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An interactive flash application as a supplementary teaching tool in higher education

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An interactive flash application as a supplementary teaching tool in higher education

by

Eunice Cho

A thesis submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of

MASTER OF FINE ARTS

Major: Graphic Design

Program of Study Committee:
Sunghyun Ryoo Kang, Major Professor
Debra Satterfield
Mikesch Muecke

Iowa State University
Ames, Iowa
2005

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Graduate College
Iowa State University

This is to certify that the master’s thesis of

Eunice Cho

has met the thesis requirements of Iowa State University

Signatures have been redacted for privacy
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ABSTRACT

Educational Flash applications have received the attention of researchers and educators in higher education as a result of the evolution of technology, including high-speed Internet, advanced hardware and software, and the seeking of new learning paradigms from the constructivist's point of view. However, existing educational websites utilizing Flash contain limited interactivity, and few websites have been created which adapt valuable educational theories that sustain and enhance the learning processes that suit the Net generation. The purpose of this study is to examine educational theories which are relevant to current educational contexts and learners and to propose a guideline for developing an educational application. In addition, by providing an educational Flash application, the author discovers potential applications using Flash to enhancing the learning process, based on literature which has been previously discussed. To create the educational Flash application, the author selected the subject, "learning grid systems" for design students in higher education. The validity of this application is examined by learners' evaluations. The guidelines proposed by the author can be utilized by developers and educators to create instructional applications based on valid educational theories. Also, the Flash application as the prototype for this study is an illustration of a higher education use of Flash.
CHAPTER 1. INTRODUCTION

The evolution of technology, including high-speed Internet and advanced hardware and software, has been considered one of the major factors that has prompted social and cultural changes. In everyday life, checking e-mails, reading news and buying movie tickets online are no longer foreign activities to people living in this new millennium. People frequently spend time shopping online, in the same way they enjoy perusing shopping malls and department stores. People also take advantage of opportunities to manage their financial activities online.

Advanced technology also encompasses changes in educational contexts. Communication among faculty, students, and institutions consist mainly of e-mail and Intranet transfers. Academic libraries support electronic catalog services. Online learning courses and electronic educational applications, such as tutorials, have been expanding rapidly in the area of higher education. In the context of these social, cultural, and educational changes, there have been consequences in the characteristics of learners and their learning styles.

However, educational changes proceed from not only the evolution of technology, but also from pedagogical achievements in the last few decades. From Jean Piaget's studies about the development of human intellect and constructivism, to sensory perception and experiential learning theories, many studies have been conducted to support this new paradigm of education. Utilizing new technology as a medium in learning environments, providing new instructional technologies and e-learning environments, based on these educational theories, is an exceedingly important issue in higher education.

From this standpoint, while many educators have begun to demonstrate an interest in Flash as an instructional tool, many commercial websites have also been developed using Flash technology. Research confirms the effectiveness of interactivities for e-commerce websites in attracting the attentions of customers, reporting that “The interactive nature of websites has been credited with increasing the desire to browse and purchase online.” (Fiore & Jin, 2003, p. 38) For instance, apparel sites, such as Kenneth Cole and Land’s End, provide image interactivity functions for showing the sensory or aesthetic features (e.g. color, texture) of their merchandise. Customers can visualize what the products would look like by zooming in and out, and may view the products with a customized model from 4 different views. Also, numerous websites of automobile manufacturers, such as Seikousa.com, Miniusa.com, and Vw.com, display “showrooms”, in which users can observe
products with a $360^\circ$ view of the exterior and interior. It appears to be undeniable that users cannot only envision products, but also enjoy browsing the websites.

Even though applying Flash for educational websites and applications has attracted the attentions of innumerable colleges and universities, there are few websites and applications utilizing Flash for educational purposes. Some websites use Flash for more interactive navigational methods, by using animation, and some help in visualizing resources or simulations by using Flash for better understanding. However, these websites and applications use very little interactivity compared to commercial websites, even though Flash promises diverse potential for educational purposes, based on educational theories.

The objective of this study is to examine the educational theories which are relevant to current educational contexts and learners, and discover the potentials for using Flash for enhancing the learning process, based on prior literature and theories. The author will propose a Flash-based educational application as a prototype for this study. The selected subject of this application is “learning grid systems” for design students in higher education. By developing this application and from the learners’ evaluation, following questions will be addressed in this study.

1. How important is it to provide various interactivities and sensory information, and support learning styles to enhance the learning process and the student’s willingness to learn?
2. Does Flash have the potential to create various interactivities, deliver sensory information, and support various learning styles?
3. How would Flash educational applications enhance students’ learning processes and their willingness to learn?
CHAPTER 2. METHODOLOGY

The thesis methodology starts with a literature review. This literature review consists of six parts: social and cultural changes, educational context changes, the Net Generation and their learning style, interactivity in E-learning, educational theory and the current use of Flash.

In this literature review, the author examines how the social changes and the changes in educational context have developed. Another area to be studied relates to the characteristics of the current young generation, called the “Net Generation” and the nature of their social and educational expectations. The previous literature on interactivity and its dimensions will also be reviewed, examining the role of interactivity in E-learning environments and those aspects, which are important to enhancing communication and the learning process.

The research on constructivism is for understanding educational theory, which is influential and relevant to the current educational context. This study of constructivism provides the definition of knowledge, experience, learning environments, and the learning process. Existing learning styles, based on four learning modes, are discussed by reviewing experiential learning theory. The research also examines how sensory input supports learners.

The author also analyzes current use of Flash technology in higher education and industry to investigate what Flash can do to enhance the learning process.

This literature review illustrates the basic outline of an interactive educational application, and provides the criteria which designers and instructors may apply, to enhance the learning process from a constructivist’s point of view.

A subject matter is selected which is visualized in a Flash-based educational application. This application will be used as a supplementary tool in higher education. The Flash-based educational application contains various interactivities and sensory information to support various types of learning styles. Finally, the Flash-based educational is tested with the validity test form, developed by the author for students’ evaluation.

Guidelines for developing the educational Flash Application

1. This application should be visually attractive to the Net generation since the majority of users will likely be university or community-college students, considered to be the Net generation.
2. The level of interactivity should be a combination of “Reactive level” and “Proactive level” in which learners not only respond to the stimuli as a quick navigational response, but
also generate their own knowledge with creative activities. However, there will be limitations which will provide a control over the content, since this application will be a supplementary tool. (Rhodes, D. M. & Azbell, J. W, 1985; Thompson, J. & Jorgensen, S., 1989; Schwier, R. A. & Misanchuk, E., 1993)

3. The interactivity of this application should have learner’s options choices so that the learning process is not limited to a linear sequence, and learners can control the sequences of their learning. (Laurel, B. K., 1986; Heeter, C., 1989; Borsook, T. K. & Higginbotham-Wheat, N., 1991; Ha, L. & James, E. L., 1998)

4. This application should provide a sense of playfulness in terms of interactivity. Since the users are from the Net generation, by providing a playful environment, learners could be encouraged to participate actively in the learning process and help keep them motivated. (Ha, L. & James, E. L., 1998; Tapscott, D., 1998)

5. Sense of place. By providing activities and interactivity, learners could feel sense of place in this E-learning environment, where they actually experience new information and participate in the learning process. (Downes, E. J. & McMillan, S. J., 2000)

6. Constructivist’s learning environments – this application is not only a tool, but also an E-learning environment, providing the opportunity to experience new information and reconstruct knowledge rather than just delivering information. (Gros, B., 2002)

7. Supporting various learning styles. By providing four learning modes, which are the basis of four different learning styles, this application should support all students who have different learning styles. (Kolb, D., 1984; Kolb, A. & Kolb, D., 2004)


Objectives of the Application

This Flash-based educational application will be utilized not only as a tool for teaching or delivering information, but also as an electronic environment in which learners experience new information, practice for themselves and construct their own knowledge. This Flash-based educational application provides sensory information for improved understanding and new experiences. It will also include some activities or exercises with interactivity, rather than simply to present information, so that learners can assume an important role in the learning process.
Within this application, students learn the “grid system”, which designers utilize to place design elements, such as text, photographs, and diagram, in systematic ways. Learners will master basic information such as the definition of grid systems, grid system terminology, the history of grid systems, etc. This application also provides activities in which learners will receive experience in the proper methods of constructing grids. However, those activities will not include actual design projects, since this application will only be used as a supplementary tool in conjunction with a design class.

Contents of e-Studio for Learning Grid Systems

The author takes some of the information used as learning content from two books, Hurlburt’s “The grid” and Muller-Brockmann’s “Grid systems in graphic design”, and Bear’s article from the About Inc.’s Website. The following paragraphs contain the information that has been used as the content for the interactive Flash activities in this application.

The development of grid systems

Origins

Dictionaries define the grid as “a network of uniformly placed horizontal and vertical lines for locating points by means of coordinates.” Grids were used by Renaissance artists as a method of scaling their sketches and cartoons to fit the proportions of monolithic murals. Grids are basic to cartography and for centuries military plans have been plotted on the coordinates of grids. Classic architects used grids to plot perspective and scale their plans. From the time of Gutenberg typographers have used grids to design letters and complete the makeup of the printed page. (Hurlburt, A., 1978, p. 9)

By the time civilization had spread across the Aegean Sea and reached its culmination in the acropolis at Athens, clear rules of aesthetic proportion had been laid down. It was Phidias, the master planner of the acropolis, and Ictinus, the architect of the Parthenon, who demonstrated the design potential of the division of a line into an extreme and mean ratio. This was the division of space that was later to be known as the “golden section”. (Hurlburt, A., 1978, p. 10)

One of the earliest definitive statements of the formal order of aesthetic form was contained in a book written by Fra Luca Pacioli in 1509 called De Divina Proportione. The proportion that he called divine is the continual proportion way that the proportion of the full distance to the larger part
should correspond geometrically to the proportion of the larger segment to the smaller. When extended, these proportions become a Fibonacci series (named for a thirteenth century mathematician from Pisa). This is a series in which each succeeding number is equal to the sum of the two preceding numbers. (Hurlburt, A., 1978, p. 10)

**Golden Section**

This set of proportions is based on the pentagon-a regular five-sided polygon—that, together with its related pentagram, or five-pointed star, consists of scores of golden sections. The golden rectangle is constructed with the short side equal to the extreme section of the long side. It is also possible to construct a golden rectangle beginning with the square of the extreme section.

The golden section is an irrational number, 1.61803398, known as $\Phi$- a symbol chosen to represent it in the early twentieth century because it is the first letter in the name of the Greek sculptor and planner, Phidias. The golden section is usually expressed algebraically as $a:b = b(a+b)$.

In the twentieth century two people played a primary role in the revival of the golden section as a design element. One was Jay Hambidge, an author and art instructor, whose book “Elements of Dynamic Symmetry” was first published in 1920. The other was Le Corbusier, an authentic genius of twentieth century design, who developed the first clearly identifiable design system called the Modulor. (Hurlburt, A., 1978, p. 10-14)

**The Modulor**

Le Corbusier began to work out a system of architectural proportion called the Modulor. He developed the Modular system based on the golden section and the human proportions and built it around three main points of the anatomy- the top of the head, the solar plexus, and the tip of the raised hand. In any event the Modulor made a major contribution to the form of modern architecture and became the foundation stone for most design systems and modern grids.

The most important contribution of the Modulor to two-dimensional design was the inspiration it gave to the typographic designers of Germany and Switzerland to create the modular systems that would transfer utilitarian makeup sheets to design-oriented modern grids. (Hurlburt, A., 1978, p. 15-16)
The Modern grids

Because the development of the modern grid was an evolutionary process, it is impossible to isolate a single designer as its inventor or accurately list all the pioneers who contributed to the development of modular systems of graphic design. The design schools of the European continent were its principal laboratories, and its influence spread swiftly around the world in the 1950s and 1960s.

In recent years the grid has been used to solve a wide range of design problems. It has been an important aid in the preparation of annual reports, brochures, directories, catalogues, sign systems, advertising campaigns, and corporate identification programs. (Hurlburt, A., 1978, p. 17-26)

Constructing Grid Systems

Traditional Grid System

The traditional grid system is often used for book design. The proportions of this grid system are similar to the golden section, but are not exactly the same.

Grid System Terminology

Margins. Margins define the outside boundary of your page. They frame the content of your pages. Margins may not be equal all around (but are normally consistent from page to page or panel to panel). In most programs you would set the margins when you define the page dimensions (format). You can also adjust the margins "on the fly" by moving the guides on screen (in some programs). (Bear, J. H., 2005)

Alleys. When you divide the interior space of your page into uniform parts the white space between units are alleys. Depending on how you've set up your grid the alleys may run horizontally, vertically, or both directions on your page. In some designs this would translate to the white space or "gutter" between columns of text. (Bear, J. H., 2005)

Gutters. In a two page or two panel spread, the gutter is the inside margin. It's the space on either side of the fold. In some page layout programs the space between two columns of text is sometimes called the "gutter" as well. (Bear, J. H., 2005)
Margin proportions

The type area is invariably surrounded by a marginal zone. For one thing, there are technical reasons: as a rule discrepancies of between 1 and 3 mm and often as much as 5 mm occur when the pages are trimmed. Without a proper margin the text itself might be mutilated. For another, there are aesthetic reasons. A well-proportioned margin can enhance the pleasure of reading enormously. All the famous typographic works of previous centuries have marginal proportions which have been carefully calculated using the Golden Section or some other mathematical formula.

If the margin is narrow, oblique trimming of the page leaps to the eye at once. The wider the margin, the less likely it is that technical inaccuracies, which always exist, will detract from the appearance of a well-designed page. If the margins are too large, it is difficult to avoid a sense of extravagance and the feeling that an exiguous text has been made to go a long way. Conversely, a well-balanced and proportioned relationship between the margins on sides, head and tail can produce an agreeable and restful impression. (Muller-Brockmann, J., 1985, p. 39)

Width of column and Leading

Width of column. Every difficulty standing in the reader's way means a loss of quality in communication and memorability. When a line is too short, the eye is compelled to change lines too often and this again wastes energy.

