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Philippine Biology Education for a Curricular Innovation towards Industrial Revolution 4.0: A Mixed Method

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Abstract – *No curriculum exists in isolation, i.e. each curriculum is designed to be an input to another output. The interplay of curricula in the trifocal system of education in the Philippines only becomes ideal when alignment is checked at crucial checkpoints including the most recent checkpoint – the implementation of the K to 12 Basic Education Curriculum. One field that changed is Science Education. This study, an excerpt, aimed to innovate on the Senior HS Biology curricula by integrating Industrial Revolution 4.0 Skills to help prepare them to college course, especially in Fishery Education. Using mixed-method approaches, the study found evidence that Fishery Education students consider the Senior HS Biology curricula topics as 'Useful' in their Program courses and are mostly under Biochemistry, Cell Biology, Genetics, Evolution and Biodiversity, and that, 2 years after their K to 12 graduation, they consider themselves to still 'have knowledge' on these Biology topics. Further, content analysis assessment of experts showed that, aside from these topics, Cytology and Cytogenetics and a little of Taxonomy have been considered as preparatory for advanced higher Fishery Education. Furthermore, focus group discussion revealed that IR 4.0 skills could be integrated along the Senior HS Biology topics, and results reported that 'cognitive flexibility' as a skill is the most considered for topical integration. Recommendations include generating a framework to trace which Senior HS Biology topics are most and least needed in the Fishery Education checklist by the Philippine Commission on Higher Education to conduct deeper curriculum alignment assessment.*

Keywords – Biology, Curricular Innovation, Fisheries Technology, Education 4.0

INTRODUCTION

The Philippine Education has never been exciting since the implementation of the K to 12 Basic Education Curriculum (BEC) that added a two-year Senior High School which is divided into varied academic and non-academic strands. This new curriculum changed learning and instruction and favored the approach of Spiral Progression where a major topic per subject becomes more complex as the learner proceeds from Grade 1 to Grade 10, i.e. there is a continuous learning for each subject across the grade levels. For both Grades 11 and 12, the Spiral Progression is not required.

In the Philippines, several paper articles have already surveyed areas of the whole K to 12 BEC, and the most recent ones include a post-evaluation of K to 12 in terms of subject alignment, spirality, strand, and awards [1], development and validation of a spiral and contextualized curriculum in research [7], portfolio-analysis for curricular innovation [2], and the effectiveness of predict-observe-explain to develop scientific processes in Biology [1], and the list goes on.

Impact of the Study to the International Research Community

Up to this writing, no empirical study has ever been published in journals in the Philippines and outside the country that analyzed the Senior High School Biology curricula and matched it with a college program, in this case the Bachelor of Fisheries (and Aquatic Sciences) Program, more so, with the use of mixed method approach. Thus, this study could be used as a springboard for future research studies, and even for future collaborations with researchers in the field of Science Education. Though the research is limited with the use of model in its analysis, results obtained have been analyzed objectively and much effort has been done to set ethical standards beyond proper.

OBJECTIVES OF THE STUDY

This study, an excerpt, aimed to innovate on the Biology curriculum to help provide a match between Biology in Senior HS and Biology-related subjects in BS Fisheries as a course by determining which topics in Senior HS Biology are learned by Fisheries Technology students during their Senior HS years and which have they found useful in their course, 2 years after K to 12 nation-wide implementation. Finally, the curricular innovation included a refinement to integrate Industrial Revolution 4.0 skills.

Specifically, this study aimed to:

- profile the Fisheries Technology (FT) students in the Philippines in terms of curriculum level, type of school graduated in HS, strand taken in Senior HS, and academic awards in Senior HS;
- identify the level of knowledge in Senior HS Biology of the FT students across Senior HS Biology topics;
- identify the level of usefulness of Senior HS Biology topics in Biology-related course-subjects in BS Fisheries/and Aquatic Resources Program;
- statistically correlate using paired sample tests the level of knowledge and level of usefulness of Senior HS Biology topics;
- revisit the Senior HS Biology Curriculum for content analysis; and,
- integrate Industrial Revolution 4.0 skills in the innovated Senior HS Biology curriculum.

