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INTEGRATING 21ST CENTURY SKILLS IN AN UNDERSTANDING BY DESIGN PEDAGOGICAL PLAN (UBD21) ON LIFE ENERGY AND PROCESSES

Louie B. Dasas[1] and Maricar S. Prudente[2]
[1]High School Department, St. Theresa's College, D. Tuazon, Quezon City
[2]Science Education Department, De La Salle University, 2401 Taft Avenue, Manila 1004

Abstract
This study explored the effectiveness of UBD21 in improving students' conceptions on life energy and processes, and in making the students acquire 21st century skills. An intact Biology class of sophomore high school students enrolled for school year 2012-2013 participated in the study. The students participants were exposed to a teaching-learning environment using the UBD21 learning unit plan, which has for its content focus the concepts of life energy and processes. Descriptive and inferential statistics were employed for data analyses. Students' perceptions of the 21st century skills and the results of the pre-test and post-test were analysed using descriptive and inferential statistics. Results revealed that majority of the students have correct pre-conceptions about the topic on life energy and processes. However, misconceptions were more particularly evident in the topics of photosynthesis and cellular respiration. The t-test result showed that UbD21 was effective in improving students' conceptions based on the students' gain in scores in the post-test. The significant difference between the pre-test and post-test suggested that UbD21 facilitated changes in students' conceptions on Life Energy and Processes. These increases in the weighted means and high student rating of perceived student understanding suggest that UbD21 can facilitate improvement of student conceptions on life energy and processes. Also use of UbD21 revealed a positive effect to the students' perceptions of their 21st century skills acquisition. The significant improvements in the students' conceptions on life energy and processes and in the acquisition of scientific 21st century skills during the implementation of UbD21 suggest its efficacy as a learning material.

Introduction
Global economies, innovations in technologies and the ,information revolution have transformed the world society. The world of work today differs greatly from the traditional construct of a workplace. Thus as training ground for the workplace and the society at large, schools must keep up with the fast pace of changes driven by globalization, technological advancements and diversity of learners. 21st century learners demand a more defined set of skills necessary for a society in need of problem solvers, team-players, critical thinkers, responsible leaders, among others. Aside from preparation for dynamic work field, learners of today are more exposed to vast array of information and technology. This must be paralleled with a more relevant and adaptable learning. It is therefore imperative to look into the set of skills required for a 21st century learner.
Wiggins (1993) argues that "we should treat each student as a would-be intellectual performer, not as a would-be learned spectator". Such is the principle behind the Understanding by Design (UbD), a framework in education that sprang from constructivist perspectives and ideas regarding experiential learning. McTighe, Seif, and Wiggins (2004) highlighted two major approaches relative to UbD as a framework for education – *teaching for understanding* and *teaching for meaning*. More often, teachers are faced with two misconceptions regarding education of the young. The first one regards that teachers should "teach for the test" and the second involves the perennial teacher concern of having to "cover too much". Most recent researches reveal that there is higher concept retention and better operational knowledge of learned concept through learning for meaning (Bransford, Brown, & Cocking in McTighe, Seif, & Wiggins, 2004).
The 21st century classroom does not stop in the mere identification/assumption of skills needed by the student to survive 21st century workplace/environments. The teacher must also be equipped with necessary skills to facilitate students' acquisition and/or development of 21st century skills. These are 'enabling' skills that allow the teacher to dynamically promote 21st century learning among students. Moreover, these skills reflect the ability to make connections across contents, goal orientedness, authentic assessment of student understanding, and self-reflection. It is in this context that the present study explored the effectiveness of implementing a UbD-based pedagogical plan with the integration of 21st century skills (UbD21) in enhancing students' conceptions on life energy and processes

and the acquisition of the 21st century skills with particular emphasis on the learning of the concepts of life energy and processes.

Statement of the Problem

Specifically, this study sought answers to the following research questions:

1) What are students' prior conceptions about life energy and processes
2) What are students' perceptions about their pre-existing 21st century skills?
3) Is there a change in students' conceptions about life energy and processes after exposure to UbD21?
4) What scientific concepts on life energy and processes and 21st century skills are acquired and/or enhanced as perceived by the students after their exposure to UbD21?
5) Is there a significant improvement in the students' concepts and scientific skills during the implementations of UbD21?

METHODOLOGY

Research Design

This study employed the quasi-experimental research design, using both qualitative and quantitative data to measure the effectiveness of UBD21 in improving students' conceptions on life energy and processes and in making the students acquire 21st century skills.

