An Educational Multimedia Package for Integration of Photobioprocesses and Photobioreactors into the Biotechnology Education Curriculum

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Introduction

Biotechnology techniques influence every one's life in the form of new foods, medicines and many other products that some of which are obtained by Photobioprocesses [1,2,3]. Also, cultivation of microalgae in photobioreactors may be used for biofixation of CO_2 in the atmosphere and production of hydrogen as a clean fuel for sustainability in the environment [4,5,6].

The rapidly increasing impacts of biotechnology have stirred the interest of groups of people such as researchers, producers and consumers, environmentalists, economists, politicians, and legislators. Investment, marketing and research, becomes more attractive as there is increased possibility of gaining benefits with the continuing rapid growth of biotechnology all over the world. Parallel to the development of biotechnology related sectors, biotechnology educational programs have started and have grown specifically for inclusion in the science and technology curriculum at the different educational levels.

This rapid development suggests that providing biotechnology educational materials by the conventional systems is a very difficult and time-consuming process [7]. Conventional education of biotechnology requires a specific place (classroom and laboratory), specialist/educated teacher, textbooks, and considerable investment for experimental devices. Many of the biotechnological experiments are too costly, too time consuming, too dangerous to be done easily in classroom [7]. They are among the limitations to the development of biotechnology education via conventional models.

Computer based instruction software often reduce the instruction time and students' motivation is increased [7]. Also, It make it possible to showing activities that are too costly, complex, hazardous, or lengthy to conduct in the laboratory [8]. And also decreases limitations including requirement to a classroom, specialist/teacher and laboratory. These benefits may be reason enough to consider using software instruction in biotechnology [8].

The use of multimedia software enables a high volume/quantity of information to be learned by the student. The format enables input from the basic high school student level to the learned expert in the field. Also, the information is easily transmitted at high speed to the most remote locations or can be stored and distributed in cost effective formats. This enables a larger dissemination of valuable information in an easily understood format to a wide network of students, a characteristic very important for developing countries.

In this work a Power Point based Educational Multimedia Package (EMP) was prepared for instruction of Photobioprocesses and photobioreactors. This documentary demonstration software was designed to be use as a combined or supplemented media to assist individual instruction.

Instructional design of EMP:

The overall goal of the multimedia package is introduction of the photobioprocess and photobioreactors for the student/viewer by way of showing experiments.

Photosynthetic microorganisms have vast potentials as a source of valuable food, cosmetics, pharmaceuticals, pigments, and other fine chemicals. The applications have been expanded to the area of wastewater treatment, hydrogen production, and CO2 fixation. Technical systems for the production of phototrophic microorganisms are termed photobioreactors[9].

The educational materials for teaching Photobioprocesses and photobioreactors are very rare and this package might be use for inclusion into the biotechnology education curriculum.

By following the package, student/viewer expected to understand the components of photobioreactors such as photosynthetic microorganisms, photobioreactor as well as cultivation steps, conditions and controls.

The purpose was divided to the following goals:

- Identification of present situation of CO2 in the atmosphere.
- Benefits of photobioprocess for reduction of CO2 and production of useful substances.
- General steps of cultivation of photosynthetic microorganisms.
- Identification of photobioreactors.
- Case study of cultivation of *H. pluvialis*
- Cell growth and carotenoid production conditions and controls.
- Benefits of photosynthetic microorganisms.

The following items are the prescribed-learning outcomes:

It is expected that after this program the student(s) will be able to:

- Describe the reasons for CO2 increasing in the environment.
- Describe the alternatives for reduction of CO2 in the environment.
- Describe the microalga and their ability to decrease the CO2 in the environment.
- Describe the general micro alga cultivation steps (photobioprocesses).
- Describe the photobioreactor types and function.
- Describe the preculture preparation method by *H. pluvialis*.
- Describe the culture preparation method by *H. pluvialis* .
- Describe the controls of cell growth and production during the cultivation.
- Define the other benefits of micro alga cultivation.

The presentation starts with making a problem in the mind of the student/viewer and helps them to find solution for it in the way of continuing the package. During the presentation the photobioprocesses and photobioreactor described.