MATERIALS AND METHODS

The study employed mixed method approach – the approach that combines selected data-collection strategies or analysis under both quantitative and qualitative research, and involving triangulation techniques. Triangulation is a process by which an objective is accomplished by doing several methods. In this study, the researcher triangulated the data by sending the partial results of the survey which are of significant concern to experts for comments and reflections, in this case, a person considered expert in Biology Education.

Thus, this study employed the quantitative-survey type of research, and the data were collected through triangulation techniques [6]. The survey-questionnaire was developed by the researcher and was validated by experts yielding a 'Very Highly Valid' rating *(M=4.27)*. The survey-questionnaire was based on the curriculum guide in Senior HS Biology 1 and 2 posted online at deped.gov.ph.

Further, the researcher involved content analysis [4] [5] [6] [9][10][11] of curricula of Senior HS Biology and BS Fisheries curriculum checklist. Content analysis is one type of qualitative research which examines anything with 'content' like documents and the like in order to measure the existence of indicators or parameters [6] [7][8] in a study. In this study, the content analysis was done through dichotomous key [5], i.e. Preparatory or Not Preparatory, referring to whether or not the topics in Senior HS Biology could prepare the students for an introductory content to the BS Fisheries curriculum checklist.

Finally, the study also involved Focus Group Discussion (FGD) – whose main aim was to build a consensus on which Industrial Revolution 4.0 Skills could be integrated along the Senior HS Biology curriculum. The FGD involved three (3) experts in the field of Fishery Education.

As to the sampling design, Fisheries Technology students in two best performing Fishery universities in Region I, Philippines were selected through convenient sampling, i.e. given to students who were available to answer at the time of survey administration in September 2019. Fortunately, the response rate was high (83.7%). Only first year and second year students were considered in the data analysis, and survey-questionnaires answered by non-Kto12 graduates were not included in the data analysis. Survey data were analyzed using SPSS v21, and the software print out files are presently kept by the secretariat of PARESSU, Inc. with Code No. K12_010110

RESULTS AND DISCUSSION

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Profile of the Fisheries Technology Student-respondents in Region I, Philippines

Table 1. Frequency and Percentage of the profile of Fisheries Technology Student-respondents *(n=171)*

Profile Variable	*f*	*%*
Curriculum level		
First Year	*102*	*59.6*
Second Year	*69*	*40.4*
Type of School		
Public	*149*	*87.1*
Private	*22*	*12.9*
Strand in SHS		
STEM	*9*	*5.3*
GAS	*63*	*36.8*
HUMSS	*16*	*9.4*
ABM	*14*	*8.2*
TVL	*69*	*40.4*
SHS Awards Received		
With Highest Honors	*6*	*3.5*
With High Honors	*14*	*8.2*
With Honors	*55*	*32.3*
No Academic Awards	*96*	*56.1*
Total	***171***	***100***

Table 1 displays the profile of the respondents – the Fisheries Technology Students of Region I, Philippines across four (4) variables, viz: present curriculum level, type of school graduated, strand in Senior HS graduated, and academic awards received in Senior HS [12].

Table 1 displays the profile of the respondents – the Fisheries Technology Students of Region I, Philippines across four (4) variables, viz: present curriculum level, type of school graduated, strand in Senior HS graduated, and academic awards received in Senior HS.

Generally, the table shows that majority of the student-respondents are presently enrolled as First Year students *(59.6%)*, have graduated from public Senior HS *(87.1%)*, took and graduated from the Technical-vocation and Livelihood (TVL) Strand *(40.4%)*, and did not receive any academic awards upon graduation *(56.1%)*. While majority of the student-respondents graduated from non-academic strand, it is interesting to note that students graduating 'With Highest Honors' enrolled in the course *(3.5%)*.

Comparative levels of knowledge and usefulness of Biology Topics in Fisheries Technology Education in Region I, Philippines

Table 2, in Appendix, shows the means across the twenty-nine (29) Senior HS Biology topics in terms of the two (2) major variables, viz, level of knowledge and level of usefulness. The standard deviations and the mean descriptive equivalents were also shown, and at the right-most of the table is a column of an interpretation of the mean difference. The standard deviations is reported because, in statistics, the weighted mean is usually interpreted with a standard deviation. Standard deviations refers to how close or how spread the data are from one another.

