recorded instantly to enable reliability of the online Delphi study.

2.3. Data collection and analysis

2.3.1. Data collection
Online Delphi method was utilised to determine the relative importance of the principles of the research. In order to determine the robustness of the findings, 'robustness of the findings' (Leavitt & Shneiderman, 2004) form and content analysis were used.

2.3.1.1. Modified online Delphi method
During the Delphi method, intramethod mixing approach was employed. Intramethod mixing is a data collection mixed method strategy which includes mixed method strategy to collect data simultaneously on a single question sheet (Tashakkori & Teddlie, 2003, p. 299). The validity and reliability of this method to provide a framework or a model based on the results of the study has been proven by researchers (Brunk, 2003; Cross, 2002; MacDonald, 2003). The procedures of the modified online Delphi method are given below:

1. Invitations to 98 experts were sent. Upon acceptance of 92 experts, the Delphi process started and ended with the participation of 90 experts after the elimination of two experts.
2. During the Delphi method, initially necessary topics and opinions were specified and first questionnaire form was prepared to include the questions that would help the participants brainstorm individually to produce as many ideas as they could. To help the experts to produce ideas, the main topics used in adaptive online learning environments were identified.
3. During the first lap, the experts that formed the Delphi panel identified the principles and expressed their general opinions on the free text area.
4. The data of the first lap were examined. The principles determined by each panellist were checked if they were within the online learning environments and adaptability. Similar principles were examined by pre-assessment group which comprised of seven field experts and after the interrelated principles were combined, second lap started. To check the appropriateness of the principles, a five-point Likert Type (completely appropriate, appropriate, partly appropriate, inappropriate and absolutely inappropriate) online evaluation form was developed. Text entry fields under each principle were formed for the experts to be able to revise each idea in terms of strong and weak points and add new ideas. A second form which experts could use and share each idea freely was sent to the experts with a guideline.
5. After the completion of the second questionnaire form, the data were collected and their agreement levels were calculated. The items on which the experts could not have any agreement were eliminated and a third questionnaire form was prepared. The items from the third questionnaire form was rearranged to include mean scores of the answers, standard deviation (SD) values and scores given by the experts to each item.
6. The third form showed that there were no new ideas and all the strong and weak points of the items were determined. After this lap during which experts had agreement on all items, latest principles and instructions were sent to them.

2.3.1.2. Content analysis and evaluation of the robustness of the findings

During the study, extensive searches on common electronic databases were made and the searches were limited to full text refereed articles, English and Turkish dissertations, international and national conferences and presented and published papers in symposiums. Basic keyword search strategy was used to find the related papers. The keywords that were used are 'adaptive/adaptable learning', 'adaptive/adaptable hypermedia', 'adaptive/adaptable design', 'adaptivity', 'adaptation', 'adaptability' and 'personalised e-learning'. Furthermore, to reach the other works by the same authors, author search feature was also used. Finally, within the aims of the research, by revising the references of the related studies, snowball method was utilised.

In order to evaluate the robustness of the findings, the criteria which Leavitt and Shneiderman (2004) used in their studies was employed. In order to check the appropriateness of the use of these criteria, both the original and Turkish versions of the form were given to the group of Delphi panellists. They were asked to complete in a five-point Likert form to see the appropriateness of the criteria and a high level of agreement (Cronbach's Alpha = 0.92) was observed, which afterwards were used in the study.

2.3.2. Analysis of the data

The details of the statistical tools, methods and techniques which were employed in the study are given below.

2.3.2.1. The data analysis of the modified online Delphi study

Data were collected during each lap of the study and the first lap of the method consisted of qualitative data. Both qualitative and quantitative data were employed together. The third and fourth laps included quantitative data only. In order to determine the levels of agreement of the experts on modified online Delphi method, arithmetic mean, SD and first quartile deviation were calculated. The levels of agreement on the basis of mean and SD scores consist of four categories (Shah & Tillman,

2011) which are given in Table 1, and high and low values are calculated according to the SD and mean score.

Table 1. Scale matrix to show categories

		SD values	
		Low ⟷ High	
		I	II
Mean value	High	High agreement of great importance	Low agreement of great importance
		III	IV
	Low	High agreement of low importance	Low agreement of low importance

When the studies that employed Delphi method were examined in the literature, it was observed that agreement levels were measured by examining the arithmetic mean, median and SD; however, no certain standard is observed about the ranges of these values in these studies. In this study, the most suitable ranges for each level in the literature were used to determine the agreement levels of the experts (see Table 2).

