Structuring Instructional Software Design : A Students Evaluation Approach

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الملخص

تهـــدف هذه الدراسة إلى إعادة هيكلة عملية تصميم وتقييم البرمجيات التعليمية بحيث تـــأخذ في الاعتـــبار تقييم الطالب كمعيار أساسي في عملية التصميم من خلال هيكل مقترح لتقييم الطالب ونمط العلاقات التي تربط الهيكل بأداء الطالب والمتغيرات الأخرى في هذا السياق وتهـــدف الدراســـة أيضاً إلى تبين فعالية البرمجيات المرتكزة على الفيديو التفاعلي كبديل فعال لبرمجيات المحاكاة لمختبرات العلوم وقد أكدت النتائج وجود هذا الهيكل والتأثير المباشر على أداء الطالب كما بينت النتائج فعاليه هذه البرمجيات مقارنة بالطريقة التقليدية .

Abstract

The study aims at restructuring the process of instructional software design and evaluation taking into account student's evaluation as basic design criterion through a proposed structure for student's evaluation and a pattern of relationships that links this structure to students performance and other variables in this context. The study also aims at demonstrating the effectiveness of IVBS as an efficient alternative to simulation software for science lab. The results have confirmed the existence of this structure and its direct effect on students performance, the results have also shown the effectiveness of IVBS compared to the conventional method .

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Introduction

Multimedia learning environments have been found effective in stimulating students' thinking and memorizing process, and in enhancing learning (Alessi & Trollop, 2001). In an educational setting, the term "multimedia" indicates computer controlled interactions of information from different media-text, sounds, images, graphics and video to create an instructional software (Tiene & Albert, 2001). Combining sound with video in a digital format that is stored in and controlled by a computer software in an interactive manner leads to the creation of a new type of instructional software known as "interactive video based software" (IVBS) (Lozano, 1997). Interactivity in instructional software is embedded in the design of interactive instructional software as a basic component known as the graphical user interface (GUI). The GUI organizes the relationship between the human operator and the technology- the human- computer interface (HCI) perspective. The process of designing an interactive GUI involves a wide range of disciplines including software engineering computational linguistics, artificial intelligence, cognitive science (understanding, thought, creativity), sociology, ergonomics, organizational psychology, mathematics, and social psychology (sims, 1997). Computer-based multimedia has the potential to allow users to interact with information as they might interact with a human expert, they are, however, almost useless without a good interface. While good human-computer interfaces are important in all software areas, they are essential in allowing the user to interact in any meaningful way with a multimedia environment, which is a clear indication of the importance of user interface in the design of interactive instructional software.

One of the challenging areas of instructional software design is the design of software for use in science labs. The main use of instructional software in such a setting is for simulation software, which are expensive and hard to use in poor and occupied society as the one in Gaza.

The use of interactive video based instructional software (IVBS) in the form of lab demos may offer an effective solution to this problem.

Instructional IVBS: A Literature review

The embedding of interactive video clips in instructional software can greatly enhance the authenticity of a computer based learning environment. The need for authentic learning experience is strongly argued by constructivists (Boyle, 1997). One of interactive video's greatest strengths is

the power to generate attitudes and emotions as no other medium can, thus providing an excellent tool for displaying affective information, where the user could select what is to be seen and control the pace of the material, and could go back and fourth, stopping, making annotations, or comparing its relation to other material
(Azarmsa, 1996). Several studies have shown that such use of IVBS led to more effective results- in terms of students performance- compared to the conventional methods (Bidarra et al, 2000; Chambel,2000; Siegle & Foster, 2000; Sherry et al, 2001; Fandorey, 2001; Sanchez et al, 2002). Several studies were concerned with the user interface in instructional software in an attempt to identify user interface design problems as they relate to computer aided instruction (Sims, 1997; Feifer & Tazabaz, 1997; Chalmers, 2000; Polonoli, 2000).

The studies on the impact of interactive multimedia (including IV) are based on ideas that were developed by multimedia developers of applications to support education and training in the post secondary and vocational sectors, rather than those specifically designed for school applications. These studies also ignored the possible use of cost effective IVBS demos as an efficient alternative to expensive, and complicated, lab simulation software, thus, giving no clues or guidelines to the design, implementation, and evaluation of the user interface in IVBS that are used for lab demos.

The potential computer assisted instruction user interface design improvements discussed in these studies are based on learning and instruction theory and totally ignore the student as an end user, thus violating the "user satisfaction" criterion which is an essential software engineering concept (Lee, 1999). The studies conducted on the user interface in instructional software also ignore computer hardware as an essential part of the user interface despite the fact that user interface is defined as "hardware, software (including menus, screen design, keyboard commands and command language), or both that allows a user to interact with and problem operations on a system, program, or device"(McDaniel, 1994). As computers become more and more integrated into educational activities, the need to study the design criteria of the instructional software that is use emerges. When students learn with computers, they do so with the software programs and the computer provides the vehicle for the learning. It is imperative, therefore the design criteria for instructional software be restructured to support the use of computers (hardware + software) as a primary learning tool.