Generally, Table 2 shows that the respondents are 'With Knowledge' on the Senior HS Biology topics *(M=3.17;sd=1.06)*, and that they find the Senior HS Biology topics to be 'Useful' in their BS Fisheries/and Aquatic Sciences (BSF/AS) Program *(M=3.35;sd=1.12)*. The mean difference appears to be 'negative' (-) because the level of knowledge is less than the level of usefulness, which means that the students found the Senior HS Biology topics as more useful but not learned enough 2 years ago to help them in their courses at the present time.

Further, there were three (3) topics shown in Table 2 claimed by the student-respondents to have 'High Knowledge', namely, Proteins *(M=3.53; sd=1.03)*, Photosynthesis *(M=3.75; sd=1.11)*, and Respiration *(M=3.64;sd=1.14)*. It could be noted that along seven (7) topics more, the same three (3) Senior HS Biology topics were considered as 'Highly Useful' in their BSF/AS Program, viz, Proteins *(M=3.64; sd=1.10)*, Photosynthesis *(M=3.81; sd=1.11)*, and Respiration *(M=3.74;sd=1.10)*. Interestingly, most of the Senior HS Biology topics considered by the respondents to be 'Highly Useful' are topics under Biochemistry, Cell Biology, Botany, and Zoology.

Statistical Non-significance of the paired means for levels of knowledge and usefulness of Biology

Table 3, in Appendix, shows the Senior HS Biology topics that reported no statistical significance when the level of knowledge and the level of usefulness was statistically compared. By the term statistical significance, the researcher means that the difference may exist but the difference may not be significant, or that it could be due to chance alone,, in this, 0.05 level of significance.

This suggests that, while there is a difference between the level of knowledge and level of usefulness of the paired means of the eleven (11) Senior HS Biology topics, the difference is not enough to say that is because of 'something' else, and not chance. Thus, it can be said that the paired means are equal, even if a topic is perceived to be 'Highly Useful' (Pairs 9, 10, 11, 12, 14, 15, & 17) but is rated only as 'With Knowledge' by the student-respondents. Interestingly, Table 1 shows no statistical difference when the difference is not higher than 0.15, with reference to Pair 28 as the highest.

Statistical Significance of the paired means for levels of knowledge and usefulness of Biology

Table 4 shows the Senior HS Biology topics that reported a statistical significance when the level of knowledge and the level of usefulness was statistically compared. In statistics, when a statistical difference occurs, this generally means that a difference exists and that the difference is not due to chance but because of 'something' else. Simply, when a statistical difference happens, this means that the 'difference, no matter of how large or small, matters'.

Further, Table 4 shows of eighteen (18) pairs that reported a statistical difference. Not surprisingly, and as earlier revealed in Table 2, most of the Senior HS Biology topics that reported statistical difference are mostly under Biochemistry, Cell Biology, Genetics, Evolution and Biodiversity.

This finding suggests that while the student-respondents consider the usability of these Senior HS Biology topics in their present Program, the level of their knowledge in these topics may not be enough. Arranged from decreasing level of mean difference, the topics could be ranked as in the following: Central Dogma of Molecular Biology > Transport Mechanisms > Mendel's Laws of Inheritance > Carbohydrates > Feedback Mechanisms > Cell Types > Cellular Modifications > Meiosis > Mitosis > Recombinant DNA > Plant Organ System/Functions. Furthermore, curriculum innovation is hoped to revisit these topics in Senior HS Biology and integrate the Education 4.0 in respective syllabi.

Finally, the Standard Error of the Mean (SEM) is the standard deviation of the distribution of sample means taken from a population, and are below 1.0 - generally considered small. This means that the sample means less deviate from the population mean because the smaller the standard error, the more representative the sample will be of the over-all population. This suggests that we have confidence on the data's representativeness and accuracy.

Revisiting the Senior HS Biology Curricula

The DepEd Curriculum Guide, generally, consists of the Subject Title, the Grade level, the Quarters to which the subject is supposed to be taught, the number of hours per quarter, the subject description, the course outline, the code book legend and the references. The Course Outline is further categorized in columns which includes the following: Content, Content Standard, Performance Standard, Learning Competencies, Code, and Science Equipment. The Senior HS Biology 1 and 2 curricula described here is the latest copy (August 2016 copy) uploaded at www.deped.gov.ph, and retrieved on August 2019.

