QUELLMALZ HIGHER ORDER THINKING SKILLS AND STUDENTS' ACADEMIC PERFORMANCE IN PHYSICS

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ABSTRACT

The study intended to determine the level of Quellmalz higher order thinking skills (HOTS) in physics of college students and its relationship with their academic performance in physics.

Results show that most students have average level physics performance. However, BS Forestry (BSF) and BS Nutrition and Dietetics (BSND) students have below average performance while BS Agricultural Engineering (BSAE), BS Nursing (BSN) and BS Applied Statistics (BSAS) students have above average performance.

Overall, BS Forestry (BSF) and BS Nutrition and Dietetics (BSND) students have below average level of HOTS while BS Agricultural Engineering (BSAE), BS Nursing (BSN) and BS Applied Statistics (BSAS) students have above average level of HOTS. The rest of the students from the other degree programs have average level of HOTS.

The level of HOTS on evaluation has the greatest influence in the physics performance of students followed by comparison, inference and lastly analysis.

Keywords*: Quellmalz Higher Order Thinking Skills (HOTS), Physics Performance, Mathematics Performance*

INTRODUCTION

Thinking is a conscious act. Thinking demands space and time, and the act of thinking is often considered by using the terms which refer to a range of different thinking skills that might be used or applied in particular circumstances.

Thinking skills are at the heart of learning in that they make certain learning possible, and make possible the acts of carrying out certain tasks. It is possible to consider learning without thinking (learning by rote, or learning by accident), as well as learning with thinking. The role of memorization is clearly important since memorization plays a different role in the case of learning without thinking to that which it does in the case of learning with thinking. Internalization of information can occur in the same ways in both cases, but internal processing in the case of learning without thinking relies vitally upon memorization, while in the case of learning with thinking memorization is only a part of the wider internal processing of thinking and learning (Passey, n.d.).

Higher order thinking is thinking on a higher level. It is best described by Thomas and Thorne (n.d). in the following:

> *Higher Order Thinking is more than memorizing facts or telling something back to someone exactly the way it was told to the person. When students memorize and give back the information without having to think about it, it is called rote memory. That's because it's much like a robot; it does what it's programmed to do, but it doesn't think for itself. Higher Order Thinking, or HOT for short, takes thinking to higher levels than just restating the facts. HOT requires that students must do something with the facts. They must understand them, connect them to each other, categorize them, manipulate them, put them together in new or novel ways,*

and apply them as they seek new solutions to new problems.

Different theoreticians and researchers use different frameworks to describe higher order skills and how they are acquired but all frameworks are in general agreement concerning the conditions under which they prosper (King *et al*., n.d.).

In this study, the Quellmalz Framework of Thinking Skills was utilized because the levels are conceptually clear and straightforward making coding of questions easy. It divides thinking skills into five categories: recall, analysis, comparison, inference, and evaluation. The categories of analysis, comparison, inference, and evaluation are collectively called higher order thinking skills (HOTS) or critical thinking skills (Stiggins & Conklin, 1992).

Analysis involves understanding relationships between the whole and its component parts and between cause and effect; sorting and categorizing; understanding how things work and how the parts of something fit together; getting information from charts, graphs, diagrams, and maps.

Comparison refers to explaining how things are similar and how they are different. It starts with the whole/part relationships in the analysis category and carry them a step further.

Inference means reasoning inductively or deductively. In deductive tasks, students reason from generalizations to specific instances and are asked to recognize or explain the evidence.

In inductive tasks, students are given the evidence or details and are required to relate and integrate the information to come up with the generalization.

Evaluation involves expressing and defending an opinion. Evaluation tasks require students to judge quality, credibility, worth or practicality using established criteria and explain how the criteria are met or not met.

Higher-order thinking requires students to manipulate information and ideas in ways that transform their meaning and implications (Department of Education, Training and Employment Education). This transformation occurs when students combine facts and ideas in order to synthesize, generalize, explain, hypothesize or arrive at some conclusion or interpretation.

