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การปรับปรุงประสิทธิภาพของครูฝึกสอนวิชาพันธุศาสตร์โดยการใช้ซอฟต์แวร์แบบปฏิสัมพันธ์

Improving the Performance of Pre-Service Teachers in Genetics Through an Interactive Software

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บทคัดย่อ

การวิจัยในครั้งนี้มีวัตถุประสงค์เพื่อปรับปรุงการปฏิบัติงานของครูฝึกสอนวิชาด้วยการใช้ TPACK โมเดล และใช้ซอฟต์แวร์แบบปฏิสัมพันธ์ เพื่อทดสอบทักษะด้านเทคโนโลยี การสอน กลุ่มทดลองมีจำนวนทั้งสิ้น 27 คนในการเข้าร่วมเป็นผู้ตอบแบบสอบถามการเก็บรวบรวมข้อมูลเชิงปริมาณโดยเครื่องมือที่ใช้ในการสำรวจทางวิทยาศาสตร์ที่พัฒนาขึ้นโดย Graham Burgoyne Smith St Calir และ Harris (2009) และวัดมโนทัศน์ทางพันธุศาสตร์ 30 รายการทั้งก่อนและหลังการทดลอง ผลการวิจัยพบว่ามีความแตกต่างกันอย่างมีนัยสำคัญระหว่างผลก่อนและหลังการทดลอง ซึ่งเป็นการยืนยันว่าซอฟต์แวร์แบบปฏิสัมพันธ์มีประสิทธิภาพในการปรับปรุงผลการปฏิบัติงานของครูฝึกสอนด้านพันธุศาสตร์ ข้อเสนอแนะการวิจัยระบุว่าครูฝึกสอนควรได้รับการฝึกอบรมเพิ่มเติมเกี่ยวกับมโนทัศน์ทางพันธุศาสตร์และการใช้คอมพิวเตอร์ในการสอน นอกจากนี้บทเรียนแบบมีปฏิสัมพันธ์นั้นสามารถถูกนำมาใช้เพื่อเพิ่มระดับความเชื่อมั่นในการใช้รูปแบบ TPACK

คำสำคัญ: ปฏิสัมพันธ์/ ซอฟแวร์/ พันธุศาสตร์/ TPACK/ ครูฝึกสอน

ABSTRACT

This research aimed to improve the performance of pre-service teachers in Genetics and develop their TPACK (Technological, Pedagogical, and Content Knowledge) confidence level using an interactive software. The one-group pretest-posttest experimental design was used to examine the

Pre-service teachers' TPACK and to test the effectiveness of a validated interactive software. Twenty-seven pre-service teachers served as the respondents for the study. The quantitative data was collected using the two instruments as pre and posttests, namely the TPACK in Science Survey developed by Graham, Burgoyne, Smith, St Calir & Harris. (2009) and a validated 30 – item pretest/posttest on Genetics concepts. Based on the findings of the study, there was significant improvement between pre and post scores on all of the TPACK constructs and results indicate a significant increase for all constructs. Likewise, there was a significant increase in the scores in posttest. It implies that the interactive software is effective in improving the performance of the preservice teachers in Genetics. Based on the findings, it is recommended that pre-service teachers be trained more on Genetics concepts and the use of computer in teaching the subject. Also, the interactive lesson can be utilized to increase the TPACK confidence level and performance of pre-service teachers.

KEYWORDS: INTERACTIVE/ SOFTWARE/ GENETICS/ TPACK/ PRE-SERVICE TEACHERS

Introduction

According to the study of Tasar et.al (2010) at the University of Turkey, the turn of the 21st century marked the beginning of a much common and widespread use of computer technologies in science classrooms. This is due to the fact that personal computer hardware became affordable to larger populations and applications with enhanced visual characteristics were created with lesser effort not only by computer experts but also by science educators. Not to mention the availability of other gadgets not only the desktop personal computers. Accordingly, Computer Assisted Teaching (CAT) has also helped teachers to better teach and associate technology in their teaching. However, using technology in science classes requires teacher competence in technology. Teachers need to have a coherent knowledge

about content, pedagogy and technology. Pre-service and in-service science teachers need to develop technological pedagogical content knowledge of the most effective ways to teach various science concepts, principles, and now how to create a technology rich environment.

