CHAPTER II

RELATED KNOWLEDGE

2.1 Multimedia Technology

Multimedia is the integration of media includes text, graphics, sound and animation. Multimedia can be presented in various ways such as Linear Multimedia, Interactive Multimedia and Hypermedia. Composition and type of multimedia would be described in this topic as the following.

2.1.1 Type of multimedia

2.1.1.1 Linear multimedia

In linear multimedia, user's involvement was restricted to move next or previous screen. The sequence of presentation can not be changed by users. This type of multimedia is also known as Passive Multimedia. Examples of this type are TV or slideshow.

2.1.1.2 Interactive multimedia

Interactive multimedia gives users a more control of the pathway. For example, clicking on a predefined area (known as a hotspot) will navigate to another point in the program. The hot spot can be text, an image or a movie clip. Figure 2.1 shows the example of interactive multimedia application, when users move mouse on the hot spot area, it would be highlight and the pointer changes to hand image.

Figure 2.1 Example of interactive multimedia application.

2.1.1.3 Hypermedia

Hypermedia application uses media (image or animation) as the link to navigate through information stored at remote site. Applications on the internet are the best example of Hypermedia. Figure 2.2 shows the concept of internet application that used hypermedia to access information located on other places.

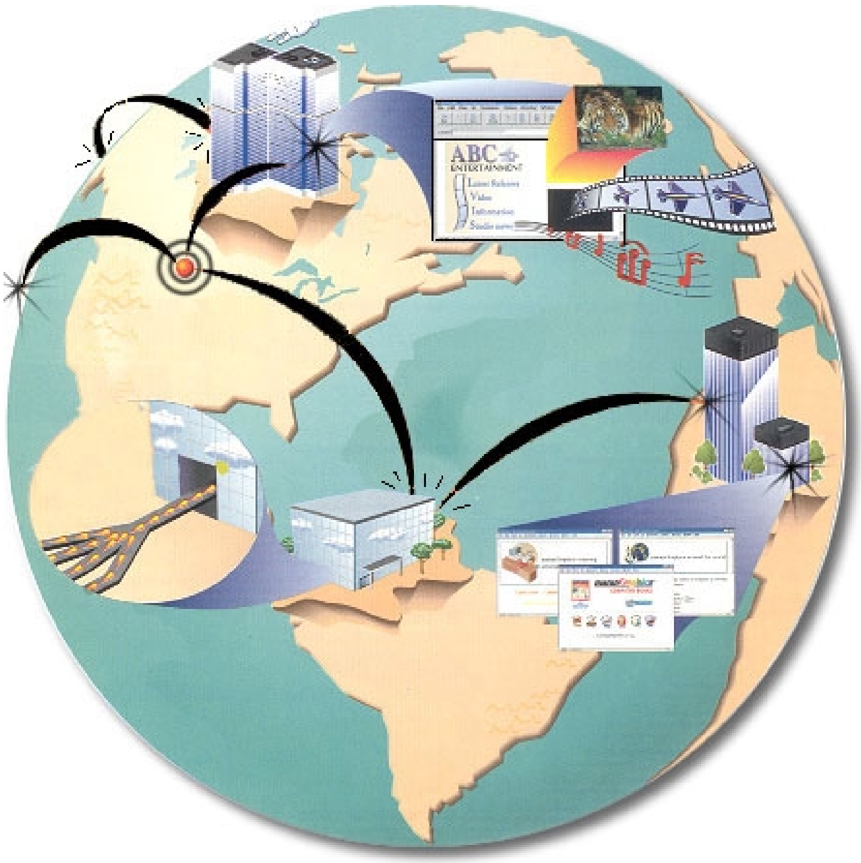


Figure 2.2 Concept of Hypermedia on internet application.

2.1.2 Composition of Multimedia

Multimedia consists many kind of media combined together. Each media has special characteristic and these will be described in the following sections.

2.1.2.1 Graphics

Computer displays graphics in either vector or bitmap format. Vector graphics describe images using lines and curves, called vector, that also include color and position properties. In Figure 1.3a, the leaf's outline is described by points and lines, the leaf's color is determined by the color of the outline and the color of the area enclosed by the outlines. Vector graphic can be edited by changing the properties of the lines and curves without losing any quality.

