BUILDING AND USING DIGITAL LEARNING MATERIALS IN TEACHING THE TOPIC “METABOLISM AND ENERGY TRANSFORMATION ON THE BODY LEVEL” IN GRADE 11 BIOLOGY

Do Thanh Trung¹, Pham Minh Thuy¹*, Tran Tuan Anh²

Abstract. Digitizing learning materials for teachers and students is one of the most vital tasks in education. Building digital learning materials in Biology subject plays a crucial role in developing self-study competence towards the goal of "lifelong learning" for students and improving quality of teaching. However, practical investigation has revealed that the constructing a digital learning set for teaching biology still faces many difficulties. Therefore, the aim of this study is to create a set of digital learning materials for the topic “Metabolism and energy transformation on the body level” in Biology 11. This study determined the process of building and using a digital learning set for the topic "Metabolism and Energy transformation on the body level" in Biology 11 and built a set of 219 digital learning materials including images, videos, and worksheets,... to enhance students’ self-study capacity. Through consulting experts and conducting pedagogical experiments, the results demonstrate that constructing of a set of digital learning materials for teaching the topic "Metabolism and energy transformation on the body level" in Biology 11 contributes to the development of students’ self-study competence.

Keywords: Digital learning materials, metabolism and energy metabolism, self-study, self-study competence.

1. INTRODUCTION

According to the United Nations Educational, Scientific and Cultural Organization - UNESCO (2013), the goal of learning is “learning to know, learning to do, learning to live together and learning to be”. Therefore, learning is essential for everyone.

However, with the changing social context, industrial revolutions broke out one by one, replacing the backwardness and obsolescence of the times with advanced technologies and creating “real values” for humanity. In particular, the industrial revolution 4.0 is a turning point marking the change of many fields from life - society, economy - politics, culture, defense - security to education. Electronic equipment and high-tech equipment gradually replace human manual labor. This is both an opportunity and a challenge for manifields, including education. Many experts have asked the question "Will technology and robots replace the position and role of teachers in society?".

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Equipment and technology are tools for both teachers and students. Therefore, when there is support from technology and techniques, it is extremely urgent to digitize traditional materials into digital learning materials to help students and teachers access latest human knowledge easily and quickly.

The topic “Metabolism and energy transformation at the body level” - Biology 11 researches at the level of multicellular organisms, with the contents focusing mainly on the mechanisms and processes that take place in animals and plants. Although this knowledge is not new, it is relatively abstract for students. Therefore, the content in the research is very suitable for building a digital learning set through images, videos, and online support software.

Currently, there are many free and paid sources of Biology learning materials on the Internet. Such as Biology Corner (Address: https://www.biologycorner.com/), Biology Web (Address: http://www.cellbiol.com/),... However, a large amount of these materials are not systematic, not logically arranged, not exactly followed the general education program 2018 and they have not been detailed for each lesson. Thereby, teachers and students still have difficulties in finding highly reliable learning materials.

In Vietnam, there have been many studies on digital learning materials, how to apply them in teaching and learning, such as the article “Designing and using electronic lesson plans on a learning website in the direction of exploratory teaching” published in the Journal of Education Science - Education - No. 38, November 2008 - authored by Pho Duc Hoa and Ngo Quang Son (2008), in the PhD thesis of Educational Sciences by author Ninh Thi Hanh (2019) presented the assessment of the Using e-learning materials in subjects is an inevitable trend and or in the article “Design and construction of electronic learning materials for online training requirements” of two authors Tran Thi Lan Thu and Bui Thi Nga - Hanoi Open University. However, there are still no specific studies on building digital learning materials for the topic “Metabolism and energy transformation at the body level” - Biology 11. Therefore, we carry out the project “Building and using a digital learning set of topics Metabolism and energy transformation on the body level - Biology 11” in order to build a highly reliable, easy-to-use source of learning materials, easily approach learners, increase interest in studying Biology and contribute to the development of self-study competence for students.

2. RESEARCH METHODOLOGY

- Theoretical research method: Theoretical overview, theoretical analysis, experience summary about digital learning materials and self-study competence.

- Practical research method:
  + The investigation method through observation and questionnaires was built on the use of digital learning materials in high schools and students’ self-study capacity.
  + Expert method: Seek expert opinions on the structure of self-study capacity, the process of building digital learning materials, the quality of digital learning materials, the process of organizing learning activities using digital learning materials and pedagogical experimental content.
+ Experimental method:
- Statistical method: use Microsoft Excel software to process experimental data, analyze statistical characteristic values and evaluate the feasibility of the experimental plan.

