Development and Evaluation of a Life Sciences Multimedia Learning System

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Abstract
In this research, we used multimedia and computer-aided educational facilities to design a life sciences curriculum. The objective of this curriculum is to introduce and explore the mysteries of life. In daily life, children always feel curious and sometimes dubious about many aspects of life. However, at present, very little educational material for life science is available. The present teaching system was designed to guide 10 to 14 years old young students from the basic all the way through to a detailed understanding of life functions. Structurally, the software package comprises four individual theme areas, namely “What is life?”; “The birth of life”; “The inheritance of life”; and “The progress of life”. Each theme area contains three sections. The “What is life?” section includes a definition of life, details the structure of human bodies, and explains how life is created; the “Birth of Life” illustrates the structure of sperm and eggs, and explains fertilization, and the formation of a fetus; the “Inheritance of Life” includes an introduction to DNA, and introduces some sexual and asexual organisms; finally, the “Progress of Life” illustrates human evolution and specialization. Each section brings together animation, pictures, images, sound, and written words to educate and to create numerous virtual simulations. The effect is a multifaceted educational experience.

Keywords: Life Sciences, Inheritance of life, Progress of life, Multimedia, Computer-aided Instruction.

1. Introduction
Life science is a field of science closely related to the myriad aspects of life. On our planet (alone) life has grown and evolved for 3 billion years. But what, after all, is life? What is it that allows living organisms to display qualities that we associate with life? On the surface, these seem easy questions to answer. However, not every parent or teacher can provide a satisfactory or complete answer. For this research project, we created
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a relaxing and interesting learning environment for children, which use multimedia technologies to stimulate the senses and encourage full involvement of children in learning about the serious and important issues of life functions.

These days, we rely heavily on technology for effective communication. Technology has altered the very fabric of our daily lives and transformed traditional methods of education. In light of the fact that educational needs in depth and width vary greatly from one individual to another, technology holds out the potential of achieving a more effective educational curriculum tailored to an individual student’s needs at a cost far below the traditional solution of teaching in big classes or one-on-one private instruction. Also, a greater flexibility regarding teaching time and location is achieved. Advancing computer technologies have made this medium a platform for continuous innovation and development, in which more effective applications are greatly employed by educators and computer engineers, who are working in tandem to design software for education in many disparate fields. The computer’s role in education is that of educational medium (1, 2). Using application programs and associated data pre-designed into a software package, the computer can create a two-way dialog with the user (the student), where the student can determine the scope and level of this dialog. One software package may have many different facets through which to interact with users, and software designers typically will select ways of displaying the features of a particular software package in a manner appropriate to its theme and purpose in order to ensure the best possible educational results (3, 4).

Computer-aided education has become a popular tool due to its unique characteristics 1) users can determine the pace of the learning process in accordance with their individual situations and needs; 2) users respond to on-screen images or sounds and receive feedback based upon such; 3) a particular subject may be reviewed for an unlimited number of times, thereby raising retention levels of the subject material; and 4) as software can be started, paused, and stopped based upon user requirements, the “time” factor does not hold the overriding importance it holds in traditional education (5). Numerous studies have been conducted to assess the impact that computer-aided education has on the educational process (6, 7). In general, results have shown that computer-aided education both raises the effectiveness of a student’s efforts and reduces the average study time required to master a subject.

Per definition, multimedia is the combined use of written words, images, sound, video, animation, and interactive conversation to transmit information. Multimedia helps to ensure that many categories of information are included (6, 7). Knowledge obtained through multimedia software packages is retained longer than knowledge obtained through traditional means. The effectiveness of multimedia educational tools has already been confirmed by academic professionals and students (8, 9). The potential fields of application for multimedia education programs is seemingly unlimited (10, 11). Special characteristics of computer-aided multimedia education include: student control, fully integrated visual and audio documents, sensory interaction, innovation, creativity, and education within a virtual environment. The multimedia experience turns schools into amusement parks while at the same time ensuring a comprehensive educational experience. This medium is definitely worth promoting (6).
2. System Outlook and Functions

Our planet teems with life, from the darkest ocean depths to the highest of windswept slopes. Life flourishes in roiling volcanic slag, on the hidden surfaces of rocks, and even under layers upon layers of snow and ice (12). However, while life is clearly all around us, it is not easy to clearly define. The biological science uses the following characteristics to define living organisms: living organisms consume energy and food, grow, excrete waste, and respond to outside stimuli (13). Apart from these, the final and most important characteristic is that living organisms reproduce. Reproduction not only ensures survival over multiple generations, but also permits organisms to gradually change and adapt over time (14). We explore the above mentioned characteristics and describe how organisms "live" using a plethora of different chemical and physical processes.