The Senior HS Biology is divided into two, General Biology 1 taken in Grade 11 and General Biology 2 taken in Grade 12 in the Philippines. Both are taken up by students under the Science, Technology, Engineering and Mathematics (STEM) Strand. Both have a 40-hour allocation per quarter. Genera Biology 1 is a subject that is designed to enhance the understanding of the principles and concepts in the study of biology, particularly life processes at the cellular and molecular levels, and it also covers transformation of energy in organisms.

On the other hand, General Biology 2 is a subject which is designed to enhance the understanding of the principles and concepts in the study of biology, particularly heredity and variation, and the diversity of living organisms, their structure, function, and evolution. Quantitative content analysis on the Senior HS Biology curricula appear below.

Table 5, on the right, reveals the topics which are rated as preparatory ('Yes'= 17 of 29 topics, *58%*) or not preparatory ('No' = 12 of 29 topics, *42%*) by the curriculum assessors. There are more topics that are preparatory for BSF/AS than topics which are not. When compared for analysis with Table 2, which shows the level of knowledge and level of usefulness of Senior HS Biology topics, the following topics are not found as highly useful by the Fishery Technology Students but are considered as Fishery Preparatory by the experts: *Mitosis, Meiosis, Transport Mechanisms, Mendel's Laws of Inheritance*, *Sex Linkage*, *Central Dogma of Molecular Biology*, and *Identification of Organisms.*

Interestingly, most of these topics fall either under Cytology, and Genetics with a little of taxonomy as an outlier. Consequently, all of the topics stated in Table 2 which were rated as highly useful by the Fishery Students were all rated as preparatory of the curriculum assessors, and this is 53%. This means that 53% of the topics the curriculum assessors and the Fishery students agree on which is highly essential and thus preparatory (9 of 17 topics).

Table 5. Senior HS Biology Preparatory Topics

No	*Topics in Senior HS Biology*	*Fishery Preparatory*			
		1	***2***	***3***	*Remarks*
1	Cell Theory	*N*	*N*	*N*	No
2	Cell Structure and Function	*N*	*Y*	*N*	No
3	Cell Types	*Y*	*Y*	*Y*	Yes
4	Cellular Modifications	*N*	*Y*	*N*	No
5	Mitosis	*N*	*Y*	*Y*	Yes
6	Meiosis	*N*	*Y*	*Y*	Yes
7	Transport Mechanisms	*Y*	*Y*	*Y*	Yes
8	Carbohydrates	*Y*	*Y*	*Y*	Yes
9	Lipids	*Y*	*N*	*Y*	Yes
10	Proteins	*Y*	*Y*	*Y*	Yes
11	Enzymes	*Y*	*Y*	*Y*	Yes
12	Nucleic Acids	*N*	*Y*	*Y*	Yes
13	ATP Cycle	*Y*	*N*	*N*	No
14	Photosynthesis	*N*	*Y*	*Y*	Yes
15	Respiration	*Y*	*Y*	*Y*	Yes
16	Plant Organ Systems and Functions	*N*	*Y*	*Y*	Yes
17	Animal Organ Systems/Functions	*Y*	*Y*	*Y*	Yes
18	Feedback Mechanisms	*N*	*N*	*Y*	No
19	Mendel's Law of Inheritance	*Y*	*Y*	*Y*	Yes
20	Sex Linkage	*Y*	*Y*	*Y*	Yes
21	Central Dogma of Molecular Biology	*Y*	*Y*	*N*	Yes
22	Recombinant DNA	*Y*	*Y*	*Y*	No
23	Mechanisms of Evolution	*Y*	*N*	*N*	No
24	Evidences of Evolution	*N*	*N*	*N*	No
25	Theories of Evolution	*N*	*N*	*N*	No
26	Principles of Naming Organisms	*N*	*Y*	*N*	No
27	Nomenclature of Organisms	*N*	*Y*	*N*	No
28	Identification of Organisms	*Y*	*Y*	*Y*	Yes
29	Classification of Organisms	*N*	*N*	*Y*	No