Participants

Sophomore high school students of a private school in Quezon City who were enrolled for SY 2012-2013 participated in the study. The members of the class were heterogeneously grouped comprising of high performing, average and low performing students. The students were exposed to classroom instruction using the Understanding by Backward Design (UbD) based module, which integrated the 21st century skills acquisition.

Data Gathering Procedure

A UbD-based pedagogical unit plan that integrates 21st century skills was developed and was dubbed as UbD21. Prior to the implementation of UbD21, pre-test was administered to determine students' prior conceptions about life energy and processes. In addition, the students were made to conduct self-assessment of their perceptions about their pre-existing 21st century skills. During the implementation of UbD21, the students were engaged into an on-going assessment in the form of the parallel concept test. The scores of the whole class was taken into account and not the individual scores of the students. In order to check the development of the skills of the students during the implementation of UbD21, the students were engaged in a number of performance tasks. These were graded using Exemplars® Science Rubric. After the implementation of the pedagogical plan, the students answered a post-test to assess conceptions gained/enhanced through the unit plan. The results of the pre-test and post-test were compared to describe changes in students' conceptions about Life Energy and Processes. The students also completed the Life Energy and Processes Concepts Checklist, which includes the essential concepts for the four topic clusters: plant parts and functions, photosynthesis, cellular respiration, and energy flow in the ecosystem. Furthermore, the students were made to accomplish a questionnaire that reflects their perceptions of the 21st century skills after exposure to UbD21. The results of the performance tasks were also used in the analysis of scientific skills acquired by the students during and after the implementation of UbD21.

Instrumentation

The instruments used in gathering data for this study are as follows: Life Energy and Processes Concept Test, Life Energy and Processes Parallel Concept Test, Student Perceptions of 21st Century Skills (P121Q), IRF Chart, Student Reflections, Life Energy and Concepts Checklist, and Structured Interviews. Life Energy and Processes Concept

Test, Life Energy and Processes Parallel Concept Test, and Student Perceptions of 21st Century Skills (P121Q) were all content and face validated by a pool of experts in the academe. In addition, these instruments were pilot tested for reliability.

Data Analysis

Results of the pre-test and post-test were used to determine if there was a significant difference in the conceptions of students on life energy and processes. The prior conceptions of the students are assessed through the IRF Chart. The improvements of the concepts of the students were assessed through the Life Energy and Concepts Checklist. In addition, the researcher monitored the improvements in the conceptions of the students on during the implementation of UbD21 through the Life Energy and Processes Parallel Concept Test. The students were made to answer two questions for twenty-five session days. The overall scores of the class in the twenty-five session days were monitored not the individual scores of the students.

While the prior 21st century skills were assessed through Structured Interviews and pre-test on P21Q. The skills acquired and/or enhanced by the students were monitored through on-going transfer/performance tasks. The transfer/performance tasks were rated using a generic science rubric adapted from Exemplars® Science Rubric. The rubric incorporated four skills constructs namely Scientific Concepts and Related Content, Scientific Communication and Using data, Scientific Procedures and Reasoning Strategies, and Scientific Tools and Technologies. Students' ratings on the performance tasks were analysed using a four rating scale described as 4- Expert, 3- Practitioner, 2- Apprentice and 1- Novice.

Results and Discussion

Majority of the student participants recorded increases in their scores from the pre-test to the post-test. Some students even reflected significant increases in their scores with a difference >30%. One student posted the highest increase in the percentage of correct answers at a difference of 38%. During the pre-test, only 18 students from the class had scores of 50% and higher. This constitutes only 36.73% of the total class population. In the post-test, 39 students or 79.59% from the class obtained scores of 50% and higher. This result suggests a significant increase in the number of students who correctly answered the test, indicating conceptual understanding.

Table 1. Results of the Life Energy and Processes Concept Test before and after implementation of UbD21.

Topic	Total Number of Points	Before implementation of UbD21		After implementation of UbD21	
		WM	SD	WM	SD
Plant Parts and Functions	10	3.92	1.67	6.88	1.90
Photosynthesis	16	7.39	2.27	9.20	2.32
Cellular Respiration	16	6.63	2.32	9.31	2.96
Energy Flow in the Ecosystem	8	4.82	1.69	5.02	1.65

N= 49; WM – weighted mean; SD - standard deviation

As can be gleaned in Table 1, there was marked improvement in the percentage of items correctly answered by the students after the implementation of UbD21. The students were able to get 68.78% correct answers for the topic on Plant Parts and Functions in the post-test. All the other remaining topics likewise posted increases in the percentage of items correctly answered. The topic with the lowest percentage of correct answers was on photosynthesis at 57.53%. It can be observed from the data that for all four topics, the students were able to correctly answer 57% of the test. Therefore, results of the pre-test and post-test suggest an improvement in the conceptions of the students on the topic of life energy and processes. It was observed that there was a significant difference between the means of the pre-test and post-test. This result further suggest that UbD21 have positively influenced the improvement of students' conceptual understanding.