From the above discussion it is evident that the current practice of designing, implementing, and evaluating instructional software is unstructured and avoids deeper investigation of the end user (i.e., the student) as a basic criterion in the design process of user interface, in fact such lake of structure is a well documented problem in instructional software design research (Shneiderman, 1998; Reeves, 2000; Mayen etal, 2002). This lake of structure in multimedia based instructional software design process is due to the challenges met in any attempt to structure the design context (Boyle, 2001):

1-The creation of the internal structure of the context.

2-Structuring of the context's substructures (if any) interrelationships for each other

The researcher believes that restructuring the design process of the user interface design in IVBS so that "student evolution" is a basic criterion in evaluating instruction software design is the key solution to the problems associated with the lake of structure that dominates the current practice of designing and evaluating instructional software in general and IVBS in particular.

The researcher also believes that "students evaluation" - as a structure - is actually the missing link between instructional software design and students performance.

In this research we attempt to develop a theoretical model of "students evolution" of IVBS. This model is intended to describe the structures that compose the context of student evaluation of IVBS and the pattern of interrelationships that exist between these structures and other variables that exist in the context of IVBS use in the form of a structural model. The research also attempts to confirm the existence of such a context (or structure) when IVBS is used to teach lab demos in science labs (chemistry, physics, and biology) and for male and female students to establish whether or not it is subject and gender independent. The researcher also studies the effect and effect size of students evaluation of IVBS on their performance and the effectiveness of using IVBS in demonstrating lab experiments.

Student evaluation of IVBS: the proposed structure

The proposed structure is based on the observations obtained by the researcher in earlier studies of computer aided instructions (CAI). The proposed structure attempts to model students evaluation of the instructional software that is being used to teach them in the form of IVBS lab demo's in chemistry, biology, and physics (i. e., science labs). The structure is based on the interaction of two sub structures: the user interface and the computer as a tool of delivery (i. e., hardware + software interaction), thus avoiding the misleading results obtained when the software is separated from the hardware that operates it - as mentioned earlier- these structures are:

A- Computer as a tool of delivery: which is the structure in which students evaluate the use of computer as a tool of delivery. Computers operate the software used to teach, and is an essential component of human-computer interaction according to the definition of interactivity given earlier; so that the first step in ensuring effective use of the software by students is to examine their view (or attitude) of the use of computers as a tool of delivery and whether or not its use causes any problems to students, which gives this substructure a particular importance in the context of instructional software design. A good design is one that works efficiently, with harmony with the device - the computer - that operates it, and without causing any problems to the user which is the true meaning of interactivity between the software, the computer that operates it, and the user. The proposed dimensions of this structure are:

1) **Computer competency:** which is a measure of how students evaluate their competency in using computers in aspects of operation, dealing with software, handling computer problems, experience, and learning about computers. Student with a positive evaluation of their competency in using computers will be more confident and competent in using it to run instructional software which in turn enhances their performance thus, leading to better results in terms of learning.
2) **Computer Importance:** which is a measure of how important is the computer from students perspective. Computer importance is a significant factor that influences students acceptance of computers as tools of delivery. Student will not respond effectively when taught using a tool they view as "unimportant".

B-User interface design: which is the substructure in which students evaluate the design of the user interface of the software being used to teach them. Any internal design features of the software made by the software engineer are reflected through the user interface, students are only exposed to the user interface, and the internal structure is of no importance to them because it is hidden from them in the mist of code lines in the computer memory. The user interface is actually the structure that governs student-computer interaction, it is the manifestation of the goals and objectives for which the software engineer designed the software to realize them, and it is the tool through which students respond to these goals and objectives in an interactive manner, which gives this structure a significant importance as a design criterion: students will not respond effectively to an instructional software with a user interface they evaluate as unfriendly or hard to use which will lead to a decline in their performance.

The proposed user-interface structure has five composing dimensions (i. e., factors):

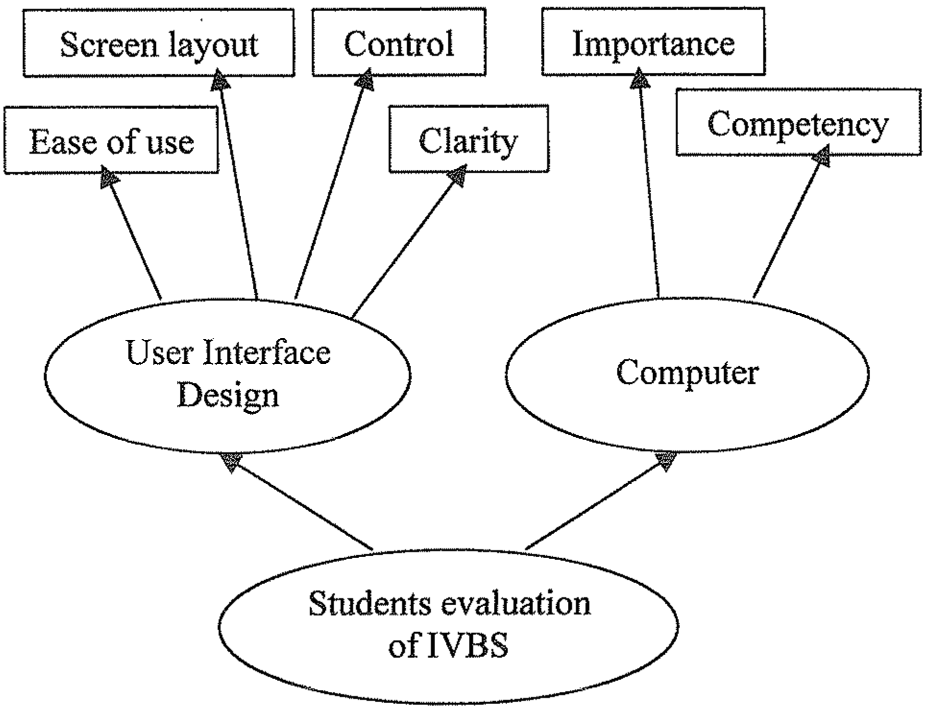
1. **Ease of use:** which is a measure of the usability of the software's user interface from students perspective. Ease of use is measured by whether or not: the student faced any problems using the interface, movement between the different screen in the interface was easy, the interface was difficult to use, exterior help was needed to use the interface (e. g., instructor), and the preliminary explanation given to the student about the interface was enough to use the software without any difficulties. The importance of this factor stems from the fact that students will be reluctant to use a software with a difficult to use interface, which badly influences their performance and may seriously decrease the benefits of using such a software.