In nature, only organisms of similar type will reproduce together. This is the basis of the subcategory "species". Up until as late as the 17th Century, much of humankind still believed that each organism was inalterably pre-designed and created for a specific purpose. Modern thinking casts doubt on this belief, however, and geological proof was found that earth is far more ancient than previously thought. The identification of fossils, relics from earth's past, demonstrated that many organisms once living on the planet had perished long before humankind came into being and that the earth seems to be in a state of perpetual change over the eons. During the 19th Century, the English botanists Darwin and Wallace provided a theory for this change. They postulated the theory of natural selection, the survival of better adapted organisms at the expense and death of other organisms less well equipped for their environment (15, 16). The theory of evolution remains one of the cornerstones of modern research in biology to this day.

Reading books is the traditional one-way method of transferring information. Leveraging computer technology to design course materials is a way to create the conditions for interactive study. The student may enter a piece of information into the computer via input devices such as keyboard and mouse after receiving a variety of sensory and mental stimuli. The computer can then process the entered information and react to the student in a manner unique to that user. This type of interactive educational environment not only avoids the stigma attached to traditional lectures, but also raises the effectiveness of learning activities in an associated manner (1, 5). In order to help those students with an interest in exploring the mysteries of life in more depth, this research utilizes many images, animation clips, voice recordings, and written words to provide students with pertinent, interesting data at every step of the learning process. The system responds to a student's learning either through images and explanations or through more complex animation clips. The system's reaction to the user helps to heighten his or her acquisition and retention of knowledge and understanding of the subjects taught. In addition, many academics believe that the challenge, newness, and enjoyment of computer games added to the education process will keep students coming back for more (2, 3). Therefore, this software package uses a format similar to that of computer games. Each unit's design incorporates a testing function designed along the lines of a computer game. The simulation of competition in this format maximizes the student's retention of information and increases interest in study.

This software package is designed along a "gameware" format in order to heighten a student's interest. Each area within the
software incorporates a quiz in the form of a computer game to test the results of the study process. The package incorporates multimedia and a multifaceted interface to fully realize the current potential of computer-aided education.

3. System Architecture

The four theme areas within this software are: “What is life?”; “the birth of life”; “the inheritance of life”; and “the progress of life” (Fig. 1, 2).

"What is life?” incorporates four sections (Fig. 3):

1. The formation of life: This area describes the formation of life from the very beginnings of life on earth. The description begins with basic molecules-amino acids, proteins, and RNA which are the building block of cells. Images and ample descriptions and explanations give young students a thorough introduction to these subjects.

2. The Building Blocks of Life: With the birth of cells and the passage of tens of millions of years came the appearance of multi-celled organisms. It is at this point in time that two major branches - plant and animal life appear. This unit educates students regarding the difference between plant and animal cells.

3. The human body: This unit introduces the basic structure and systems of the human body, including the four major structural components (muscular, connective, epithelial, and nervous) and four major systems (vascular, nervous, muscular, and digestive). This unit helps students to better understand these systems and their structures.

4. Tests/quizzes: Tests and quizzes are presented in a game-like puzzle format allowing students to select the correct puzzle to finish out of a choice of three. This method of quizzing helps to enhance the effectiveness of the learning process.

"Birth of Life" comprises four sections (Fig. 4):

1. The structures of sperm and egg cells: This unit describes the structures of the two most important elements in the creation of life. Animation combined with dialog is used to describe the creation of both sperm and eggs to involve students in the process.

2. Fertilization: This unit introduces the fertilization of the egg by a sperm. A race begins at the moment sperm are allowed direct access into the womb. Only a sperm that reaches the egg at the appropriate time has the opportunity to join with the egg. This unit employs animation to display events.