The progression of information technologies such as interactive and computer-based instruction has expanded the range of conventional education. One of the greatest innovations in computer and communication technologies is the use of the Internet and the World Wide Web. Their development has allowed access to global communications significantly increased the number of resources available for the 21st century learners. With the changes induced by these advancements, computer-based instruction and the Internet in schools, the use of technologies in the teaching and learning strategies sustain a high level of educational effectiveness.

Chi-Yan Tsui and David F. Treagust (2002) explored teachers' pedagogical content knowledge (PCK) through the story of Linda, a preservice science teacher, who participated in this study while she taught Genetics in a Year 10 classroom during her practice teaching. The study utilized a case-based research methodology with multiple sources of data that included interviews, observations, and information and communication technologies (ICT). Linda developed her PCK while teaching Genetics and trying to use BioLogica, an interactive multimedia program. Although Linda did not have a strong content knowledge of Genetics, she was able to expand it in response to students' learning demands. She also improved her pedagogical knowledge through reflection upon her teaching practice despite difficulties she encountered. Classroom observations showed that students had been highly motivated and actively engaged in their learning during Linda's teaching. Her expectations and reflections in the interviews corroborated with our view that she had undergone change in her conception of teaching genetics and substantially improved her PCK. The findings of this research had implications for improving preservice Science Teacher Education. It may be useful to highlight preservice teachers' PCK for teaching in their domain-specific areas

and to introduce the functions of multiple representations in ICT learning environments for improving classroom use of technology. The findings of this case study had some implications for Science Teacher Education and Research: to help preservice teachers to use ICT in teaching for understanding, teacher education courses should be geared towards a more domain-specific approach to classroom, use of ICT and as computer-based multiple representations have provided new opportunities for learning but also new challenges for teaching, teachers' PCK for using ICT in subject areas has become a gap in teacher education and research. Both teacher education and research agenda should put more emphasis on this special type of PCK.

On the other hand, a number of researchers worked on developing instructional materials for most of the topics in Biology such as Ecosystem, Cells, Organ System, Life Energy and Biodiversity but less for the concepts in Genetics. Over the past two decades, researchers in Australia, New Zealand, the UK and the USA have unanimously found that Genetics remains linguistically and conceptually difficult to teach and learn in secondary schools. As such, new teachers are likely to find Genetics even more difficult to teach. It is considered to be one of the most difficult subjects for students in both schools and higher learning institutions. Genetics difficulties appear to be a function of both the teaching methods and nature of the subject itself (Baxter 2008). Based on observations, most textbooks place Genetics as the last topic in Biology. Moreover, in the new K to12 Curriculum, the Learners' Material for Grade 8 Science, Biology is the last module in the 4th quarter. This module focuses on Mendelian Inheritance which lay the foundation in learning Genetics and Heredity. For this reason, teachers often would not have enough time to tackle Genetics and some would deem this as the most difficult topic to teach. Some teachers and most students are not familiar with the works of Mendel, how traits are passed from parents to offspring, the modern gene technology and other Genetics concepts. These concepts need to be simplified in activities where students may enjoy.

The findings of this study are of great importance to pre-service teachers specifically Biology or Biological Science majors who will be future secondary science teachers to equip them with the basic concepts and develop their TPACK confidence level as well. Through the interactive software and the activity – based lessons presented in an enjoyable way, they will appreciate the subject more and be updated with the most recent innovations in Genetics (i.e. Gene Technology, Molecular Genetics, Recombinant DNA and Biotechnology), thus, making them more effective and competent. Curriculum planners may also use the feedback of the study to plan on the government's goals and objectives to offer quality education and to improve Science education. This study can provide baseline information on the extent of using computer technology in the classroom and how this will help the new curriculum. Eventually, the present study aims to produce competitive students who are equipped with scientific concepts and applications of Genetics which will pave way towards excellent performance of Science Education in the country. In the 21st century, the Philippines need citizens with special training in Science and Technology who could be the globally competitive students. The results of the study will be used by future researchers and graduate students as basis for verification or replication of the study for future endeavors.

