Interactive Geometry Education by Developing of Multimedia Web Resources

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Abstract: *The purpose of this paper is to develop interactive web resources for high school mathematics, concentrating on Geometry, based on the results of our previous surveys (M.Behnoodi, J.moriyama ATCM 2006) and (M.Behnoodi, J.moriyama ATCM 2007).We designed the web resources in eight types of categories. Utilising video conference, this web site taught 38 first-grade high school students in a city of Japan. Employing the ARCS model, online pre-testing and post-testing was used to evaluate the motivation for mathematics learning and to survey the usability, eagerness and motivation of the students. The results demonstrated the explanation and site structure had a significant positive impact on motivation. Further, although multimedia did not have a substantial impact on students' level of satisfaction, the effectiveness of multimedia design in changing the students' eagerness for usage of ICT was considerable. In light of these results, it is suggested to find the characteristics of visualizing in multimedia to make a meaningful relationship between multimedia and learning.*

1. Introduction

One of the most important things that preoccupy teachers' time is the preparation of presentable material for their classrooms. With the help of computers, the teacher can effectively address the challenge of organizing mathematics instruction in such a way that it attracts and develops the abilities of the greatest number of students possible.

The National Council of Teachers of Mathematics (NCTM, 1989) recognizes the importance of geometry and spatial sense in its publication "*Curriculum and Evaluation Standards for School Mathematics*.**"** Spatial understandings (3-Dimension imagination) are necessary for interpreting, understanding, and appreciating our inherently geometric world. Insights and intuitions about two and three-dimensional shapes and their characteristics, the interrelationships of shapes, and the effects of changes to shapes are important aspects of spatial sense. With multimedia capabilities, a computer has the capacity to appeal to our eyes, ears, and feelings, thus being able to widen and enrich the content and scope of our educational experiences. With computers, students are able to visualize mathematical concepts that are difficult to comprehend by themselves without any imagination. In a typical classroom, computers provide easier and clearer illustrations than those a teacher would make.

The purpose of this study is to develop a web resource for teachers and students based on NCTM standards, mathematics standards in new geometry textbooks used in Iran and the result of online surveys done by mathematics teachers from various countries around the world (M.Behnoodi , J.Moriyama ATCM 2006 and 2007). The results of the online surveys made clear both the teachers' needs and viewpoints in respect of web resources as a tool for developing their curriculum in mathematics. Taking in to account these viewpoints, along with a comparison of web resources which allowed us to determine their respective weaknesses, a new mathematics web resource was

designed. The teacher's recommendations and opinions related to the following: A) Lesson planning, B) Dynamic and interactive, C) Printable worksheets, D) Explanation in details, E) Engage the students in challenging mathematics learning, F) Projects and Presentations, G) Questions and answers, and H) How to use web resources and math software. It is explained how to employ ICT in Mathematics Education in class activities by the usage of digital contents. By these web resources it is expected that the teachers access virtual sections by printing or using simulations and active functions which can be controlled by students. They can also see the results of students' progress at the end of each lesson by checking the answers of the questions. The present study administered two questionnaires: a questionnaire measuring students' motivation in pre-test and post-test in class activities based on ARCS Model, and a questionnaire to measure the effect of the usage of developed web resources in Mathematics class (The usage of ICT) on students' usability and eagerness.

2. Development of Multimedia Web resources

The Web resources were developed according to the needs of teachers in the previous survey. Lesson planning with dynamic and interactive activities and a clear structure is the most important need as far as the teachers are concerned. Lesson planning should contain dynamic and interactive components while activities should sometimes be controlled or manipulated by the students who are the active learners in the lesson. The web resource was designed by Java Applets and Java Script for interactive activities. For those students who struggle to understand mathematics through written proof, we have used animations and simulation in GIF files or streaming to allow them to visualize and thereby better understand the problems. The students can answer questions and immediately see the results. Some additional detailed explanations were made for better understanding as well as more difficult questions for those students who are functioning at higher mathematics levels. In this way, the students are engaged in challenging mathematics learning in addition to mastering the different technological software used in the web site. The students become fully engaged and can even create some new parts by themselves and submit those to the website to possibly be linked for usage by other users. Furthermore, if the teachers have interesting teaching methods in their classrooms, they can record their speech and actions then send it to the coordinator for linking on the website.

