Application of Bioinformatics in the Internet of Things-
Construction of Mushroom Cloud Digital Learning Platform

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Abstract. In recent three years, the practical spirit of “DIY(Do-It-Yourself)” advocated in European and American education to combine the value of creativity and innovation is developed to a word “Maker” after integrating into the education system, which comes from the idea of “Hacker” and “Self-creator”. The Maker transforms one-way learning model of “listening” and “writing” in the past to school curriculum of “image” and “practice”, causing a reversal of traditional educational concepts. Educational policy in Taiwan naturally moves with the tide of the world. What characteristics of DIY, trouble-shooting, creativity sharing and community link emphasized by the Maker is in consistent with the transformation of technical and vocational education and the innovation of higher education that focus on the spirit of exploration and practice as well as innovation? The school used to participate in High Scope Program Phase II, including the development of “eco-art” course module for the first three years focused on plant observation along with the use of photography, presenting the idea of truth, goodness and beauty with the practice of “scientific drawing” in Fine Art Department; and, elaboration and promotion stage for the following two years focused on the reinforcement of introduction to biological course and the function of “online plants learning platform”, expanding to university and senior high schools, including of the Affiliated Chongli Senior High School of National Central University, Taishan and Sanming Senior High School for the development of more functions.

As the theme of mushroom nutrition & health care, the school continues the spirit of exploration and practice by integrating Dept. of Home Economics’ food safety issues, Dept. of Chemistry’s extraction analysis, Dept. of Physics’ spectrograph analysis and Dept. of Computer Science’s internet of things(IoT) into curriculum framework to develop courses module for additional learning platform of mushroom classification based on “online learning platform” within application of bioinformatics in the IoT. The content for logic concept of plant retrieval classification and feature concept of fungi classification is processed in our Mushroom Digital Learning Platform by combining tablet PC and interactive web pages of “Online plants and herbs(mushroom) learning platform” for multiple assessment, in order for teachers to understand the learning effect of each student and analyze the data through the cloud platform.

1. Introduction

With the development of digital technology, traditional teaching method has been unable to meet the needs of students, so that teachers should change their teaching methods to respond to the changing times.
for students’ requirements. Therefore, creative courses in School with IoT combine the development of technological application and scientific literacy to distinguish course designs from teachers’ traditional teaching methods. Appropriate practical courses allow students to personally observe and record detailed features [1] and cultivation of each parts of plants and mushroom through plant reconnaissance, dissecting microscope and camera, establishing logic concept of plant retrieval classification and feature concept of fungi classification, and combining tablet PC and interactive web pages of “Online plants and herbs (mushroom) learning platform” for multiple assessment, in order for teachers to control each student’s learning effectiveness anytime; as cloud digital learning platform can make students continue to explore the learning field after class, it is a good teaching aids; the platform can also provide students with a complete database for plant features, campus plants and herbs (mushroom), so as to further understand their distribution, name, source, literary allusion, customs purpose, nutrition and health care as well the relevant information.[8][9]

| Table 1. Mushroom Cloud Digital Learning Platform—Bioinformatics in the IoT. |
|---------------------------------------------------------------|
| **Theme Exploration**                                      | **Number of faculty members in 2019** |
| Chemistry’s extraction analysis                             | 350 (person-times)                  |
| Home Economics’ food safety issues[7,1]                     | 530 (person-times)                  |
| Physics’ spectrograph analysis                              | 160 (person-times)                  |
| Computer Science’s internet of things                       | 180 (person-times)                  |
| Self-practice and quiz                                      | 650 (person-times)                  |
| **All Themes**                                              | 1870 (times/one year)               |

There are the following major themes in the platform, including of Chemistry’s extraction analysis, Home Economics’ food safety issues, Physics’ spectrograph analysis, Computer Science’s internet of things and Self-practice and quiz. According to the statistics of the number of teachers used on the cloud platform within a year, as shown in Table 1, it is found that in addition to the test quiz, the most popular topic is Home Economics’ food safety issues.