After the development of an interactive software in Genetics, the researcher aims to help pre-service teachers to be conceptually and linguistically ready to teach the subject as they also develop their TPACK confidence level. The researcher would also like to test the effectiveness of the validated interactive software in the perspective of the pre-service teachers, thus, this study.

Research Objectives

The study aimed at assessing the technological pedagogical and content knowledge of Pre-service Science teachers and to test the

effectiveness of an interactive lessons software in Genetics. The specific objectives of the study are:

1. To determine the perceived confidence level of pre-service Science teachers' related to the four TPCK constructs before and after exposure to the interactive software (i.e., TK, TPK, TCK, TPCK).

2. To determine the significance differences on the pretest and posttest mean values of the teachers' confidence level related to the four TPACK constructs.

3. To determine the performance of the group exposed to the interactive resource material in terms of the pretest mean scores and the posttest mean scores.

4. To determine if there exist significant difference between the groups' pretest mean scores and posttest mean scores.

Research Methodology

Research Design

This study focused on the use of descriptive and experimental research designs. The descriptive research method was used in order to determine pre-service Science teachers' TPACK confidence level and their pre-assessed Genetics concepts knowledge using a survey questionnaire and Genetics test. One-group pretest-posttest experimental design was also used to examine if there is an improvement on the pre-service teachers' performance and TPACK confidence level after the class was taught using an interactive resource material in Genetics.

Population and Sample

There were 27 Pre-service teachers who served as the respondents for the TPACK confidence level assessment and the same group was given the pretest and posttest for the Genetics concepts. These students were the Fourth Year BS Biological Sciences major enrolled in the BSc 127 Course-Genetics for the 1st semester, SY 2014-2015.

Data-Gathering Procedures and Instrumentation

TPACK Instrument

The quantitative data was collected using the "TPACK in Science Survey (TPACKSS)" developed by Graham, et al. (2009). It was administered to the 27 pre-service teachers as pre and posttests.

Pretest/Posttest on Genetics Concepts

A validated 30 – item pretest/posttest on Genetics concepts was used which was evaluated by proficient educators in the fields of Science based on the following characteristics of a good multiple-items test: a) clarity of stems, b) plausibility of options, c) simplicity of responses, d) significance of concepts, e) appropriateness of vocabulary, and F) similarity of options using the scale: 5 (4.21 – 5.00) – Very High, 4 (3.41 – 4.20) – High, 3 (2.61 – 3.40) – Fair, 2 (1.81 – 2.60) – Low, and 1 (1.00 – 1.80) – Very Low.

Based on the content evaluation done by these experts, the competency test on Genetics was rated "very high" with a mean of 4.67. Few items of the test were revised according to the suggestions and comments of the evaluators.

Reliability of the Test

To establish the reliability of the test, the tests were given to 10 selected non-respondent Biology pre-service teachers but of equal characteristics with the target respondents. The papers were scored according to frequency and percentages of correct responses, and analyzed through Kuder-Richardson Formula 20 (K-R 20). K-R 20 is sometimes referred to as Item Analysis because of the following basic reasons: 1). It selects the best items for inclusion on a test; 2). It identifies poorly written test items; 3). It identifies content areas/skills where the class as a whole could benefit from review; and 4). It identifies areas of weakness for individual students.