An additional advantage of this site is the software training provided can be used for making the applets and animations. When software is designed for use across a variety of mathematical topics, it can be designed for many different applications and the user can examine the area of mathematics in which the software will be used and develop lessons that promote the type of learning on which they will focus. A dynamic geometry program allows the user to construct, measure, and manipulate what is displayed on the screen, providing immediate feedback as the object changes size or shape.

The main advantages of this kind of web site are, *free and easy access* without requiring an ID or password, printable worksheets, and unlimited use for any movies, animations or applets in education by teachers and students. Students interactively discover the properties of geometric figures and literally create geometry for themselves. In order to teach students how to use the software, they were shown how to produce a variety of activities which integrate the computer skills forming a parallel with the geometry content.

By doing the activities on this web site, the students learn, practice, and apply rotations, translations and reflections and link mathematics to space and form in the world around them. In this way students investigate two-dimensional and three-dimensional space by exploring shape,

area, and volume; studying lines, angles, points, and surfaces; and engaging in other visual and concrete experiences.

Figure 1 shows the *lesson contents* with a *hint* for teachers. In lesson contents there are some animations and simulations with pictures for better understanding. Each lesson has been written according to the NCTM standards and Iran Standards in Mathematics. The *hint* for teachers provides additional explanations in other fields of science which bear a connection to geometry, demonstrating the relationship between mathematics other sciences. In fact, many daily life activities which are connected to mathematics can be viewed by students though using these hints.

Figure 2 shows how students can visualize the proof of a theorem by employing animations and streaming. This can be helpful for the students in visually imagining a theorem and then creating a hypothesis for academic proof. In the case of streaming with movies or animations, the teacher can pause in each part if it is necessary to give an explanation in more detail or repeat some of the sections.

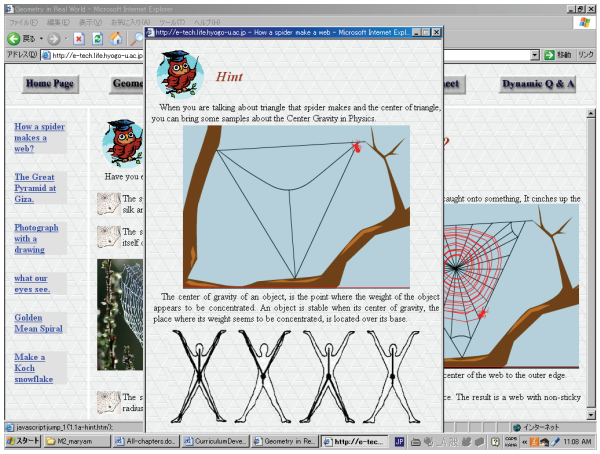

Figure 1. Hint for teacher in lesson plan

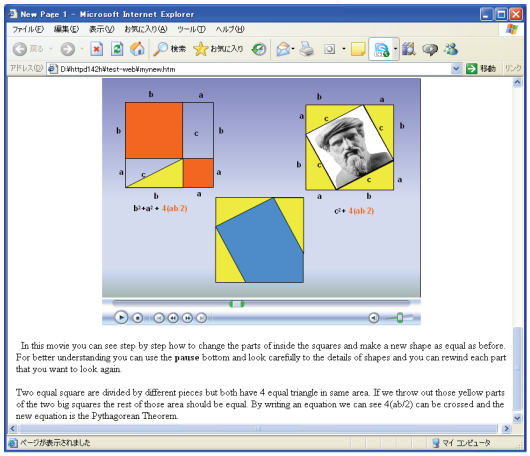

Figure 2. Animation with streaming

Figure 3 shows the dynamic question and answer sheets designed by Java Script which are presented for class activities. There are two frames: one containing the worksheet and one containing the answer sheet. In this kind of multiple choice answer sheet the students can answer each question by clicking on A, B, C, or D. After finishing the quiz they can see the results of their examination, and then by choosing the solution of each question, see the correct answer achieved in different ways as well as learn in which part they made a mistake. In ordinary worksheets the students only observe a paper in black fonts and shapes which are often drawn by hand, however by using the computer generated illustrations, the students gain a more accurate sense about questions by looking at the animations and can come to understand the different situations of each question. Figure 4 shows the results of the student's answers. In this case one of the students answered four questions correctly and one wrong. S/he can immediately learn the answer of that question in detail. Using Java Applet, the students can change the shape on the screen, and then by comparing the data can gain a better visual understanding for the reasoning of the proof.