A two-tailed t-test was employed to test the significant difference between the pre-test and post-test scores of the students in the Life Energy and Processes Concept Test. The computed value for t (7.366448) was greater than the critical value of t (2.0106) at 0.05 level of significance, with a P value of 1.07286E-14 at df 48, implying that there is significant difference between the results of the pre-test and post-test. This result provides evidence that the implementation of UbD21 improved the students' conceptions on life energy and processes. The post-test scores of the class recorded a Hake gain (<g>) of 0.28. To further examine percentage gain of the students, the researcher used the standard error of measurement and standard error of difference.

Table 2. Characteristics of the pre-test and post-test.

Test	N	K	Sd	Cronbach alpha	Sm	SD
Pre-test	49	50	5.24396	0.814946	2.26656	3.16218 (2) or 6.32435
Post-test	49	50	6.97590	0.896653	2.20501	

N- number of students
K – number of items in the test
Sd – standard deviation
Sm – standard error of measurement
SD – standard error of difference

It can be gleaned fromTable 2 that all the students who obtained a gain score of 6.32435 or higher from pre-test to post-test had a significant gain in the post-test. The standard error of difference was multiplied by 2 to get a 95% probability to make the result more stringent. It was found that 29 students or 59.18% had significant gains in the post-test. On the other hand, there were 20 students or 40.82% who did not post a significant gain in their scores

Table 3. Common Initial ideas of students as reflected in their IRF chart.

PHOTOSYNTHESIS	CELLULAR RESPIRATION
• Food-making process in plants* • Required materials: CO2, H2O, sunlight* • Produces sugar and energy* • Happens in the leaves of plants • Source of energy • They use glucose as energy • Chloroplasts produce the food • Carried out by autotrophs* • Only plants can photosynthesize • Transfer of sunlight to the leaves	• Needed for transpiration • Requires H2O and O2 • Happens in plants, animals, humans* • CO2 is produced • Process of CO2 going to the plants and exchanging it to O2 • Breathing • Breaking down food* • O2 breaks down energy • Involves blood cells for transportation of O2 • Gas exchange • Water breaks down the components involved • Production of ATP from food*

*identified correct conception

Most of the students had the correct conceptions that photosynthesis being the food-making process in plants and it produces sugar and energy (Table 3). The students were able to associate the process of photosynthesis with autotrophs and identify the needed materials: carbon dioxide, water, and sunlight. On the other hand, the process of cellular respiration involves the production of ATP from breaking down food. The students were also able to identify that cellular respiration occurs in plants, animals, and humans. Moreover, the students described photosynthesis as a source of energy. This idea is quite vague and can be considered partially correct. Photosynthesis can be considered as a source of energy for heterotrophs however, it is not the ultimate source of energy. The students however were able to modify the idea by stating that photosynthesis is the transfer of light energy to become chemical energy in the form of food. The students were able to surface out some misconceptions regarding cellular respiration. Some students described cellular respiration being needed for the process of

transpiration. It was also mentioned that water and oxygen are raw materials needed to fuel the reaction. This is partially correct since oxygen is one of the raw materials for cellular respiration. However, another misconception was oxygen is the one involved in breaking down the energy. Another set of answers reveal the students thinking that water is involved in breaking down the components involved in the process. The aforementioned ideas were revised by the students after the implementation of UbD21. The students were able describe that cellular respiration is different from gas exchange and breathing. They were able to state correctly that cellular respiration harvests energy coming from the food intake. Most of the students were able to correctly state the chemical formula involved in the process of cellular respiration. UbD21 incorporated the use of computer simulations and computer-aided instruction to improve and increase concept retention of the students.

Life Energy and Processes Parallel Concept Test

The researcher engaged the students to a daily concept test through the Life Energy and Processes Parallel Concept Test, which was patterned after the Life Energy and Processes Concept Test. Here the overall score of the entire class is considered and not the individual scores of the students. As seen in Fig. 1, there was an increasing trend in the weighted mean score of the class during the implementation of UbD21. This result is indicative of improvement in the students' conceptions on life energy and processes during the implementation of UbD21.