When students engage in the construction of knowledge, it will allow them opportunities to engage in higher-order thinking. A student with such skills will have the tools of life-long learning.

Physics can be considered as HOT -- higher order thinking. It entails critical/creative/constructive thinking which is closely related to higher-order thinking. It is also an important science subject that makes immense academic demands on students in its learning (Adeyemo, 2010). And because of its enormous importance to science and technology, there is understandably huge interest in students' achievement in Physics, hence the conceptualization of this study.

Objectives

The study intended to determine the level of Quellmalz higher order thinking skills (HOTS) in physics of college students and its relationship with their performance in physics. Specifically the study intended to: (1) determine their level of academic performance in physics; (2) determine the HOTS level on analysis, comparison, inference and evaluation when grouped according to degree program; (3) compare the HOTS level on the four areas when grouped according to degree program; and (4) determine the relationship between the HOTS level and the academic performance in physics.

For the hypotheses, the statements are the following: (1) The level of physics performance of students is average; (2) Students have average HOTS level on the four areas when grouped according to degree program; (3) There are no significant differences on the HOTS level of students on the four areas when grouped according to degree program; and (4) There is no significant relationship of the HOTS level on the four areas of students to their academic performance in physics.

METHODOLOGY

The research was conducted at Benguet State University during the school year 2010-2011.

All students who were enrolled in the 3 – unit course Physics 11 during the first and second semesters of the SY 2010 - 2011 were the respondents of the study. The topics covered under this subject were the same for all the courses taking up this subject. A total of 454 students coming from the different degree programs were included. The respondents comprise the following: Bachelor of Science in Forestry (BSF), 55, Bachelor of Science in Development and Communication (BSDC), 51, Bachelor of Science in Agricultural Engineering (BSAE), 57, Bachelor of Science in Nursing (BSN), 45, Bachelor of Science in Nutrition and Dietetics (BSND), 58, Bachelor of Science in Applied Statistics (BSAS), 40, Bachelor of Science in Environmental Science (BSES), 31, Bachelor of Science in Information Technology (BSIT), 65, and Doctor of Veterinary Medicine (DVM), 52.

To measure the level of HOTS of students on analysis, comparison, inference, and evaluation, an 80 – item teacher-made test was developed. The four areas were allotted 20 items each. The test covered topics on kinematics, dynamics and statics. A reliability test was conducted obtaining a coefficient of 0.65. The physics performance of students was measured using their final grade in Physics 11.

Mean was used to measure the levels of physics performance and Quellmalz HOTS on analysis, comparison, inference and evaluation. Kruskal - Wallis test was used to compare the HOTS level on the four areas among students in the different degree programs while the t test was used to compare the levels of physics performance and HOTS with the average level. Regression analysis was used to determine the interrelationship of the HOTS level of the four areas with students' performance in Physics.

RESULTS AND DISCUSSION

Academic Performance in Physics of College Students

Figure 1 presents the level of physics performance of students grouped according to degree program. From the nine degree programs, BSND have the highest number of students with average level of physics performance of 93% followed by BSIT and BSN students. On the other hand, BSAE students have the highest number with below average physics performance followed by BSES, BSDC and BSAS students. In contrast, six of the nine degree programs have students with above average level of performance and the highest number of students came from the BSAS program with 30%. The other degree programs are BSF, DVM, BSN, BSDC and BSAE.