2. **Clarity:** which is a measure of students satisfaction with the software's interface explanation of the subject being taught -lab experiment- and is measured by a clear explanation of: the overall experiment, the experiments steps, tools, terms, substances used, and whether or not there are areas of the subject matter let unexplained (or ambiguously explained) by the software interface. This factor is particularly important in instructional software interface design because students will not respond positively to software that they find its content unclear and difficult to understand, which again leads to a decline in their performance.

3. **Screen layout:** which is measure of the appropriateness of the interface screen elements: color, sound, and video clips. These interface screen elements should be appealing and satisfactory from a student's perspective. Such appropriateness can be measured by student's satisfaction with: color coordination, video and sound coordination, forehead and background colors, and video clips clarity and accuracy. Also, in such a setting, an important measure is whether or not the interface gave a realistic experience compared to the instructors performance.

   A good screen layout attracts students attention to the subject being taught thus leading to a better performance.

4. **Control:** which is a measure of students control over their interaction with the software via its user interface : control is measured by the degree of control over the software offered the interface, allowing video clips playback whenever the student wants to do so, operating the software at the students own pace and without any pressure to complete a task within a time limit and without any source of imparsment to the student operating the interface because the software IVBS Lab demo is intended for class use. A user interface that offers a high degree of control to the user (i. e., the student) - according to the measurements given above - encourages positive student - software interaction, thus, enabling the student to learn free from any pressure that may negatively effect his performance. Students will interact better with a software they feel that they have control over it. The path diagram in figure (1) depicts the proposed structure that models students evaluation of an IVBS.



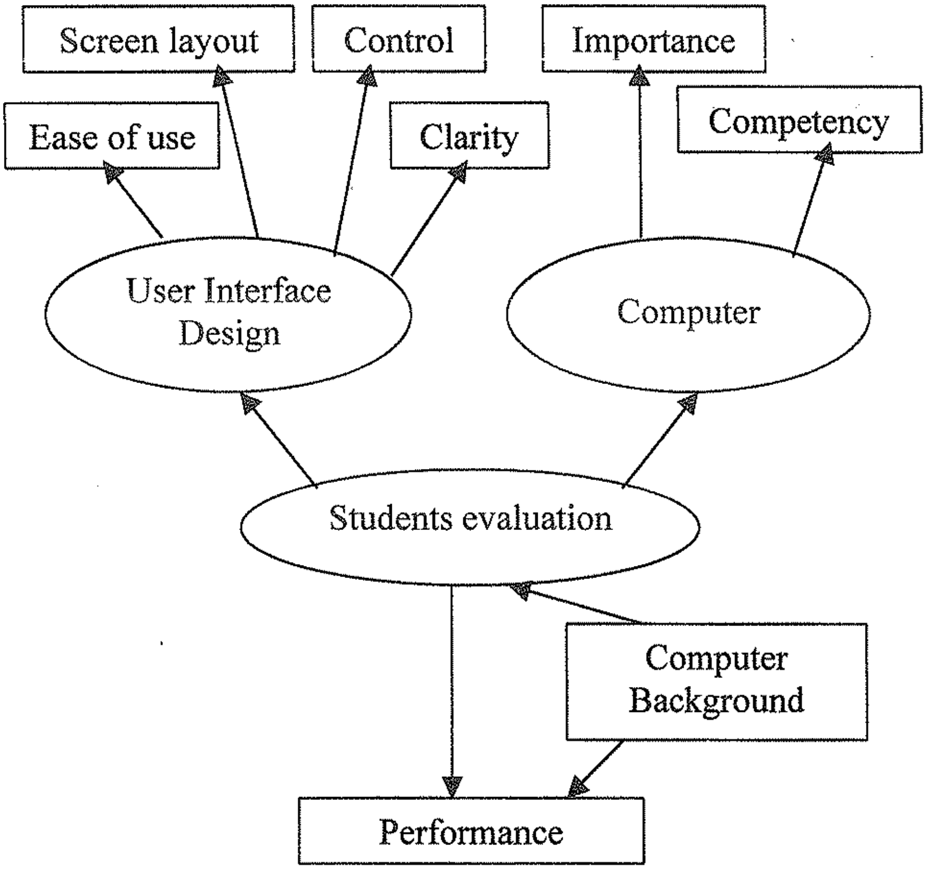
Fig(1) Path diagram for student's evaluation of an IVBS