2. Bioinformatics of Mushroom: Contents, operation and features of the platforms

Our mushroom research digital learning platform is a resource sharing platform jointly built by teachers of Dr. Y-F Lin, C-H Lin, M-F Lin, Y-R Yo, M-C Ying, Y-W Chin and L-H Lin. It provides course resources and student’s learning outcome through online sharing resources for elective course “Mushroom exploration and practice” based on interdisciplinary curriculum and switch-classroom; besides, we welcome any teachers, students or the public who take interest in it to use resources of web pages for self-learning. Mushroom exploration and practice course is divided into four units, i.e. “Discovery of fungi”; “the Food & Chemical analysis of mushroom”, “Great fun for mushroom cultivation” and “Spectrum analysis of mushroom”, which will provide students with multiple learning processes through lots of practices from learning by doing and train their abilities in scientific inquiry whenever they are in the future. Platform constructed as course requirements is divided into four parts, i.e. “Mushroom knowledge construction”, “Student outcome”, “Live class” and “Cross-school cooperation”.

2.1. Mushroom knowledge construction

It provides basic classification features of fungus, brief instruction to mushroom features, instruction to common mushroom features [2] (as shown in Figure 1 and Figure 2), teaching materials and presentation files for the concerned courses in each unit.
2.2. Student outcome

The function shares student’s learning outcome, including experiment learning sheet, mushroom creative cooking film and dot painting (as shown in Figure 3.), This kind of artistic integration is very important for the description of the characteristics of mushrooms [3], and can be placed in the cloud database. In addition, the part of “Live class” shares photos of interaction between teaching and learning (as shown in Figure 4.) in the implementation process for mushroom exploration courses in each semester per academic year. The actual video is published in mushroom research digital learning system, and teachers can share the live lesson in real time and feedback-based teaching.

2.3. Cross-school cooperation

This provides the relevant teaching materials or presentation files for cross-school cooperation courses, along with photos of students’ learning experience feedbacks and activities. At present, we have cooperated with National Taiwan University and Chung Yuan Christian University, the former for the observation experiment of fungi and the latter for the measurement of mushroom protein and polysaccharide [4][5][6].

The school database can even go through network platform to share with teachers and students in other schools, and partnership school also can copy our mode to establish teacher community for further cooperation with us to build cross-school community and expand database contents. Resource sharing is the biggest feature in this course. Mushroom digital learning platform not only can provide teachers with teaching resources, but also is a favourable assistant for teachers’ teaching; meanwhile, students can develop teamwork peer-learning through group discussion; they can use this platform after class to achieve the effect of cloud learning and multiple assessment from web pages, so that teachers can control each student’s learning effectiveness anytime. The platform can be said a place to record and share the teaching process and the best assistant to accompany students’ learning and growth. Going through this digital learning platform will let students share flexible and independent learning process and reduce face to face pressure between teachers and students. Students may go online to learn anytime and anywhere, either preview before class or after-school review at home, while traditional education requires
students to face-to-face learn from teachers. Additionally, digital learning platform is not a linear learning mode as students don’t need to learn step by step but can control the progress of the course to select courses according to their own levels.

3. Innovations and Achievements

3.1. Curriculum integration
(a) The curriculum makes students better internalize the knowledge from practice and learning to their own learning through lots of hands-on activities and observation, by which the spirit of active learning and exploration can be cultivated for the construction of students’ independent abilities to learn science, and their experimental logic can be trained in this process, e.g. basic concept and test method of food additives, homemade spectrograph. Teachers can integrate information into their teaching and share with curriculum information through the cloud system (Google Drive); students can upload experimental record learning sheet and release achievement PPT in order for teachers to assess students’ learning effects in many ways.
(c) Mushrooms as required in learning field are from the school’s mushroom plant. Curriculum is designed to let students independently design menu and share cooking from their own experiences in mushroom growing and gathering, which they can use as samples for food additives testing and fungi observation and experiment for the promotion of do-it-yourself experimental atmosphere.
(e) Students can understand and actively explore knowledge of mushroom related to life through High Scope curriculum and apply what they have learned to their daily life. That the role of student becomes knowledge explorer and teacher knowledge navigator through High Scope teaching is consistent with nowadays’ flipped teaching based on learner. Through mushroom growing, cooking and mushroom plant visiting, students can extend informal learning from classroom to campus to learn any abilities whenever they are in the future and experience in hands-on science for the fun of it.

3.2. Knowledge innovation and talents cultivation
(a) Besides providing plant-related information for users, “Plant learning platform” will incorporate the school’s continuous development of “Mushroom learning platform” into the school’s featured course of natural science; meanwhile, it can combine the relevant information database jointly established by different social organizations to achieve popular science sharing platform jointly built with common resources. The concept of internet of things can be introduced to design the relevant courses by IOT sensing technique observation for the influence of environmental change on mushroom cultivation.
(c) Students are encouraged to attend inside and outside the school competition, short essay presentation and scientific show, so as to improve their practical abilities and experiences. The relevant talents from senior high school can be trained for spectrum analysis to analyse mushroom spectrum with simple dispersion spectrum equipment. Their abilities can be trained by introducing all kinds of microbiology and actual operation from the very beginning to engage in molecular biology in the future. They can be instructed to build their abilities in experimental operation and data analysis through group cooperation.