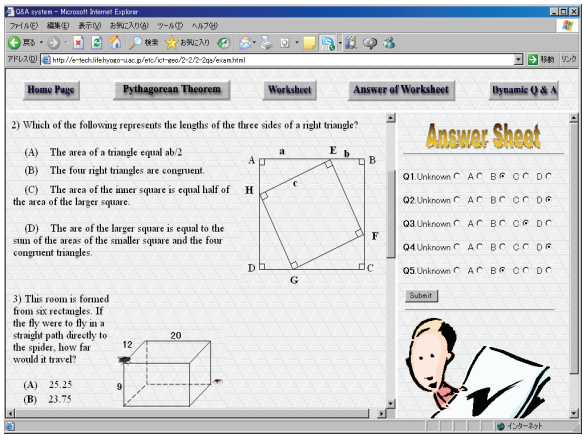

Figure3. Dynamic Questions and Answer sheet

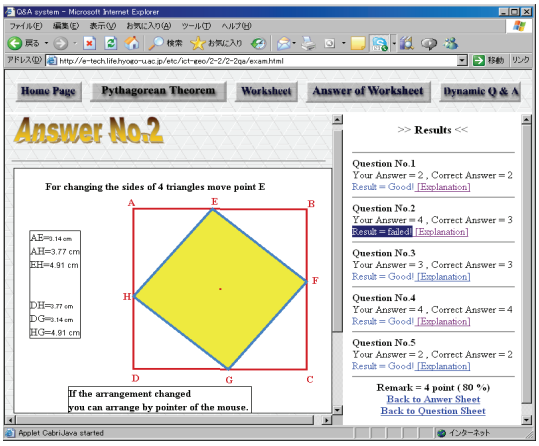

Figure 4. usage of Java Applet for explanation

There are three types of worksheets for each lesson: worksheet A for common students according to the samples of lesson; worksheet B for students of a higher level who require a greater challenge and broader thinking; and worksheet C for top students who are eager to increase their knowledge. If the students solve these problems step by step, at the end they can discover some new rules which correspond to the proof that can be seen in their text book. This allows them to look at problems with a different perspective.

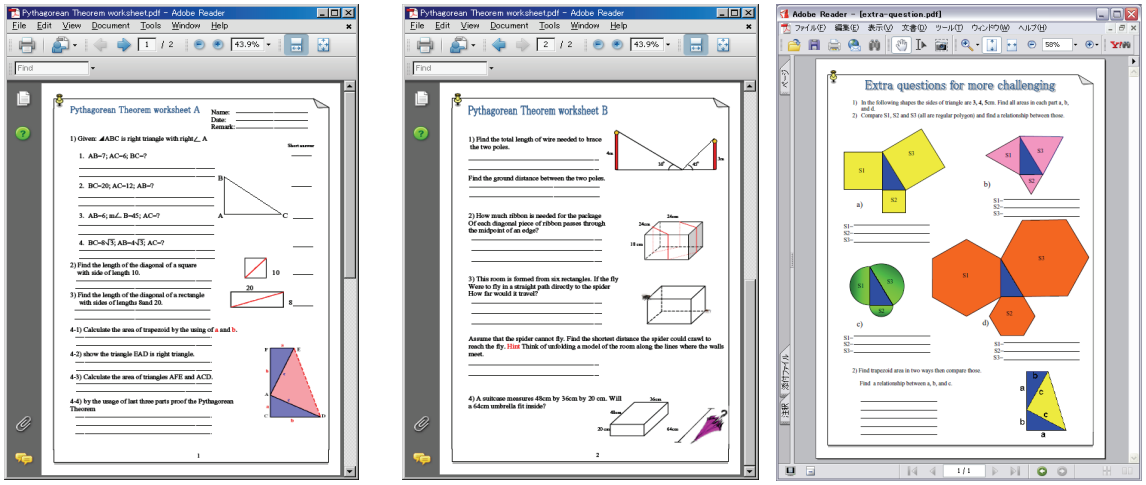

Figure5 three types of worksheet for three levels of students.