3. RESEARCH RESULTS AND DISCUSSION

3.1. Digital learning materials

Learning materials is a concept that has been studied for decades. The Ministry of Education and Training of Vietnam has issued Circular No. 11/2018/TT-BGDĐT, in which learning materials are defined as “physical means of storing, carrying or reflecting learning, research and analysis content. Materials are divided into two main categories according to their use, namely, traditional learning materials (pictures, card images) and electronic learning materials”.

In this study, it can be understood that learning materials are all pedagogical documents presented in different forms (image channels, text channels) for purposeful and meaningful teaching and learning activities.

According to the Circular of MOET No. 11/2018/TT-BGDĐT about issuing criteria to determine specialized goods that directly serve education, “e-learning materials are learning materials that are digitized according to a certain format architecture and scenario, which are stored and stored on electronic devices such as CD, USB, computer, computer network to serve teaching and learning. The digitized format can be text, data tables, audio, images, video, computer software, and a mixture of the foregoing”.

Thus, digital learning is both a teaching tool for teachers and a learning tool for students. The use of digital learning materials in teaching is becoming the trend of education. At the same time, the use of digital learning materials also plays an important role in developing learners’ competence, especially self-study.

3.2. Self-study competence

Self-study is a research issue that has been interested for a long time, including research in the world and Vietnam. Self-study can be explored from two broad perspectives (1) self-study can be individual and collaborative, and (2) self-study can be teaching and research. The first view is said to include the second (Loughran, John & Gunstone, Richard, 1996).

In 1999, in the book “Discussion and experience on self-study” by Prof. Nguyen Canh Toan, stated that “Self-study is self-directed brainstorming, thinking, using intellectual abilities (observation, comparison, analysis, synthesis,...) and sometimes muscles (when having to use tools) and their own qualities, then motivations, emotions, both the philosophy of human life and world views (such as honesty, objectiveness, will to progress, not afraid of difficulties, afraid of suffering, perseverance, patience, passion for science, the will to pass the exam, turn difficulties into advantages,...) to occupy a certain field of human knowledge, making that field their own”. According to the author, self-study is the self-coordination of logical and muscular thinking operations to master
knowledge. In 2009, according to Dang Vu Hoat and Ha Thi Duc, “Self-study is a form of individual cognitive activity, aiming to master the knowledge and skill system conducted by the learners themselves in class or at school or out of the classroom or not according to the prescribed curriculum and Textbooks. Self-study is closely related to the teaching process, but it is highly independent and has personal performances”.

According to author Phan Thi Thanh Hoi and Kieu Thi Thu Giang (2016), “Comprehensive competence is the ability of learners to independently and self-consciously determine learning goals, design and implement learning plans, to self-assess and adjust their work, to optimize knowledge acquisition and skill/competence development”.

Using digital learning materials in teaching will stimulate students' curiosity and discovery which is related to the lesson. When there is a useful source of digital learning materials with clear pedagogical purposes, students can take advantage of them in their learning and self-study thoroughly. Teaching and learning using digital learning materials contributes to the changing of students' learning methods, the development of skills in learning planning, searching, selecting and processing information. Thereby, using digital learning materials are associated with the development of each element of self-study competence.

3.3. Structure of self-study competence

Through an overview study “on the history of research on self-study competence and digital learning materials in teaching SH11, we define a self-study structure consisting of 4 components including: Developing a self-study plan and implementing a self-study plan; Reading comprehension, taking notes, memorizing; Exploiting, understanding information sources and processing information; Evaluate and self-assess.

Table 1. Manifestations of self-study ability

<table>
<thead>
<tr>
<th>Components of self-study ability</th>
<th>Expression</th>
</tr>
</thead>
</table>
| Develop a self-study plan and implement a self-study plan | - Develop a self-study plan:  
(1) Identify the content to be learned in the lesson.  
(2) Anticipate the necessary learning materials in the lesson.  
(3) Anticipated activities/tasks to learn the content in the lesson.  
(4) Anticipate the required products.  
- Implement a self-study plan:  
(1) Implement the plan on time, the expected content.  
(2) Design products according to the expected plan.  
(3) Report/Present the planned product. |
| Read, understand, take notes, | (1) Take full lesson notes with scientific logic. |
### 3.4. The process of building a digital learning set