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Highly Useful and Fishery Preparatory Topics in Senior HS Biology for IR 4.0

No	*Topics*	*Top 10 IR 4.0 Skills for Curricular Integration and Innovation*
3	Cell Types	[1][2][**3**][4][5][6][7][8][9][10]
5	Mitosis	[1][**2**][3][4][5][6][7][8][9][10]
6	Meiosis	[1][**2**][3][4][5][**6**][**7**][8][9][**10**]
7	Transport Mechanisms	[1][**2**][3][4][5][6][7][8][9][10]
8	Carbohydrates	[1][2][3][4][5][6][7][**8**][9][10]
9	Lipids	[1][**2**][3][4][5][6][7][8][9][10]
10	Proteins	[**1**][2][3][4][5][6][7][8][9][10]
11	Enzymes	[1][2][**3**][4][5][6][7][8][9][**10**]
12	Nucleic Acids	[**1**][**2**][3][4][5][6][7][8][9][10]
14	Photosynthesis	[1][**2**][3][4][5][6][7][8][9][10]
15	Respiration	[1][**2**][3][4][5][6][7][8][9][10]
16	Plant Organ Systems and Functions	[1][2][**3**][4][5][6][7][8][9][10]
17	Animal Organ Systems/Functions	[1][**2**][**3**][4][**5**][6][**7**][8][9][**10**]
19	Mendel's Law of Inheritance	[**1**][2][3][4][5][6][7][8][9][**10**]
20	Sex Linkage	[**1**][2][3][4][5][**6**][**7**][8][9][**10**]
21	Central Dogma of Molecular Biology	[**1**][2][3][4][5][6][7][8][9][**10**]
28	Identification of Organisms	[1][2][3][**4**][**5**][6][**7**][8][**9**][**10**]

Legend: Fourth Industrial Revolution 4.0 Skills (Those in **bold red**)

1. Complete Problem Solving Skills
2. Critical Thinking
3. Creativity
4. People Management
5. Coordinating with Others
6. Emotional Intelligence
7. Judgement and Decision-making
8. Service Orientation
9. Negotiation
10. Cognitive Flexibility

Table 6 reveals that all the top 10 Industrial Revolution (IR) 4.0 Skills could be used for curricular integration for innovation in Senior HS Biology Curricula. Further, the table reports that, next to critical thinking *(47%)*, cognitive flexibility *(41%)* is next in rank in the most appropriate skill for curricular integration. Other skills are ranked as follows in decreasing manner: Complex Problem Solving *(29%)*, Creativity *(24%)*, Coordinating with Others *(12%)*, Emotional Intelligence *(12%*), People Management *(6%),),* Judgment and Decision-Making *(6%),* Service Orientation *(6%),* and Negotiation *(6%)*.

CONCLUSIONS AND RECOMMENDATIONS

The researcher concludes the following:

- The Fisheries Technology students in Region I, Philippines for F.Y. 2019 were mostly first year *(59.6%)*, who have graduated under the TVL Strand *(40.4%)* from public schools *(87.1%)*, and while the enrolment showed a small portion of students graduating with 'With Highest Honors' *(3.5%)*, majority did not receive any academic awards during their graduation *(56.1%)*;
- The Fisheries Technology students, 2 years after their K to 12 graduation, consider themselves to 'Have Knowledge' *(WM=3.17; sd=1.06)* in Senior HS Biology topics with Photosynthesis receiving the highest mean *(WM=3.75; sd=1.11)*;
- The Fisheries Technology students, basing on their experience, claimed that the Senior HS Biology Curricula are 'Usable' *(WM=3.35; sd=1.12)* in their Program with Photosynthesis receiving the highest mean *(WM=3.81; sd=1.11)*;
- Correlates on paired samples of perceived knowledge and perceived usefulness of Senior HS Biology topics in Fisheries Technology Education revealed eighteen of twenty-nine (18 of 29) topics which reported a statistical difference, which means, 'they find the topics useful, but not learned enough', and these topics are mostly under Biochemistry, Cell Biology, Genetics, Evolution, and Biodiversity;

- Revisit of Senior HS Biology topics by experts through content analysis revealed major topics which were not considered as 'Highly Usable' by the Fisheries Technology students but are still considered as preparatory, namely, *Mitosis, Meiosis, Transport Mechanisms, Mendel's Laws of Inheritance, Sex Linkage, Central Dogma of Molecular Biology,* and *Identification of Organisms;* and, lastly
- Through Focus Group Discussion, 'Cognitive Flexibility' was found to be, through curriculum innovation, the most integrated IR 4..0 skills, among nine (9) others.