3.3. Promotion of curriculum and digital platform
(a) “Plant showplace course” and “mushroom exploration and practice course” is established to reserve for other partnership schools’ cooperation and jointly develop the function of campus plant web system. All partnership schools can use the same platform to share the database of campus plant platform for the establishment of their schools’ featured courses, achieving resource sharing and expanding teaching fields, so as to expect the development of the maximal effect from the plant learning platform.
(b) A set of healthy and practical “Plant learning platform” and “Mushroom learning platform”, “Plant database” and “Mushroom database” will be established to link school’s homepage and share it with the public. Through the cultivation of the talents related to fungus safety detection and spectrum analysis, students will be able to pursue future advanced studies in the relevant scientific fields.

(c) Mushroom additives testing experiment provides learning on food safety issues, allowing learners to understand the nature of the additives through experimental theory and design and have basic knowledge about food additives and food science. Additionally, experimental design can lead students to think about how to design a complete experiment, how to develop detection reagent by means of chemical reaction and how to design experimental process to acquire meaningful data, by which data is presented through graph for further analysis and discussion. And thus, it can not only make learners know additives and testing methods, but also improve research ability in preparing scientific papers to cultivate basic scientific literacy. Through international education exchange and visit, R&D courses can be introduced to sister schools in Japan and Korea and provided participatory learning for foreign students.

4. DNA Experiment and Quantity Analysis of Mushroom

4.1. DNA crude extraction experiment

4.1.1. the purpose of the experiment

- First, understand the principle of crude DNA extraction & Learn simple DNA extraction methods.
- Second, the experimental steps & extract the DNA of mushrooms, then preparation of mushroom juice: Put the right amount of mushrooms into the juicer, add 100 mL of distilled water and mix up, then destroy mushroom cells.
- Pour the mushroom gravy into a 200mL beaker, add 3mL dishwashing detergent, and stir slowly with a glass rod for 5 minutes.
- Certain other common mathematical functions, such as cos, sin … etc., should appear in Roman type.
- Dissolve chromosomes: add 10ml of salt water (5M, 29.25g of salt + 100ml of distilled water) to the mixture from step 2 and mix well for 5 minutes.
- Purify DNA: add 10mL of fresh pineapple juice to the mixture in step 3. Continue to stir slowly for 5 minutes.
- Collect the DNA filtrate: use two layers of gauze to filter the mixture of step into a 100ml beaker to filter out excess impurities (DNA is present in the filtrate).
- Extract DNA: take 20ml of filtrate and put it into a clean 50ml beaker, slowly pour 40ml of 95% ice alcohol along the inner wall of the beaker, and then you will see the solution layering and a white mist at the junction of alcohol and water, that is for DNA, use a dropper to suck out and store it in a container filled with 70% alcohol.

4.1.2. results of DNA experiment

To a white cloud appears at the junction of alcohol and water, which is DNA. DNA converges into filamentous structures. After DNA extraction and purification, further qualitative and quantitative control analysis (Quality Control Assay) is required, including: Agarose Gel Electrophoresis Analysis and UV Absorption Analysis.

4.2. Determine DNA purity

The light absorption qualities of nucleic acids are mainly at the wavelengths of 230 nm, 260 nm and 280 nm. 230 nm is the residual organic salt, 260 nm is the concentration of nucleic acid, and 280 nm is the protein. Therefore, the ratio of A260/280 can predict the purity of the nucleic acid in the sample, and the ratio of A260/230 represents whether there is residual salt contamination.
1 O.D. represents different concentrations in different types of nucleic acids. For double-stranded DNA, 1 OD = about 50 µg/ml. According to the above concentration, the concentration of nucleic acid can be calculated according to the formula (1) and formula (2).

\[
\text{DNA concentration} = \text{OD260} \times 50 \text{ µg/ml} \times \text{dilution factor.} \quad (1)
\]

\[
\text{DNA purity (A260/A280) = \left( \frac{\text{A260 reading} - \text{A320 reading}}{\text{A280 reading} - \text{A320 reading}} \right)} \quad (2)
\]

Strong absorbance around 230nm can indicate that organic compounds or chaotropic salts are present in the purified DNA. A ratio of 260nm to 230nm can help evaluate the level of salt carryover in the purified DNA. The lower the ratio, the greater the amount of thiocyanate salt is present, for example. As an ideal line, the A260/A230 is best if greater than 1.5[8]. A reading at 320nm will indicate if there is turbidity in the solution, another indication of possible contamination.