The path diagram in fig (1) indicates that there is a higher order latent structure called "student evaluation" of the IVBS used to teach them - that operates among a set of two latent substructures that measures students perceived value or of: user interface design and the computer as a tool of delivery.

So far we have only proposed the constructs or structures that compose the context of "students evaluation" of IVBS lab demos. What remains is the actual pattern of relationship between these constructs and other variables in the context, namely, student performance and students previous computer experience (measured by his grade in the computer course offered at his school).

The researcher assumes that the following pattern of interrelation ships exists within the context of students evaluation of IVBS lab demo's:

1. Students evaluation of the IVBS used directly effects their performance.
2. Previous computer experience directly effects students evaluation and students performance when taught using IVBS. Thus, students evaluation is a mediating factor between previous computer experience and students performance. The hypothesized pattern of relationships is depicted in fig (2).



Fig(2). Pattern of interrelationships in an IVBS context.

The researcher also makes the following general hypothesis about the structure and pattern of relationships infig (2):

1. The proposed structure exists in any experience that involves the use of IVBS in science lab demos regardless of the subject being taught (physics, chemistry, or biology). That is, the proposed structure is subject independent.
2. The structure continues to exist regardless of student's gender (male or female) in the context of science lab demos. That is, the structure is gender independent.

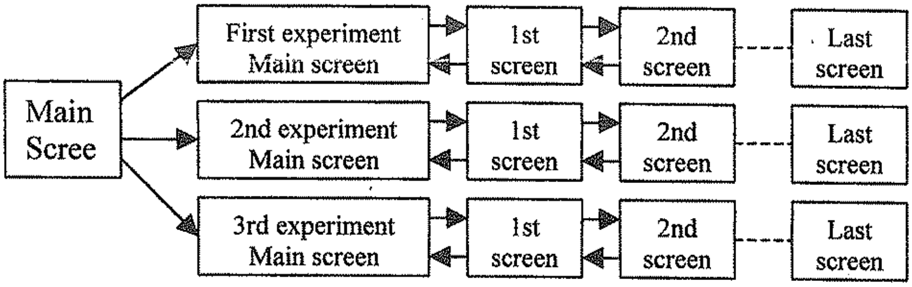
The structures and pattern of relation ships in fig (1) and fig (2) need to confirmed first.

Figure (1) represents a confirmatory factor model, while figure (2) represents a structural equation model. The process of confirming the existence of models (1) and (2) is known as "structural equation modeling" which is a powerful statistical technique enables researchers to test for the existence of their hypothesized structures and pattern of relationships with great degree of flexibility. This process involves developing scales that represent these structures, where the items in these scales are the manifestation (measurement) variables of the hypothesized structures. Such measurement models specify what observed variables are needed to measure latent variables (structures). Since each scale contains several items (i. e., observed variables), the sum of items in each scale (e. g., importance) represents the value of the observed variable that in turn serves as a measure of the latent factor (or structure) under study. The actual reliability of these scales and their internal consistency is determined after the model is fitted to the data and tested for "goodness of fit" (Marcoulides & Hershberger, 1997; Tabchcick & fidell, 1996;).

The process of determining the existence of structure, its reliability, and internal consistency is determined by the factor loadings of the proposed items on their proposed factors. A good model is one that explains most of the variance present in the data and its constituting items (i. e., variables) have high factor loadings (>0.30), which is a process that is entirely different from exploratory scale building (Leohlin,1998). The proposed scales and their items are given in Appendix A.These scales are in the form of a 5-point lekert - like scale , with a total of 42 items,thus , the highest obtainable score is 210 points , and the lowest is 42.

IVBS for lab demos: the proposed design

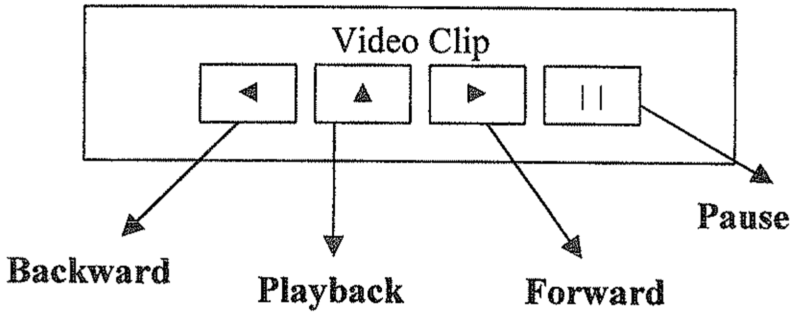
The software used was a stand-alone, plug and play, software controlled sequence of video clips demonstrating a lab experiment. These video clips were linked together using Visual Basic 6 programming language, the software contains three experiments connected by a main screen in the branching design shown in figure(3)



Fig(3). The proposed branching design of lab demos.