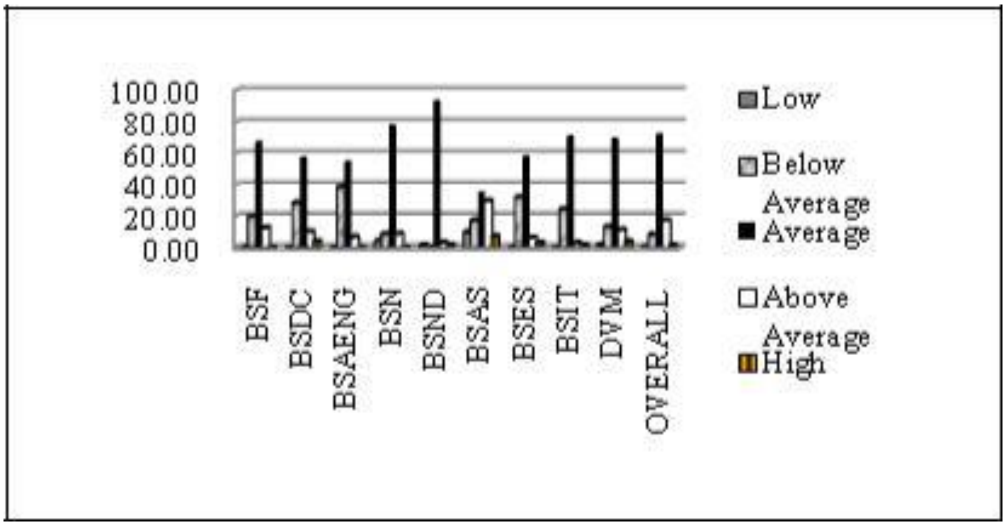

Figure 1. Level of Physics Performance of students grouped according to degree program

Comparison of Level of Physics Performance of Students to Average Level Performance grouped according to Degree Program

Table 1 presents the comparison of the level of physics performance of students to average level performance when grouped according to degree program. BSF, BSAE, BSN, BSND and BSAS students have significantly different level of physics performance compared to average level. The hypothesis is therefore rejected implying that these students do not have average level physics performance. The positive t values for BSF and BSND students indicate they have below average level physics performance while the negative t values for BSAE, BSN and BSAS students indicate above average level performance in physics. This is not the case for students enrolled in the courses BSDC, BSES, BSIT and DVM where the computed t values indicate no significant difference of their level of physics performance with average level performance. The hypothesis is therefore accepted implying that these students have average level performance in Physics.

Level of Higher Order Thinking Skills of Students

Figure 2.a shows the level of HOTS on analysis of students. It could be seen from the graph that the highest percentage of students enrolled in BSAE, BSN, BSND, BSAS and BSIT have an average level of HOTS on analysis while more than half of BSF, BSDC, BSES and DVM students have below average level. As a whole, almost half of all students have below average level whereas about 42% have an average level of HOTS on analysis.

Table 1. Comparison of Level of Physics Performance of Students to Average Performance Grouped According to Degree Program

	Groupings								
	BSF	BSDC	BS AE	BSN	BSND	BS AS	BSES	BSIT	DVM
t	7.223**	.502	-2.670**	-7.118**	3.093**	-3.907**	1.057	1.148	-.669