The right width of column is essential for an even and pleasant rhythm of reading which enables the reader to relax and concentrate wholly on the content.

According to a well-known empirical rule there should be 7 words per line for a text of any length. If we want to have 7-10 words per line, the length of the line can be calculated. (Muller-Brockmann, J., 1985, p. 30)

Leading. Good leading can carry the eye optically from one line to the next, giving it confidence and stability, and enabling it to absorb and remember more easily what has been read. When reading is smooth and easy, the meaning of the contents is grasped more clearly. Like the right width of column, the right leading of the text is also a factor determining easy legibility.

Too open a pattern disrupts the cohesion of the text and the lines appear isolated and figure as independent elements. In this case, the print loses its compactness and looks dead and lacking in design. The reading speed is slowed down unless new motivating factors are operative.
A similar negative effect can also be produced by composition in which the lines are set too close together. The type appears too dark and the lines forfeit their optical clarity and restfulness. (Muller-Brockmann, J., 1985, p. 34-35)

**Construction of type area**

The format of the page and the size of the margins determine the size of the type area. The general aesthetic impression created depends on the quality of the proportions of the page format, the size of the type area, and the typography. When preparing a sketch, the number of columns on a page is one of the points to be considered.

- 1 column for a text and illustrations leaves too little freedom to reproduce pictures in large, small or medium size.
- 2 columns for text and illustrations give more scope: the text can go in the first column and the illustrations in the second. Text and illustrations can also be placed in the same column one below the other. Moreover the 2-column division can be subdivided again to form a 4-column page.
- 3 columns can also afford a variety of opportunities for accommodating text and arranging the illustrations in various sizes. The 3-column system can also be subdivided into a 6-column arrangement. The disadvantage of the 3- or 6-column layout is that the lines of text become relatively narrow and consequently a small typeface would have to be selected. This is a question that depends on the function to be performed.
- Division into 4 columns is advisable where space has to be found for a lot of text and a large number of pictures or where statistics have to be displayed with copious figures, graphs and trend lines. The 4-column can also be further subdivided into 8, 16 and more columns, which is convenient for showing statistics. (Muller-Brockmann, J., 1985, p. 49-56)
CHAPTER 3. LITERATURE REVIEW

Social and Cultural Changes

In the last few decades, the world has made outstanding progress in the area of communications and in the manner in which people live. People frequently use digital devices; not only computers, but also DVD players, digital cameras, camcorders, PDAs, and mobile phones. Subrahmanyam, Greenfield, Kraut, and Gross say that over the past few years a growing number of U.S. households have added these digital devices and they have connected the Internet to some of those devices, such as the telephone, radio, TV, and stereo system. (Subrahmanyam et al., 2001)

High-speed Internet access and the advanced hardware and software of information and communication technology have promoted huge changes that have led to the new way people live. By using the Internet, people do their shopping, look for movie schedules, pay their bills, and even conduct research. In the U.S., under the Clinton administration, it became public policy to make computer access and the Internet available to all U.S. residents.

“As Clinton’s assertion suggests, in the 1990’s computer access was a goal – indeed, a symbol – of the mission to educate the broader U.S. public, to prepare all citizens for life in the twenty first century. Computers and the Internet were introduced to the lives of the poor and working classes through initiatives to make computer use commonplace in public schools, libraries, and museums – institutions shaped by a mission to educate the broad public.” (Goldfarb, B., 2002, p. 9)

As a consequence of new technological developments and U.S. government policy, Internet access has rapidly increased. In October of 1997, 50.8% of households with computers had Internet access, and it has since increased to 81.4% of households with computers have Internet access. (Hughes, R. J. & Hans, J. D., September, 2001, p. 778-792) Today, 94 million American adults have Internet access. In 2000, 55% of those with Internet access, approximately 52 million people, go online daily and perform a wide range of activities. Howard, Rainie and Jones say that 48 million Americans are using e-mail, searching for information or completing a transaction. (Howard, P.E.N., Rainie, L. & Jones, S, 2001, p. 383-404)

It seems that the Internet has become an important tool for many Americans in their daily lives. According to Howard et al., three-quarters of Internet users think that the Internet helps them to acquire new information. Half of them say the Internet improves the way they pursue their hobbies.
37% report that it improves the way they do their jobs. Thirty-four percent say the Internet improves their ability to shop and 26% say it has improved the way they manage their personal finances. (Howard et al., 2001)

Not only for American adults, but also for the younger generations, the Internet has evolved into an essential tool for their everyday lives. Many studies have been conducted about how the Net Generation uses the Internet, and what their perceptions are of the Internet. They appear to be more willing to explore new technologies and to use these technologies than the older generations. The authors of the article, ‘The Impact of Computer Use on Children's and Adolescents' Development’, state that teenagers are more likely than adults to report using the Internet for social purposes. (Subrahmanyam et al., 2001) For example, teenagers are more likely to report using the Internet to communicate with friends, meet new people, obtain personal help, and join groups. They are also more likely to use the Internet to listen to music, play games, and download software. Teenagers also use the Internet for schoolwork, for finding information related to their interests and hobbies, and obtaining educational materials. In summary, teenagers use the Internet for a variety of reasons, such as communicating with others, enjoying their lives and acquiring new information.

Roberts, Foehr, Rideout, and Brodie conducted an interesting survey which shows how the Internet is important to teenagers in their everyday lives. The survey states that when a national sample of children and teenagers were asked to pick which medium they would choose to bring with them to a deserted island, more children from the ages of 8 to 18 chose a computer with Internet access than any other medium. (Roberts, D. F., Foehr, U. G., Rideout, V. J., & Brodie, M., 1999)

From those statistics of computer ownership and Internet access, and the qualitative studies on the impact of computer use and Internet access, we can see how people’s lifestyles have changed over the last few decades. People are more likely to use e-mail, rather than letters, for communicating with friends and family. They also use the Internet for searching for information instead of traveling to the library to review books or magazines. People often spend their time shopping online rather than perusing shopping malls or department stores. People also take advantage of opportunities to manage their financial activities on-line. In this context, businesses and organizations have to provide their own web-sites to advocate for themselves to their clients and promote their products and services. Many organizations manage their web-sites to afford better communication among their members, and to introduce their activities to others.
Education Changes

Extensive changes in the world of communication have affected the context of education. Large numbers of on-line courses have been created, and many different types of media have been adapted in the teaching and learning environment. The result of surveys by the U.S. Department of Education's National Center for Education Statistics show the evidence of these changes; such as the development of Distance Education Programs. An increasing number of college courses incorporate information and communications technology. (Waits, T. & Lewis, L., 2003) Finally, an increasing amount of a student's study time is being performed on the Internet, and a growing number of institutions are using the World Wide Web. Those educational changes in terms of learning environment, use of technology in learning process can be explained as one of the factors that draws the changes of learners' learning styles and learning behaviors. (Naidu, S., 2003)

The following line graph demonstrates how the learning environments have changed in terms of using computers and the Internet in the school (Figure 1). As this graph shows, the percentage of instructional rooms with Internet access increased rapidly from 50% in 1998 to 85% in 2001. Approximately 99% of schools had access to the Internet in 2001. (Kleiner, A. & Farris, E., 2002)
One other significant change involves the communication between instructors and students. Since most students have Internet access either at home or in public spaces, one of the most common individual methods of communication is the e-mail feature of the Internet. By exchanging e-mail, a student can receive individual guidance from the instructor. A student might be hesitant to ask a question in a classroom. By utilizing e-mail, he/she doesn’t need to check an instructor’s schedule, make an appointment and actually go to the office to have his/her questions answered.

As one of the asynchronous communication methods, some on-line courses have on-line message boards, which allow students to post questions and offer replies by the instructor. In Vonderwell’s qualitative study, ‘An Examination of Asynchronous Communication Experiences and Perspectives of Students in an On-line Course: a Case Study’, Vonderwell claims that with the anonymity that the asynchronous discussion boards offer, students feel more comfortable, and it presents more opportunities to ask questions and open more chances to interact with an instructor. (Vonderwell, S., 2003)

Recently, numerous papers related to social and educational changes have been published. Within this research, a host of new terminologies have originated in the educational arena, such as:
on-line learning, virtual learning, distributed learning and etc. Each of these terms has its own unique attributes, but all of them refer to the educational processes that utilize information and communications technology. Based on Vonderwell’s study, the author uses ‘E-learning’ as a large category that includes all the above terminologies.

The demand from constituencies

Naidu listed the forces of deriving the growth and development of ‘E-learning’ in the research as follows: (Naidu, S., 2003)

1. The increasing accessibility of information and communications technologies and also their decreasing cost.
2. The capacity of information and communications technology to support and enrich conventional educational practices through resource-based learning and synchronous and asynchronous communication.
3. The need for flexible access to learning opportunities from distributed venues such as the home, workplace, the community-learning center, as well as the conventional educational institution.
4. The demand from isolated and independent learners for more equitable access to educational opportunities and services.
5. The belief among many educational institutions that the application of information and communications technology will enable them to increase their share in an increasingly competitive educational market.
6. The need, among educational institutions, to be seen to be “keeping up with the times” in order to attract the attention of parents, students, and other donors.
7. The belief and the expectation that ‘e-learning’ will reduce costs and increase productivity and institutional efficiency.

As Naidu listed, advanced information and communication technologies allow resource-based learning to support synchronous communication as well as asynchronous communication with affordable costs. (Asynchronous learning means that ‘teaching’ and ‘learning’ for learning processes happen in some time lag. There are some kinds of medium, which contain information, resources or messages from an instructor and students can read the information, resources or messages later. Contrary to this, synchronous learning means ‘teaching’ and ‘learning’ happen simultaneously.) Because of the social changes mentioned earlier, such as high speed Internet access, and the new ways of communicating and living, changes occurred in the learner’s behaviors and the learning-
teaching environments. Students demand flexible access to educational resources and services, and the high-speed Internet has enabled flexible access and asynchronous communication to be made available in the learning process in many educational institutions. Also, as one of the involved constituencies, parents desire an advanced educational environment for their children. The heads of educational institutions also want to advocate their programs by providing a more advanced educational environment. These aspects have worked as a catalyst for the development of ‘E-learning’.

**Constructivist learning theory**

The teaching-learning environment has changed from instructor-centered education to student-centered education. Increasing attention to the role of learners in the learning process has been directed towards focusing on more effective ways of facilitating appropriate learning environments for learners, rather than the focus being on more simplistic methods for instructors to teach. The educational theory that has been borne of this trend is constructivism. Constructivism is a philosophy of learning in which the fundamental idea is that learners construct their own understanding of knowledge based on prior experiences and prior knowledge. Therefore, learning is not just understanding new information that instructors deliver, but adjusting and reconstructing prior experiences to accommodate new knowledge. This theory has precipitated the educational area in establishing the best teaching methods and what instructors should do for their students.

The authors of “Delivering Digitally” define good teaching as follows:

“Considered at one level, we can say that teaching should be directed at creating opportunities to develop the ability to act appropriately within a particular domain of action. Considered at a deeper level, we could say that teaching ought to involve providing the contexts in which learners can acquire both the tactic and the conceptual knowledge from which appropriate action arises. (Inglis, A., Ling, P. & Joosten, V., 1999, p. 31)

What the authors are focusing on at the deeper level is **good teaching**. Teachers ought to be able to create environments in which learners can not only acquire knowledge from experiences that give rise to intuition and imagination, but also acquire conceptual knowledge which is provided by theoretical frameworks to practical experience. In the new environments, by practicing tacit knowledge and theoretical knowledge, learners construct their own awareness.
Based upon the constructivist learning theory, educators began to shift their attention to focus on competent environments for effective learning and how to encourage learners to analyze, synthesize and predict information.

**The “Net Generation” and Their Learning Styles and Preferences**

In the article “Knowledge construction and technology” (2002), Gros points out that “one of the most important problems facing education and training today is that most instructive approaches do not correspond to the needs of today’s children and young people or the type of society in which they live.” (Gros, B., 2002, p. 326) What Gros emphasizes is that by considering knowledge to be something static which would be delivered by an instructor, teaching cannot enable learners to construct their own knowledge and take responsibility in the learning process. This would compel learners to act in a passive manner, and the learning process would become ineffective. To encourage an effective learning process, instructors should understand the characteristics of learners and their learning styles, so that instructors can provide and facilitate appropriate learning environments in which learners can take an active role in the learning process.

**The definition and the characteristics of the “Net Generation”**

Demographers call the period between 1977 and 1997 the “Baby Boom Echo”, and the people born in the era became known as the “Net Generation”. The term the Net Generation defines the characteristics of the Baby Boom Echo generation, and means that they have grown up with more exposure to digital media (television, videos, CD players, Gameboy, computers, the Internet, PC games, etc.) than any previous generation. Obviously, they have grown up with very different environments than other generations and their characteristics are distinguishable. The author of “Growing Up Digital” explains the characteristics of the Net Generation as fierce independence, emotional and intellectual openness, inclusion, free expression and strong views, innovation, preoccupation with maturity, investigation, immediacy, sensitivity to corporate interest, and authentication and trust. (Tapscott, D., 1998, p.68-77)

**The Net Generation and their learning styles**

Numerous studies have been conducted about the characteristics of the Net Generation and their learning styles. There are some disagreements about the characteristics of childhood and the impact of digital technologies. David Buckingham, author of the book “Media Education”, makes a
valuable point when he compares two representative researcher’s views. (Buckingham, D., 2003) One opinion is expressed by the author of the book “The Disappearance of Childhood” (1983), by Neil Postman. The other conviction is offered by Don Tapscott, author of the book “Growing Up Digital” (1998). Postman’s main argument is that our modern perception of childhood is a creation of the print media, and new forms of media, such as television, are destroying it. Children are being exposed to bad ‘secrets’ of adult life, such as sex, drugs, and violence, and they need to be protected from the new media. (Postman, N., 1982) Buckingham points out that Postman wants to return to an imaginary “Golden Age” of traditional moral values – and thereby reinforce adult authority and control, and that schools are the fortress in the defense of the print culture. On the other hand, even though Tapscott acknowledges the negative impacts of digital technology, he interprets it in a very different way, and goes on further to explain how to use the new technologies. He believes that the Net Generation are savvy, self-reliant, analytical, creative, inquisitive, accepting of diversity, socially conscious and globally oriented. By separating the Internet from television, he considers the Internet as a form of liberation or ‘empowerment’ for the Net Generation. (Tapscott, D., 1998)

Basically, these differing views provide insights into interpreting the characteristics of the Net Generation. Tapscott considers the Net Generation to be active learners or creative thinkers who possess positive self-esteem, and the ability to analyze new information and express their own ideas. Because of these positive characteristics, the adversarial aspects of digital environments cannot negatively influence the Net Generation. Challenging this argument, Buckingham believes that media education is the new paradigm, because those new media such as Internet, computers and etc. are the major contemporary means of communication, and he directs the focus on the application of the media to education.