The researcher, with all these conclusions, recommends to generate a framework to trace which Senior HS Biology topics are preparatory to each course under the Fisheries Technology Program as mandated by the Philippine Commission on Higher Education in order to conduct a deeper curriculum alignment assessment.

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APPENDICES

Table 2. Comparative Means, Standard deviations (s.d.) and Descriptive Equivalents (d.e.) of Level of Knowledge (LK) and Level of Usefulness (LU) of Senior HS Biology topics, and an interpretation of their mean difference (m.d.) *(n=171)*

No	***Topics in Senior HS Biology***	***LK (Mean)***	***s.d.***	***d.e.***	***LU (Mean)***	***s.d.***	***d.e.***	***m.d.***
1	Cell Theory	*3.29*	*1.01*	*wK*	*3.35*	*1.08*	*U*	-
2	Cell Structure and Function	*3.27*	*1.00*	*wK*	*3.36*	*1.11*	*U*	-
3	Cell Types	*3.20*	*0.99*	*wK*	*3.45*	*1.10*	*HU*	-
4	Cellular Modifications	*3.09*	*1.00*	*wK*	*3.33*	*1.05*	*U*	-
5	Mitosis	*3.13*	*1.09*	*wK*	*3.36*	*1.13*	*U*	-
6	Meiosis	*3.11*	*1.08*	*wK*	*3.35*	*1.16*	*U*	-
7	Transport Mechanisms	*2.92*	*1.02*	*wK*	*3.26*	*1.08*	*U*	-
8	Carbohydrates	*3.39*	*1.03*	*wK*	*3.68*	*1.07*	*HU*	-
9	Lipids	*3.40*	*0.95*	*wK*	*3.52*	*1.06*	*HU*	-
10	Proteins	*3.53*	*1.03*	*wHK*	*3.64*	*1.10*	*HU*	-
11	Enzymes	*3.36*	*1.00*	*wK*	*3.49*	*1.11*	*HU*	-
12	Nucleic Acids	*3.34*	*1.01*	*wK*	*3.46*	*1.12*	*HU*	-
13	ATP Cycle	*3.16*	*1.06*	*wK*	*3.30*	*1.17*	*U*	-
14	Photosynthesis	*3.75*	*1.11*	*wHK*	*3.81*	*1.11*	*HU*	-
15	Respiration	*3.64*	*1.14*	*wHK*	*3.74*	*1.10*	*HU*	-
16	Plant Organ Systems and Functions	*3.36*	*1.15*	*wK*	*3.57*	*1.15*	*HU*	-
17	Animal Organ Systems/Functions	*3.33*	*1.15*	*wK*	*3.45*	*1.14*	*HU*	-
18	Feedback Mechanisms	*2.81*	*0.99*	*wK*	*3.09*	*1.10*	*U*	-
19	Mendel's Law of Inheritance	*2.86*	*1.12*	*wK*	*3.19*	*1.21*	*U*	-
20	Sex Linkage	*2.84*	*1.01*	*wK*	*2.99*	*1.15*	*U*	-
21	Central Dogma of Molecular Biology	*2.71*	*1.16*	*wK*	*3.06*	*1.17*	*U*	-
22	Recombinant DNA	*3.02*	*1.12*	*wK*	*3.26*	*1.11*	*U*	-
23	Mechanisms of Evolution	*3.05*	*1.09*	*wK*	*3.20*	*1.06*	*U*	-
24	Evidences of Evolution	*3.16*	*1.01*	*wK*	*3.31*	*1..06*	*U*	-
25	Theories of Evolution	*3.19*	*1.04*	*wK*	*3.38*	*1.12*	*U*	-
26	Principles of Naming Organisms	*3.01*	*1.11*	*wK*	*3.17*	*1.14*	*U*	-
27	Nomenclature of Organisms	*2.88*	*1.04*	*wK*	*3.08*	*1.07*	*U*	-
28	Identification of Organisms	*2.98*	*1.11*	*wK*	*3.12*	*1.12*	*U*	-
29	Classification of Organisms	*3.07*	*1.10*	*wK*	*3.24*	*1.17*	*U*	-
	Total	***3.17***	***1.06***	***wK***	***3.35***	***1.12***	***U***	**-**