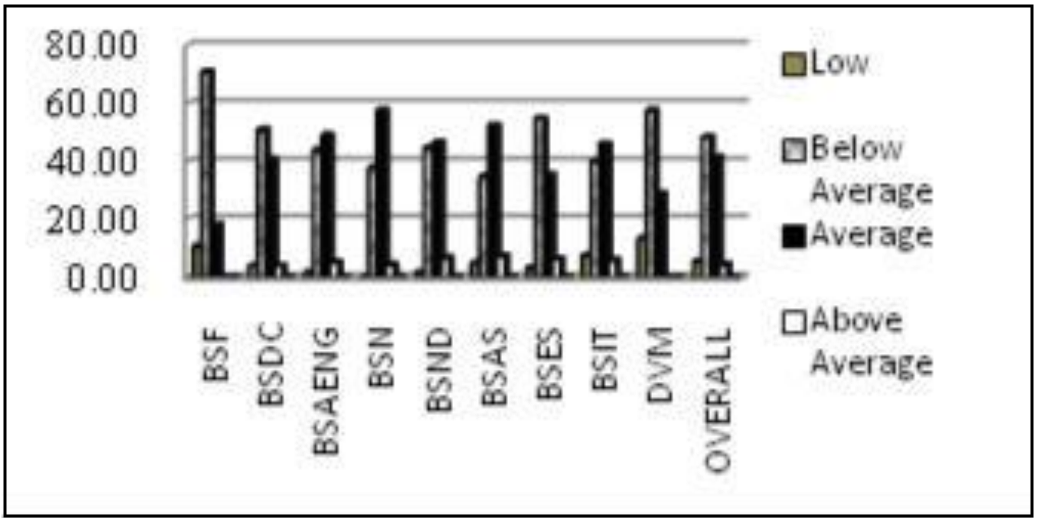

Figure 2a. Level of higher order thinking skills on analysis in physics of students grouped according to degree program

Figure 2.b presents the level of HOTS on comparison grouped according to degree program. The figure shows that almost 50% of the students have below average level while about 34% have an average level of HOTS on comparison. Among the nine degree programs,BSAS students have the highest percentage of with average HOTS level on comparison while BSES students have the highest percentage with below average HOTS level on comparison.

Figure 2.c shows the level of HOTS on inference of students. Among the students in the nine degree courses, BSIT students showed the highest number of students with average HOTS level on inference followed by BSAE and BSAS students.

The highest number of students with below average level is observed among BSN students. As a whole 68% of the students have an average HOTS level, 34% have below average HOTS level while less than 10% have above average HOTS level on inference.

Figure 2.d presents the level of HOTS on evaluation of students. Forestry students have the highest number with below average HOTS level while BSDC and BSN students have the highest number of students with an average level of HOTS on evaluation. Overall, almost 50% of the students in the nine degree programs have below average HOTS level while only one third have average HOTS level on evaluation.

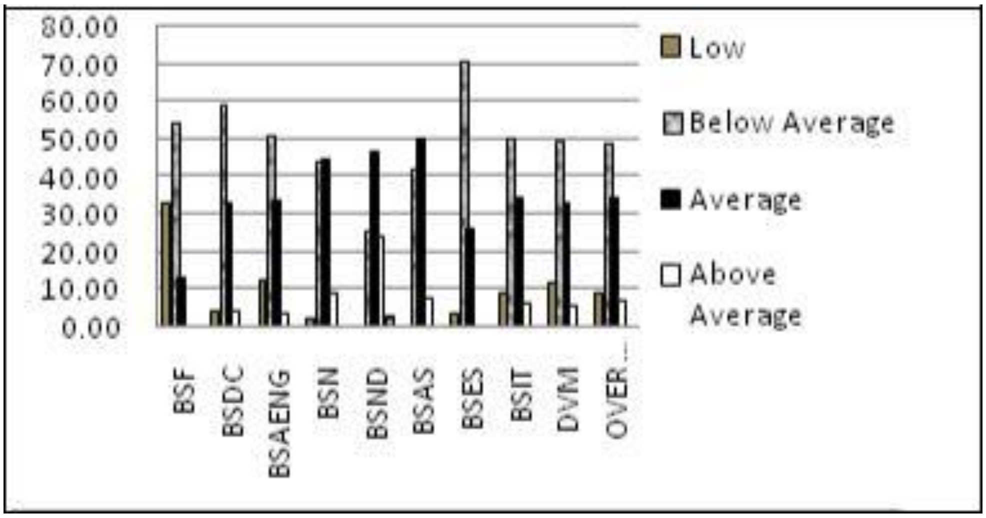

Figure 2b. Level of Higher Order Thinking Skills on Comparison in Physics of Students Grouped According to Degree Program