Based on the process of building a digital learning set of previous researchers (Phan Thi Thanh Hoi and Kieu Thi Thu Giang, 2016) in this study, the process of building a digital learning set consists of 7 steps as follows: **Step 1: Determine the lesson objectives** → **Step 2: Identify key and basic knowledge** → **Step 3: Systematize learning materials** → **Step 4: Collect available learning materials, select materials to design new learning materials** → **Step 5: Select tools and software for digitizing materials** → **Step 6: Test** → **Step 7: Arrange the learning materials set in logical order (packaging).**

**Example of the process of building a digital learning set**

The process of building a digital learning set for the content of Overview of matter and energy metabolism in the topic of Metabolism and energy transformation - Biology 11, the 2018 general education curriculum:

**Steps 1, 2, 3: Identify lesson objectives; Identify key and fundamental knowledge; Systematization of learning materials**

1. Lesson objectives are determined based on the requirements to be achieved in the lesson corresponding to the topic in the 2018 curriculum, which is the goal that students are able to achieve after the lesson.
2. Clearly indicate the core knowledge, basic knowledge and basic content of the topic.
3. Systematize the learning materials in 3 phases corresponding to the time axis: online - in person - online (See details at: https://bom.so/kFpZ0H).

**Step 4: Collect available learning materials, select design materials to design new learning materials.**
First, in order to get learning materials, teachers need to have the skills to search and filter from a variety of learning materials.

Next, screen and select learning materials suitable for learning activities. Among the collected learning materials, there are some foreign language learning materials (mainly English), teachers need to Vietnameseize these materials so that all learners can access the best learning materials.

Finally, with available materials but not really suitable to the teacher's intentions, what needs to be done is to design new learning materials based on available materials or with completely new ideas by taking materials from different channels available or designed from scratch. Suggest some websites with resources for rich designs in the form of png suitable for designing learning materials such as: Flaticon (https://www.flaticon.com/), Freepik (https://www.freepik.com/),... You can also use the Palette uniform design support tool - color scheme: Scheme Color (https://www.schemecolor.com/color/light-blue).

Step 5: Select tools and software to digitalize materials

Digitizing raw materials into digital learning materials using Microsoft, Google, Adobe tools and some other educational websites:

- Collected learning materials that are preserved will be digitized (for hard copies) and stored with the Google Drive tool.

- Learn Vietnameseization or new design using tools such as MS PowerPoint, MS Word, Adobe Photoshop, Canva, Liveworksheet, ...

Step 6: Test

In this step, the teacher builds the lesson plan according to the process of learning activities set out with the idea of teaching methods and techniques to ensure the required requirements of the program and the objectives of the original lesson. Next, from the built digital learning materials, select the materials that are suitable with the pedagogical ideas that have been designed and used. Teachers can completely choose and use some other digital learning materials depending on the context, as well as the proposed pedagogical ideas. During this process, teachers need to record the points that need to be changed (if any) to edit and complete the digital learning materials.

Step 7: Arrange the digital learning set in logical order (packaging) - Test case with correct solution

The author uses Google Site to build a website for a digital learning resource on the topic of Metabolism and energy transformation at the body level - Biology 11 by two main groups of reasons. First, Google Site is a tool in Google Suite along with Google Drive. Second, this tool has outstanding advantages, it is easy to store, design, use and embed stakeholders in the website effectively (such as Youtube, Google Suits tools, links,...), especially not demanding high programming ability like some building tools to create website domains (eg html).
The link to access the website - Biology - Ly Tu Tan (abbreviated name: BIOLOGY-LTT) is as follows: https://sites.google.com/view/biology-ltt-hn/.

System of digital learning materials with the topic "Metabolism and energy transformation at the body level" - Biology, the 2018 general education curriculum

According to the process of building the above digital learning set, we have designed and built a website containing a system of learning materials including: images, videos, study cards, a system of multiple choice exercises, similar games. work. The digital learning set of the topic Metabolism and energy transformation - Biology 11 is shown at the following link: https://bit.ly/TDCvaCHNL-SH11-LTT.