The learning styles of different generations vary by personal preferences, gender, age, and culture. To understand the general learning styles of the Net Generation, it is worthwhile to examine their culture in the Net environments. The Net Generation spends considerable time doing their schoolwork, searching information, and engaging in social activities on the Internet. This applies if we consider culture as “the predominating attitudes and behavior that characterize the functioning of a group or organization. (Dictionary.com)” The following characterize these predominating attitudes and behaviors:

First, the Internet is a liberated place in which anybody can play without disclosing one’s personal information, such as age, gender, nationality, etc. By maintaining anonymity, the Net users are allowed to be increasingly open in expressing their ideas. The Net users act independently within their anonymity. The Net users can effortlessly run their own homepages or create on-line...
communities according to their preferences, hobbies or interests. The homepage or on-line community owners do not want to be controlled by others, but they do desire spontaneous participation from others.

Second, the heart of the Net culture is interactivity. The Internet provides different types or levels of interactivity with which the Net users navigate and perform their activities. From simple navigational interactivity to deeper levels of interactivity, Internet users experience and interact with information, environments, and other people.

Third, the Net environment has the potential to be playful. Numerous websites are available for every conceivable subject matter. After retrieving a variety of websites, Net users are afforded hundreds of choices, so that they are able to leave one site when they lose interest, and move on to other sites. Net users are also capable of engaging in multiple tasks simultaneously. For example, they are likely to maintain several browser windows distinctly for listening to music. For these reasons, the Web hosts try to hold a Net user's attention by attracting them with interesting site contents, eye-catching visual images or animation, games, etc.

Based on his study of the Net Generation, Tapscott introduces a new learning paradigm - "Interactive Learning". This technique includes the following eight shifts from traditional practices to this new paradigm: 1. from linear to hypermedia learning, 2. from instruction to construction and discovery, 3. from teacher-centered to learner-centered education, 4. from absorbing material to learning how to navigate and how to learn, 5. from school to lifelong learning, 6. from one-size-fits-all to customized learning, 7. from learning as torture to learning as fun, 8. from teacher as transmitter to the teacher as facilitator. (Tapscott, D., 1998)

The author believes that, based on the characteristics of the Net culture, these shifts that Tapscott introduces seem to be valid claims for the constructivist's point of view.

The Interactivity in e-Learning

Traditionally, interactivity refers to face-to-face communication. Based on recent advanced developments in information and communication technology, different types of interactivity have been receiving attention; such as human-to-contents communication, human-to-machines communication, and human-to-human communication through a machine. By utilizing the new technology (the Internet, CDs, and DVDs) as learning tools, in which learning resources and information could be stored as digital forms and virtual learning space could be provided, asynchronous teaching and learning has become possible. This means that teaching and learning
happen in a different physical and temporal space. In terms of the characteristics of the E-learning environments, the interactivities take on an important role for enhancing the quest for knowledge.

In E-learning environments, providing diversified interactivities allows a learner varied ways of communicating with the environment and its contents. In other words, with those interactivities a learner can be involved in the teaching and learning process, responding to E-learning environments. An instructional technology designer could generate interactivities, creating possible ways of communicating between learners and environments or by providing an authorization of the learning process to students.

Weller defines interactivity as a characteristic that allows learners to control the instruction to meet their needs and capabilities. According to Weller, a learner is considered an active participant in the instruction. By bringing interactivity to them, learners have more control over the learning process, such as the amount of time to study, the pace of learning, the sequence of the instructional materials, etc. (Weller, H., 1988, p. 23) Sims also believes that "interactivity plays a crucial role in knowledge acquisition and the development of cognitive skills, and that interaction is essential for effective instructional practice and individual experience". (Sims, R., 1997, p. 157)

What both Weller and Sims focus on is the relationship between interactivity and learners. The role of interactivity in the learning process is to enable learners to be active and provide them with engagements and controls. With interactivity, learners are no longer passive knowledge receivers, but active participants, and can practice and experience individually.

The authors of "Distance Education- A Systems View" (1996), Moore and Kearsley, claim three types of interaction that allow students to learn effectively in distance learning environments. These are: learner-content interaction, learner-instructor interaction, and learner-learner interaction. (Moore, M. G., & Kearsley, G., 1996; Moore, M. G., 1989) Learner-content interaction is defined as the method in which a learner communicates with course materials or contents. This learner-content interaction brings out actual learning and changes in the learner's understanding and perspective. Learner-instructor interaction refers to the mode of communication between a learner and an instructor, and this learner-instructor interaction could motivate and stimulate the learner. By enabling learners to be active, the learning process could be more effective. Finally, when learner-learner interaction occurs, a student can feel engaged in learning without actually seeing other learners in their physical space. The most fundamental form of interaction in distance learning environments is learner-content interaction, in which the student becomes involved with the subject matter.

However, Hillman, Willis, and Gunawardena pointed out that Moore's three relationships exclude the learner-interface interaction that occurs between learners and the technologies that deliver
the instruction and contents. (Hillman, D. C., Willis, D. J., & Gunawardena, C. N., 1994) The learner-interface interaction is important because the interface is the actual means of delivering contents to learners. When learners accomplish certain tasks using the interface successfully, the learning process can be achieved effectively. Therefore, in the four types of interactive interaction, the interface becomes one of the parties.

Next, the author examines studies defining interactivity from many different points of view, such as the levels of interactivity, the dimensions of interactivity, and the interactivities in different environments.

**Dimensions of interactivity**

Broadly classifying interactivity, Schwier and Misanchuk provide three dimensions: levels (reactive, proactive, mutual), functions (confirmation, pacing, navigation, inquiry, elaboration), and transactions (keyboard, tough screen, mouse, voice). Schwier and Misanchuk define ‘levels’ as the capability of a learner’s controls. The second dimension is ‘functions’, which are the different types of interactive activities according to different roles or purposes. The third dimension is ‘transactions’, which are the actual ways or methods that learners use to communicate, using electronic devices. (Schwier, R. A., & Misanchuk, E., 1993)

It is worthwhile to examine the levels of interactivity in detail, since the learner’s involvements or controls are very important in constructivist’s learning environments. Then, the author investigates proposed dimensions of interactivity in other studies.

**Levels of interactivity as a dimension of interactivity**

The level of interactivity could be considered as one of the dimensions of interactivity and it refers to the degree of capabilities of controls which are allowed to learners in the process of learning. In other words, the level of interactivity refers to the power given to learners and the degree to which learners can control the learning process or the structure of the learning system.

Rhodes and Azbell propose three levels of interactivity. The first level is the ‘reactive level’ of interactivity, which provides a minimum of learner control in terms of content and structure. Program-directed options and feedback are manipulated so that learners can be led to react in ways the designer has preset. The second level is the ‘coactive level’ of interactivity, allowing learner control in the areas of sequence, pace, and style. So, with the ‘coactive level’ of interactivity, learners manage extended control of either structure or content, but not both. Finally, the third level is the
'proactive level' of interactivity, offering learners extended control of both structure and content. (Rhodes, D. M., & Azbell, J. W., 1985)

Similar to Rhodes’ and Azbell’s three levels of interactivity, Tompson and Jorgensen suggest three interactivity models. The first model is the ‘reactive model’. In this model, the learner is reacting to a stimulus with a pre-determined response, and knowledge is transmitted or delivered from an instructor or media to learners. The second model is the ‘proactive model’. The learner is actively involved in composing instruction and deducing principles from his/her own experience. The last model is the ‘interactive model’. This is a combination of the reactive and proactive models. This model can be positioned at the center of the continuum, which has two sides; the ‘reactive model’ and the ‘proactive model’. Thus, the ‘interactive model’ allows active input and involvement from the learner by an exchange between information transmission and simpler levels of learner involvement in contents and activities. Proposing these concepts, Tompson and Jorgensen emphasize that the ‘proactive model’ is not always appropriate for all learning situations and the ‘interactive model’ could be another option utilizing positive aspects of the ‘reactive model’ and the ‘proactive model’. This idea seems valid since it is not always possible to give all the control to learners in terms of content or learning objectives in a particular curriculum. (Thompson, J., & Jorgen sen, S., 1989)

Schwier and Misanchuk (1993) employ Tompson and Jorgensen (1989) three levels of interactivity and extend those definitions, providing a detailed explanation of each level of interactivity. They name the three levels: 1) reactive interaction level, 2) proactive interaction level and, 3) mutual interaction level, where the learner plays an important role with an active mode in the instructional environment. (Schwier, R. A., & Misanchuk, E., 1993) The reactive interaction is the same idea as Tompson and Jorgensen’s reactive level of interactivity, which allows a linear response for learners to the contents, such as feedback, email, etc. Also, Schwier and Misanchuk’s proactive level is same as Tompson and Jorgensen’s proactive level. This proactive level enables learners to construct their own sequence of learning and contents and it emphasizes learner’s constructive and generative activities. Schwier and Misanchuk’ significant level is the mutual interaction level, which is characterized by artificial or virtual reality designs.

Basically, the discussion of interactivity levels deals with the learner’s controls or involvements, and the outcomes of the learner’s responses to the contents and the structure of the learning process. Even though there are many different terminologies defining the levels of interactivity, it seems that there are three common concepts of the levels. These shared ideas are: the stimulus response level and two active levels of the learner’s control of contents and the learners’ control of structure in the learning process. As a constructivist providing E-learning environments, it
is important to encourage learners to be active participants in the learning process by providing the control of contents as well as the structure. It is widely held that learning is not an understanding of what instructors deliver, but the learners adjusting and reconstructing their prior experiences to accommodate new knowledge. By organizing their own structure and contents, which fit their learning styles, learners could take a more important role in the learning process and ultimately reconstruct their own knowledge.

**Other dimensions of interactivity**

Laurel defines interactivity as the degree to which a system exhibits ‘first-personness’. Laurel chose the word, ‘first-personness’ as a grammatical metaphor. (Laurel, B. K., 1986) The personal pronouns show the relationship between a viewer and a hero or heroine. In most movies and novels, a viewer or a reader is the third-person. Adapting this metaphor, Laurel emphasizes that interactivity could provide a first-person relationship between a learner and the context, enabling learners to be active. The three interactive aspects of first-personness are frequency, range and significance. Interactive frequency is a measure of how often user input is enabled. Range refers to the variety of choices available to a user during the interaction. Last, interactive significance is a measure of the impact of a user’s choices and actions upon the whole outcome/experience of an interactive session. Proposing these three aspects of interactivity, Laurel asserts that providing greater frequency of interaction and a wider range of choices will engage learners more actively and motivate them to perform more effectively.

Based on Laurel’s dimension concept, Kettanuak, Ramamurthy, and Haseman propose three dimensions of the degree of interactivity: frequency, range and modality. The only difference is the third dimension, which is modality. They define modality as ‘the use of different sensory systems both by the system and the learner’. (Kettanuak, V., Ramamurthy, K., & Haseman, W. D., 2001, p. 545) They indicate that different types of media channels and language variety are two attributes that could enhance higher interaction. An instructor should be able to choose appropriate media for a certain type of learning procedure. This seems to be a valid theory considering modality as one of the dimensions of interactivity, since there are many ways to present or transform information such as audio, graphics and video.

However, Heeter further defines six detailed dimensions in his article, “Implications of New Interactive Technologies for Conceptualizing Communication”. (Heeter, C., 1989, p.221-224)

- Complexity of available choice, meaning the amount and variety of user choices; also referred to as “selectivity”.

• The amount of effort any user of a media system must exert to access information.

• Responsiveness: interactivity is a continuous variable measuring how “actively responsive a medium is to user”. Also referred to as “conversationality”.

• Information use monitoring, that is, how well information selection can be monitored across an entire population of users.

• Ease of adding information, meaning the degree to which users can add information for access by a mass, undifferentiated audience. The most common example is Bulletin Board Systems (BBS) that are comprised almost entirely of user-generated content.

• Interpersonal communication facilitation, which comes in at least two forms: asynchronous (allowing users to respond to messages at their convenience) and synchronous (allowing for concurrent participation).

Heeter’s six dimensions seem very useful to communication technology developers and focus on the functional aspects of interactivity. These aspects include: providing information use monitoring and interpersonal communication facilitation, making the user’s input available, and ease of adding information. In fact, including the user’s effort to access information as one of the dimensions, Heeter emphasizes that the depth of interactivity or procedure to perform an inquiry or a task should be effortless for users. (Heeter, C., 1989)

Borsook and Higginbotham-Wheat suggest seven conceptual dimensions for interaction within a computer-assisted learning environment. These are: 1) immediacy of response either between people or between the student and the software program, 2) non-sequential/non-linear access to information, 3) adaptability, 4) choices of user options, 5) feedback, 6) bi-directional communication and 7) appropriate grain-size. One of the interesting dimensions is ‘grain-size’, which is defined as the length of time required of a given sequence before allowing for further input. (Borsook, T. K., & Higginbotham-Wheat, N., 1991)

Ha and James, in their analysis of business website’s interactivity, define interactivity as “the extent to which the communicator and audience respond to or are willing to facilitate each other’s communication needs”. They identified five dimensions of Web interactivity that fulfill different communication needs: (Ha, L., & James, E. L., 1998, p. 461)

• Playfulness; measured by the presence of such curiosity-arousing devices as “Question and Answer” formats and games.