The main objective of the program is “teaching how to use the software” that is used for making interactive parts in each session**.** The users not only can use the interactive parts for learning geometry, but they can also create new tasks provided their school allows for common usage**.** Movie demonstrations are provided in each part of the program allowing the users to pause as needed and learn step by step.

Multimedia presentations are advantageous because they can develop students’ levels of understanding more effectively than in a traditional classroom setting.

3. The Evaluation of Developed Web Resources

Motivation consists of the amount of effort a person is willing to exert in pursuit of a goal; hence, motivation has magnitude and direction. Consequently, motivational design is concerned with connecting instruction to the goals of learners, providing stimulation and appropriate levels of challenge, and influencing how the learners will feel following successful goal accomplishment, or even following failure. Will, for example, the students want to continue pursuing the same goals? (Keller, J. M. 1987).

For this reason we chose ARCS Model *(**A**ttention, **R**elevance, **C**onfidence, and **S**atisfaction)* (John M. Keller1983, 1984, 1987) because the ARCS motivational design process is a systematic problem solving approach that requires knowledge of human motivation and progresses from learner analysis to solution design.

In order to analyse the effect of the web resource on teaching and the learning process, online questionnaires were given to students both prior and after being taught the digital contents through the internet by video conference. The post-test questions contained five parts: *F1: Design of explanations, F2: Design of multimedia and F3: Design of structure*, **ARCS** Model, and Eagerness to use ICT

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3.1. *Method*

The method chosen to teach the students was video conference, F2F (Face to Face) and web sharing through the server.

3.1.1 *Subjects*

It was decided that the website would be tested in a high school in Japan. There were 38 students (19 boys, 19 girls) from grade 10 who participated in the video conference class.

3.1.2 *Arrangement of classroom for Video Conference Class*

Prior to commencement of the conference class, a test-run was performed by an expert technology teacher who discovered some problems with the setup. He found that whilst conducting the class there was some delay with regard to the opening of URL pages and students weren't able to view what the teacher was seeing at the same time. As such, we decided through consultation to have an arrangement for sharing the data and monitoring (see Figure 6).

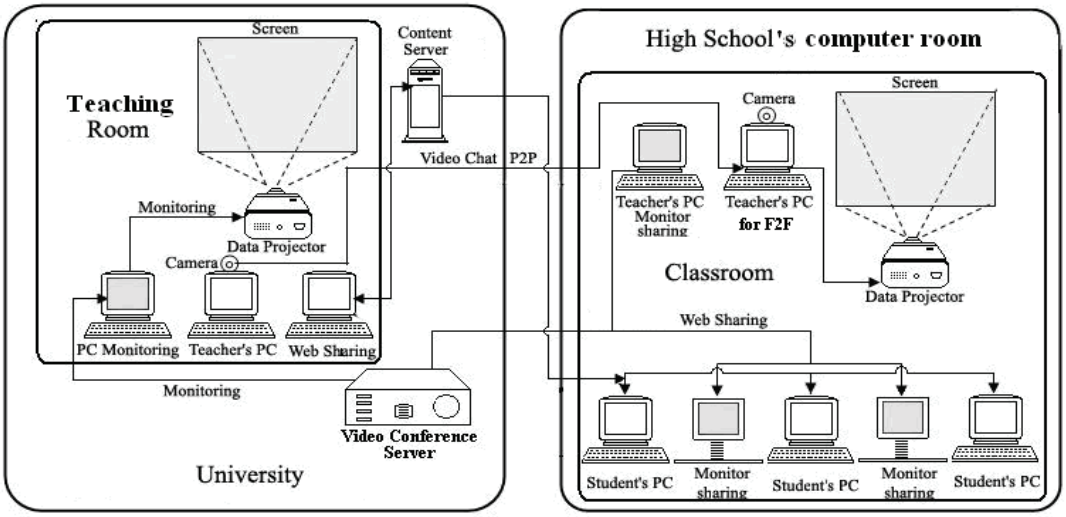

Figure 6: The arrangement of a classroom for teaching through video conference

The website was sent through the University Server to the students' PC, and shared the PC Monitoring to the Students' monitor through Video Conference Server. (Figure 6)

Each student had their own computer in which they could access the web resources for personal activities, whilst one monitor showing the teacher (F2F) was shared between two students. The teacher also had a computer to access the web resources as well as a monitor showing all the students participating in the class.