Bitmap graphic describes images using colored dots, called pixels, arranged within a grid. In Figure1.3b, the image of leaf is described by the specific location and color of each pixel in the grid. Creating an image is in the same manner as a mosaic. Editing a bitmap graphic can change the quality of its appearance. In particular, resizing can degrade the image quality.

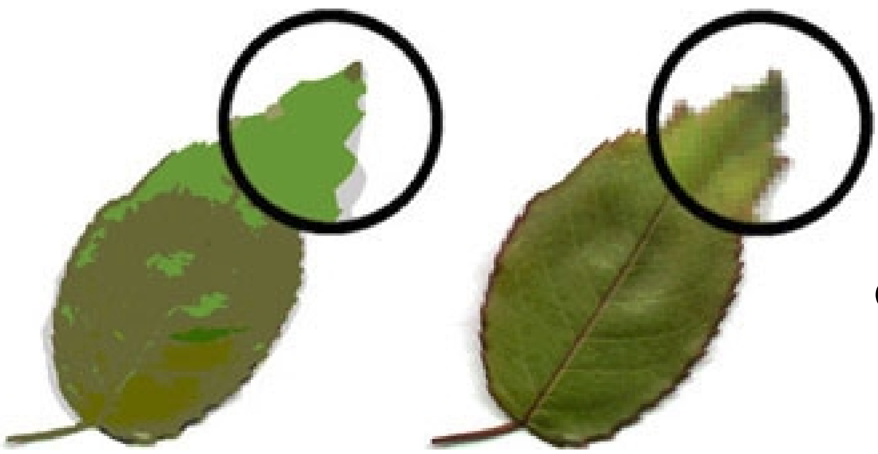
(a)  (b)

Figure 2.3 Type of graphic file: (a) Vector graphic and (b) Bitmap graphic.

2.1.2.2 Sound

Sound in multimedia can be generated by two methods. The first method, sound that generated by computer software such as Cakewalk, Sonic Foundry Sound Forge,etc. The second method, sound (analog format) are recorded with microphone and converted to binary data (digital format) in suitable format.

2.1.2.3 Animation

Animation is divided into 2 types, Frame by Frame and Motion tween. Frame by Frame is generated by running the series of the graphics (frames) rapidly enough to produce a moving picture. Figure 2.4a shows each action of character that represented as a frame.

About Motion tween, only start and stop frame (namely keyframe) are prepared, the intermediate frames (tweened frames) are generated automatically by computer software. Figure 2.4b shows frame1, frame5 that are keyframe and frame2 to frame4 that are tweened frame. It should be noted that each tweened frame are generated by transformation process (scale and position).

(a)

(b)

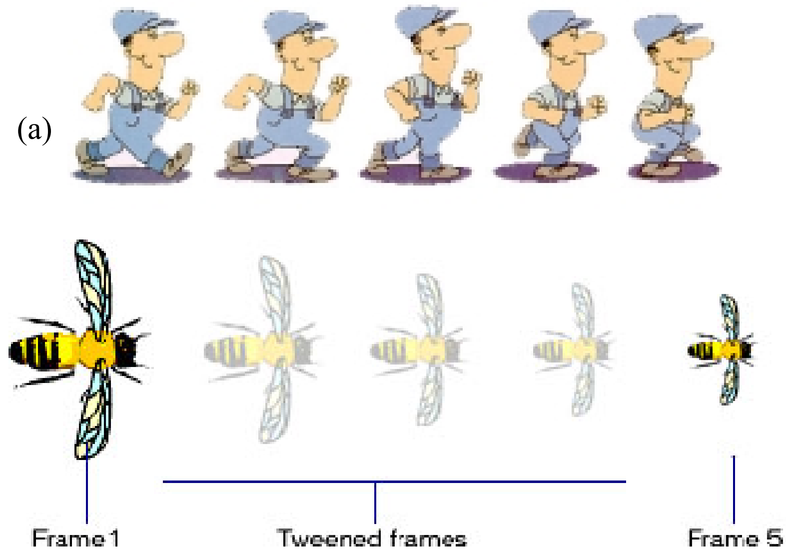


Figure 2.4 Type of animation technique: a) Frame by Frame and b) Motion tween.