The following formula and reliability guidelines were used in the test for reliability:

$$\text{variance } \sigma^2 = \frac{\sum dx^2}{N}$$

$$r_{kr20} = \left[\frac{k}{k-1}\right]\left[\frac{1-\sum pq}{\sigma^2}\right]$$

where:

rkr_{20} – reliability coefficient using Kuder-Richardson 20 Formula

k – the number of items in a test

σ^2 – the standard deviation of the test or variance

p – proportion of students passing a given item

q – proportion of students who did not pass the item

pq – product of the proportion who passed and proportion who failed

Reliability guidelines:

87 and above – Very High Reliability

.71 - .86 - High Reliability

.51 - .70 - Moderate Reliability

0 - .50 - Low Reliability

The computation for the reliability obtained an rkr20 value of 0.94 which denotes high reliability of the test.

The Use of the Interactive Software

The class experienced the interactive lessons in Genetics after the administration of the TPACKSS and Genetics concepts pretests. The topics were limited to the Mendelian and Non-Mendelian Inheritance and the Central Dogma of Molecular Biology topics which are also the topics included in Grades 8, 9 and 10 Biology modules in the K to 12 Curriculum.

Data Treatment and Analysis

The data gathered were subjected to statistical treatments. The TPACKSS survey consists of thirty-one items along the areas of

technological knowledge (TK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPCK) and the scale for answering consisted of 6 points level of confidence. For each of the survey items descriptive statistics including means and standard deviations was calculated. The mean differences were obtained through the pre mean minus post mean for each item. Pre and post means values were calculated for four TPACK constructs using t-test to determine if there is a significant increase for all constructs.

To determine if there exist significant differences between the means of the pretest and posttest of the group, the t-test was also employed at 0.05 level of significance.

Research Findings

The TPACK Confidence Level of the Pre-service Teachers

The TPACKSS instrument was used to assess the pre-service teachers' confidence level along the four TPCK constructs namely Technological Knowledge (TK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK) and Technological, Pedagogical, Content Knowledge (TPCK). The TPACK in Science Survey consists of 31-item test items along the four constructs with 6-point measurement scales:1= Not Confident, 2=slightly confident, 3=somewhat confident, 4=fairly confident, 5=quite confident and 6=completely confident.

Table 1 TPACK Confidence Level of the Pre-service Science teachers

	Pre-survey Mean	Post-survey Mean	Mean Difference
TPCK 1	4.07	5.48	1.41
TPCK 2	4.81	5.67	0.85
TPCK 3	4.41	5.44	1.04
TPCK 4	4.56	5.52	0.96
TPCK 5	4.59	5.63	1.04
TPCK 6	4.33	5.63	1.30

	Pre-survey Mean	Post-survey Mean	Mean Difference
TPCK 7	4.41	5.70	1.30
TPCK 8	4.26	5.56	1.30
Average	4.43	5.58	1.15
TPK 1	4.78	5.85	1.07
TPK 2	4.70	5.52	0.81
TPK 3	4.26	5.70	1.44
TPK 4	4.74	5.59	0.85
TPK 5	4.63	5.59	0.96
TPK 6	4.59	5.59	1.00
TPK 7	4.59	5.59	1.00
Average	4.61	5.63	1.02

Table 1 answers the question on the perceived confidence level of the pre-service science teachers along the four TPCK constructs. The average mean values were calculated for each item and the overall mean values for the four constructs.

Continuation of Table 1

	Pre-survey Mean	Post-survey Mean	Mean Difference
TCK 1	4.04	5.63	1.59
TCK 2	3.96	5.70	1.74
TCK 3	4.15	5.59	1.44
TCK 4	4.37	5.63	1.26
TCK 5	4.22	5.74	1.52
Average	4.15	5.66	1.51
TK 1	5.22	6.00	0.78
TK 2	5.15	5.78	0.63
TK 3	5.00	5.70	0.70

	Pre-survey Mean	Post-survey Mean	Mean Difference
TK 4	5.22	5.70	0.48
TK 5	5.07	5.63	0.56
TK 6	4.37	5.70	1.33
TK 7	4.70	5.70	1.00
TK 8	4.67	5.78	1.11
TK 9	4.41	5.67	1.26
TK 10	4.48	5.67	1.19
TK 11	3.30	5.63	2.33
Average	4.69	5.72	1.03