• Choice: measured by the number of alternatives for color, speed, language, and other non-informational aspects.
• Connectedness; measured by the presence of information about the product, company, third-parties, and other content of interest to visitors.
• Information collection: measured by the presence of such monitoring mechanisms as registration forms and counters.
• Reciprocal communication; measured by the presence of response mechanisms, including the Webmaster’s e-mail address, surveys, and purchase others. (Ha, L., & James, E. L., 1998, p. 461-464)

Even though these five dimensions are for Web interactivity, some of the dimensions are still worthwhile to adapt for the designing of educational multimedia applications, especially playfulness, choice, information collection, and reciprocal communication. Specifically, it is interesting that they consider ‘playfulness’ as one of the dimensions of Web interactivity. To engage learners in the learning process, it is very important to provide motivations and it seems that ‘playfulness’ could be an effective motivation. In addition, by providing many choices and reciprocal communication methods, learners could receive more controls that would enable them to participate more actively.

Downes and McMillan propose six interactivity dimensions for multiple forms of computer-mediated communication in their qualitative research. They interviewed ten individuals, examining the user’s perceptions of interactivity. From these interviews there emerged certain concepts of interactivity. They proposed six dimensions, which are: 1) direction of communication, 2) time flexibility, 3) a sense of place, 4) a level of control, 5) responsiveness, and 6) a perceived purpose of communication. (Downes, E. J., & McMillan, S. J., 2000, p. 151) One of the interesting dimensions they proposed is a ‘sense of place’. According to Downes and McMillan, the more interactive a computer-mediated communication environment becomes, the more likely that the individual will feel that he or she has been transported to a virtual locality.

**Interactivity for involvements or engagements**

Hoyet Hemphill provides the levels of learner engagement in technology-based training, adapting Schwier and Misanchuk’s three interactivity levels. It is very interesting to note that Hemphill considers the levels of interactivity as levels of engagement.

The first level of learner engagement is simply a passive response to ‘page forward’, or some other action, to move to the next screen like Schwier’s stimulus-response interactions.

At the second level of engagement, the learner has some choices over instructional navigation and the control of information. For example, the learner can choose to get more information by
clicking on a target or branching to other screens. Those responses do not require an understanding of contents but do require mastery of simple navigation controls.

At the third level of engagement, the learner is required to understand the contents and make the appropriate response for a question or other form of inquiry. The question could be a simple factual one, or it could require some level of deeper comprehension or analysis.

At the fourth and highest level of engagement, the learner is asked to participate in a game or simulation, which Schwier calls ‘mutual artificial’ or ‘virtual reality’ designs. The simulation usually requires the learner to understand a simple to complex skill or procedure in some context, which could be a portion of or a whole model, or some real or imaginary task environment. The learners not only respond to simple navigational inquiries or questions but also interact with some environment, and they are transported to a model of real situations. (Hemphill, H., 2000)

Based on Hemphill’s model of engagement, obtaining more controls for the learning procedure and interacting with a portion of the whole environment means the level of engagement is reaching a higher level.

In the qualitative study of student perceptions of group interaction, Driver provides an interesting thesis, “the student’s perceptions of overall interaction in a web-enhanced environment could be improved through small group online activities rather than through one-on-one instructor attention and individual exchanges among all class members.” (Driver, M., 2002, p. 42) Driver examines the relationship between the learner’s satisfaction and interactivity. Even though this study has some limitations in making generalizations about other situations because of its exploratory nature, it seems nonetheless noteworthy that “small group learner-learner interaction may effectively enhance a student’s class experiences in the form of social presence, being part of a larger learning community, and enjoying the class in general”. (Driver, M., 2002, p. 43) Citing Fulford and Zhang’s findings (Fulford, C. P., & Zhang, S., 1993), Driver also asserts that the vicarious interaction can affects student class satisfaction, and group interaction can be vicarious when it comes to overall class interaction in the absence of significant learner-learner interaction. So, it seems that the small group learner-learner model could be substituted for other types of interactions such as instructor-learner interaction, or large group learner-learner interaction. This could possibly increase the learner’s perceptions of involvement or engagement, which could enhance the learner’s attitude toward the learning process.
Educational Theory

Constructivism

It has been said that the current educational paradigm has its roots in constructivism.

Jean Piaget is considered to be one of the most influential thinkers in the twentieth century field of Developmental Psychology and Constructivism. His approach was based on an evolutionary epistemology, which explains the development of human intellect within a biological point of view. According to Piaget, the development of human intellect proceeds through ‘adaptation’ and ‘organization’ when human mental structure communicates with its environment. Adaptation is a process of ‘assimilation’ and ‘accommodation’. (Piaget, J., 1963; Piaget, J., 1971) Assimilation occurs when a mental structure meets new external events. The mental structure uses an existing mental structure, called ‘schema’, to assimilate the events into thoughts. When new and unusual events cannot be explained within an existing mental structure, human beings try to change the mental structure and reconstruct the schema to accommodate the new and unusual events. (Huitt, W., & Hummel, J., 2003) Based on the concept of the development of human intellect, Piaget also proposes that there exist four major periods of development in the evolution of human mind: the sensorimotor period, the pre-operational period, the concrete-operational period, and the formal-operational. Learners in higher education are classified in the formal-operational period (adolescence and adulthood). Children start to use symbols or abstract reason. Instead of receiving information that they can immediately understand and use, individuals learn by taking in impressions through the senses and transforming these impressions into mental models that include logically structured beliefs and conceptions. (Piaget, J., 1963; Boudourides, M. A., 1998; Aik, C. T., & Tway, D. C., 2003) In this period, rather than providing information, it would be more successful to provide appropriate environments in which learners can construct their own knowledge by using impressions that they receive from the learning environment and activities. Therefore, Piaget’s human intellect development theory explains the basis of the constructivist’s concepts of ‘knowledge’ and ‘learning’ and it also gives us a clue about the importance of the environment and communication are to a learner in the learning process.

It has been considered that there are the two main branches of constructivism, which are cognitive constructivism and social constructivism. Cognitive constructivism holds that learning should be concerned with real situations, and whatever information is provided to the learner should be connected with real activities. (Piaget, J., 1997; Knowles. M. S., 1980)
By creating the four major periods of development in the evolution of human intellect, Piaget stands on cognitive constructivism, stressing the importance of individual learning rather than social or group learning. However, it does not mean that Piaget discards the social learning subject, but rather emphasizes the individual’s interaction toward the environment by using the assimilation and accommodation process. Piaget thinks that learning takes place when prior knowledge meets new knowledge. (Gros, B., 2002; Boudourides, M. A., 1998)

Lev Vygotsky is considered to be a leader of social constructivism. His main premise is that the child’s mind is inherently social in nature, and Vygotsky thinks that thought development proceeds the development of language through social interaction. Even though social constructivists admit that learning itself involves the individual’s personal and unique interpretation, they surmise that it takes place within a social context by exploiting other’s skills and providing social support to each other. In social constructivism, collaborative learning activities are important to enhance and explore the social process of participation. (Boudourides, M. A., 1998; Aik, C. T., & Tway, D. C., September, 2003)

However, Chong-Tek Aik and Duane C. Tway differentiate the constructivism from cognitivism. In cognitivism, which emphasized stimuli-response for the learning process, instructors have a central role in the learning process and have to provide structured knowledge to learners. According to Chong-Tek Aik and Duane C. Tway, cognitivists think that information is processed in three stages. First, information enters through the senses, and, if it is important or interesting, it then proceeds to short-term memory. Some of the short-term memory may then become long-term memory. Even though cognitivists and constructivists both consider learners to be active participants in the learning process, cognitivists prefer to focus on the methods instructors could use to interpret or deliver information and provide a context in which learners could perform tasks and solve problems to obtain structured knowledge. (Aik, C. T., & Tway, D. C., September 2003)

Chong-Tek Aik and Duance C. Tway point out that cognitivists emphasize that in order to explain learning behaviors, it is necessary to refer to internal mental processes and states, which can be called ‘human cognition’. Since constructivism uses human cognition as its starting point, it is said that constructivism stems from cognitivism. (Aik, C. T., & Tway, D. C., September 2003)

However, constructivists such as Piaget and Vygotsky go further beyond human cognition and emphasize the significance of individuals constructing their own knowledge, and this is the basis of ‘constructivism’. (Neo, K. T. K. & Neo, M., 2001; Jonassen, D., 1991) Even though learners are considered as active participants in cognitivism, cognitivists think that instructors take the main role in the learning process. Contrary to that, in the constructivist’s learning theory, learners take the
important role in the learning process, since they compose their own knowledge in the constructive context, and knowledge cannot be simply delivered by instructors. While cognitivism focuses on the goal of achievements with activities, constructivism emphasizes the experience with activities in constructivist environments. Although instructors have specific goals to accomplish, those goals are flexible; Instructors accommodate unplanned activities for learning and they must be facilitators in the construction of knowledge structures. (Dunlap, J. C., & Grabinger, R. S., 1996; Gros, B., 2002)

Significant view of constructivism is based on how to project the definition of knowledge. In the constructivists' view, knowledge is not an object, which can be simply achieved by doing tasks or solving problems, written in a book or transmitted to learners. The constructivists think that knowledge is something complex that must be rendered by learners when the new knowledge interacts with prior knowledge. (Gros, B., 2002)

Kamii and Ewing introduce Piaget's concrete concept of knowledge providing several examples. According to Kamii and Ewing, there are three kinds of knowledge: physical, social, and logico-mathematical knowledge. Physical knowledge is knowledge of objects in external reality, such as the color and the weight of a block. Social knowledge is information constructed by social agreements, such as holidays, written and spoken languages, customs, etc. On the other hand, logico-mathematical knowledge means the relationships created by various objects. For example, the similarity between different colors of blocks is logico-mathematical knowledge. Even though the colors are the properties of the objects in external reality and are observable, the logico-mathematical knowledge concepts such as relationship and similarity would not exist by themselves. Instead, relationship and similarity are determined by the connection between the objects. Therefore, the theory follows that the source of logico-mathematical knowledge is in each person's mind, because the knowledge exists when a person places the objects into the relationship. From these definitions of the three kinds of knowledge, the relationships between them have been noted, and it has been pointed out that the physical knowledge cannot be recognized without knowing the classification, which is included in social knowledge. Also, social knowledge without a logico-mathematical framework would not be recognized. Providing those three definitions and the relationship between them, Kamii and Ewing emphasize that knowledge is not something that could be transmitted to learners, and they support Piaget's concept of knowledge and constructivism. (Kamii, C., & Ewing, J. K., 1996)

Introducing Piaget concept of knowledge, Glasersfeld supports the idea that knowledge is not the representation of external things but the reconstructed experience by learners.
Piaget took the notion of adaptation out of the biological context and turned it into the cornerstone of his genetic epistemology. He had realized early on that whatever knowledge was, it was not a copy of reality. The relationship of viable biological organisms to their environment provided a means to reformulate the relationship between the cognitive subject's conceptual structures and that subject's experiential world. Knowledge, then, could be treated not as a more or less accurate representation of external things, situations, and events, but rather as a mapping of actions and conceptual operations that had proven viable in the knowing subject's experience.” (Glasersfeld, E. V., 1996, p. 3)

Since the constructivist's concept of knowledge is 'reconstructed experience by learners', it must be stated that learning is not a process of the transmission of structured knowledge, but learning is a process of analyzing new information and reconstructing knowledge.

So, constructivists put emphasis not on teaching, but rather on contexts or learning environments where learners would take an important role. Gros defines the constructivist's learning environment as a place where students can work together, helping each other, using a variety of informative instruments and resources that enable them to search for the learning objectives and activities for solving problems. (Gros, B., 2002)

According to Renate Motschnig-Pitrik and Andreas Holzinger (2002), the environment needs to have three conditions: realness, acceptance, and empathic understanding. They assert that in this environment, learners perform with superior academic results and even personal growth in terms of higher self-confidence, openness to new experiences, etc. (Motschnig-Pitrik, R., & Holzinger, A., 2002)

As a summary of the constructivist's view, since knowledge is considered as the learner's reconstructed experience, learners come to a learning environment with a cognitive structure based on previous experiences for incorporating new experiences. When those previous experiences or prior knowledge interact with new experiences, learners construct their own knowledge. Therefore, it is important when providing or facilitating appropriate learning environments, where learners who have cognitive structures based on previous experiences, to provide new experiences, encouraging active participation, and coach learners in the knowledge construction process.
Learning styles

Learning styles refer to individual differences in terms of perceiving information or new environments. Even though researchers have classified learning styles from various perspectives, many of these studies have their roots in Piaget's human intellect development theory. As mentioned earlier, Piaget proposes four major periods of development in the evolution of the human mind, by age and by how the development of human intellect proceeds through 'accommodation' and 'assimilation'. By assimilating new experiences into existing concepts and accommodating existing concepts to new experiences, learning processes are initiated. Based on Piaget's theory, Kolb also stresses experience, and defines learning as "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience". Kolb develops his own learning style theory, called the "experiential learning theory", and the "learning style inventory". (Kolb, D., 1984) Recently, Kolb's experiential learning theory has become very popular and widely accepted, not only in the field of education, but also in other areas, such as management, information science, psychology, and so forth. (Kolb, A., & Kolb, D., 2004)

Proposing the "experiential learning theory", Kolb acknowledges that his theory is also influenced by John Dewey, Kurt Lewin, William James, Carl Jung, Paulo Freire, and Carl Rogers, and indicates that the "experiential learning theory" is built on six main concepts from those scholars, including Jean Piaget. At first, learning is best conceived as a process, not in terms of outcomes. Second, all learning is relearning. Third, learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world. Fourth, learning is a holistic process of adaptation to the world. Fifth, learning results from synergetic transactions between the person and the environment. Sixth, learning is the process of creating knowledge. (Kolb, A., & Kolb, D., 2004)

Mainly, Kolb focuses on learning as a process in which a learner uses his or her own ways to understand and react to new information or new environments. He calls the patterned ways of learning "learning styles". He states that "learning style" describes individual differences in learning, based on the learner's preferences, which are influenced by personality type, educational specialization, career choice, and cultural influences.