Activities in class

Lessons' Title: Geometry in real World

Activity No. 1 Showing an animation to observe the geometric structure in creatures
Activity No. 2 Showing an animation in 3D in order to better visualize spatial shapes
Activity No. 3 Draw nautilus shell curve on printable worksheet as practical activity
Activity No. 4 Discussion in group activity to solve environmental issues relating to Mathematics
Activity No. 5 Using Java applets to expand their imagination
Activity No. 6 Dynamic Q&A whereby students take a quiz and then discuss the answers in detail
Activity No. 7 Homework in 3 types, for common students, upper and highest level students

3.2 Results and discussion

3.2.1 Usability of the web resources

In both pre-testing and post-testing, the level of *motivation for mathematics learning* was surveyed by video conference. In post-testing each factor contained the different categories of concepts and also evaluated the digital contents (Ichihara, Moriyama 2003)

Table 1: The evaluation of the design explanation

F1"Design of Explanation"	Male(n=19)		Female(n=19)		t - test		Total(n=38)	
	Mean	S.D.	Mean	S.D.			Mean	S.D.
Colorful texts are appropriate with the website.	3.58	0.61	3.38	0.81	t(36)=0.84	ns	3.61	0.59
The arrangement of information is good.	3.42	0.77	3.41	0.80	t(36)=0.04	ns	3.50	0.69
the size of fonts is good	3.21	0.92	3.27	0.76	t(36)=0.21	ns	3.42	0.79
the explanation is well edited.	3.21	0.63	3.41	0.84	t(36)=0.81	ns	3.34	0.63
Good impression of colorful design	3.26	0.87	3.43	0.75	t(36)=0.61	ns	3.45	0.76
The layout of text,pictures,illustrations are good.	3.21	0.71	3.31	0.87	t(36)=0.38	ns	3.42	0.68
Average of F1	**3.30**	**0.54**	**3.22**	**0.69**			**3.45**	**0.50**

As Table 1 shows most of the students satisfied the "*Design of explanation*", however there are no differences between male and female students.

Table 2: The evaluation of design of multimedia

F2"Design of Multimedia"	Male(n=19)			Female(n=19)		t - test		Total(n=38)	
	Mean	S.D.		Mean	S.D.			Mean	S.D.
The interactive Q&A and simulation are good.	3.26	0.81		3.45	0.79	t(36)=0.71	ns	3.42	0.76
The resolution of animations and pictures are good.	3.42	0.77		3.30	0.91	t(36)=0.43	ns	3.50	0.69
The accessability of animations and pictures are good.	3.26	0.93		3.41	0.82	t(36)=0.51	ns	3.34	0.85
The size of animations and pictures are good.	3.42	0.69	>	2.60	0.84	t(36)=3.20	**	3.47	0.69
The effect of sound and voice is good.	2.47	0.77	<	3.30	0.77	t(36)=3.23	**	2.66	0.78
The effects of movie ,animations and picture are good for expla	3.22	0.73	>	2.67	0.77	t(36)=2.20	*	3.41	0.64
Average of F2	**3.30**	**0.54**		**3.22**	**0.69**			**3.45**	**0.50**

** p<0.01

* p<0.05

From Table 2 it can be recognized that male students satisfied each part, except the *effect of sound and voice,* with the highest rate belonging to *resolution*, *size of animations and pictures*. For females, the highest average belongs to the *interactive Q&A and simulation*. By comparing the satisfaction between females and males by t-test, the first three items had no significance. However, for the *size of animation* and the *effect of sound* there are strong differences between males and females pertaining to the effect of *animations and pictures for explanation*.