The digital learning material on the topic Metabolism and energy transformation at the body level - Biology 11, the 2018 general education curriculum after the process of collecting, editing and designing was newly built on the website Biology - Ly Tu Tan with a large quantity. Specific statistics for each type of digital learning material are shown in the tables below:

Table 2. Body-level Resettlement & Rehabilitation Subject Learning System - Biology 11

<table>
<thead>
<tr>
<th>Courseware</th>
<th>Collect</th>
<th>Edit</th>
<th>New design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image</td>
<td>31</td>
<td>34</td>
<td>15</td>
</tr>
<tr>
<td>Video</td>
<td>13</td>
<td>40</td>
<td>3</td>
</tr>
<tr>
<td>Checklist</td>
<td>0</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Study card</td>
<td>3</td>
<td>4</td>
<td>27</td>
</tr>
<tr>
<td>Interactive game</td>
<td>3</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Exercise system</td>
<td>7</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Infographic</td>
<td>3</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>References</td>
<td>9</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>69</strong></td>
<td><strong>93</strong></td>
<td><strong>67</strong></td>
</tr>
</tbody>
</table>

3.5. The process of using a digital learning set materials in teaching

The process of using digital learning materials

With important roles for the lessons, it can be seen that the learning materials in general and the digital learning materials in particular are meticulously processed by the teachers, with the aim of creating the success of the lesson and then aiming for the goal of students' self-reliance and self-control of vast scientific knowledge of the world. As a result, based on the construction process and digital learning materials mentioned above, we propose the process of using digital learning materials to develop students' self-study abilities as follows: **Step 1**: Determine the lesson objectives → **Step 2**: Determine the content circuit, the sequence of learning activities and the duration → **Step 3**: Determine the form, method, teaching technique, assessment plan → **Step 4**: Design the teaching scenario) corresponding to the digital learning set → **Step 5**: Testing, editing and adjusting the lesson plan.
Example of the process of using a digital learning set of content "Practice: Experimenting with water exchange in plants, hydroponics, and aeroponics" - Biology 11

Below is an example illustrating the process of using digital learning materials to develop self-studying energy for students with the content Practice: Experiments on water exchange in plants, hydroponics, aeroponics - the topic Metabolism and energy transformation on the body level - Biology 11:

**Step 1: Determine the lesson objectives**

Lesson objectives “Practice: Experimenting with water exchange in plants, hydroponics, aeroponics” - Biology 11, the 2018 general education curriculum: Observing the structure of stomata in leaves; Experiments to demonstrate root water uptake; transport of water in the stem and transpiration in the leaves. Practice watering and caring for plants”; Practice hydroponics and aeroponics.

**Step 2: Define content circuit, learning activity sequence and duration**

The content circuit under the topic Body-level metabolism and energy transformation - Biology 11 immediately follows the content circuit of water and mineral exchange in plants.

- The series of learning activities includes:

<table>
<thead>
<tr>
<th>Activities</th>
<th>Content</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1: Self-study at home</td>
<td>Self-study at home with guidance. Study lessons, self-directed learning with digital learning materials on the website.</td>
<td></td>
</tr>
<tr>
<td>Stage 2: During live lessons</td>
<td>Activity 1: Summarizing self-study activities at home</td>
<td>The teacher summarizes students’ self-study activities at home, checks the self-assessment checklist of students on the system. 5 minutes</td>
</tr>
<tr>
<td>Activity 2: To correct knowledge</td>
<td>Students report experimental products in groups that have been conducted at home in front of the class. Organize practice observing the structure of stomata under the microscope; Organize discussions and answer questions from students.</td>
<td>30 minutes</td>
</tr>
<tr>
<td>Activity 3: Practice</td>
<td>Activity 3: Practice Students doing tests on the website.</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Stage 3: After the live class</td>
<td>Review, practice at home</td>
<td>Review the lesson, review, practice through replaying interactive games.</td>
</tr>
</tbody>
</table>
Step 4: Design a teaching scenario corresponding to the digital learning set

- Link to see details: https://bom.so/lugp1z

Step 5: Test, edit and adjust the lesson plan

The teacher implements this lesson plan in the experimental class, carefully records the secondary errors and reviews, corrects and completes the lesson plan accordingly. Note, lesson plan can change and refine depending on each student.

3.6. Experimental results of the digital learning set with the topic “Metabolism and energy transformation at the body level” - Biology 11

- Experimental purpose: Assessing the applicability, posibility and effectiveness of the digital learning set with the topic "Body-level metabolism and energy transformation" - Biology 11, the 2018 general education curriculum, has contributed to improving the quality of teaching and learning and the student's self-efficacy in Biology 11.

- Experimental content: Testing and experimenting the digital learning set of topics Metabolism and body-level energy transfromation - Biology, the 2018 general education curriculum and the process of using the designed digital learning set for the content of the lesson: Practice: Experimenting with water exchange in plants; growing hydroponic, aeroponic plants - SH11 at Ly Tu Tan High School - Hanoi.