In this design, the main screen contains an overall a description of the three experiments to be taught and offers the student a path to any experiment via a move button when clicked moves the student the main screen of the chosen experiment.

The main screen of each experiment contains the element of the experiment to be taught by the following sequence of video clips: objectives, tools, substances and path to a sequence of video clips demonstrating the actual experiment. Associated with each video clip(screen) is a set of interaction tools in the form of: play pack, pause, forward and backward buttons, which allows the student to play a current video clip, review a previous one, move to the next clip, or even pause a certain view as shown in figure (4).



Fig(4). Screen layout

In explaining the experiment steps, the software uses a video + voice combination. No text is used in the software that is intended to keep the software strictly interactive video based.

Three versions of this software were developed for three science lab demos: chemistry, physics, and biology. These demos are intended to help the instructor to teach lab experiments in a class setting, that is, the software is instructor supervised.

It is the researcher's belief that this design offers a feasible, coast effective, and effective substitute to expensive simulation software that can't be used because of economic and a political governing Palestine.

Purpose & objectives:

The study of IVBS lab demos aims at:

1. Studying the possible use of IVBS for lab demos as effective substitute for expensive lab simulation software.
2. Structuring the design process of the user interface of instructional IVBS taking into account:

a) Software/hardware interaction.

b) Student perspective(i. e., evaluation) as a main design criterion.

In view of these aims the following objectives were formulated.

1. Developing an effective science lab demo IVBS.
2. Proposing a structure for evaluating the design of the proposed IVBS lab demo (i. e., student evaluation).
3. Developing scales to measure the composing factors (or substructures).
4. Confirming the existence of such a structure and its composing substructures.
5. Evaluating the effectiveness of the proposed lab demo IVBS compared to the traditional method.

Sample & frame:

The researcher involved a sample of 600 students (300 males & 300 females) from Gaza's secondary schools. The sample was divided into three groups (100 males & 100 females each). Each group is to be taught using the software design described above, demonstration from the other two groups (i. e., chemistry, physics, or biology). For each group there was a control group (100 males & 100 females) taught using the conventional method only (instructor's demonstration).

Procedure & Data collection:

Each group was studied three lab experiments in three different sessions. After completing these sessions, the students were asked to fill out the questioner (the proposed evaluation scale). Filling out the questioner toke 20 minuets on the average. The students were then asked to perform the experiments they studied using the IVBS and their performance was graded. Previous experience (measured by the grade obtained in the computer course offered at their schools) was also recorded for each student in each group. Thus, the data collected for each student were sex, questioner, computer grade, and the group he/she was assigned to, which complies with the proposed model in fig (2).

Statistical analysis:

A. To confirm the existence of the structures depicted in fig(1) & fig(2), the statistical package AMOS 4 was used to calculate:

1) A t-static (also referred to as a critical ratio) for each path in fig (1) & fig (2) to test for significance of each path. For a path to be significant t must be greater than 2.

2) A chi-square statistic for the models in fig(1) & fig(2) to test the goodness -of- fit of a model. The null hypothesis tested her is that the model fits the data. Thus failing to reject the null hypothesis indicates a good fit.

3) Goodness of fit indices (GFI & AGFI): which are measures of the relative amount of variance explained by the model. These measures are scaled to range between 0 and 1, with larger values indicating better fit. Values above 0.9 are considered generally to indicate well-fitting models. These indicate also serve as indicators of the reliability of a personal model and the internal consistency of the structure it represents. The above process will be repeated for each sub-sample (according to subject taught) for male & female students. To test for the independence of the proposed structure (i. e., student evaluation) from gender & subject being taught. Such a procedure is known as "cross validation". Cross validation is the ultimate test of any proposed structure (Loehlin, 1998). If the proposed structure is valid it should be reflected by the data in every sub-sample under study. That is, students evaluation is a structure so stable that will be found (confirmed) in any sample concerning the use of the use of IVBS regardless of subject being taught (chemistry, biology, or physics) and regardless of sex (male or female). If so, such a structure is judged to be reliable (Hecks, 1998). In doing so, we would be able to confirm the existence of the structures and pattern of relation ships proposed in earlier sections.

B. The effect size of students evaluation and previous computer experience on students performance and their interrelationships will be calculated using correlation coefficients an effect size indicators.

C. The factor loading of the proposed items in each of the proposed structures in "student evaluation" will be calculated to give further evidence of the reliability of the models (loadings >0.3 are considered very reliable).

D. A t-test was used to test for variations in performance between the conventional groups and the IVBS lab demo group, to Varify the effectiveness of the proposed IVBS lab demo design.

Results & discussion:

1. The results of the confirmatory analysis of the structure in fig (1) across all sub samples by subject being taught (chemistry, physics, or biology) are given in table (1) and table (2) for male and female samples respectively.

Subject	N	Chi-square	Sig	GFI	AGFI
Chem	100	1.69	*	0.99	0.99
Physics	100	1.68	*	0.99	0.99
Biology	100	1.83	*	0.99	0.99

(*) Non significant.