Based on the table, there was an increase in the pre and post mean values for each item as shown by the mean difference-pre mean minus post mean. Their TPACK confidence level was low before they were taught using the interactive software and increased after using the software. This implies that pre-service teachers TPACK confidence level was elevated positively after using the interactive lessons software. TPACK can be described as how teachers understand educational technologies and it is the complex interaction among content, pedagogy and technology. Tasar (2010) mentioned Niess (2005) who proposed that teachers exhibit TPCK when they demonstrate an overarching concept of what it means to teach a particular subject in which technology is integrated into learning; knowledge of instructional strategies and representations for teaching specific topics with technology; knowledge of students' understandings, thinking, and learning with technology in a particular subject; and knowledge of curricula and curriculum materials that integrate technology with learning in specific subject area (Niess, 2005)

The same increase is evident with the other three constructs. Among the four, TK increased the greatest followed by TPK, TPCK and TCK. Previous studies also show that technological knowledge (TK) increased

the greatest since this is the foundational knowledge of TPACK framework (Graham, et al. 2009; Tasar, 2010). The eleven items under TK are basic operations in using the computer. This implies that the pre-service teachers are knowledgeable on these basic skills. Among these items, saving images from the internet to a hard drive (TK 1) obtained the highest mean increase and the least is creating their own website (TK 11). According to Koehler and Mishra (2006), TK is associated with the ability to use technological tools but also the knowledge behind this technology. This finding reinforces the idea that confidence in TK is foundational to developing confidence in the other three forms of knowledge measured. This makes sense if one believes that some basic technical awareness and skills are a prerequisite to being able to meaningfully integrate technology into teaching.

TCK, on the other hand, was the second highest that mean that the pre-service teachers after being taught using the interactive software improved on knowing how to incorporate content and technology. This agrees with the study conducted by Tasar (2010) wherein quantitative data showed that pre-service teachers asserted that they do not know how to incorporate technology with content.

Following TCK was TPK which means that the pre-service teachers already have knowledge on incorporating technology and pedagogy as well for the topics in Genetics. Though it is the lowest in score, TPACK increased also as the pre-service teachers gained knowledge of the complex interactions among content, pedagogy and technology which is primarily achieved when the teacher knows how technological tools transform pedagogical strategies and content representations for teaching particular topics, and how technology tools and representations impact's a student's understanding of the topic.

Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, and Sendurur (2012) found that teachers' attitudes towards technology play an important role in their integration efforts. According to Ertmer, Conklin, and Lewandowski (2001), pre-service teachers' beliefs about technology will be shaped by educators

who help them increase their competence in technology integration, and TPACK is believed to assist in improving technological confidence (Mishra & Koehler, 2006). Positive first hand experiences of pre-service teachers may affect their future applications of information technologies (Bhattacherjee & Premkumar, 2004).

Table 2 Paired-sample t-Test for the Pre and Post TPACK constructs

	Mean	SD	t	p
Pre TPACK	4.43	0.94	2.36	8.16E-07*
Post TPACK	5.58	0.50		
Pre TPK	4.61	0.92	2.45	1.25E-05*
Post TPK	5.63	0.50		
Pre TCK	4.15	1.24	2.78	4.58E-05*
Post TCK	5.66	0.49		
Pre TK	4.69	0.00	2.23	6.39E-05*
Post TK	5.72	0.00		

*-Significant at 0.05 level

Paired–sample t-Test was used to determine significant difference between the four TPACK constructs. The computed t-value for the difference between the means of the pretest and posttest among the four constructs were significant at $p < 0.05$.There was a significant increase in the scores in posttest and pretest. This means that the pre-service teachers' TPACK confidence improved as compared to the initial pre-test.

Performance of the Pre-service teachers in Genetics

Table 3 Descriptive Statistics for the Pretest and Posttest mean scores on Genetics

	N	Minimum	Maximum	Mean	Std. Deviation
Pretest	27	6	14	10.48	2.455
Posttest	27	17	28	21.37	2.830

Table 3 shows the performance of the two groups in the Pretest and Posttest. It can be gleaned from this table that there was an increase in the average mean score of the group in the posttest after being taught using the interactive lessons software. The posttest scores ranged from 17 to 28 points out of the 30-item Genetics test. This denotes that the performance of the pre-service teachers improved with the use of the software in Genetics.