Table 2. Arithmetic mean, SD and first quartile deviation agreement values*

$\bar{X}$	SD	Q_1	Comments	Interpretation of values
1.00–1.49	SD ≥ 0.75	$3 \le Q_1$	Insignificant agreement	1
1.50–2.99			Middle level agreement	2
3.00–3.74			Mostly agreement	3
3.75–4.49	0.50 ≤ SD < 0.75	$3 < Q_1 \le 4$	Significant agreement	4
4.50–5.00	SD < 0.50	$4 < Q_1 \le 5$	Almost perfect agreement	5

*Note: For the ranges, the most accepted studies in the literature were utilised (Cetinkaya, 2013; Cetinkaya & Keser, 2018).

2.3.2.2. Content analysis

Of the total 1,180 studies on online learning environments, 270 studies which involve parameters that were employed in the design of interaction within the context of adaptability were taken into consideration. The studies were systematically examined and analysed by using inductive method.

2.3.3.3. Data analysis of all the principles

Intraclass correlation coefficient (ICC) was calculated for all principles. ICC involves inter-rater reliability and statistical methods to measure the inter-rater agreement (Gwet, 2001). ICC is a statistical method which is used to analyse data agreement. This method is defined as the proportion of variance of an observation that is due to between subject variability in the true scores (Everitt, 1996). The reliability range of ICC is given in (Youdas, Carey & Garrett, 1991) Table 3.

Table 3. Reliability range of ICC

ICC	Comment
<0.69	Low reliability
0.70–0.79	Enough/middle level reliability
0.80–0.89	High reliability
0.90–1.00	Excellent reliability

3. Findings and interpretations

Adaptive interaction signifies the adaptations which aim to initiate or support interactions of the learners with the system without any intervention to learning content and adaptations that occur within the interface of the system (Paramythis & Loidl-Reisinger 2004). During the study, 10 principles related to the adaptation of the interaction in online learning environment have been identified.

The principles and relative importance of each principle, values related to the robustness of the findings, related literature and the findings attained through Delphi method from experts are presented with their comments below.

Adaptation of interaction	Relative importance	Robustness of the findings
1. Pay attention to learners' individual characteristics and the data in the learner model when designing interactive environments.	5	5

Experts had *almost full agreement* on principles ($\overline{X}$ = 4.92, S_s = 0.27, Q_1 = 5.00). One hundred and thirty eight sources in relation with the identified principle have been accessed and the findings that support the fact that considering the learner characteristics in the design of interactive environments and employing them in learning environments enhance and facilitate the interaction have been found during the literature review. Accordingly, based on the evaluation criteria for the robustness of the findings, it could be argued that the principle has *strong research support*.

2. Use technologies based on learner characteristics and collaboration which support learning environment.	5	5

The experts had *almost full agreement* on the principle ($\overline{X}$ = 4.88, S_s = 0.33, Q_1 = 5.00). One hundred eighteen sources in relation with the identified principle have been accessed and findings supporting the fact that adaptive collaborative learning environments had a component that improves learning effect, have been obtained. Furthermore, it is often highlighted in the literature that how the interaction tools are used in an online learning environment is important and that the guidance given to students for their effective use would contribute to success. Accordingly, based on the evaluation criteria for the robustness of the findings, it could be argued that the principle has *strong research support*.

3. Promote learner–teacher interaction.	5	5

The experts had *almost full agreement* on the principle ($\overline{X}$ = 4.92, S_s = 0.27, Q_1 = 5.00). One hundred and thirteen sources in relation with the identified principle have been accessed. The findings obtained from these sources indicate that learner–teacher interaction in adaptive learning environments is of profound importance. It is also noted that setting up an effective interaction between learner and teacher contribute to learning outcomes and learners' motivation positively. Accordingly, based on the evaluation criteria for the robustness of the findings, it could be argued that the principle has *strong research support*.

4. Promote learner–learner interaction.	5	5

The experts had *almost full agreement* on the principle ($\overline{X}$ = 4.92, S_s = 0.27, Q_1 = 5). One hundred and fifteen sources in relation with the identified principle have been accessed and the findings indicate that the interaction between learner–learner is important in adaptive learning environments. Setting up an effective interaction between learner and learner contribute to learning outcomes and learners' motivation positively. Accordingly, based on the evaluation criteria for the robustness of the findings, it could be argued that the principle has *strong research support*.