Table (1) confirmatory analysis result by subject for male samples.

Subject	N	Chi-square	Sig	GFI	AGFI
Chem	100	1.77	*	0.99	0.99
Physics	100	1.33	*	0.99	0.99
Biology	100	1.48	*	0.99	0.99

(*) Non significant.

Table (2) confirmatory analysis result by subject for female samples.

The results in table (1) and table (2) confirm the existence of the structure proposed in fig (1) in all samples under study regardless of the classification of these samples (sex & subject being taught). The proposed model for "student evaluation" fitted the data (chi-square was non-significant) in all samples. This process (cross validation) gave evidence of the reliability of the proposed structure. Thus, student evaluation exists as a structure with the dimension (i. e., factors) as depicted in fig (1). These results also confirm our prior assumption that this structure is not effected by sex or the subject being taught. Furthermore, the results obtained on the fit indices (GFI & AGFI) in all samples show that the proposed model is accountable for 98-99% of variance in the data which gives further evidence of the goodness of fit, reliability, and internal consistency of the proposed model for student evaluation of IVBS. The paths of the proposed model in fig (1) were all found to be significant (t>2) which is another indication of internal consistency of the proposed structure.

2. The results of the confirmatory analysis of the pattern of relationships between student evaluation, performance, and previous computer experience depicted in fig (2) across all samples (by subject being taught) are given in table (3) and table (4) for male and female samples.

Subject	N	**Chi-squar**	**Sig**	**GFI**	**AGFI**
Chem	100	1.66	*	0.993	0.988
Physics	100	1.05	*	0.996	0.99
Bioloy	100	1.3	*	0.99	0.98

(*) Non significant.

Table (3) confirmatory analysis results of fig (2) for male samples.

Subject	N	**Chi-squar**	**Sig**	**GFI**	**AGFI**
Chem	100	1.73	*	0.99	0.98
Physics	100	1.32	*	0.99	0.98
Bioloy	100	1.81	*	0.99	0.98

(*) Non significant.

Table (4) confirmatory analysis of fig (2) for female samples.

The results confirm the pattern of relationships proposed by the model in fig (2). The results indicate the goodness of fit of the proposed model and that it is accountable for 98-99% of variance in the data, in all sub-samples, thus, confirming the reliability of the proposed model of pattern of relationships depicted by fig (2). The results of cross validation given in table (3) and table (4) also indicate that the proposed pattern of relationships is independent of sex and subject being taught, thus, this pattern of relationships can be considered stable, and reliable and consistent. Furthermore, the paths between student evaluation, previous computer experience (i. e., computer course grade) and performance were all found to be significant (t>2), which confirms our initial proposition that student evaluation directly effects student's performance, and previous computer experience also effects students evaluation and students performance. thus, student evaluation serves as a mediating factor between previous computer experience and students performance - when taught using IVBS - which is a very important issue; because the effect of previous computer experience on students performance has been already established across the literature. However, no description of the mechanism of how previous computer experience effects students performance is given. But is it reasonable to suggest that variations in previous computer experience are the main source of variation in students performance when taught IVBS? Perhaps not. Instead, fig (2) suggests an alternative mechanism of effect: previous computer experience increases a student's evaluation level and this higher evaluation level - of the software used - leads to a better performance (i. e., a higher grades). Thus, the relationship between previous computer experience and students performance is "mediated" by students evaluations. Thus, the path between previous computer experience and performance indicates an indirect effect. This indirect effect is measured by the product of paths between computer experience & student evaluation, and student evaluation & performance, the existence of the mediation process just described was confirmed by results of fitting the model of relationships given in fig (2) as shown in table (3) & table (4). This point is best illustrated by an example from our study. In our overall sample, the correlation coefficients between student evaluation, previous computer experience, and performance are given in table (5).

Variable	Student eval.	Experience	performance
Student eval.	1	0.717	0.625
Experience	0.717	1	0.913
Performance	0.625	0.913	1

Table (5). Correlation coefficient for the pattern of relationships in fig (2).

Now, the assumption that previous computer experience directly effects students performance - with no mediating factors involved, and indicated by the correlation coefficient R=0.913, implies that the computed effect size (R-SQUARED) of previous computer experience on student performance is 0.82 (large), that is, the statistically large effect of previous computer experience is also accountable for 82% of variance in students performance, which leaves only 18% of unexplained variance attributed to other factors including the software used. While it is reasonable to assume that computer experience has a large effect size, it is not reasonable however to assume that it has the maximum importance in a (CAL) context because there are other factors such as software design, teacher roll… etc, considering the fact that the computer experience investigated is the computer course (Dos + Windows) given in secondary schools, which indicates the need for a more realistic assumption.