- Experimental subjects: Control class: 11A4 (44 students) - Ly Tu Tan high school. Experimental class: 11A1 (44 students) - Ly Tu Tan high school.

- Experimental results:

  Table 3. Sample characteristic values of control class and experimental class
  (After experiment)

<table>
<thead>
<tr>
<th>Sample characteristic values</th>
<th>Experimental class</th>
<th>Control class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>7.16279</td>
<td>5.72093</td>
</tr>
<tr>
<td>Standard Error</td>
<td>0.20223</td>
<td>0.2165</td>
</tr>
<tr>
<td>Median</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Mode</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1.32612</td>
<td>1.41968</td>
</tr>
<tr>
<td>Sample Variance</td>
<td>1.75858</td>
<td>2.0155</td>
</tr>
<tr>
<td>Confidence Level (95,0%)</td>
<td>0.40812</td>
<td>0.43691</td>
</tr>
</tbody>
</table>

According to the after experiment’s results in Figure 1, it shows that the scores of the two classes of control and experiment have changed. Specifically, the experimental class layer spectrum (green line) deviates to the right compared to the control class layer spectrum (orange line). Thus, the preliminary assessment of the experimental class score was better than that of the control class, the mode value - the score with the highest frequency of the experimental class was 7 (13 students) higher than that of the control class 6 (13 students).
Looking at Table 3, it can be seen that the mean value of experimental class is higher than that of control class ($7,16279 > 5.72903$), which means that the average score of experimental class is higher than that of control class. Thus, the average statistical characteristics of the experimental and control classes shown in Table 3.6 have shown that the level of awareness and ability to systematize knowledge of experimental class students is really high and focused average than the control class. This is also the basis to be able to generalize if the plan proposed by the study is applied.

**The progress of students' self-study**

**Table 4. Results of quantitative assessment of students' self-study competence criteria in teaching the topic "Metabolism and Energy metabolism on the body level" - SH11**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Level</th>
<th>Result</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level</td>
<td>Experiment 1</td>
<td></td>
<td>Experiment 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SL</td>
<td>%</td>
<td>SL</td>
<td>%</td>
<td>SL</td>
</tr>
<tr>
<td>Developing a self-study plan and implementing a self-study plan</td>
<td>4</td>
<td>16</td>
<td>36.36</td>
<td>18</td>
<td>40.91</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>21</td>
<td>47.73</td>
<td>19</td>
<td>43.18</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3</td>
<td>6.82</td>
<td>4</td>
<td>9.09</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>4</td>
<td>9.09</td>
<td>3</td>
<td>6.82</td>
</tr>
<tr>
<td>Reading comprehension, taking notes, memorizing</td>
<td>4</td>
<td>13</td>
<td>29.55</td>
<td>16</td>
<td>36.36</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>22</td>
<td>50.00</td>
<td>18</td>
<td>40.91</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>6</td>
<td>13.64</td>
<td>5</td>
<td>11.36</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>3</td>
<td>6.82</td>
<td>5</td>
<td>11.36</td>
</tr>
<tr>
<td>Exploiting, understanding information sources and processing information</td>
<td>4</td>
<td>14</td>
<td>31.82</td>
<td>17</td>
<td>38.64</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>17</td>
<td>38.64</td>
<td>14</td>
<td>31.82</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>11</td>
<td>25.00</td>
<td>13</td>
<td>29.55</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>4.55</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Evaluate and self-assess</td>
<td>4</td>
<td>19</td>
<td>43.18</td>
<td>19</td>
<td>43.18</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>7</td>
<td>15.91</td>
<td>9</td>
<td>20.45</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5</td>
<td>11.36</td>
<td>10</td>
<td>22.73</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>13</td>
<td>29.55</td>
<td>6</td>
<td>13.64</td>
</tr>
</tbody>
</table>

From Table 4 shows, students' self-study ability tends to change in a positive direction. After 3 times of experimental evaluation, the rate of level 4 gradually increased.
and accounted for a relatively high rate, level 1 gradually decreased in all 4 criteria. Thus, through three evaluation stages, we found that students' self-study ability has improved markedly after applying the project's plan.

4. CONCLUSION

Digital transformation and educational innovation are two processes that are closely linked, parallel, and mutually influencing each other. When considering the significant changing factors to education, it is urgently important to digitize materials. The development and utilizing of digital learning materials on the topic of Metabolism and energy transformation is necessary and highly effective in its application to teaching practice, contributing to the improvement the quality of teaching and learning, to the developments students’ skills and components of self-study competence.

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