Table 3: The evaluation of design of site structure

F3"Design of Site Structure"	Male(n=19)			Female(n=19)		t-test		Total(n=38)	
	Mean	S.D.		Mean	S.D.			Mean	S.D.
The difficulty of learning is fit with your understanding.	2.37	0.68	<	3.24	0.74	t(36)=3.67	**	2.63	0.74
There are many resources for learning in this website.	3.11	0.81		3.13	0.77	t(36)=0.08	ns	3.24	0.68
The structure of learning contents is good.	3.16	0.76		2.77	0.88	t(36)=1.42	ns	3.16	0.68
The access to the pages and finding the subjects are easy.	2.89	0.66		3.24	0.78	t(36)=1.45	ns	2.82	0.80
The menue is well structured.	3.26	0.73		3.27	0.89	t(36)=0.04	ns	3.34	0.67
Average of F3		**0.73**		**3.18**	**0.54**			**3.30**	**0.51**

** p<0.01

This table shows the students who *satisfy* the *design of site structure*. There were differences between male and female in the case of "*Is difficulty of learning fit with your understanding?*"

3.2.2 Students' motivation for learning

Table 5: The evaluation of ARCS Model in compare of pre-test and post-test

Total	Pre		Post		paired-sample t-test	
	Mean	S.D.	Mean	S.D.		
Attention	2.11	0.95	3.29	0.80	5.65	**
Releveance	2.37	0.97	3.11	0.89	3.34	**
Confidence	2.42	0.86	2.79	0.84	2.05	*
Satisfaction	2.29	0.90	3.16	0.82	4.2	**

n=38

** p<0.01

* p<0.05

The paired sample t-test (Table 5) is used in this case, because the population of samples was the same and the group did not change. Only the effect of some activities was surveyed by this test. In all four parts, *attention*, *relevance*, *confidence*, and *satisfaction*, we had differences between pre-test and post-test which indicated that "*The method of teaching was effective*."

3.2.3 Relationship between usability and motivation

As a result of the statistical analysis in each factor (Chart 1), the students *satisfied* situation proposed by the *explanations*, *multimedia* and the *structure of the web site*. With multi-regression analysis, it is observed F1 and F3 significantly increased efforts on *motivation,* but F2 did not have any significant change in *satisfaction*. The effect of *explanation design* had the most effects on *attention and satisfaction,* and the *site structure design* had a strong effect on *satisfaction*.
The students' comments showed that, as for promoting the *attention* and *satisfaction* of students' learning, that the *explanation design* was very important because they could learn difficult problems by repeating the simple examples in detail in class. By presenting different examples, we can try to show that *many aspects of everyday life depend on science,* and students can enjoy mathematics and find it interesting.