5. Provide proper synchronous and asynchronous communication tools in pursuant of learner preferences.	5	5

The experts had *almost full agreement* on the principle ($\overline{X}$ = 4.90, S_s = 0.30, Q_1 = 5.00). Eighty-two sources in relation with the identified principle have been accessed during the literature review, there is no data accepted by everybody which shows the superiority of synchronous and asynchronous tools over each other. Findings indicate that the form of interaction in online learning environments should be chosen according to the course, learner, teacher and other variables and appropriate instruction design be employed. They also suggest that the learner characteristics in online interaction environments be considered and the employment of the synchronous and asynchronous tools which are appropriate could be useful. Accordingly, based on the evaluation criteria for the robustness of the findings, it could be argued that the principle has *strong research support*.

6. Provide learners with interactive discussion environments.	5	5

The experts had *almost full agreement* on the principle ($\overline{X}$ = 4.87, S_s = 0.34, Q_1 = 5.00). Fifty-three sources in relation with the identified principle have been accessed during the literature review and findings indicate that forums in online learning systems enable interaction and team work and create opportunities for learners to

exchange ideas with their peers on different topics. In the studies, often creation of effective discussions and continuous participation of learners be encouraged and the need for the design of the learning environments which will increase learner satisfaction are emphasised. Accordingly, based on the evaluation criteria for the robustness of the findings, it could be argued that the principle has *strong research support*.

7.   Assess the learner performance and allow for self-assessment.   5   5

The experts had *almost full agreement* on the principle ($\overline{X}$ = 4.93, S_s = 0.25, Q_1 = 5.00). One hundred and twenty-one sources in relation with the identified principle have been accessed during the literature review and findings show that evaluations of learning process provide teachers and learners with opportunity to assess learning. In the studies, it is often underlined that the effective design of the assessment in online learning is important for the evaluation of the process and giving proper feedback to students. Accordingly, based on the evaluation criteria for the robustness of the findings, it could be argued that the principle has *strong research support*.

8.   Provide different instructional supporters by considering the   5   5
      information in the learner model.

The experts had *almost full agreement* on the principle ($\overline{X}$ = 4.89, S_s = 0.32, Q_1 = 5.00). One hundred and nine sources in relation with the identified principle have been accessed during the literature review, the findings obtained indicate that by considering the information in the learner model, providing different instructional supporters is quite effective in the success of learning and learner motivation. Moreover, the design of the supportive systems pursuant to pedagogical rules and so that it can meet the needs, is often emphasised in the studies. Accordingly, based on the evaluation criteria for the robustness of the findings, it could be argued that the principle has *strong research support*.

9.   Provide learners with extensive and timely feedback.   5   5

The experts had *almost full agreement* on the principle ($\overline{X}$ = 4.94, S_s = 0.23, Q_1 = 5.00). One hundred and forty-three sources in relation with the identified principle have been accessed during the literature review. Findings show that during the interaction of the learner with the system and the teacher, the development of the systems that enable the expression of social clues effectively and extensive and timely feedback is essential. It was inferred that such systems could affect the learner's success and motivation positively. Accordingly, based on the evaluation criteria for the robustness of the findings, it could be argued that the principle has *strong research support*.

10.   Provide learners with adaptive guidance/coaching   5   5

The experts had *almost full agreement* on the principle ($\overline{X}$ = 4.88, S_s = 0.36, Q_1 = 5.00). Fifty-four sources in relation with the identified principle have been accessed during the literature review. Findings show that provision of information is essential in learners' future assignments, topics or methods that they should follow for their progress. Also in the studies, it is stated that adaptive guidance/coaching contribute to learning and it is necessary to use these systems in learning. Accordingly, based on the evaluation criteria for the robustness of the findings, it could be argued that the principle has *strong research support*.

It was found that all experts had 'almost full agreement (5)' on all 10 principles which were identified according to the relative importance criteria as a result of Delphi process, and categorical evaluation showed a strong research support. Findings indicate that the agreement of the experts on the principles increased after each lap of Delphi process (see Table 4).

Table 4. The level of agreement of the experts for the laps of questionnaire

	Delphi process questionnaire laps		
	One lap	Two lap	Three lap
Agreement of the experts (ICC)	0.817	0.860	0.903
Mean values	4.78	4.87	4.91

Among the 1,180 studies on online learning environments, 207 (17.54%) of them were reviewed and included in the study within the context of adaptability in relation with the adaptation of interaction. After the categorical evaluation which was done in accordance with 'the robustness of the findings' evaluation form, it was found that there was 'strong research support (5)' in all principles.