2.2 Computer Assisted Instruction (CAI)

Computer Assisted Instruction (CAI) is an educational media in which instructional content or activities are delivered by computer. Students learn by interacting with the computer. After any action was performed by user, an appropriate response from the CAI software is provided. Students will obtain the answer, suggestion or the next instruction to continue the lesson [1].

2.2.1 Categories of CAI

2.2.1.1 Drill and Practice

Drill and practice CAI emphasize on practice and skill. The knowledge that has previously been learned is revised by doing the practice until the student can understand the lesson thoroughly. The students are forced to learn step by step. They can not skip to the next step unless they could pass the elementary step.

2.2.1.2 Tutorial CAI

Tutorial CAI focuses on the conclusion of a lesson that student should be known. In addition, it was used as extended teaching and semi-revision teaching. Student can study before and after learning in the classroom. This CAI often start with introduction part that inform the lesson name, content, objective and revision of knowledge then follows by the detail of lesson.

2.2.1.3 Instructional Game

This type of CAI base on indirect learning. The students are stimulated to learn with the attractive games. The main principle is that learning from entertaining instruction (game) gives a better result on learning and long time memory than from traditional instruction. This type of CAI always suits for the learner in preschool, primary school and also the high school.

2.2.1.4 Simulation

This type of CAI provides the emulation of reality that does not require the expense of real life or its risks. It contains suggestion part that help in decision to solve the problem. The program in this type, for example, the pilot training program and chemical experiment program, use to protect danger from any error in the real situation.

2.2.1.5 Discovery

Discovery CAI provides a large database of information that challenges the learner to analyze, compare or evaluate based on their explorations of the data. Learning was obtained from viewing the knowledge compositions that lead to overall knowledge which can be regarded as "Discovery".

2.2.1.6 Problem Solving

Problem Solving CAI teaches specific problem solving skills and strategies. The computer assists students in making decisions, following logical steps, and finding answers though the provided informations. This type of CAI is applied to solve the problem in business, mathematics or scientific field, etc.

2.2.2 CAI Developing Process

CAI developing process include of the following steps:

2.2.2.1 Objective Setting

This step defines target student and objective of the course by using the course outline and a teaching plan.

2.2.2.2 Content Specification

This step specify the course content according to objective that has been set.

2.2.2.3 Content Analysis

Content analysis is performed for managing of learning activities that must correspond to the objective. In this step, the topic contents would be obtained and further dividing into appropriate sub-topics can be performed.

2.2.2.4 Behavioral Objectives

Behavioral objectives are defined to inform the student the target result of studying. Learning efficiency can be monitored through these objectives.

2.2.2.5 Teaching Strategies and Model of Delivery

This step determine teaching strategies by using figures, animations or movies for communication to students. These strategies often give better result than explanation given by plain text.

2.2.2.6 Design and Implementation

This step performs the CAI software development by using all informations from all prior steps. These include designation, instruction coding and then integration.

2.2.2.7 Delivery

This step determine strategies to provide knowledge to learner by using the following principles:

- emphasize on friendliness between the CAI software and student.
- give a chance to contribute in the studying to student
- student can choose the topics they are interested in without time limitation

2.2.2.8 Evaluation

This step evaluates the contents and learning activity respect to the objective.

2.2.3 Member of CAI Production Team [1]

CAI is usually designed and produced by Instructional Design Teams. A good developing needs the persons from different fields of knowledge that may be named as instructional design team. The roles and activities of each member are described as following.

2.2.3.1 Knowledge Expert or Subject Expert

The Knowledge Expert is the person who has a full knowledge of the content being develop. The Knowledge Expert works closely with the Designer in designing and developing, for example, analyze the contents, determine the assessment method, set the learning objective and outcome.

2.2.3.2 Designer

Designer determines the most appropriate lesson design, the screen design and always acts as an interpreter between the Knowledge Expert and the Author/Programmer.

2.2.3.3 Special Effect

Special Effects refers to the technique that attract the learners such as the appearant of graphics, sound effect or the movie clip. Sometimes, the Author / Programmer may perform this function, or it may be done by another member.

2.2.3.4 Author/Programmer

The role of Author/Programmer is integration scenes, special effects and the course content into the instructional code.

2.2.3.5 Evaluator

The Evaluator determines the effectiveness of CAI software. Evaluation process is divided into formative evaluation and summative evaluation.

- Formative Evaluation

This type of evaluation takes place during the development process. It assists in finding any problems in order to modify in the intermediate step.