To get attention and demonstrating the effectiveness, importance and application of photobiorectors in the daily life, the instruction starts with the problem of increasing harmful dose of CO2 in the atmosphere. Also benefits of the photobioprocesses in the hydrogen production by photosynthetic microorganisms such as *Rodobacter capsulatus* as the clean fuel energy sources were described.

The presentation starts based on the junior high school. Also, some primary scientific information such as cell biology and other necessary information for using the package are included for students who are not so familiar with the subject.

To reach to the prescribed goals, the information was presented with the following main topics.

- Problem of increasing CO2 and other harmful gases in the environment.
- Alternatives for reduction of harmful gases (especially CO_2) in the environment.
- Photosynthetic microalgae.
- Cultivation of microalgae.
- Preculture preparation.
- Culture preparation
- Controls of cultivation
- Some examples of industrial production of microalgae.
- Photo-bioprocess components and flow sheet

Each topic is presented as a separate frame supplemented by educational materials such as more information, questions of different levels of learning, and home works to reach to the goals. These supplementary materials are included in separate linked pages. To assessment of the goals, separate set of questions and answers also included in each topic.

Technical characteristics of EMP

A Power Point based multimedia was used in this package. It is consists of several media including text, picture, graph, sound and video. This EMP is multilingual, i.e. English, Japanese and Persian.

Each main slide introduces one topic with separate parts for the title, text, graph, sound, picture or movie. There is also an icon at the bottom of the slides “More information” that links to educational supplementary material slides and other icons to change the topic backward, forward or exit. The “More information” icon contains references with a brief explanation. Figure 1 shows the frame of main slide.

The icon "Questions" links to questions designed to evaluate different levels of learning. The icon "Homework" links to activities and local questions. In addition to the main slide, pages such as "contents", "Glossary" and "Help" were included. Also, a help page is included to describe using methods of EMP. All of the pages/slides have colored backgrounds and some animated pictures to increase the attractiveness of EMP.

Evaluation of the EMP

An evaluation of the contents, instructional and technical characteristics of the multimedia package were carried out based on Micro SIFT as a questionnaire and implemented by some university professors, teachers, and students. The 20 questions of questionnaire were answered by ten college and ten high school students and three professors and five teachers totally 28 respondent. The contents of the questionnaire are in the Table 1. The results of the questionnaire are shown in the figure 2.