A more realistic approach is that the effect of previous computer experience is mediated by student evaluation as depicted in fig (2). The correlation (R) between computer experience and students evaluation is 0.717 indicating an effect size (R- SQUARED) of 0.5 which indicates that previous computer experience has a large effect size on students evaluation and is accountable for 50% of variance in students evaluation, note that previous computer experience directly effects students evaluation which in turn directly effects performance. The direct effect of student evaluation on performance measured by correlation coefficient (0.625) indicates a large effect size (0.4) of student evaluation and that is accountable for 40% of variance in students performance which is a reasonable assumption because it takes into consideration that other factors effect student evaluation (accountable for the remaining 50% of variance in evaluation) and students performance (accountable for the remaining 60% of variance in students performance). Thus, the confirmed student evaluation model in fig (1) and the pattern of relationships model in fig (2) may actually serve as baseline models in studying CAL in general and IVBS on their lab performance justifies our study of such an evaluation as a structure and the importance of such a structure in an IVBS context.

The results clearly indicate that students evaluation is a significant structure (or factor) that effects students performance when taught us in IVBS (accountable for 40% of variation performance). The results also a very important background variable in formulating students evaluation of IVBS (accountable for 50% of variation in evaluation). Pervious computer experience reflects students earlier exposure to computer (hardware and software) and is responsible for formulating their response or attitudes to computer as tools of delivery which gives such an experience considerable significance in evaluating an instructional software design.

3. The items of the composing substructures of student evaluation and their associated factor loading are given in Appendix A. These loading are all greater than 0.3 indicating a high internal consistency of the proposed structure in fig (1).
4. Table (6) gives the results of the t-test between the conventional groups and the IVBS groups.

Group	N	t	Df	Significance
Chem	200	19.8	198	*
Physics	200	20.1	198	*
Bioloy	200	19.71	198	*

(*) significant at the 0.01 percent level.

Table (6) t-test comparisons between the conventional groups and the IVBS groups.

The results in table (6) show significant differences in performance in favor of the IVBS group which is an indication of the effectiveness of IVBS compared to potential benefit of using IVBS as a coast effective substitute to expensive lab simulation software.

Summary of results

1. The results confirm the existence of the structures and pattern of relationships depicted in fig (1) & fig (2), and that "student evaluation" is a reliable and consistent structure that is also subject and gender independent.
2. "student evaluation" has a significantly large effect on student performance which justifies it use as a basic design criterion in the design of instructional software.
3. Previous computer experience is a significant factor in an IVBS context. It effects "student evaluation" and performance indicating a large value as a background variable in evaluating the design, implementation, and effect of IVBS.
4. The confirmed structures and pattern of relationships in fig(1) and fig(2) provide a link between the design of IVBS and students performance and describe the mechanism in which students interact with the IVBS (software + hardware) used to teach them and other background variables.
5. The confirmed structure serves as a "baseline model" for an IVBS context. It explains a significant portion of variations in performance indicating that it's a significant factor but not the only factor that effects students performance. The structure is also effected by previous computer experience, but there other factors that "student evaluation" as a structure. That is, there is still room for expansion of the model to incorporate other structures from other disciplines that are involved in the design, implementation, and evaluation of instructional software.

Such an expansion is intended to investigate the remaining portion of unexplained variation pattern of relationships in fig (2).

6. The results show the effectiveness of the proposed IVBS lab demo design compared the conventional method, thus offering a coast effective substitute to expensive lab simulation software.
The students responded very positively to the developed IVBS with a positive evaluation of 90% of the total score of the proposed scales.

Improvements & challenges:

The baseline model studied in this research can be expanded to include improvements on both the design and evaluation process. Such improvements can be achieved by revision of the current structure or by including other structures and pattern of relationships which will give rise to new challenges in restructuring the new process of designing instructional software in general and IVBS in particular. We now discuss the potential improvements of the proposed baseline model and the associated challenges.

1. Feedback from the students who participated in this experiment has shown that students want text explanation of lab experiments to accompany the video clips. They claimed it would improve their understanding of the subject being taught. Such an improvement - adding text to the screen design - poses the following challenges:

a) The screen layout in fig (4) has to be redesigned to incorporate text as a basic component of the screen design of the IVBS. In other words, a new text-enhanced software design has to be proposed.

b) The embedding of text in the design will alter the screen layout in the user interface substructure in fig (1). Such an improvement will give rise to the layout evaluation of the interaction between the screen layout components (sound + text + colors + video clip) which add a new factor the user interface design process which implies that the user interface substructure has to be restructured to include this new factor and that a new scale is to be developed to measure this new factor. The remaining factors in the user interface design will probably remain unchanged - but one never knows!.

c) Will students performance be further enhanced by this improvement - embedding text explanation - compared to the strictly interactive video experience developed so far?, and if so, what is the size of this enhancement in performance (i.e., effect size)?. The current design and evaluation structure contributes by 40% of explained students performance, will the new improved design and evaluation structures explain more in terms of students performance. In other words, are there potential benefits to be gained that justify this improvement in terms of performance and percent of variance explained.

2. From field observation during the experiment, the researcher believes that there is structure that is yet to be investigated. This structure is about the experience that results from the use of IVBS as lab demos. The researcher hypothesis that this structure has the following two substructures: enjoyment & enthusiasm, and productivity improvement (how IVBS improved their performance) but this implies that:

a) A new scale is to be developed to measure this new structure and its compassion factors.

b) The presence of this structure "resulting experience" in an IVBS posses the following question: is this structure a composing factor of "students evaluation" (i. e., a third factor) or is an independent structure that effects students evaluation and hence their performance. In other words, the expansion of the baseline model to include "resulting experience" implies that the pattern of relationships and the associated percent of variance explained by the model be revised.