3. The development of the embryo: This unit describes events that occur following fertilization. Realistic displays and verbal description of events draw the students into this unit and teach them about the creation of nascent life.

4. Quiz: Quizzes are based around a multiple-choice format, allowing students to select correct answers from a number of choices. This format heightens students’ understanding of the subject.

“The inheritance of life” incorporates the following four sections (Fig. 5):

1. An introduction to DNA: DNA is the key player in heredity between successive generations. This unit explains the fundamental structure of DNA.

2. Sexual reproduction: Reproduction as the result of the mating of sperm with an egg is defined as sexual reproduction. This unit provides examples from both the animal and plant kingdoms to introduce the characteristics of sexual reproduction.

3. Asexual reproduction: Asexual
reproduction implies that everything that is necessary to produce offspring is incorporated in a single organism’s body. This unit uses examples of asexual reproduction in insects, molds, and yeast.

4. Quiz: The quiz in this section employs a stimulating response format to train student response abilities and to ensure unit lessons are retained.

“The progress of life” comprises the following three sections (Fig. 6):

1. Human evolution: This unit explains the process of human evolution from apes, to proto-humans, and on to homo sapiens.

2. Evolution of cells: This unit explains the evolution of cells from the earliest single-celled organisms to the profusion and specialization of cells observed today. Examples include cells from animals, plants and molds.

3. Quiz: The format of this quiz is a question and answer forum that tests students’ understanding of lessons taught.

This software package is written in Borland C++ Builder. System requirements are the following: IBM Compatible PC (recommended processor of 486 or higher), 16MB minimum RAM, 256 colors or better monitor, CD-ROM drive, sound card, and Windows 95 operating system.

4. Results and Discussion

When this software package was shown during Taiwan 1999 Children’s Information Month, 20 students were selected to evaluate their learning efficiency. Before the students used the system, every student was asked to take a pretest first and then they were introduced to all of the functions of the system and they were instructed about some points they should pay attention to. Then, the students after having used the software system, were given a posttest. The questions of the pretest and posttest were similar. Also, to ensure that the tests were fair and objective, students who had taken the tests were asked not to discuss test topics with other student who had taken the test yet. Since the students’ ages and personalities are different, each of them took different a time to finish the program. The time used was between 50 min. to 100 min. and the learning efficiency was different for different test times.

In addition to the evaluation of the students’ learning efficiency, ten of the parents of the students or their teachers were selected to evaluate the software package. Evaluated items included were: system introduction, user friendliness, teaching contents, design and layout, quality of quizzes, curriculum management, and determination if the curriculum contents were suitable for the learners and the curriculum arrangement appropriate.

The 20 students’ test results and the data record of their learning process, highlighted four factors that affect learning efficiency: 1. the degree of a student’s life science knowledge, 2. the learning time, 3. the learning intention and perseverance, 4. the student’s age. The results are shown in Table 1.

The software package was evaluated by the 20 students and 10 of their parents or teachers. The results are shown in Table 2. The evaluating data shows that the students gave “quality of quizzes” items a very high score, meaning the students liked those game-like quizzes a lot. Moreover, the students and parents expressed a highly affirmative response about the “design and layout”, “teaching contents”, and “over all “ items, indicating that the students and parents generally consider this software to be
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Table 1. The Results of Learning Efficiency Study