- Summative Evaluation

This type of evaluation is used to determine the effectiveness of CAI software after it has been developed. Statistical testing was applied to this process as described in Chapter 5 : Software Evaluation.

2.3 Impact of CAI

CAI has shown its important influence on education field. Impact of CAI has been evaluated and measured through its effectiveness on teaching and learning outcome.

It has been shown to be less effective, on average, than other forms of intervention in education. This may be due to confounding between the medium and the method, poor design and poor measures of outcomes. Exclude of quality of the literature reports used for assessment, there are also many variables that influence on the results including: technological change, feature of CAI software, level of students, treatments, methodologies, educational level, course content or subject area, and student characteristics.

As found in many literatures, the impact of CAI was assessed by using the Meta analysis method. Meta-analysis is an integrative statistical analysis or reanalysis of previous research as a means to answer new questions using old data (Glass et al., 1981). It combines results from multiple similar individual research studies to generate a single effect size that illustrates the treatment effect across all studies, so as to make studies comparable. This method uses the effect size (Es) as indicator for comparison. There are many possible ways to estimate effect sizes. One of the fundamental formula is: Es = (Mc-Me)/ Sc. Where Mc is the mean of control group, Me is the mean of treatment group and Sc is the standard deviation of the control group. An effect sizes are often expressed as percentiles or percentage improvement in learning to help with interpretation of what a particular effect size means. There is the question of what is a reasonable effect size in terms of classroom significance. This is difficult one. Hattie (1990, 1992, 1999) reported a synthesis of 337 meta-analysis, 200,000 effect sizes from 180,000 studies representing more than 50 million students and covering almost all types of innovation in education. His conclusion was that most innovations that are introduced to schools improve achievement by, on average, 0.4 of a standard deviation. This provides a benchmark figure by which to judge effects as it is based on the effects of actual educational innovations. There are also other different ideas. Cohen (1977) provided the following ranges for mean effect size interpretation: 0.2-0.49 = small effect; 0.5-0.79 = medium effect, and $\geq$ 0.80 = large effect. Tallmadge (1977) suggests that an effect size of 0.25 or more is educationally significant.

There are several recent major reviews of meta –analytic reviews that may provide an updated overview of CAI effectiveness since 1970s as referred in Parr J.M.'s review [3]. These include of *Fletcher-Flinn& Gravatt*, *1995*; *Kulik, 1994*; *Niemiec & Walberg, 1987*. These reviews provide (1) a clear description of predetermined criteria for selection of studies, showing that their data searches were unbiased and replicable and (2) specification of how effect sizes are derived.

Niemiec and Walberg (1987) synthesises what is known about CAI at all levels of implementation during the period 1978-1985. They reported an average effect size of 0.42 in their meta-analysis of 16 major reviews since the 1960s. This is considered a moderate effect , showing that, on average, students who received computer-assisted instruction scored at the 66 th percentile on tests of achievement compared to students in the control conditions without CAI who scored at the 50 th percentile. However, they make a point that achievement may be differentially related to instructional level, as a number of studies reported student gains to be highest at elementary schools (0.46) and lowest at college/university level (0.26), with high schools in between (0.32).

Kulik (1994) synthesises findings from 546 individual studies at all levels of include computer-based instruction (CBI) implementation conducted during the period 1978-1991. He reported average effect sizes ranging from 0.25 to 0.57, or between 10 and 22 percentile gain over a control group who performed at the 50 th percentile. Kulik also reported that students learned more in less time when they received computer-based instruction, and that students liked their classes more and developed more positive attitudes when their classes CBI. These finding suggest that students who engaged in CBI performed significantly better than students who did not. However, the positive effect differed with educational level. At elementary level, effect sizes were greater, 0.37-0.40, whereas at secondary and college level, effect sizes were smaller, 0.25 and 0.29, respectively. Kulik finding is similar to the findings of Niemiec and Walberg (1987).