Table 4 confirms that the performances of the two groups are significantly different in terms of the average means in the pretest and posttest.

Table 4 Paired Sample t-test results for the pretest and posttest mean scores.

	Paired Differences					t	df	Posttest - Pretest
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Posttest - Pretest	10.889	3.154	.607	9.641	12.137	17.938	26	.000*

*-significant at 0.05 level

As shown in Table 4, based on the computed p-value, there exist significant difference between the pretest and posttest mean scores of the group. It also implies that the use of the interactive lessons is effective in improving the performance of the preservice teachers' in Genetics. The findings confirm the assertion of Heinrich that students can do activities on their own pace and can go back to previous lessons using programmed instruction. This not only leads to higher scores, but also indicates that

students enjoy the experience more than those in conventional classes. Moreover, Huppert, Yaakobi & Lazarowitz (1998) found out when he used computer simulations in high school microbiology courses to supplement instruction in cell growth and division students performed better on post-tests than students in the traditional labs.

Conclusion and Discussion

This research focused assessing the technological pedagogical and content knowledge of Pre-service Science teachers and to test the effectiveness of an interactive lessons software in Genetics. Specifically, the study determined the following: (1) perceived confidence level of pre-service Science teachers' related to the four TPCK constructs before and after exposure to the interactive software (i.e., TK, TPK, TCK, TPCK), (2) significance differences on the pretest and posttest mean values of the teachers' confidence level related to the four TPACK constructs, (3) performance of the group exposed to the interactive resource material in terms of the pretest mean percentage scores and the posttest mean percentage scores, and (4) significant difference between the groups' pretest mean percentage scores and posttest mean percentage scores. One-group pretest-posttest experimental design was used to examine the Pre-service teachers' TPACK and to test the effectiveness of a validated interactive software in the perspective of the pre-service teachers. Twenty-seven pre-service teachers served as the respondents for the study. The quantitative data was collected using the two instruments as pre and posttests, namely the TPACK in Science Survey developed by Graham et al. (2009) and a validated 30 – item pretest/posttest on Genetics concepts. Based on the findings of the study, there was significant improvement between pre and post scores on all of the TPACK constructs and results indicate a significant increase for all constructs. Likewise, there was a significant increase in the scores in posttest and pretest. It implies that the interactive software is effective in improving the performance of the preservice teachers in Genetics.

From the realities revealed in this study, the following conclusions were drawn:

1. The TPACK framework consisting of four constructs can be used to assess the TPACK confidence level of pre-service teachers in teaching Science particularly the use of the TPAKSS instrument. In this study, there was an improvement in the four TPACK constructs which indicate that interactive lessons can help pre-service teachers develop their confidence level along the TPACK framework that would aid them in teaching Genetics which is noted to be conceptually and linguistically difficult to teach.

2. A significant difference was established in the performance of the pre-service teachers in the pretest and posttest. Therefore, the interactive lessons aided in improving their performance and can be used to help them teach Genetics as future educators in the field of Science.

Based on the foregoing findings and conclusions, the researcher humbly advance the following viable recommendations:

1. Teacher education institutions should provide science teacher preparation programs that would guide pre-service teachers to develop their competence in using technology and to combine it with appropriate pedagogy in the delivery of the content and become an effective teacher in the field.

2. It is suggested that science teachers in HEIs may design and plan suitable technology rich environments and resources to address the development of pre-service teachers' knowledge along the four constructs of the TPACK framework.

3. Available interactive resources can be used to effectively enhance TPACK confidence and performance of pre-service teachers such as the interactive lessons software in Genetics used in this study.

4. Further researches can be conducted aside from measuring TPACK confidence but also to develop other TPACK performance assessment to directly measure the TPACK constructs.

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