Kolb describes two dialectically related modes of grasping experience and two dialectically related modes of transforming experience in learning cycles. In terms of grasping experience, some people perceive new information by using their senses in concrete reality, while others think or analyze new information through abstract conceptualization. Kolb calls the first mode "Concrete Experience" (CE), and the latter "Abstract Conceptualization" (AC). In transforming experience, some people tend to observe how others relate to experiences, while others try to experiment by
themselves right away. The first mode is called “Reflective Observation” (RO), and the other is called “Active Experimentation” (AE). Based on these four basic learning modes, Kolb proposes four different types of learning styles: Diverging, Assimilating, Converging and Accommodating.

According to Kolb, learners with diverging styles use CE and RO, and are best at viewing concrete situations from many different points of view. They have broad cultural interests and tend to be imaginative and emotional. Learners with assimilating style use AC and RO, and are best at understanding a wide range of information and putting it into a concise, logical form by analyzing and observing new information. They tend to have interest in science. Learners with converging styles use AC and AE, and are best at finding practical uses for ideas and theories. They have the ability to solve problems and make decisions, and their interests lie in technical tasks and problems rather than social and interpersonal issues. Learners with accommodating styles use CE and AE, and they learn from “hands-on” experience. They grasp new information by feeling, learn by doing, and are best at marketing or sales careers. Learners with accommodating styles use CE and AE for their learning. Those who utilize this learning style likely engage in “hands-on” learning and are eager to be involved in new and challenging experiences. They tend to learn from “feeling” rather than logical analysis. (Kolb, D. A., Boyatzis, R. E., & Mainemelis, C., 2004)

Recently, David Kolb and Alice Kolb have expanded their research to include nine learning styles, adding five more styles. These include the “Northerner”, “Easterner”, “Southerner”, “Westerner” and “Balancing” learning styles. However, these new learning styles have been identified within the combinations of three or four basic learning modes. For instance, the Northerner emphasizes feeling (CE), while balancing acting (AE) and reflecting (RO). (Kolb, A., & Kolb, D., 2004). Therefore, to support all learners who have various learning styles, it is important for an instructor, as a facilitator, to encompass these four basic learning modes.

**Sensory Perception**

Printed materials and lectures have been used as the basic forms of teaching in learning environments. Those methods will most likely remain as the main tools of teaching for the foreseeable future. However, new technologies have enabled education professionals to seek and explore new methods, and explore new possibilities in teaching. In recent research areas, virtual reality is one of the most inventive areas in education to enhance learning environments. Specifically, in virtual reality, by using multimedia, multi-sensory information could be provided, including image, audio, animation, video information, etc. By experiencing the sensory information, learners are
motivated to participate in the learning process, communicate with the environments and reconstruct their knowledge. (Peters, O., 2000)

In the constructivist’s point of view, knowledge is not the representation of external objects or information, but the reconstructed experience. Learning is not a process of the transmission of structured knowledge, but a process of analyzing new information and reconstructing knowledge through the learner’s past experiences. Consequently, the environment is a place where learners experience new information and participate actively. The environment is the crucial medium to constructivists for enhancing learnability. In other words, according to Lonergan’s theory, “human knowing is not just the experiencing of data, or the development of insights, or the forming of judgments alone, but it is a dynamic and integrated whole whose parts are sensory experience, understanding, and judging.” (Roscoe, K., 2004, p.542) In human knowing process, sensory experience is one part of the learning process or human knowing.

Similar to the constructivist’s concepts of knowledge as an individual’s reconstruction of experience in the learning process, psychologists J. Kevin O’Regan and Alva Noe also give emphasis to human activity or reaction in experience. They also claim that experience is not generated by the brain processes themselves, but rather is constituted by the way these brain processes enable a particular form of “give-and-take” between the perceiver and the environment. Hence, experience is not something that happens in our brains, but is a process of reacting toward the external environment. For instance, our feeling of present redness consists in our awareness of our perceptual access to environmental redness. In their definition of experience, O’Regan and Noe focus on human reactions toward the external world and consider it as the communication between a human and an environment rather than a brain process. (O’Regan, J. K., & Noe, A., 2001)

Some researchers provide more detailed explanations of the process of experience by dividing the process into sensation and perception. Goodson defines sensation as the outcome of processes in neurological machinery as they are activated by sensory information in the environment. Sensation is the way the knowing processes of our body transform the external world. Sensation allows organisms to adapt more effectively to their environment. (Goodson, F. E., 2003)

According to Humphrey, both sensation and perception utilize sensory stimulation as their starting point. Whereas sensation then proceeds to represent the stimulation as a given, perception combines the evidence of stimulation with contextual information, memory, and rules, so as to construct a hypothetical model of the external world, as it exists independently of the observer. (Humphrey, N., 2000)
Goodson also introduces three categories of sensory input as sensory stimulation or information: primary activation input, secondary activation input, and information input. Primary activation is related to physiological operations of the body or external energy application, such as pain, heat, cold, thirst, hunger, etc. Secondary activation has to do with human emotion; for example, a person’s fear, envy, and anger in response to certain situations. For this thesis, information input is a relevant category to sensory perception related to learning environments. According to Goodson, information input implies the experience of light, sound, taste, odor, and a variety of sensations derived from stimulations of the skin. Goodson says that vision, hearing, and olfaction provide the major windows into the world. Information input provides the countless numbers of sensory variations that could create the highly refined and subtle differential behaviors. Also, information input provides unique information about each survival circumstance and allows a moment-by-moment monitoring of the external environment. Information input contributes vital information about the organism’s relative position, velocity, and progress as it moves within the environment, and provides the basis for the encoding of salient features of the environment. (Goodson, F. E., 2003) By classifying these information inputs, we can see how a learner could experience the relationship between themselves and their environment and reconstruct one’s own knowledge by experiencing the environment.

With the processes of sensation and perception, learners experience their environment, and sensory stimulation enables learners to react toward their environments. By obtaining sensory information, learners can first read and analyze the resources and then learners construct their own knowledge through this learning process.

Emphasizing that virtual reality helps the learning process mainly in its first phase, as well as in the learner’s active role in the learning process, Mikropoulos seeks the main reasoning for this theory in the sensory input. Mikropoulos says that involving all the senses increases the experience enhancement in virtual reality. (Mikropoulos, T. A., 1997) Not only in virtual reality, but also in a multimedia learning environment, by providing sensory information to learners, each learner possesses the capability of choosing the sense or senses to exploit for the receipt of specific information. (Peters, O., 2000) When knowledge is considered as a learner’s constructed experience in constructivist learning environments, at the primary phase of the learning process, the human brain receives sensory stimuli-information inputs from the learning environment. As a process of transforming new information, the human brain then organizes the sensory inputs into meaningful prototypes for the understanding of the world, and develops abstract types of thinking and learning. From this process or experience, learners construct their own knowledge. Thus, providing sensory
input or information in a constructivist' learning environment is important to enhance learner's experiences at the first phase of the learning process and sensory information can be provided by utilizing multimedia in an E-learning environment.

**Current Use of Flash**

The development of "Flash" technology has led to many arguments about its usability and accessibility for handicapped people. In the article “Flash: 99% Bad”, Nielsen pointed out that it increases the likelihood of bad design, breaking with the Web's fundamental interaction style, such as the “back” button of a browser. It is also difficult to frequently update content. (Nielsen, J., 2000) Nevertheless, more and more attention has been driven to Flash and recently it is considered a powerful tool for multimedia instruction. Especially in engineering, chemistry and other similar areas, Flash animation is used for simulating and better understanding laboratory procedures. In addition, Jakob Nielsen recently announced that Flash has improved through a new version, “Flash MX”, by solving some technical usability problems such as the “back” button issue. Macromedia has released the article, “Macromedia’s Top 10 Usability Tips for Flash Web Sites,” and has provided guidelines for developers. Although Flash still discourages ease of usability, it is challenging to update new contents because of accessibility issues. Studies still emphasize that Flash is a dynamic, interactive and attractive tool for young users, and it could be a useful tool, depending on a website’s or an applications’ purpose. (Schaller, D. T., Allison-Bunnell, S., Chow, A., Marty, P., & Heo, M., 2003; Cho, J. M., Choi, S. I., Lee, D. K., & Nam, Y. J., 2003)

In this chapter, the author examines current use of Flash in educational websites and applications by reviewing some educational Flash websites as well as commercial websites. The detailed technical issues of usability and accessibility are not included in this study since this study focuses on the applications of Flash in higher education.

**Navigation**

Not only fully Flashed websites, but also many websites developed in HTML, use Flash for navigation methods. Flash allows more interactivity in navigation, such as flowing buttons and mouse rollover functions. In addition, some websites show submenus by using the mouse rollover function on main menus, and it is simple to insert audio clips on buttons. Here are some examples of navigation methods developed by using Flash:
NDT Resource Center

The primary purpose of this website is to provide educational information in the field of Nondestructive Testing (NDT) and to introduce the career field to students. According to the NDT Center, it is an interdisciplinary field that encompasses many areas of engineering. As is characteristic of an educational website, this site is very informative and heavily text driven. This site uses Flash mainly for the header as a main navigational method and as a footer, which provides quick links. The header, as a main navigation method, has the mouse rollover function which brings up the submenu.

![NDT Resource Center Homepage](image)

Figure 2. NDT Resource Center Homepage
Biomedical Information Technology at Stanford

Biomedical Information Technology at Stanford (BITS) is an interdisciplinary research group in computer graphics, scientific computing, medical imaging, and biomechanical modeling applications in biology, bioengineering, and medicine. BITS has developed this website to provide an international resource in the biotechnology, biomedical device, computing, medical imaging, and software industries. For the use of Flash, this site has a main navigation bar at the right. This navigation bar includes verbal sound effects and animated icons with the mouse rollover function. Also, with the animated small icons, the large text of the title of the main menu appears at the back of the menu. In addition, as Figure 3 shows, this site utilizes Flash animation in the intro page, which becomes a Flashed campus map. This is an additional navigation method linked to the pages, providing information about participating laboratories.

Figure 3. Biomedical Information Technology Homepage
Rhode Island School of Design

This is the website of the Rhode Island School of Design. Instead of intro animation, this site uses an animated navigation method in a large portion of the homepage. The animated homepage has flowing text as the main navigation method. With the mouse rollover functions, the flowing text stops and brings up a submenu. When a user moves the mouse out of the menu, the text flows again. This navigation method is a good example of using animation for the navigation. Each main page of the main menu has a Flashed banner showing animated images related to the topic of the main menu.

Figure 4. Rhode Island School of Design Homepage

The preceding three websites illustrate different types of navigation methods that can be created in Flash. The first website, of the NDT Center, has a simple mouse roll-over function in the navigation bar. The website of BITS includes audio effects and animated icons in the navigation bar. The website of the Rhode Island School of Design has an animated navigation method. The first website of NDT can be created in HTML, since it is static and only shows the submenu. In some website publishing software, such as Macromedia Dreamweaver or Microsoft Frontpage, simple mouse rollover functions can be embodied by swapping two images of the same size. However, the second navigation method used in the website of BITS cannot be created in HTML, because it has audio effects with mouse rollover function, and animated text images of the title of the main menu are not limited in size. Lastly, the website of the Rhode Island School of Design uses flowing texts as the navigation method and serves as an example of the interactive navigation method which can be visualized in Flash, but not in HTML. Even though it is a particular style of navigation method, it shows what Flash can do.
Animation

One of the main reasons for considering Flash as a powerful instructional tool might be that it offers a simple means of creating animation. Even though animated GIF images can be used in HTML pages, Flash animation can be created in more elaborate ways. In educational websites, animation has been used in many different ways. Simple animation appears as banners to present research areas. Some animation has been used for instructional purposes to explain concepts or show simulations, and other animation has been created within interactivity for navigation.

Westminster College

The website of Westminster College, which is located in Salt Lake City, Utah, includes an intro page featuring an animated image which seems to be pursuing the participant into the research areas of microbiology, ecology, and chemistry, all related to the Great Salt Lake. By using the “fade in” function of Flash, this animated image shows people one by one, and finally the whole image is embodied. This type of animation is commonly used in intro pages, not only in educational websites, but also in commercial websites.

![Figure 5. Westminster College Homepage](image-url)
Polaris Project at Iowa State University

This site provides resources for on-line courses in Astrophysics and Astronomy at Iowa State University, located in Ames, Iowa. This site has been created mostly in HTML format, but contains animation developed by using Flash to explain scientific concepts or mechanisms of planets and the sky in astronomical perspectives. Animated images show the process or the mechanisms, and proceed by users clicking the mouse on the “play” or “stop” buttons.

Figure 6. Polaris Project Website’s Learning Object
Phonetics Flash Animation Project at University of Iowa

This site features two Flash main sites, called "Phonetic Sound Libraries of Spanish and English". For each letter of the alphabet, this library provides an animated articulatory diagram, a step-by-step description, and video-audio of the sound, spoken in context. The animated articulatory diagram shows how lips and tongue move when a person pronounces each letter. This animated diagram is one example of animation integrating sound effects when used in educational areas.

As shown above, the animation of educational websites seems to be a very useful tool to visualize concepts and instructional information. It seems to be more appropriate to offer animation rather than text information in some circumstances. Utilizing animation, learners can look more closely at the concepts and analyze how they work. In addition, as Phonetic Sound Libraries show, integrating sound effects helps learners understand specific information more clearly.