Fletcher-Flinn and Gravatt (1995) based their analysis on 120 studies conducted during the period 1987-1992. They examined the effect of a range of variables that related to treatments, methodologies, educational level, course content, and student characteristics. Their results and estimates were similar to previous reviews showing a learning benefit for CAI. The mean effect size of CAI for the year1987-1992 was 0.24, suggesting that CAI students would out perform 60 percent of the students from traditional classes. However, no significant difference in effect size between educational level was found. The effect size also did not differ with CAI type. CAI implementation for drill-and-practice, tutorial, simulation, or word processing had a similarly moderately effect size of 0.23, 0.25 and 0.22 respectively. On the other hand, achievement was found differentially related to course content, with highest gains in mathematics, 0.32 or 13 percentile gain, and lowest in reading and writing, 0.12 or 5 percentile gain, an effect size considered not to be educationally significant.

Although it is expected that with more advanced hardware and software available there would be a significant increase in effect size over time, the findings of Fletcher-Flinn, Gravatt (1995) and Kulik (1991) showed effect size fluctuated over years. Kulik and Kulik (1991) reported effect sizes of 0.24 for studies from 1966-1974, 0.36 for studies from 1974-1984, and 0.30 for studies from 1974 to 1985, and Fletcher-Flinn and Gravatt (1995) reported and effect size of 0.24 for studies from 1987 to 1992. The implication of these findings is that effectiveness of CAI has not depended overly on advanced technology in courseware.

Christmann, Badgett and Lucking (1997a) compared the academic achievement of students in grade six through twelve who received either traditional instruction and or traditional instruction supplemented with CAI across eight curricular areas. Based on their 42 conclusions, and overall mean effect six of 0.21 was calculated, indicating that, on average, students receiving traditional instruction supplemented with CAI attained higher academic achievement than did 58.2 percent of those receiving only traditional instruction areas. The comparative effectiveness of CAI showed that the effect size for science subject was the highest, 0.64, and English the lowest, -0.42, whereas maths was in between, 0.18.

Parr[5] summarized that the finding show a general learning advantage for CAI over traditional instruction, though the level of effectiveness of CAI may vary with specific student population, course content and CAI type. However, it has yet to be established if this gain is simply an artifact of poor research design. He assessed the effect of computer technology on learning and achievement by analyzing 219 individual research studies conducted from 1990 to 1997 across all learning domains and all learner ages. He reported that a) students in technology rich environments experienced positive effects on achievement in all major subject areas; b) students in technology rich environments showed increased achievement in preschool through higher education for both regular and special needs children; and c) student's attitude toward learning and their own self-concept improved consistently when computers were used for instruction. However, he acknowledged that the level of effectiveness of educational technology is influenced by the specific student population, the software design, the educator's role, and the level of student access to the technology.

The review reported by Roblyer[7] also used the meta-analysis procedure for summarizing data from research reviews. He conducted a review by analyzing studies between 1980 and 1987 and focus on impact in specific areas and with specific kinds of students. An overall finding was that computer applications had a statistically significant positive effect ($p<0.05$) in a majority of the areas examined. However, there was a wide variation in the focused, procedures, materials, and finding among the studies included in the meta-analysis, as well as a puacity of acceptable studies in many categories. Therefore, he suggested that the results must be interpreted cautiously until more studies of similar types and with similar reporting styles are available to confirm or deny these trends. From the study results, he provides answers to some questions being asked about the effectiveness of Computer-based instruction, for example:

1) Are computer applications more effective at certain grade levels?

Significant effects were found at all levels.

2) Are computer applications more effective with certain types of content?

It seemed to have slightly greater effects with mathematics than with reading/language skills, but the difference was not statistically significant. One of the highest effects observed in the entire review was that for science, but the number of acceptable studies was especially small.

3) Are computer applications more effective with certain kinds of students?

The study found no statistically significant evidence of a relationship between student ability level and the effectiveness of computer-based applications.

4) Do student attitudes improve as a result of using computers?

The trend in the data was positive.

5) What is the comparative effectiveness of various application types (drill, tutorial, and other)?

Only applications in mathematics and reading/language skills were analyzed, since these were the only content areas with enough studies to support comparison. The effects seemed slightly higher for tutorials in reading but statistical results allow no firm conclusions about the superiority of any type of application.

Specifically for science subject area, it was reported in several literatures [6, 8, 9] about the positive effectiveness of CAI on teaching and learning outcome. Stephen Lower, Chemistry lecturer at Simon Fraser University concluded that CAI can make a real difference to teaching and learning, but it must make a point that this does not happen by magic, and that a lot of restructuring of a traditionally-taught course must be done in order to realize the potential of this tool. One of many CAI usefulness found with his experience is that CAI can help learning complex topic (e.g. the 3-dimention graphs) in a shorter time. It was found that this CAI-based lesson made a significant difference.