High level reliability was observed as a result of the ICC (ICC = 0.903) which was used in order to determine the agreement level among the inter-raters of the principles which were identified after the practise of modified online Delphi method and robustness of the findings. ICC values which show the agreement and are used to analyse the compatibility of the data, are given in Table 5.

Table 5. The agreement of the Delphi panellists on principles

	ICC	Confidence interval (95%)		F	p
		Lower limit	Upper limit		
Sample mean	0.903	0.870	0.930	10.201	0.000*

Relative importance and evaluation results for the robustness of the findings show the tendencies of both field experts and literature.

4. Results and recommendations

It was determined that the experts had almost full agreement on the principles which were identified as a result of the study that was based on a mixed and comparative type of relational screening model and aimed to determine the design principles of interaction adaptation in adaptive online learning environments. Moreover, after the content analysis of the related studies and based on the evaluation criteria for the robustness of the findings, it was observed that all the principles have *strong research support*. Accordingly, the results related to the principles are given below.

- The interaction needs and inclinations of the learners depending on their individual differences in online learning could vary. The evaluations of robustness of the findings and relative importance show that individual differences of the learners and the data in the learner model need to be considered during the design of the interactive environments. The related studies suggest that considering the learner characteristics in the design of interactive environments and employing them in learning environments enhance and facilitate the interaction.
- In the recent studies related to online learning, the importance of interaction is often highlighted. The evaluations for the robustness of the findings and relative importance show the need for the interaction between learner–teacher and learner–learner. Related literature has shown that setting up an effective interaction between learner–teacher and learner–learner contributes to learning outcomes and learners' motivation positively.
- Learners' interaction with each other, their educators and online resources is of great importance. The type of the tools used in these interactions is also effective for the success of the interaction. There is no data accepted by everybody which shows the superiority of synchronous and asynchronous tools over each other according to the findings from the literature review. The evaluations for the robustness of the findings and relative importance need the provision of proper synchronous and asynchronous communication tools by following the learners' preferences. Hence, the form of interaction in online learning environments should be chosen according to the course, learner, teacher and other variables and appropriate instruction design should be employed.
- The forums in online learning systems enable interaction and team work; hence, provide opportunity for the exchange of information and ideas on various topics with their peers. In the studies, evaluations for the robustness of the findings and relative importance show the need for the provision of interactive discussion environments for the learners. In the literature, often the creation of effective discussions and continuous participation of learners be encouraged and the need for the design of the learning environments which will increase learner satisfaction are emphasised.
- The assessments in online learning environments play an important role in the evaluations of the learning process, learners and teachers. The evaluations for the robustness of the findings and relative importance suggest that assessing the learner performance and allowing the learners for self-assessment is necessary. It is often underlined in the studies that the effective design of the assessment in online learning is important for the evaluation of the process and giving proper

feedback to students. Moreover, it is also determined that by the help of adaptive test designs, quite successful results have been achieved in the evaluations of the learners' individual characteristics.

• Supporting the learners in the learning process, assisting them in organising their learning process and employing various instructional support systems is important. The evaluations for the robustness of the findings and relative importance suggest that it is necessary to provide various instructional supporters to learners by considering the information in the learner model. Moreover, it was found that adaptive guidance/coaching should be provided to learners for the purpose of provision of information which is essential in learners' future assignments, topics or methods that they should follow for their progress. The related studies which were examined during the literature review indicate that the provision of various instructional supporters by considering the information in the learner model is effective in the success of the learning and increase learner motivation. Furthermore, the design of the support systems in accord with the needs and pedagogical rules is often underlined in these studies.

• During the learner/teacher-system interaction, not only specifying what the teacher or system would tell and when would it be told to the learner but also the careful planning of how it would be told is of great importance. Therefore, the evaluations for the robustness of the findings and relative importance in this study suggest that comprehensive, timely feedback using appropriate words is necessary for their future assignments of the learners. The studies show that during the interaction of the learner with the system and the teacher, the development of the systems that enable the expression of social clues effectively and comprehensive and timely feedback is essential. The results of the studies assert that such systems affect learner success and motivation positively.

In conclusion, it could be suggested that the principles which show the common inclinations both in the literature and of the field experts could be employed during the design of the interaction components in adaptive online learning environments. Accordingly, it is believed that experimental studies on the applicability and evaluations of the identified principles could also be useful.

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