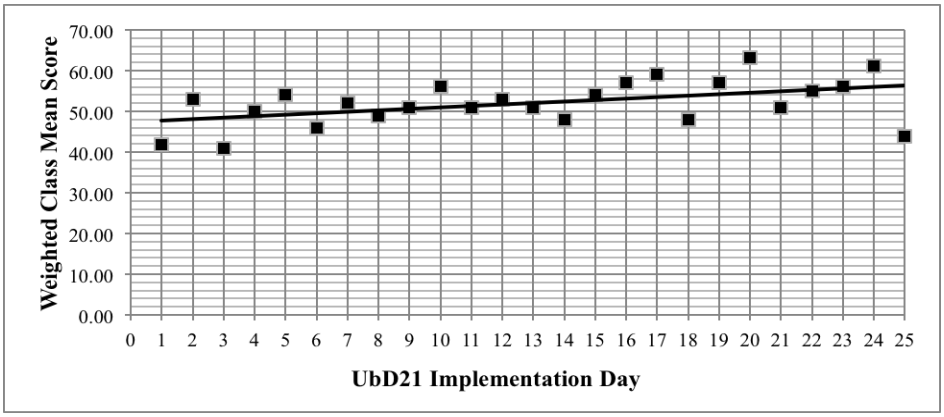

Figure 1. Results of the Life Energy and Processes Parallel Concept Test.

Performance Tasks

The researcher monitored the acquisition and/or enhancement of skills of the students through on-going transfer/performance tasks. These were rated using a generic science rubric adapted from Exemplars® Science Rubric. The rubric included four skills constructs: Scientific Concepts and Related Content, Scientific Communication and Using data, Scientific Procedures and Reasoning Strategies, and Scientific Tools and Technologies.

Table 4. Weighted mean rating and standard deviations of the four performance tasks based on the four scientific skills constructs.

Skills	Performance Tasks							
	Leaf Collection		Photosynthesis Experiment Design		Cellular Respiration Case Study		Urban Gardening Design	
	WM	SD	WM	SD	WM	SD	WM	SD
Scientific Concepts and Related Content	2.735	0.836	3.367	0.602	3.745	0.570	3.861	0.351
Scientific Communication/ Using	2.225	0.715	2.531	0.710	3.234	0.758	3.326	0.606

data								
Scientific Procedures and Reasoning Strategies	2.653	0.805	2.653	0.751	3.383	0.610	3.395	0.760
Scientific Tools and Technologies	2.653	0.991	2.694	0.796	3.170	0.739	3.233	0.718

N= 49; WM= weighted mean; SD= standard deviation

Table 4 reveals that all the four scientific skills constructs increased in weighted mean during the implementation of UbD21. Scientific Concepts and Related Content had the highest increase in weighted mean from 2.735 or 68.38% to 3.862 or 96.11%. The high increase in the weighted mean score of the class revealed an increase in the conceptions of the students manifested particularly in the last performance task involving Urban Gardening. This performance task incorporates all the learned concepts: Plant Parts and Functions, Photosynthesis, Cellular Respiration, and Energy Flow in the Ecosystem. On the other hand, Scientific Tools and Technologies had the lowest decrease in weighted mean from 2.653 to 66.33% to 3.233 or 80.81%. In addition, Scientific Tools and Technologies had the lowest weighted mean at the end of the implementation of UbD21. This would suggest that the students effectively used some appropriate tools and technologies (e.g., rulers, pH paper, hand lens, computer, reference materials, etc.) to gather and analyse data, and committed only minor errors during the laboratory activities.

Conclusion

Based on the findings, it can be deduced that most of the students had correct pre-conceptions about the topic on life energy and processes. However, some misconceptions were identified, and these misconceptions were more evident on the topics of photosynthesis and cellular respiration. The t-test result provided evidence that UbD21 was effective in improving students' conceptions based on the students' gain in scores during the post-test. The significant difference between the pre-test and post-test suggested further that UbD21 facilitated changes in students' conceptions on Life Energy and Processes. The significant gain in the scores of the students between the pre-test and post-test could be attributed to the intervention factor which was the implementation of UbD21. The increases in the weighted mean and high student rating in the Life Energy and Processes Concepts Checklist were also indicative that UbD21 can facilitate improvement in students' conceptions on life energy and processes. Moreover, the increase in the weighted means for all 21st century skills clusters after implementation of UbD21 is suggestive of significant improvement in the way students perceive that they manifest the skills most of the time. Thus, UbD21 as an intervention revealed a positive effect to the students' perceptions of their 21st century skills acquisition.

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