Collier[6] review the literatures on the topic " The enhancement of the teaching and learning of the sciences in secondary schools using computer-assisted instruction". Collier found the following importance of CAI in the science curriculum: 1) CAI increases motivation and reinforcement, 2) it improves problem-solving and critical thinking skills and 3) it reduces time and cost. He concluded from the literatures review that instruction supplemented by properly designed CAI is more effective than instruction without CAI. Computers can be used for text and test reading, games, tutorial, drill and practice, and simulation of laboratory experiments. CAI can play an important role in classrooms and laboratory work not as substitute for other activities but as an additional tool. Therefore, one should emphasize the importance of the teacher's instruction and presence in the classroom and laboratory, the importance of using text-books and having students "hands-on" in real experiments together with the use of computer programs. But the efficient use of the computer in the classroom is heavily dependent upon the positive approach of the teacher toward the use of the computer.

Edwin Christmann [9] also reported the same trend of CAI impact on the science curricula. The mean effect size calculated for science students who supplemented traditional science instruction with CAI is 0.266, indicating that the average student exposed to CAI showed academic achievement that was greater than that of 60.4% of those students who were exposed to traditional instruction. Moreover, the typical student moved from the 50^{th} percentile to the 60.4 th percentile when exposed to CAI (Christmann & Badgett, 1999). Christmann, Badgett, and Lucking (1997) compared CAI with traditional instruction, finding the largest mean effect size occurred in science (0.639), which indicates that the average science student exposed to CAI attained academic achievement greater than that of 73.9% of those science students exposed to traditional instruction.

2.4 Comparison of Authoring Tools

The popular tools used for creating CAI are investigated. It was found that PowerPoint, Macromedia Authorware and Asymmetric Toolbook II are the most popular tools in Thailand. However, each tool has both strong and weak point of their own. In order to select the most suitable tool for CAI software development, important features of such tools should be compared.

PowerPoint is the simplest tool used for creating CAI. Dominant feature of PowerPoint is the ease of use: adding text, graphics and other simple media can be done easily via a good user interface. Its weakness is difficulty in controling and synchronization of all media. For example, user can not control sound to play or stop at a specified time. Although this tool supports hyperlink, it has no function for tracking user's response and it can not create a quiz because there are no multiple choice control.

Asymmetric Toolbook II create application in a book style. Some programming or scripting are required to activate multimedia effects. Although the programming language or script language are intuitive and easy to learn, it is still quite complicate for end user.

Macromedia Authorware is the icon-based authoring tool. It create application in flow chart style. Simply programing can be performed by dragging a desired icon onto flow-line without using a script language. Values are easily assigned to parameters in any icon via dialog boxes or pull-down menu. The structure of icons on the flowline is a logic that be interpreted to the instructions of CAI software

In conclusion, PowerPoint is suit for simple courseware creation but not suit for a higher level interactive courseware although it is considerably easier than Authorware or Toolbook. However, there are some other factors that should be considered in order to produce a powerful CAI software. These factors including:

1) ease of use (template and wizard)

2) ability to create quiz

3) activeX support (capability to include extra functions from activeX technology)

4) database handler

5) tracking variable (variables that keep track of informations of current user such as score, remain time, number of trial and error) and

6) ability to weight answer's score.

The three authoring tools were compared in terms of all important features as shown in table 2.1.

Table 2.1 Comparison among the three popular tools for CAI software authoring.

Feature	**PowerPoint**	**Authorware**	**ToolBook II**
Template and wizard	yes	yes	yes
Media Management Options	no	yes	no
Full text search	no	yes	no
ActiveX support	no	yes	yes
Interaction	some	yes	yes
Built-in tracking variable	no	yes	no
Database handling	no	yes	yes
Flash 5 and Voxware support	no	yes	some
Quiz creation	no	yes	yes
Weight quiz answer	no	yes	yes

The best authoring tool should have more interactive capabilities while it is easily to use. As can be seen from table 2.1, Authorware is the most powerful tool in this group. It has almost important features necessarily for CAI development. Therefore, in this thesis, Macromedia Authorware is selected as authoring tool and its features will be described in more details in 3.2.1