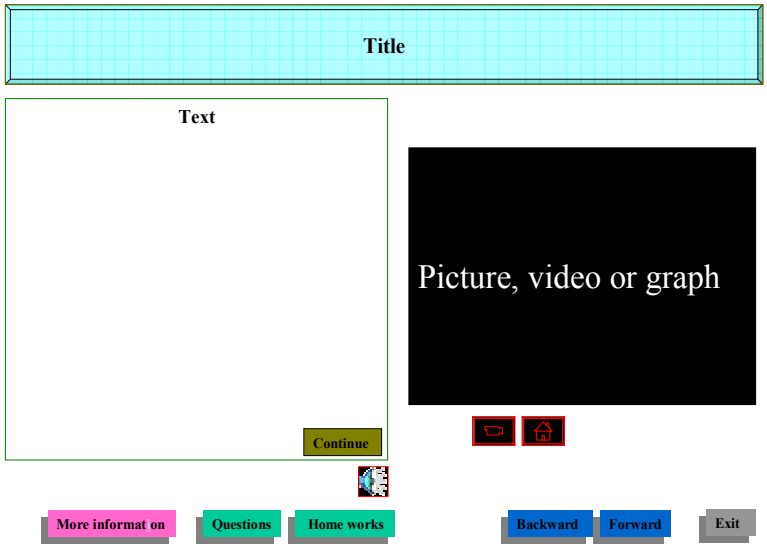

Figure 1: the frame of main slide

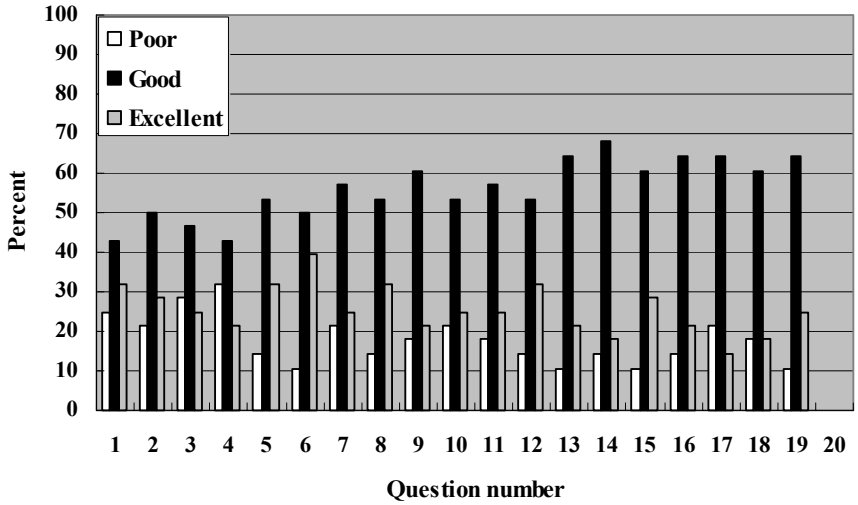

Figure2: The results of software evaluation

Table1: contents of questionnaire of EMP

Questionnaire

This Questionnaire is designed for the evaluation of the educational multimedia package of the "Photobioprocesses and photobioreactor". It is designed as a self study package. Please after look to the package, answer to the following questions.

1. The purpose and objectives of the package defined:
   ☐Poor ☐Good ☐Excellent
2. The achieves to the defined purpose and objectives was:
   ☐Poor ☐Good ☐Excellent
3. The logic consequence of the contents was:
   ☐Poor ☐Good ☐Excellent
4. The clearness of the contents was:
   ☐Poor ☐Good ☐Excellent
5. The degree of simplicity for the target audience was:
   ☐Poor ☐Good ☐Excellent
6. The motivational of the package was:
   ☐Poor ☐Good ☐Excellent
7. The assessment of the student/viewer was:
   ☐Poor ☐Good ☐Excellent
8. The generalization of learning to other situations was:
   ☐Poor ☐Good ☐Excellent
9. The easiest operation with the package was:
   ☐Poor ☐Good ☐Excellent
10. The easiest control of the learning with the package was:
    ☐Poor ☐Good ☐Excellent
11. The educational contents of the texts were:
    ☐Poor ☐Good ☐Excellent
12. The amounts of the texts were:
    ☐Poor ☐Good ☐Excellent
13. The educational contents of the pictures were:
    ☐Poor ☐Good ☐Excellent
14. The number of pictures was:
    ☐Poor ☐Good ☐Excellent
15. The educational contents of the movies were:
    ☐Poor ☐Good ☐Excellent
16. The amounts of the movies were:
    ☐Poor ☐Good ☐Excellent
17. The educational contents of the narrations were:
    ☐Poor ☐Good ☐Excellent
18. The amounts of the narrations were:
    ☐Poor ☐Good ☐Excellent
19. The number of the icons was:
    ☐Poor ☐Good ☐Excellent
20. What are your comments for improving the package? Please explain.

Thank you for responding to this questionnaire

The recommendations by responders were divided to the following items:

1. Simplification of some of the terms.
2. Adding some more information for college students for designing photobioreactors.
3. Using HTML files.
4. Preparing an online package.
5. Using animation in the multimedia

The contents have been revised based upon the feedback.

Conclusion

The teaching of Photobioprocesses and photobioreactors are very rare in biotechnology education curricula. Using new educational methods that utilize computerized educational software can decrease some of the limitations of the traditional educational systems such as necessity to the classroom and professional teacher. In this self-study multimedia, the photobioprocesses and photobioreactors were introduced with showing sample experiments. During the media, some questions, homework experiments and additional resources for more information were introduced to reach the educational goals. These goals were asset by a set of questions/answers. The evaluation of this software was carried out through a questionnaire of students, teachers and university professors. According to their comments some modifications were made. This EMP was commended for being useful for the teaching of photobioprocesses and photobioreactors.

Future developments of the EMP include increased usage of simulations and user – EMP interface. This allows the student/user to experiment with varying parameters and observing the results. Also, the development of said EMP in another format (especially HTML) is being studied to empower its use across great distances.

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