<table>
<thead>
<tr>
<th>Student</th>
<th>Age</th>
<th>Degree of life science knowledge</th>
<th>Time used (min)</th>
<th>Pretest score</th>
<th>Posttest score</th>
<th>Learning efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14</td>
<td>High</td>
<td>60</td>
<td>70</td>
<td>100</td>
<td>43%</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
<td>Middle</td>
<td>70</td>
<td>60</td>
<td>80</td>
<td>33%</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>Middle</td>
<td>70</td>
<td>60</td>
<td>85</td>
<td>42%</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>Low</td>
<td>50</td>
<td>50</td>
<td>60</td>
<td>20%</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
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<td>55</td>
<td>60</td>
<td>70</td>
<td>17%</td>
</tr>
<tr>
<td>6</td>
<td>11</td>
<td>Middle</td>
<td>75</td>
<td>60</td>
<td>80</td>
<td>33%</td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>Middle</td>
<td>70</td>
<td>60</td>
<td>75</td>
<td>25%</td>
</tr>
<tr>
<td>8</td>
<td>13</td>
<td>High</td>
<td>60</td>
<td>80</td>
<td>95</td>
<td>19%</td>
</tr>
<tr>
<td>9</td>
<td>12</td>
<td>Middle</td>
<td>75</td>
<td>70</td>
<td>85</td>
<td>21%</td>
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<tr>
<td>10</td>
<td>10</td>
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<td>50</td>
<td>60</td>
<td>20%</td>
</tr>
<tr>
<td>11</td>
<td>10</td>
<td>Low</td>
<td>65</td>
<td>55</td>
<td>65</td>
<td>15%</td>
</tr>
<tr>
<td>12</td>
<td>11</td>
<td>Low</td>
<td>60</td>
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<td>70</td>
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<tr>
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<td>70</td>
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<tr>
<td>16</td>
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<td>70</td>
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<tr>
<td>17</td>
<td>10</td>
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<td>14</td>
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<td>100</td>
<td>25%</td>
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<tr>
<td>19</td>
<td>11</td>
<td>Middle</td>
<td>100</td>
<td>80</td>
<td>95</td>
<td>19%</td>
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<td>20</td>
<td>13</td>
<td>Middle</td>
<td>80</td>
<td>70</td>
<td>80</td>
<td>14%</td>
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</table>

Table 2. The Results of Software Evaluation Study

<table>
<thead>
<tr>
<th>Item</th>
<th>Basic score</th>
<th>Students (20)</th>
<th>Parents or teachers (10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>System introduction</td>
<td>5</td>
<td>4 (80%)</td>
<td>4 (80%)</td>
</tr>
<tr>
<td>User friendliness</td>
<td>10</td>
<td>8 (80%)</td>
<td>9 (90%)</td>
</tr>
<tr>
<td>Teaching contents</td>
<td>30</td>
<td>26 (80%)</td>
<td>27 (90%)</td>
</tr>
<tr>
<td>Design and layout</td>
<td>20</td>
<td>18 (90%)</td>
<td>18 (90%)</td>
</tr>
<tr>
<td>Quality of quizzes</td>
<td>10</td>
<td>10 (100%)</td>
<td>9 (90%)</td>
</tr>
<tr>
<td>Curriculum arrangement</td>
<td>10</td>
<td>8 (80%)</td>
<td>8 (80%)</td>
</tr>
<tr>
<td>Over all</td>
<td>15</td>
<td>15 (100%)</td>
<td>14 (90%)</td>
</tr>
</tbody>
</table>

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5. Conclusion

Life science is an area of science closely tied to human existence. Having said this, the education in life sciences currently provided for our children lacks an introduction and explanation of such connections. Traditional education provides only a cursory at best and non-existent at worst, introduction to the topic of the process of life creation. Most educational software targeting children focus on teaching math, languages, biology, and life skills. Software introducing life sciences, a topic which is the subject of much curiosity for children, is noticeably absent. Therefore, we have chosen to design just such a software package with the expectation that, upon completion, it will provide children with an accurate, engaging, and interesting introduction to the fascinating world of life sciences that leads them to appreciate and value life more. At present, we are further developing the functions of this software package, including the miracle of life and reproduction and an introduction to genes and genetic functions. We are also keeping in stride with current developments in the field of life sciences by exploring the subject of cloning new life. Through this software package, we sincerely hope to provide children with a straightforward, interactive, and multifaceted educational environment. This software package was shown during Taiwan 1999 Children’s Information Month in Taichung and Tainan, and was exceptionally well received by parents and children alike.

Acknowledgements

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References


What is life

The inheritance of life

The progress of life

Birth of life

The formation of life

The building block of life

The human body

Tests/quizzes

Sexual reproduction

Asexual reproduction

An introduction to DNA

Quiz

Human evolution

Evolution of cells

Quiz

The structures of sperm and egg

Fertilization

The development of the embryo

Quiz

Fig. 1
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Fig. 2. Main menu of the system

Fig. 3. What is Life

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Fig. 4. Birth of Life

Fig. 5. The Inheritance of Life
Fig. 6. The Progress of Life