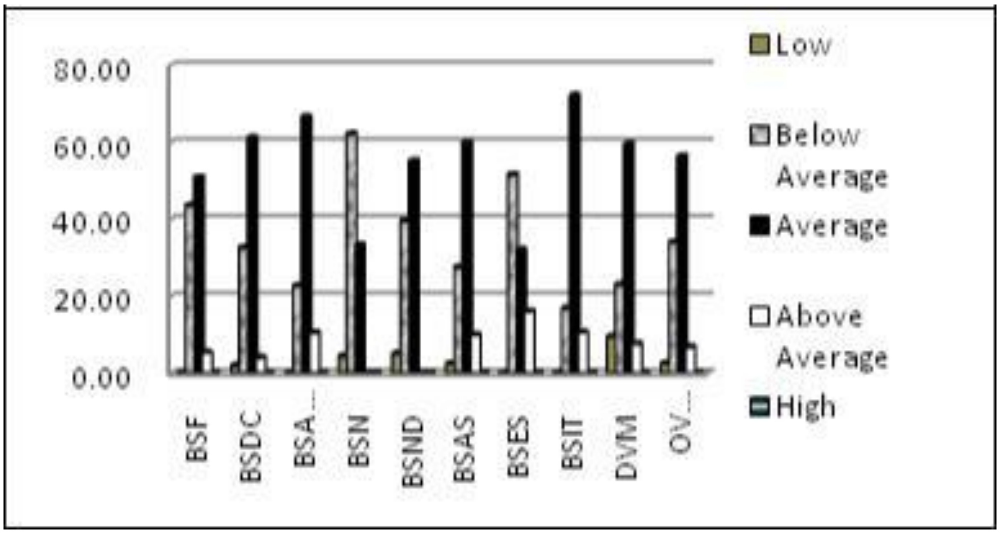

Figure 2c. Level of Higher Order Thinking Skills on Inference in Physics of Students Grouped According to Degree Program

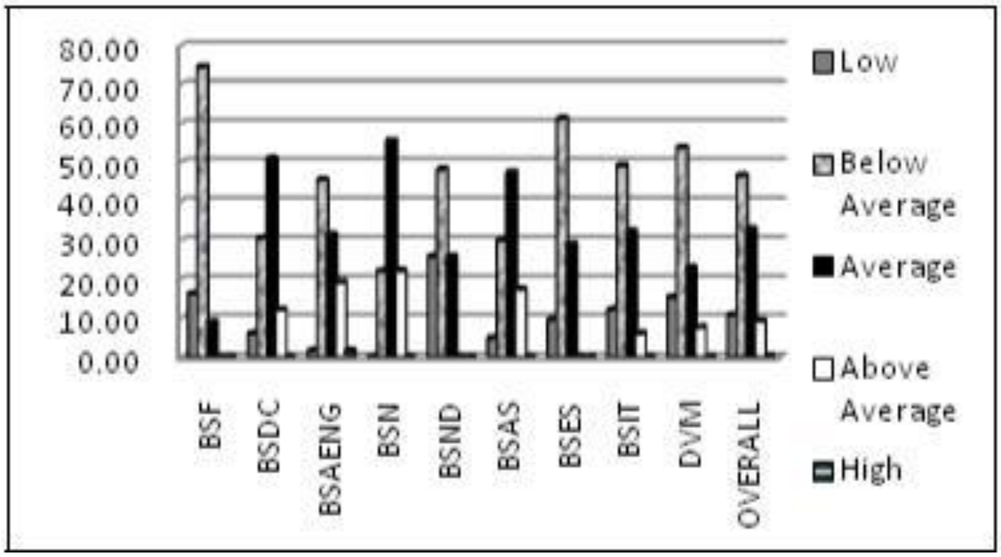

Figure 2d. Level of Higher Order Thinking Skills on evaluation in physics of student grouped according to degree program

Comparison of HOTS Level of Students on Analysis, Comparison, Inference and Evaluation to Average HOTS Level

Table 2 presents the comparison of the level of HOTS of students on the four areas to average level HOTS. On analysis thinking skill, students from BSF, DVM and BSN programs have significantly different levels from the average HOTS level. The negative t value indicates that BSF and DVM students have lower level than the average while the positive t value indicates that nursing students have higher level than average.