The author presents more commercial Flash websites to illustrate how they use animation in their websites:
Bembo’s Zoo Homepage

This is the website for the book, “Bembo’s Zoo”, by graphic designer, Roberto de Vicq de Cumptich. From this site, young children learn the alphabet with animal names and animation. This site is fully developed by using Flash and is wholly animated in terms of contents as well as navigation. The navigation method is very simple, even though this site has been developed in Flash, since this site is for children. The navigation method consists of clicking the alphabet from the main page. Once a letter is chosen, it will bring the name of an animal whose name starts with that letter and an animated illustration of the animal is brought up. Then it automatically returns to the main page. This site also includes sound clips, such as the giggling of children, animal sounds, nature sounds, etc.

Figure 8. Bembo’s Zoo Homepage and Animations
**Ingo Maurer**

This is the website of the Ingo Maurer Lighting Company. It also has been developed fully utilizing Flash. However, the interactivity and presentation of information are very simple and clear. This site uses a simple animation of lighting in the intro page and the homepage, and it displays the identity of this site. When moving from the main page to the submenu, a user sees the animated transition of changing spaces. A few simple lines creating 3-dimensional spaces give us a sense of space. Through the use of animation, they illustrate their expertise at effective lighting.

![Figure 9. Ingo Maurer’s Homepage, Animations and Gallery](image)

**Dia Sin’s homepage**

This is an apparel site created by Flash. The intro page shows an animation of a spacecraft in the universe. Entering into this site, animation is used for transition and to create two realistic 3-dimensional towers representing the sense of space. When a user selects a tower, the lights of the tower turn on and a model appears. The animation creates a feeling of emotional engagement by bringing users into a space through animation. Animation for transition also keeps drawing the users’ attention.

Even though this site does not allow the customizing tool of a personal model, it provides a 3-dimensional model, providing 4 different angled views of what the products would look like. In addition, when a user navigates from page to page, the transitions are animated.
Other interactivities

Flash can be used for various types of creative interactivity for numerous instructional purposes in terms of level, function, and transactions. These are the three dimensions of interactivity proposed by Schwiser and Misanchuk. They also provide the three levels of interactivity. The first is "Reactive level", which is the basic stimulus-response interaction. The second is "Proactive level", 

Figure 10. Dia Sin’s Website
which is learner construction and generative activity. The last is “Mutual level”, which is shown in mutual artificial or virtual reality designs, where learners play an important role with an active mode.

Based on this literature review, the author examines the levels of interactivity of current educational websites and reviews some commercial websites:

**Rhode Island School of Design**

The Rhode Island School of Design website has a menu represented as a Gallery for showing the students’ works. Three different images slide onto the screen from the right side, one by one, and disappear in order to the left side. With the mouse rollover function, the image is highlighted. Users can see the large size image by clicking on the individual image. This interactivity requires only a simple response with a user’s mouse clicks to deliver graphic information. This interactivity is in the “Reactive level”.

![Figure 11. Rhode Island School of Design Gallery](image)
Petri Nets World

Carl Adam Petri has developed Petri Nets, defined as “a formal and graphically appealing language which is appropriate for modeling systems with concurrency and resource sharing”. This site provides a variety of online services for the International Petri Nets Community. They offer interactive tutorials, developed by using Flash for introducing the concepts of Petri Nets, state spaces, and place/transition invariants. By clicking on the “previous” and “next” buttons, or other navigational buttons, the animation proceeds step-by-step, showing the concepts and how those concepts work.

These interactive tutorials also require quick responses to let the animation proceed in order to explain, step-by-step, the concepts of Petri Nets. This interactivity also can be called the “Reactive level”.

As shown above, many educational websites demonstrate the “Reactive level” of interactivity more frequently than the “Proactive level”, which allows learners to generate activity, or the “Mutual level”, in which learners play in active mode.

To see more possibilities of interactivity developed by Flash, the author reviews some commercial Flash sites as follows:

Samsung’s new mobile promotion site – SGH-D500

Samsung’s promotional site for a new mobile phone has been created in Flash, including music and animated images. This site requires a user to type their name on the first page, and then proceeds to ask questions, using the user’s name, like a conversation, and pretends to present
customized information. This site has a very interesting navigational method for the “next” and “back” buttons. A transparent bar displaying the “next” and “back” button appears when a user moves the mouse within the window. The bar follows a mouse’s movement so that the user doesn’t need to move the mouse to navigate. When the mouse stops, or the user moves the mouse out of the window, the bar disappears.

Another interesting feature is that the browser is automatically resized when it moves from page to page. Even though this site’s interactivity is very interesting, the level of interactivity is still within the “Proactive level”, since it requires only simple responses, based on the interactivity levels proposed by the Schiwer and Misanchuk study.

Figure 13. Samsung’s SGH-D500 Promotion Website
FootJoy's Homepage

FootJoy.com provides customizing tools for golf shoes. This site has been developed in Flash. Through 5 steps, it provides options in selecting preferences for gender, size, color, etc. The shoe displayed on the left side of the screen continually changes, according to the options that a user selects. When a user moves the mouse on the image of the shoe, the magnetic image appears and shows the details of the shoe.

This site is a good example of the “Proactive level” of interactivity, since a user can generate personalized shoes with size, color, etc by using the customizing tool.

Figure 14. FootJoy’s Interactive Interface for Customization
Volkswagen Jetta’s Homepage

Many websites of automobile makers tend to be developed in Flash to show their products in greater detail. By examining Volkswagen Jetta’s official website, the typical features of Flashed automobile websites can be introduced. The most common interactive feature is providing 360° views of products. This site also provides 360° views of exteriors and interiors of the automobiles, and can be controlled with mouse-drag. To explain the details of the products, this site provides a “Feature” menu. On the “Feature” page, when a user moves the mouse on parts of the product, that area is highlighted and a small dialog box pops up explaining the features. This site also controls assorted movie clips and games. The remarkable feature of this Flash site is that it has a Flash game within the “souvenir” menu of the site, so that users not only receive information, but also enjoy entertainment at the site.

This site also provides an E-card feature. If an E-card is mailed from this site, an e-mail will be sent to a recipient, who will be provided with a link to this site along with a personal message. Volkswagen’s homepage has a menu, called “VW Engineering”. This page has animations explaining Volkswagen’s engine technology and product designs.

In terms of levels of interactivity, this site has the “Reactive levels” of interactivity in the majority of its pages. However, the E-card feature can be considered a “Proactive level” of interactivity.

![Figure 15. Volkswagen’s Homepage](image-url)
CHAPTER 4. DEVELOPMENT OF THE EDUCATIONAL FLASH APPLICATION

Concept

"e-Studio for Learning Grid Systems" is intended to provide a learning environment where students learn the nature and use of grid systems. This application is not only a tool to deliver information, but also an environment in which learners experience new information, practice using this information, and increase their computer know-how. Therefore, this application should be an open place or a student-centered place, as a constructive environment for learners, so that they can assume an important role in the learning process. In addition, since the target audience is comprised of freshman and sophomore students in the design areas, those students can be categorized as the Net generation. As is mentioned in the literature review, their culture can be represented in terms of interactivity, playfulness, etc. To accommodate their culture and different learning styles, this application should be playful in terms of visual expression and interactivity. It must also support four different learning modes: learning by sensing, learning by thinking, learning by observing and learning by doing. Since this application is intended for learning grid systems, the layout used in this application should express actual grid systems. However, even though this application should be playful and visually attractive to the Net generation, the author tries to make it simple, since this is a learning tool and learners need to focus on what they are doing and learning.

Structure of The Prototype

The information contained in this application includes four categories (Figure 16). The first category, “Seeing Examples”, displays galleries of grid systems which are used in newspapers, books, magazines, and some experimental grid systems used in various publication designs. The second category of the application is “Designing Grids”, in which learners can construct their own grid systems. The third category, “About Grids”, allows learners to manipulate traditional grid systems and provides essential information about which designers are knowledgeable in terms of grid system terminology, margin proportions, and the relationships between width of columns, font sizes, and leading and readability. This category also provides information on the four basic column systems: one-column system, two-columns system, three-columns system, and four-columns system, and some aspects of each system. In the last category of this application, learners can receive information on the “History of Grid Systems”, such as the origin, golden section, modular system, and modern grids.
The author places the categories "Seeing Grids", "Designing Grids", "About Grids", and "History of Grids" in the order named. In the traditional teaching method, the order of these categories seems unusual and awkward, since learners see examples of grid systems and construct their own grids before they are introduced to the origin and nature of grid systems. In the traditional teaching and learning environment, instructors would typically provide a history of grids and examples of grids, demonstrating construction techniques of grid systems and providing basic information. Then, as the final process, instructors would allow learners to utilize the grid systems in their design processes.

However, the author places these categories in the opposite order. In this application, learners will view examples of grid systems and actually construct their own grids before they receive the basic information about grid systems. The reason for this unusual order can be found in the previous literature on constructivism. As mentioned earlier, in the constructivist's point of view, knowledge cannot be simply delivered by instructors, and learners can construct their own knowledge, since knowledge is not an object, but 'reconstructed experiences by learners'. In other words, knowledge is reconstructed when prior information interacts with new experiences. In this context, according to constructivists, learning is not a process of the transmission of structured knowledge, but is rather a process of analyzing new information and reconstructing knowledge.

Based on this learning theory, the author intends to provide the "e-Studio for Learning Grid Systems" as a constructive environment. "Seeing Examples" becomes the first category, so that...
learners can recall prior experiences of grid systems, even though learners may not have perceived what the grid systems were and how those grids were used. With the visual information, learners can perceive what grid systems are, and this awareness can arouse their interest and increase their involvement in the learning process.

The author provides "Designing Grids" as the second category, which allows learners to create a broader understanding of grids before they take on the actual and complicated information. This category is also intended to arouse curiosity and interest in this application.

Within the category "About Grids", learners receive the background information of grid systems, such as the traditional grid system, terminology of grid systems, margin proportions, width of column, leading, and construction of type area, while experiencing activities and animations rather than simply text-driven information.

Finally, the "History of Grids" is provided to learners in an interactive way.

Even though the categories are placed in an order based on the author’s intentions, the learning process doesn’t need to be linear. Learners can control the sequence of learning by navigating as they wish, since these principal categories are placed on the top of the screen for the main navigational method.

**Initial Ideas**

Based on the concept, the author explores variations by using grid lines as design elements and various interactive navigational methods. The first draft is developed in a “Modular” grid system, and a simple layout has been applied. For the use of color, a pale brown is used for the background, representing the type of paper that is often used in newspapers (Figure 17). However, the design seems too simple and the navigational method is not especially interactive.

In the second draft, the author uses the experimental grid system (Figure 18), which appears to be more interesting than the first draft. However, these two drafts seem a bit monotonous for the target audience, in terms of color usage and interactivity. Also, the layouts are presented in a straightforward manner that does not fit the concept of constructivism, since learners are active participants in constructivism and learning should be more interactive and dynamic.
e-Studio for Learning Grid System

Learning Grid System is not only a tool for teaching but also an electronic environment in which learners experience new information, practice themselves and construct their own knowledge. Therefore, this interactive educational application should provide various sensory information for better understanding and new experience. It will also include divers activities or exercises with variety rather than just present some information so that learners can take an important role in learning process.

- Playing with Grids
- Looking at examples
- Constructing Grids
- Learning history of Grid System

Figure 17. Initial Idea A

Figure 18. Initial Idea B
In the third draft, the author applies vivid colors into the design to accommodate the target audience, the Net generation (Figure 19). Many design elements are also incorporated, such as rectangles, circular shapes and lines as grid systems, representing various interactivities, playfulness, and constructive learning environments. Then the author particularly explores the interactive navigational methods (Figure 20, Figure 21).
Learning Grid System

The e-Studio for Learning Grid System is not only a tool for teaching or delivering information about learning grid system but also an electronic environment in which learners experience new information, practice themselves and construct their own knowledge. Therefore, the interactive educational application should provide various sensory information for better understanding and new experience. It will also include some activities or exercises with interactivity rather than just present some information so that learners can take an important role in learning process.

Figure 20. Initial Idea D

Figure 21. Initial Idea F
Final Design

From earlier exploration, the author devised the following final design for the intro page (Figure 22). In this design, the animated images show the modular grids that were applied to this intro page. The white background represents the open position for learners as a constructive environment. The large circular lines are used to symbolize the dynamic environment and the interactive learning process, rather than straightforward teaching. In addition, the main navigational buttons create a sense of rhythm, representing playfulness in the learning process. The author uses these dynamic shapes and animations to illustrate that knowledge is being created within the learners’ experiences.

Use of colors

As the main colors, this application uses blue, red, purple and green to represent the characteristics of each main category.

Blue is used for the main category, “Seeing Examples”. This category provides many existing designs that use grid systems. The author wants learners not only to sense the information, but also to see those designs objectively, without detailed explanations. Since blue is a cool color, and is often
used to represent knowledge, consciousness, and intellect, it seems appropriate for this category, suggesting that learners need to use their intellect in seeing the examples objectively.

The color red is selected for the “Designing Grids” category, in which learners create grids as the main generative activity. In this category, learners take control and perform generative activities, so they can be active participants in this learning process. Since red often represents energy, enthusiasm, and vitality, the author intends to appeal to activate learners by using this color.

For the third category, “About Grids”, the author selects the color purple, which is the result of the combination of red and blue. In this category, learners study the practical issues which are intrinsic in grid systems, such as margin proportions, width of columns, leading, and font sizes related to legibility. The study related to these issues requires learners’ intellect and consciousness, which can be represented by blue. Also, this category includes interactivities which learners can perform. These interactivities require learners’ energy, enthusiasm, and vitality. So using purple has rationale, since purple combines the characteristics of both blue and red.

Green is used for the category “History of Grids”. Green is the color of nature, safety, and freshness, and this color makes the human eye comfortable. Since this category covers the development of grid systems in art history, and earlier artists sought aesthetic and natural proportions in nature, green was selected to emphasize the relationship between grid systems and nature for the history of grid systems.