3. In any of the improvements suggested above, a general question raises: will the newly developed model still be subject and gender independent? That is to say, a new confirmatory study is to be conducted for the new settings.

The developed models in this research are expandable and open: the conceptual base (baseline model) is able to capture new development in a form that relates them in a clear, structured way to the establish body of theoretical knowledge. The models are also for formalisable: the framework supports increasing precision in the representation of concepts and their relationships, so there should be no problem in using the developed baseline models to investigate the improvements mentioned above.

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APPENDIX A

The proposed scales are in Arabic, where the response for each item ranges from "strongly agree " to " strongly disagree ". The items of each structure in fig (1) are listed below along with their factor loading,where (*) indicates a negatively worded statement.

أ - الكفاءة في استخدام الكومبيوتر (computer competency) (0.653) :

1- لا أواجه أي مشكلة في استخدام الكومبيوتر .(0.512)

2- أتعامل مع برامج الكومبيوتر بسهولة .(0.89)

3- أستطيع معالجة المشاكل التي أواجهها أثناء العمل علي الكومبيوتر بسهولة.(0.591)

4- توجد لدي خبرة جيدة في استخدام الكومبيوتر .(0.845)

5- لا أستطيع فهم الكومبيوتر . (*) (0.79)

6- لم أواجه أي صعوبة في دراسة مادة الكومبيوتر. (0.60)

7- أرتبك عندما أستخدم الحاسب . (0.42)

ب- أهمية الكومبيوتر (computer importance) . (0.844)

1- استخدام الكومبيوتر أثناء الدراسة يسهل علي فهم الدروس . (0.655)

2- تعلم استخدام الكومبيوتر يضمن لي وظيفة جيدة في المستقبل . (0.76)

3- يوفر لي الكومبيوتر فرصة لأتعلم أشياء جديدة . (0.613)

4- أتعلم أشياء كثيرة عندما أستخدم الكومبيوتر .(0.83)

5- من المهم جدا لي أن أتعلم كيف أستخدم الحاسب .(0.508)

6- أتعلم من الكومبيوتر أكثر مما أتعلم من الكتب .(0.537)

7- أفضل استخدام الكومبيوتر علي مشاهدة التلفزيون .(0.468)

8- أفضل استخدام الكومبيوتر علي قراءة كتاب .(0.477)

9- أتعلم من الكومبيوتر أكثر مما أتعلم من مشاهدة التلفزيون .(0.651)

10-أتمني زيادة حصص مادة الكومبيوتر في المدرسة .(0.676)

ج- سهولة الاستخدام (ease of use) :(0.753)

1- لم أواجه أي مشكلة في استخدام البرنامج .(0.627)

2- الانتقال من شاشة ألي أخرى في البرنامج سهل .(0.655)

3- استخدام البرنامج صعب . (*)(0.49)

4- لا أحتاج أحد ليساعدني في استخدام البرنامج .(0.633)

5- الشرح التمهيدي كافي لاستخدام البرنامج بسهولة.(0.724)

د-الوضوح (clarity) :(0.70)

1-شرح البرنامج للتجربة واضح .(0.552)

2-يشرح البرنامج خطوات التجربة بشكل واضح.(0.676)

3-يشرح البرنامج مصطلحات التجربة بشكل واضح .(0.80)

4-يشرح البرنامج الأدوات المستخدمة في التجربة بشكل واضح .(0.593)

5-يشرح البرنامج المواد المستخدمة في التجربة بوضوح .(0.515)

6-يشرح البرنامج أهداف التجربة بشكل واضح .(0.626)

7-توجد نقاط في التجربة لا يشرحها البرنامج بوضوح .(0.871)

8-صورة الفيديو المستخدمة في كل شاشة واضحة.(0.831)

9-الشرح في صورة الفيديو المستخدمة في كل شاشة دقيق .(0.522)

10-صور الفيديو للتجربة واقعية و لا فرق بينها و بين التجربة العادية .(0.791)

ه-التحكم (control) : (0.86)

1-أستطيع التحكم في البرنامج كما أريد .(0.543)

2-يسمح لي البرنامج بإعادة لقطة الفيديو إذا أردت ذلك .(0.637)

3-أستطيع التنقل بين شاشات البرنامج بواسطة أزرار التحكم كما أريد.(0.824)

4-الشرح في الشاشة يناسب سرعتي في الفهم .(0.491)

5-لا يضغط علي البرنامج لأسرع .(0.611)

و-تصميم الشاشة (screen layout) :(0.784)

1-الألوان المستخدمة هادئة ومريحة .(0.66)

2-تتناسب ألوان الخلفية مع ألوان الواجهة.(0.554)

3-الألوان المستخدمة تشد انتباهي للبرنامج.(0.545)

4-الألوان المستخدمة لا تؤذي عيني .(0.51)

5-الشرح بالصوت المرافق للشاشة مناسب.(0.63)