![Figure 5. DNA experiment and numerical values (Trained & Untrained).](image)

Therefore, taking a spectrum of readings from 230nm to 320nm is most informative. When measuring DNA concentration, the ideal value of A260/280 is between 1.7 and 1.9. DNA concentration. As shown in Figure 5, there are many external factors in the DNA experiment, and the concentration value obtained by the students after training is better than that of the untrained, almost equal to the value obtained by the teacher group. Of course, the external factor is affected (when contaminated), and the value becomes worse.

### 4.3. Factors Affecting Electrophoresis

During electrophoresis, the movement rate of nucleic acid is logarithmically inversely proportional to its molecular weight, and has nothing to do with the base composition of the nucleic acid sequence, as shown in Figure 6. Other factors that affect electrophoresis include:

1. **Concentration of colloid:** The concentration is related to the pore size of the colloid. High concentration and small pore size are suitable for nucleic acid electrophoresis with small molecular weight; while low concentration and large pore size are suitable for nucleic acid electrophoresis with large molecular weight. Generally, the concentration of agarose is 0.3~2.0%, which is suitable for the analysis of nucleic acids with a size of 100~60,000bp.

2. **Nucleic acid structure:** the same kind of DNA with different shapes, electrophoresis under the same conditions, its moving speed will be different.

### 4.4 Observation of electrophoresis results

After nucleic acid electrophoresis, the nucleic acid in the colloid can be stained with ethidium bromide (EtBr). EtBr will be embedded in the base of the nucleic acid. When irradiated with ultraviolet light, the nucleic acid absorbs light of ultraviolet wavelength, and then emits light of visible wavelength through EtBr to observe the nucleic acid position. The concentration of EtBr staining is 0.5µg/ml. In addition to immersing the colloid in the EtBr solution after electrophoresis, you can also directly add EtBr into the colloid when preparing the colloid, so that the nucleic acid is stained during
electrophoresis, so as to save the time required for staining after electrophoresis. For chimeric nucleic acids, the electrophoresis rate will decrease.

Figure 6. results of after nucleic acid electrophoresis

5. Conclusion

Mushroom Digital Learning and Research Platform[1][12]-This platform is the first to propose the idea of database co-creation and resource sharing, so that teachers from cooperative schools can participate in the construction of Mushroom database.

(1). After effective training, the mushroom DNA detection experiment can be carried out.

(2). Effective determination of mushroom protein and polysaccharide.

(3). When there are more and more cooperative schools, more teachers from cooperative schools can share the same resources to help establish different mushrooms or curriculum-related information. Such a database will continue to increase (the total number of participants is counted by the platform's big data: 18,752 visits in two years, and 85% satisfaction) as shown in Table 2 and in Figure 7.

(4). Not only provide supporting teaching materials for partner teachers, but also serve as a self-study tool for students and the public, thereby breaking the boundaries between schools and becoming a learning community for resource cooperation philosophy (Create and share). Finally, we have used the Internet of Things and APP to grow mushrooms, as shown in Figure 8.

Table 2. The use satisfaction of students and teachers on the online platform and the correct ratio of test scores in the database (using big data statistics).

| personnel | 2017-2018 | 2018-2019 | Correct answer rate |
|-----------|-----------|-----------|---------------------|
| students  | 69%       | 85%       | 83%                 |
| teachers  | 68%       | 84%       | 91%                 |
| ALL       | 69%       | 85%       | 85%                 |

Figure 7. The use satisfaction of students and teachers on the online platform and the correct ratio of test scores.

Figure 8. Used the Internet of Things and APP to grow mushrooms
Acknowledgments
This research was supported by the High Scope Program of Taiwan (Grant MOST-106-2514-S-947-002) and Consociation of Yang-Ming Educational Affairs Foundation. In addition, thanks to these partners like Dr. L-C Chang, Y-R Yu, M-C Ying, Y-W Chin and L-H Lin, for their long-term dedication in teaching courses, and appreciate assistance in English and biology from C-H Lin and M-F Lin. Finally, we would also like to thank the Taoyuan Education Bureau, Longhua University of Science and Technology, National Central University and Chongyuan Christian University for their support within strategic alliances.

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