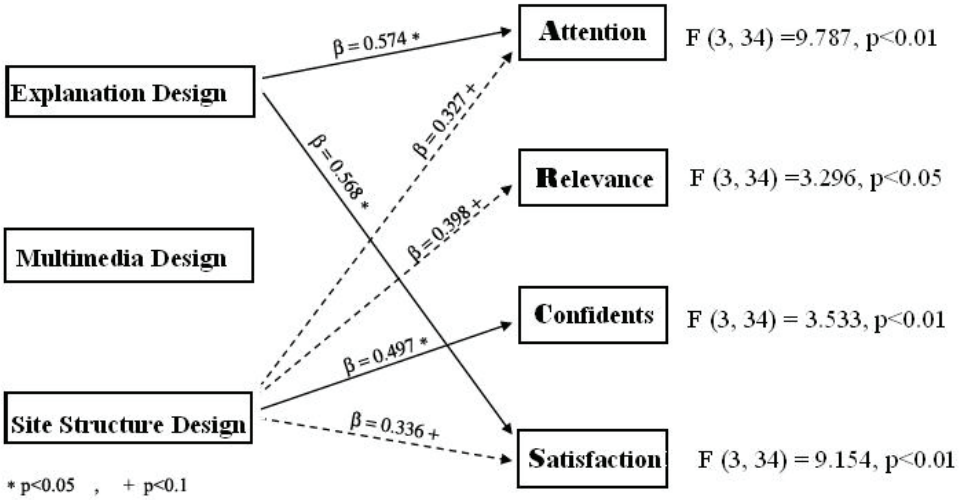

Chart 1: Relationship between usability and motivation

In the previous section we could not find any relationship between multimedia and ARCS. But it was decided to confirm the efficacy of the *change of eagerness to ICT* by the effect of F1; F2; and F3. In comparison, there was a decreased eagerness indicated in the pre-test when subjected to post-test multi-regression analysis, which had an effect on F1, F2, and F3 in the *changes* category. The ratio of the beta weights is the ratio of the estimated unique predictive importance of the independents. In this case, the *change of eagerness to ICT* is the dependent variable, and F1, F2, and F3 are the independent variables. By taking a standardized beta-regression, the effect of *multimedia design* on the level of students' eagerness to use ICT was very strong and had significant effect (See table 6).

Table 6: the standardize Beta for showing the change of Eagerness to ICT

	Standardized Beta			R	
	Explanation Design	Multimedia Design	Site Structure Design		
Changes of Earganess to ICT usage in Math.	-0.53	0.72 **	0.03	0.46	F(3,34)=3.02, p<0.05

n=38

4. Conclusion

Many mathematics teachers hope not only to be able to teach easily and understandably, but also to be able to make a difference in the lives of their students while encouraging them to learn mathematics. An effective mathematics teacher must be able to design lessons and activities that meet the needs of students. For this, there are three recommendations that have come from the results of this research.

4.1 About effective methods for designing Web resources

If the teachers are willing to start making a Website, it is suggested that they:

- Determine what standards students already know and to what degree.
- Recognize what minor modification or major changes in instruction they need to make so that all students can succeed in further instruction and assessments.
- Create appropriate lessons and activities for groups of students or individuals who are more actively seek challenges than others.
- Inform students about their current progress in order to help those set goals for improvement.

With the results of an online survey from mathematics teachers in 28 countries, it is shown that teacher almost all use web resources to find the information that they need. Their main needs are:

- Lesson planning
- Dynamic and interactive lessons
- Printable worksheets
- Detailed explanations
- Engage the students in challenging their learning of mathematics
- Projects and presentations
- Questions and answers
- How to use web resources and mathematics software

It is recommended that well-structured Web resources are dependent upon students' activities in real-life. There are some activities that depend on real-life situations where students, working in small groups, present mathematical models as solutions. These models enable students to evaluate their solutions and help sustain productive and effective problem-solving skills. On the other hand, it is recommended that a method for self-assessment by the students to evaluate their rate of their learning be implemented. Based on Web resource design, when students submit the answers to dynamic questions, it will immediately give scores and present references that can be used as a self-assessment. The system offers learners reference materials to help them find correct answers. Students, by comparing their results, will try to become better than before, paying closer attention to lessons. Also, we need patterns to visually model the use of such Websites by teachers and students.

4.2 About expanding students' interaction through the Internet

Based on online methods suggested for collaboration, we recommend the video conference come to the classroom. *Integrating video conferencing into the classroom involves overcoming several challenges, and various models and strategies can be offered.* Video conferencing should be containing:

- Giving and receiving help and assistance
- Exchanging resources and information
- Explaining and elaborating on information
- Sharing existing knowledge with others
- Giving and receiving feedback
- Challenging others' contributions (e.g. cognitive conflict and controversy leading to negotiation and resolution)
- Advocating increased effort and perseverance among peers
- Engaging in small group skills
- Monitoring each others' efforts and contributions

Teaching by video conferencing, as mentioned before, demonstrated the effect of the ARCS method on three factors of Website design: e*xplanation, multimedia, and site structure*. The results of the pre-test and the post-test for the *usage of ICT* showed that the e*agerness of students* to learn had a large difference. If we try to communicate with the other schools by video conferencing, it will have a very positive effect on promoting the usability of ICT by students. *Therefore, collaborative learning by video conferencing in the teacher community supports results in the student community as well.*

As a next step, it is necessary to identify the visual characteristics in multimedia that make meaningful relationships between multimedia and learning. Furthermore, it is necessary to design server-side multimedia that can be stored as data for analysis or used by students and teachers. Ideally, after gaining the support of teachers to promote the use of visualized geometry in their lessons, we can start thinking about how best to manage an e-learning system that covers many students who may have no opportunity to attend to school.

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