Table 2. Comparison of the Level of HOTS of students on analysis, comparison, inference and evaluation to average level HOTS

Course	t values				
	Analysis	Comparison	Inference	Evaluation	OVERALL
BSF	-5.69**	-6.03**	-.522	-6.479**	-8.157**
BSDC	-.06	-2.38*	-.754	1.654	-.387
BSAE	1.76	.92	1.369	3.116**	2.920**
BSN	2.26*	2.66*	-1.267	5.396**	4.582**
BSND	1.47	-2.17*	-3.571**	-4.689**	-3.439**
BSAS	1.57	3.95**	.886	2.822**	3.583**
BSES	.09	-.15	-.752	-2.116*	-1.167
BSIT	1.03	1.38	3.381**	-.476	1.769
DVM	-3.92*	.89	.019	-1.856	-1.692

Subsequently, the level of HOTS on comparison among BSF, BSDC, BSN, BSND and BSAS students differ significantly from the average level. Students from BSF, BSDC and BSND degree programs have a lower level than average. On the other hand, nursing and statistics students have higher HOTS level on comparison.

The level of HOTS on inference of BSND and BSIT students differ significantly with the average level. IT students have higher level than average while BSND students have lower HOTS level than average.

Lastly, students in the following degree programs – BSF, BSAE, BSN, BSND, BSAS and BSES – have HOTS level on evaluation that differ significantly with the average level. BSF, BSND and BSES students have lower HOTS level than average while BSAE, BSN and BSAS students have higher HOTS level on evaluation than average

Comparison of HOTS Level on analysis, comparison, inference and evaluation of students grouped according to degree program

Table 3 presents the comparison of the level of HOTS on the four areas. The Chi Square value for each area is significant at 0.01 level of significance indicating that the levels of HOTS on the four areas differ significantly among students when grouped according to degree program. This implies that the level of HOTS on analysis, comparison, inference or evaluation of students in one degree program is not comparable to other students in other degree program.

Relationship of Level of HOTS on analysis, comparison, inference and evaluation of students and Academic Performance in Physics

The regression equation below shows the interrelationship between HOTS level and academic performance in Physics. It indicates that the performance in physics of students is significantly influenced by the level of HOTS on the four areas.

Physics Performance= 3.447-0.094 A-0.185 C

(<0.05) (<0.01)

-0.163 I-0.467 E

(<0.01) (<0.01)

Among the four areas, the level of HOTS on evaluation has the greatest influence in the physics performance of students followed by comparison, inference and lastly analysis. This implies that the higher the level of HOTS on the four areas, the better will be the performance of students in physics class.

CONCLUSIONS AND RECOMMENDATIONS

Based on the findings, the following conclusions are drawn: (1) there are more students who are performing well in physics than those who do not although a greater number have average level performance; (2) nursing students are good in their

Table 3. Comparison of Level of HOTS on Analysis, Comparison, Inference and Evaluation of Students Grouped According to Degree Program

Areas of Quellmalz Higher Order Thinking Skills	X^2
ANALYSIS	46.418**
COMPARISON	56.727**
INFERENCE	25.132**
EVALUATION	88.493**
ALL HOTS	85.672**

analysis skills while BSF and DVM students have a need to improve such skills; (3) Nursing and statistics students are skilled in comparison while BSF, BSDC and BSND students have difficulties in applying such skill; (4) IT students are skilled in inference while BSND students need to work on such skill;
(5) engineering, nursing and statistics students have good evaluation skills while forestry, nutrition and dietetics and environmental science students need to improve this skill; and (6) students who have higher HOTS level in the four areas have better performance in physics with evaluation skill having the greatest influence to physics performance.

Based on the conclusions, the following are recommended: (1) the HOTS of students should be considered in the teaching learning process by using teaching-techniques that would enhance these skills specifically in courses such as BSF, BSND, BSDC, BSES and DVM; (2) seminars or trainings for teachers on making HOTS questions for class activities should be conducted; and (3) equal allotment of time should be given to each area of HOTS in the conduct of physics classes to help improve the physics performance of students. This could also extend to other subject areas to improve performance of students as a whole.

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