**Terminology**

The name of this application is “e-Studio for Learning Grid Systems”. To emphasize that this application is not only a tool for teaching, but is also an environment for constructive learning, the word “studio” is used, which is a term generally used for a classroom in design areas. The other remarkable thing, in terms of terminology, is that this application uses gerundial forms of verbs for the title and the main categories, such as ‘learning’, ‘seeing’, and ‘designing’. The basis for using gerundial forms is also related to constructivism, which emphasizes learners’ active participation. By using these gerundial forms, the target audience is pursued to active learning.

**Interactivity and its level**

In the constructivists’ point of view, learners should be considered active participants and take the main role in the learning process. By being offered more interactivity and control over the learning process, learners can become more active participants, rather than passive information receivers.
According to prior literature, the level of interactivity is considered as one of the dimensions of interactivity. Schwier and Misanchuk provide the three levels of interactivity: reactive level, proactive level and mutual level. From their research, the author focuses on the reactive level and the proactive level. The reactive allows a linear response for learners to the contents. The proactive level provides the controls over the sequence and timing of learning and contents, and exposes learners to constructive and generative activities.

To offer control over the sequence and timing of the learning process, the author provides the main navigational method on every page, so that learners can navigate spontaneously rather than in a linear sequence. Also, with the mouse-rollover function, learners have access directly to the subcategories, which reside in the second level of the information hierarchy (Figure 23). By obtaining control over the sequence of their learning process, learners can begin their exploration wherever they choose.

Figure 23. The Main Navigation Method
For the proactive level of interactivity, “Designing Grids” is provided as one of the constructive and generative activities (Figure 24). Rather than just delivering the information on grids, generative activities are provided, which allow learners to experience the information by creating their own grids. By participating in this generative activity, learners are not passive receivers, but may take the initiative in the learning process.

For the other constructive and generative areas, interactivities are provided in the “About Grids” category. The sub category “Margin Proportions”, in the “About Grids” section, allows learners to experience the aspects of margins by manipulating the type areas and the margin proportions (Figure 25).
Learning Grid Systems

**About Grids**: Margin Proportions

The type area is always surrounded by a marginal zone. Margin proportions are very important. The aesthetically well-proportioned margin can enhance the pleasure of reading. Also, technically it is important to have enough margin areas to avoid the text being cut in the printing process. Discrepancies of between 1 and 3 mm and often as much as 5 mm occur when the pages are trimmed.

"You can drag and drop the type areas. If you put the type area too close to the edges, you will see the problems that can occur in that position. Place the type area where you feel is most appropriate and discuss that position with your classmates or your instructor." When the type area is placed too high, it seems to be taking flight upwards.

When the inner margin is too small, the reader feels the page is overbearing. Depending on leading methods, the text might be mutilated.

On the “Width of Column & Leading” page, learners can create a format using a variety of font sizes, leading sizes, and numbers of columns, and then may view the results of their combinations (Figure 26). Generating the format of the page, learners will discover how fonts, leadings, and numbers of columns work in grid systems. On this page, rather than offering all the explanations, learners are given the opportunities of generative and constructive activities through hands-on experience.

This application also provides some animations, such as showing traditional grid systems and various layouts, and learners can control these activities by using the buttons ‘play’, ‘pause’ and ‘stop’ (Figure 27, Figure 28).
### About Grids: Width of Column & Leading

**If you click on the options, the leading of type area, font size and number of columns will be changed. Please try to read the following texts in the various options and discuss how those options affect legibility with your classmates and your instructor.**

<table>
<thead>
<tr>
<th>Option</th>
<th>Effect on Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smaller heading</td>
<td>Reduces the size of the text, making it harder to read.</td>
</tr>
<tr>
<td>Larger leading</td>
<td>Increases the distance between lines, making the text easier to read.</td>
</tr>
<tr>
<td>Smaller Fonts</td>
<td>Reduces the size of the fonts.</td>
</tr>
<tr>
<td>Larger Fonts</td>
<td>Increases the size of the fonts.</td>
</tr>
<tr>
<td>More Columns</td>
<td>Increases the number of columns, making the text narrower.</td>
</tr>
<tr>
<td>Less Columns</td>
<td>Decreases the number of columns, making the text wider.</td>
</tr>
</tbody>
</table>

---

**Figure 26. About Grids: Width of Column & Leading A**
Figure 27. About Grids: Traditional Grid System Animation
There is also some interactivity in the reactive level, which is the stimuli-response interaction. Most of the information is presented in a manner requiring interaction, such as clicking buttons, which keeps learners active in participating in the learning process and allows learners to focus on the contents of the application. For instance, the first category of this application, “Seeing Examples”, has four sub-categories which contain existing images (Figure 29). With the mouse-rollover function, those images show the grid systems that have been applied in the designs. Another example of the reactive interactivity is in the subcategory “Terminology of Grid Systems” (Figure 30). On this page, the mouse-rollover function on each category is highlighted. With this interactivity, learners can remember more effortlessly the meanings of the terminology.
In traditional teaching methods, history components are likely text-driven, and historical learning may depend upon an instructor. This may present boredom issues to the Net generation, since they are more visually oriented than previous generations. As prior literature suggests, the characteristics of the Net generation can be represented as interactive, playful, etc. To accommodate their culture, reactive levels of interactivity have been utilized. When learners arrive at “History of Grids”, five images that represent major concepts, theories, or periods are found (Figure 31). Those five images are intended to arouse the curiosity of learners, and the information appears with the mouse-rollover function.

Supporting different types of learning styles

David Kolb proposes various learning styles by combining four different learning modes: learning by sensing (Concrete Experience), learning by thinking (Abstract Conceptualization), learning by observing (Reflective Observation), and learning by doing (Active Experimentation), in terms of grasping and transforming experience.
To support various learning styles, it is essential to allow learners opportunities to experience various activities that correspond to those four different learning modes.

The first two modes, learning by sensing ("Concrete Experience") and learning by thinking, ("Abstract Conceptualization"), are intended for grasping experience. To support learning by sensing, this application contains galleries that include many examples of grid systems used in existing designs (Figure 32). The visual information provided by existing designs allows learners to feel what the grid systems are, rather than providing text-driven information. "Terminology of Grid Systems", a sub-category of "About Grids", highlights specific areas, depending on a learner’s mouse movements, to display what a particular terminology indicates (Figure 30). In addition, "Width of Columns and Leading", also a sub-category of "About Grids", has some interactivities that allow learners to illustrate the numbers of columns and various font sizes in terms of readability (Figure 33, Figure 34, Figure 35). It is also a means to train learners to use their own senses.

Figure 32. Seeing Examples: Grids in Newspapers B
Every difficulty standing in the reader’s way means loss of quality in communication and memorability. The too short line, the eye is compelled to change lines too often and this again wastes energy. The right width of column is essential for an even and pleasant rhythm of reading which enables the reader to relax and concentrate wholly on the content.

Every difficulty standing in the reader’s way means loss of quality in communication and memorability. The too short line, the eye is compelled to change lines too often and this again wastes energy.

Every difficulty standing in the reader’s way means loss of quality in communication and memorability. The too short line, the eye is compelled to change lines too often and this again wastes energy.

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Figure 33. About Grids: Width of Column & Leading A
In the "About Grids" category, the application guides learners to think and analyze what they are seeing, and to discuss the results with their classmates or instructor. For instance, once they obtain results from interactivities, they are asked to think about and analyze the problems or feelings of
problematic or appropriate positions of the type areas. These activities are appropriate for those students who learn by thinking.

In terms of transforming experience, some learners tend to learn by observation and some learn best by doing. The first learning mode of transforming experience is learning by observing, “Reflective Observation”, and the other is learning by doing, “Active Experimentation”. To support those learners who are more likely to observe, animations are presented that show procedures such as traditional grid systems. By observing this animation, learners can examine the step-by-step procedure of constructing the traditional grid system. Rather than reading information about it, seeing the procedures will be much easier to remember. In addition, “e-studio for Learning Grid Systems” contains animations for learners to perceive various layouts within column grid systems that support learning by observing. The galleries of existing designs under the category of “Seeing Examples” allow learners to observe how others use grid systems.

For the alternate learning mode, learning by doing, the interactivity of “Designing Grids” allows learners to construct their own grids. In this category, rather than thinking, sensing, or observing, learning by doing modes are supported. By making mistakes and performing activities, learners construct their own knowledge with hands-on experience and are engaged as active participants in the learning process.

Interspersing those interactivities and activities which support different types of learning modes in various places, the author seeks ways to involve learners throughout the learning process, and allows them to take a major role in this learning environment.

Sensory perception

From prior literature based on constructivism and learning styles, it is emphasized that learners' experiences are very important in terms of allowing them to take a central role in the learning process. This is achieved by providing appropriate environments in which learners can construct their own knowledge, rather than being delivered information. In addition, it is necessary to support various learning styles of students.

Other prior literature on sensory perception stresses the human knowing process and the environments. The literature states that experience is not something that happens in the human brain, but is a process of reacting toward the external environments. The focus is on how learners experience the external environments and information. Goodson states that humans transform the external environments with sensory information at the starting point, and he refers to this as
“sensation” in the human knowing process. Bringing this theory to the learning environment, sensation can take an important role in learners’ experiences. According to Goodson, vision, hearing, and olfaction provide the major windows into the world. Based on this literature, visual information is used as sensory input.

In traditional teaching and learning environments, instructors often provide text-based descriptive information with static visual images, and learners receive the information passively through reading. However, learning content can be converted from text-based descriptive information to graphical information with some interactivities. By creating animations and adding some interactivity, the need for detailed explanations of contents can be reduced, and this allows learners to absorb the information by using their senses, rather than torturous reading.

This application includes “Seeing Examples”, to illustrate existing designs which use various grid systems. By viewing those examples, learners can see what grids systems are and how those grid systems can be used in real designs, rather than reading only text-driven information. In addition, the animation of the traditional grid system under the “About Grids” category shows the procedure of drawing the traditional grid system. Without reading text-based descriptions, learners can clearly observe the information of the procedure. “e-Studio for Learning Grid Systems” provides some interactivities, which demonstrate the relationship between font size, column width, and leading in terms of legibility. Compared to descriptive information, showing the final results using interactivities will help learners understand the various aspects of the formats that have been chosen.

Flash as a Development Tool

Macromedia Flash has been one of the most popular tools in the creation of interactive websites, not only for commercial websites, but also for educational websites. In developing “e-studio for Learning Grid Systems”, using Flash MX as the main tool, the author seeks solutions which support the proactive level of interactivity in the learning process. The final prototype not only provides interactivities, but also shows examples of the learning environment within the theoretical concepts of constructivism, sensory perception, etc. Also, there are demonstrated potentials for visualizing information, supporting constructive interactivity, and different types of learning styles.

From reviewing existing websites, and within the development process of this application, the author recognizes advantages of using Flash in designer perspectives, such as creating animations, navigational methods, and learning interactivities.

Flash is a very useful tool for the creation of animations. Combining Flash action script, animations can become interactive. By providing interactive animations, designers can grasp learners’
attention and provide a sense of playfulness. Animations are very effective in providing time-based sequential information to learners.

Another advantage of using Flash is that designers can create various types of navigational methods, such as simple menus, hidden menus, and pull-down menus. Hidden menus have been used by incorporating Java script in websites, and pull-down menus have been applied as web components or created in Java script. However, by using Flash, those navigational methods can be created in much more workable and visually interesting ways. In this application, a pull-down menu has been applied as the main navigational method. On the intro page, the buttons are animated. As this application demonstrates, the interactive and animated navigational methods can be created effortlessly. Not only by making use of mouse-rollover functions, but also by providing animated images on the navigational buttons, navigating the learning environment can be enjoyable and playful.

Flash also supports various interactivity between content and learners, and allows learners to have access to generative activities, which can be called the proactive level of interactivity. In existing Flash educational websites, most of the interactivities are stimuli-response interactions, which can be called the reactive level of interactivity. However, in this application, by utilizing Flash action script, possibilities are demonstrated for creating the proactive level of interactivities which help learners construct their own knowledge. Even though Flash action script can be complicated, it remains more workable than computer programming and is much more convenient to incorporate with graphics.

Other advantages of using Flash can be found from the instructional technology point of view. For instance, “e-Studio for Learning Grid Systems” can be stored on a server, so that an instructor and students can access and open up this application using networked computers in a computer lab. In a computer lab, an instructor may use this application as a teaching tool for in-class activities. It can be opened with a Flash player and an Internet browser, such as Explorer, Netscape, or Safari. Since the file size of this application is small enough to post on the web, learners can access this application anywhere and anytime they navigate the World Wide Web.

On the other hand, there are also limitations for using Flash as a tool for developing educational applications. Since creating some interactivities and animations requires using Flash action script, the development period can be much longer than with creating static websites. It can be a difficult process to learn Macromedia Flash software for instructors who do not have experience or background in using Flash. To utilize this application in classrooms or computer labs, instructors
should make sure the systems are compatible with this application, since a browser needs to have a Flash plug-in to play a Flash application.
CHAPTER 5. EVALUATION RESULTS AND DISCUSSION

The purpose of this chapter is to examine how this type of teaching tool might be evaluated. To verify Flash’s potentials and possibilities for augmenting the learning process, the author proposed an educational application, “e-Studio for Learning Grid Systems”, which was created based on the theoretical concepts of constructivism, interactivity, sensory perception and learning styles.

As an example of an empirical study, an attempt is made to analyze whether or not this application would be appropriate for the target audience. The notion of theoretical concepts was embodied suitably for the enhancement of the learning process.

Since the target audience of this application is freshman and sophomore students in design areas of higher education, five students studying Graphic Design at Iowa State University were recruited to participating in the evaluating this teaching procedure. The author stored this application, “e-Studio for Learning Grid Systems”, in a laptop computer and observed how they used this application. While the students were using this application, the author took on the role of the instructor so that the participants could ask questions as they do in class and allowed them unlimited time for their learning while using this application. Also their mouse movements on the screen were saved in movie file form by the software SnagIt 7.2.3 to analyze their navigation and behavior while using this application. Most of participants used this application for 30 minutes to 40 minutes. Based on their use of the application and their level of interest, it seems this application is appropriate for use in the classroom. After completing the exercises on this application, students were asked to fill out validity test forms, which were developed by the author, and were then interviewed by the author.
The subjects of this evaluation test were comprised of four females and one male. The average age of this group was 25 years old. The average span of experience with using grids in their design projects was 2.2 years. Figure 36 shows the demographic information of the participants.