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Table 3. Report on 'No Significant Difference Between Paired Means' at 0.05 alpha, 2-tailed

Pair No.	*Paired Sample*	*Mean difference*	*Std. deviation*	*SEM*	*t-value*	*df*	*Sig (2-tail)*
Pair 1	[Cell Theory]	-0.05263	0.95340	0.07291	-0.722	170	0.4710
Pair 2	[Cell Structure and Function]	-0.08772	0.99907	0.07640	-1.148	170	0.2530
Pair 9	[Lipids]	-0.12281	0.84860	0.06489	-1.892	170	0.0600
Pair 10	[Proteins]	-0.11111	0.93585	0.07157	-1.553	170	0.1220
Pair 11	[Enzymes]	-0.12281	1.02447	0.07834	-1.568	170	0.1190
Pair 12	[Nucleic Acids]	-0.12281	1.05836	0.08093	-1.517	170	0.1310
Pair 13	[ATP Cycle]	-0.13450	1.10055	0.08416	-1.598	170	0.1120
Pair 14	[Photosynthesis]	-0.05848	1.03303	0.07900	-0.74	170	0.4600
Pair 15	[Respiration]	-0.09357	0.97770	0.07477	-1.251	170	0.2120
Pair 17	[Animal Organ Systems/Functions]	-0.11696	1.03940	0.07949	-1.471	170	0.1430
Pair 28	[Identification of Organisms]	-0.14620	0.99216	0.07587	-1.927	170	0.0560

Table 3. Pairs Yielding Significant Difference

Pair No.	*Paired Sample*	*Mean difference*	*Std. deviation*	*SEM*	*t-value*	*df*	*Sig (2-tail)*
Pair 3	[Cell Types]	-0.24561	1.02235	0.07818	-3.142	170	*0.0020*
Pair 4	[Cellular Modifications]	-0.24561	1.02235	0.07818	-3.142	170	*0.0020*
Pair 5	[Mitosis]	-0.23392	0.99600	0.07617	-3.071	170	*0.0020*
Pair 6	[Meiosis]	-0.24561	0.96918	0.07412	-3.314	170	*0.0010*
Pair 7	[Transport Mechanisms]	-0.33333	1.02899	0.07869	-4.236	170	*0.0000*
Pair 8	[Carbohydrates]	-0.28655	0.95474	0.07301	-3.925	170	*0.0000*
Pair 16	[Plant Organ System/Functions]	-0.21053	0.95308	0.07288	-2.889	170	*0.0040*
Pair 18	[Feedback Mechanisms]	-0.28070	0.97777	0.07477	-3.754	170	*0.0000*
Pair 19	[Mendel's Laws of Inheritance]	-0.32749	1.18237	0.09042	-3.622	170	*0.0000*
Pair 20	[Sex Linkage]	-0.15789	0.95405	0.07296	-2.164	170	*0.0320*

Pair 21	[Central Dogma of Molecular Bio.]	-0.35673	1.12522	0.08605	-4.146	170	*0.0000*
Pair 22	[Recombinant DNA]	-0.23392	1.01356	0.07751	-3.018	170	*0.0030*
Pair 23	[Mechanisms of Evolution]	-0.15789	0.96631	0.07390	-2.137	170	*0.0340*
Pair 24	[Evidence of Evolution]	-0.15205	0.95192	0.07280	-2.089	170	*0.0380*
Pair 25	[Theories of Evolution]	-0.18713	1.09009	0.08336	-2.245	170	*0.0260*
Pair 26	[Principles of Naming Orgs.]	-0.16374	1.04997	0.08029	-2.039	170	*0.0430*
Pair 27	[Nomenclature of Organisms]	-0.20468	1.05115	0.08038	-2.546	170	*0.0120*
Pair 29	[Classification of Organisms]	-0.16959	1.01193	0.07738	-2.192	170	*0.0300*