**Table 1. Demographics information**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Female</th>
<th>4</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Age</td>
<td>20 – 24 years old</td>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>30 – 34 years old</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>Experience of using Grids</td>
<td>2-3 years</td>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>1 year</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>Language</td>
<td>English</td>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Chinese</td>
<td>1</td>
<td>20</td>
</tr>
</tbody>
</table>

N = 5

The validity test form consists of 3 parts. The first part was intended for evaluating overall design issues. The second part was for examining the embodiment of the theoretical concepts. Finally, the participants answered some qualitative questions about their experiences.

From Question 1 through Question 10, participants were asked about the overall design expression. In general, students’ evaluations of this application were very favorable in terms of navigation, the ‘here-you-are’ indicator, readability of text, and grouping of links, as Table 2 shows. Relating to navigation, four participants out of five strongly agreed that the main categories and the sub-categories were presented clearly, and one participant agreed (Question 1, Question 2). Four participants strongly agreed or agreed that the navigational methods were simple and clear (Question 7). All the participants strongly agreed that the page names for the ‘here-you-are’ indicators were clearly presented (Question 3). In terms of the icons, three participants out of five strongly agreed that the icons represented what was intended (Question 4). For the readability of the text, three participants strongly agreed that the text was readable and two participants offered a neutral reply (Question 5). In addition, all the participants said the grouping of links is logical (Question 6), and also all the participants strongly agreed that the use of terminology in this application was appropriate and easy to understand (Question 8). According to the results of students’ evaluations, all the students
agreed or strongly agreed that this application offers visual information, and all of them strongly agreed that the information presented in this application was useful, as Table 2 shows.

Table 2. The results of students' evaluation about the design of “e-studio for Learning Grid Systems”

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The main sections are presented in a clear manner.</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The sub-sections are presented in a clear fashion.</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Each page has a page name. The page names are clearly presented.</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. The icons clearly represent what is intended.</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. The texts of this application are readable.</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. The grouping of links is logical.</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. The navigational methods are simple and clear.</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. The use of terminology is appropriate and easy to understand.</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. The information presented in this application is useful.</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. This application offers visual information.</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ N = 5 \]

From question 11 through question 17, queries relating to the theoretical concepts of interactivity, constructivism and learning styles were applied. Since the author provided numerous interactivities in terms of reactive and proactive levels, and strove to support various learning styles, it should become clear whether learners felt that they achieved control of the learning process, creative interactivities and the opportunity to learn by sensing, analyzing, observing, and doing.

The results of the students' evaluations seem to indicate that the author's intentions for the embodiment of theoretical concepts were suitable to learners, and valid for enhancing the learning process. Also based on these results, this method of evaluation seems appropriate for assessing the relative strengths of a Flash-based educational application.
As Table 3 shows, four participants out of five agreed or strongly agreed that this application allowed for control of the learning sequence and the timing of learning and also four participants agreed or strongly agreed that this application provided creative activities.

Table 3. The results of students' evaluation about interactivity

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. This application allows control of the learning sequence.</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. This application allows control of the timing of learning.</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. This application provides creative activities.</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N = 5

As the results of students' evaluations reveal, all the participants agreed or strongly agreed that this application provided learning by sensing, learning by analyzing, learning by observing, and learning by doing (Table 4).

Table 4. The results of students' evaluation about learning modes

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>14. This application provides the opportunity to learn by sensing.</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. This application provides learning by analyzing.</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. This application presents the possibility of learning by observation.</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. This application affords the opportunity to learn by doing.</td>
<td>3</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N = 5

As the last part of the validity test, there were four questions relating to qualitative study. Those questions were provided for learners to explain their experience while using this application, such as how the application differs from traditional teaching methods and whether this application helps their understanding of grid systems:

**Question 19: How does this application differ from traditional teaching methods?**

**Student A:** It differs because it shows a variety of grids and methods. Before I have only been taught one or two.
Student B: Interactive. In other classes, I learned about grids from books.
Student C: It is interactive.
Student D: I like it because it's visually pleasing and also it indeed uses a more simple way of helping me to learn about grids. Very clean!!
Student E: More precise in teaching. There is a specific concentration on the history of grid structure and formations of types of grids and how they are used.

As a major difference from the traditional teaching method, students B and C indicated its interactivity. Two participants, student A and student E, noted that this application provides various types of grids which were intended to support visual learning and learning by observing. Student D and student E also liked the method of teaching.

In addition, it is remarkable that four of the participants thought this application helped further their understanding of grid systems, and the fifth indicated “a little” support with understanding. They suggested their further learning from this application for various reasons, and explained how it helped as follows:

**Question 20: Does this application help further your understanding of grid systems? If yes, please explain how it helps.**

Student A: A little. Most of the information was review. The history helps but could be improved by showing how it could be used.
Student B: Yes. Easy to make adjustments, experiment with different grids and compare the effect of each grid made.
Student C: Yes. It helped me see how grids can be subdivided.
Student D: Yes. Like how traditional grid systems were constructed and about the modular or golden section, etc.
Student E: Yes. The creative part assists in producing your own grid. It helps in design and placement quickly. I also have a clearer knowledge of how type size, leading, columns widths, etc interact with each other.

Generally, what the participants indicated was related to the interactivities that were designed intentionally by the author, based on the theoretical concepts of constructivism, sensory perception, learning styles and so forth. For instance, students B and E mentioned “easy to make adjustments”, “experiment with different grids” and “the creative part” for further learning. This is in relation to “Designing Grids”, which allows learners the opportunity to create their own grids. It supports learning by doing, and constructive and generative activity as experience. Participants stated that this activity helped further their understanding of grid systems.

Student B, student C, student D and student E said that the interactivities related to “About Grids” enhanced their understanding of grid systems. The interactivities indicated are animations for
constructing the traditional grid system, construction of type area within various column grid systems, and interactivities of grid systems with columns, leading, and font size. Those interactivities are related to constructivism, visual learning and various learning modes.

After filling out the validity test forms, the author interviewed the participants. When asked how they would explain their feelings if an instructor would use this application in class, all the participants said they would be pleased. Student B said, “Yes I would. It is a lot more interesting than reading a book. Especially since you can compare things by clicking and seeing different variations in the leading and changing the size of type. It is a lot more interesting being interactive than seeing comparisons on the pages in a book.”

According to the author’s observations, three of the participants visited the categories following the intended order, while two of them visited the third category “About Grids” first, and then visited other areas spontaneously. When the participants were asked why they visited each category and how they felt about the order, three of them, who visited the categories as they were listed, said that they preferred to gain hands-on experience.

Student A said, “Actually I liked going to the designing area and then back. Maybe I should have gone back and done more designing. But, because sometimes you just want to jump in and get hands-on experience, and then learn from your own mistakes after you see them...like...when I was watching, then I saw ‘Oh, that’s how it could be done. That’s a different way’...so I could compare it to mine. Well, if I would have seen that first, or like they show you, you just think, ‘Oh, okay~’ and you go to do it, and it’s like you have to do it. It’s like a repeat almost.” Also student E gave an interesting response, saying “It is more a way to teach yourself.....What I have had is from the teacher’s perspective. What I wish we could have in class is like what you have in this program, where we can design our own grid structures, and I think it would be a lot more fun to play around with and try different ways of doing grids, with columns and so forth”.

While these participants liked the order of the categories, another preferred the traditional order of teaching. Student B explained the reason as follows, “I usually like having the history first. History usually is not very interesting about grids. That’s why I wouldn’t put that first, because usually history is boring. And I would like to read the background myself. If there were.... a book, I would see text and bunch of pictures, I would probably read the text first. That’s why I went to that first...it’s like background information. I think the most beneficial part of it is that after reading, I was seeing the examples, that was really nice.....rollover it and see the different grid lines pop up.”
As a result, even though participants' preferences were varied in terms of the navigational order, it is obvious that this application allows learners to roam as they wish, and they did actually navigate according to their preferences. From the constructivists' point of view, allowing control of the sequence of learning is important, and this application does provide that flexibility.

In summary, from the participants' evaluations, it seems that the overall design is suitable to the target audience, and they indicated strong affirmative responses. The participants clearly recognized that this application allows learners to enjoy control of the learning process in such areas as sequence and timing. From the qualitative study, the participants are aware of the major differences in the various interactivities of this application compared to traditional teaching. Also the participants declared that the interactivities aided their learning, and they would like to use this application in class.

While much further evaluation is necessary, it seems that this application is appropriate to use in classrooms and indeed fits the target audience, the Net generation.
CHAPTER 6. CONCLUSION

This research was undertaken to examine the possibilities and potentials of Flash, and to propose a Flash-based educational application, developed based on valid learning theories for the enhancement of the learning process in higher education.

At the onset of this research, the author examined literature on educational theories that are relevant to the current educational context in higher education, and the current use of Flash, to discover which factors enhance the learning process. From the study of the context of social and educational changes, constructivism, levels of interactivity, learning styles, sensory perception, and the current use of Flash in the literature review, the author proposes guidelines for developing a Flash-based educational application.

Guidelines for developing educational applications include: attractiveness to the Net generation, the reactive and proactive levels of interactivities, learners’ controls of the sequence and timing of learning, playfulness, a sense of place, opportunities to experience new information and reconstruct learners’ own knowledge, activities supporting various learning styles, and sensory information. These guidelines, developed by the author, can be used for creating educational applications or websites.

Based on the guidelines, the author developed a Flash-based educational application as a supplementary teaching tool in higher education. As the title, “e-Studio for Learning Grid Systems” implies, the subject of this application is grid systems, and its target audience is freshman and sophomore students in design areas. The prototype, “e-Studio for Learning Grid Systems”, as a supplementary teaching tool, can be used for in-class activities in design areas and for online learning, by posting it on websites.

A proto-type of a possible validity test was conducted to observe how learners interact with a Flash-based educational application and to examine how this application could enhance learning process.

The author’s preliminary findings from the validity test proto-type indicate that creating interactivities by using Flash can support the educational theories. Based on constructivism, providing creative and generative interactivities, Flash-based educational applications allow learners to experience new information and construct their own knowledge. Supporting various learning styles, the activities created by using Flash can enhance the learning process and create a memorable
experience. Visual learning can be sustained by observing information through the use of Flash. Flash also can support not only the reactive level of interactivity, but also the proactive level.

Furthermore, the author suggests that an instructor making use of this application as a teaching tool needs to coordinate discussion activities, and let students share what they have learned with classmates, since it is intended as a supplementary teaching tool.

Also, the author suggests that researchers and educators use the results of the validity test proto-type as qualitative data, since the author conducted the validity test with limited number of learners to observe their interactions with this application.

However, for further study, a usability test with a greater sample size should be conducted. The results from a larger sampling could be different from the results of this study. Applying the theoretical concepts to diverse subjects in higher education, utilizing Flash, could also be undertaken. The addition of auditory or sound components and verbal information to an interactive Flash-based application is another area for further study.
APPENDIX. VALIDITY TEST FORM FOR
“E-STUDIO FOR LEARNING GRID SYSTEMS”

These questions are to be completed after using “E-Learning Studio for Learning Grid Systems”. Please answer the following questions concerning your in reference to the application. You may leave this test if you feel uncomfortable answering at any time.

A. Demographic Information

<table>
<thead>
<tr>
<th>Gender:</th>
<th>Age:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Language:</th>
<th>Major/year:</th>
</tr>
</thead>
</table>

| Software Experiences (year): |
|-----------------|-----------------|
| Photoshop | Illustrator | QuarkXpress | Pagemaker |
| Indesign | Flash | Others: |

B. General Questions

For questions 1 – 26, choose your response from the following choices (please circle number):

1) Strongly Agree  2) Agree  3) Neutral  4) Disagree  5) Strongly Disagree

1. The main sections are presented in a clear manner.
   1 2 3 4 5

2. The sub-sections are presented in a clear fashion.
   1 2 3 4 5

3. Each page has a page name. The page names are clearly presented.
   1 2 3 4 5

4. The icons clearly represent what is intended.
5. The texts of this application are readable.

6. The grouping of links is logical.

7. The navigational methods are simple and clear.

8. The use of terminology is appropriate and easy to understand.

9. The information presented in this application is useful.

10. This application offers visual information.

11. This application allows control of the learning sequence.

12. This application allows control of the timing of learning.

13. This application provides creative activities.

14. This application provides the opportunity to learn by sensing.

15. This application provides learning by analyzing.
16. This application presents the possibility of learning by observation.
   1 2 3 4 5

17. This application affords the opportunity to learn by doing.
   1 2 3 4 5

C. Interview

18. Before using this application, did you have previous experience using grid systems for your designs? If yes, please indicate how long you have used them.

19. How does this application differ from traditional teaching methods?

20. Does this application help further your understanding of grid systems? If yes, please explain how it helps.

   If no, please give examples of which areas in this application could be improved.

21. Please write any additional thoughts or comments concerning this application.
APPENDIX B. ACCOMPANYING CD-ROM AND OPERATING INSTRUCTIONS

The CD-ROM contains the interactive Flash-based application called "e-Studio for Learning Grid Systems". This application was designed using Macromedia Flash MX 6.0. Users can use this application by opening the file called "learningGrids.html" in a browser.

Systems requirements for the CD-ROM: IBM PC; Windows 2000 or higher or Macintosh; Mac OS X 10 or higher; Explorer 5.2 or higher or Safari 1.3 or higher; and a Macromedia Flash Player which can be downloaded from the website; http://www.macromedia.com/downloads/
BIBLIOGRAPHY


http://www.irrodl.org/content/v1.1/otto.pdf

Hughes, R. J., & Hans, J. D. (September, 2001). Computers, the Internet, and families: A review of the role new technology plays in family life. *Journal of Family Issues, 22*(6), 778-792.


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