



## THE EFFECT OF KNOWLEDGE, APPLICATION, AND CRITICAL SKILLS LEVEL ON ACADEMIC ACHIEVEMENTS IN THE BIOLOGY CURRICULUM<sup>i</sup>

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### Abstract:

The purpose of the study is to investigate the relationships between the biological basic knowledge level, biological application skills level, and biological critical skills level on academic achievement variables. The quasi-experimental quantitative approach, the test, and two cluster random samples of students were selected to be used in the study. The study found a positive correlation between biological basic knowledge level, biological application skills level, biological critical skills level, and academic achievements. It is also found that the total variance of academic achievements explained by biological basic knowledge level, biological application skills level, and biological critical skills level is 66.7% for the experimental group, and 86.3% for the comparison group.

**Keywords:** biological basic knowledge, biological application skills, biological critical skills, academic achievements

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<sup>i</sup> DIE AUSWIRKUNGEN VON WISSEN, ANWENDUNG UND KRITISCHEN FÄHIGKEITEN AUF AKADEMISCHE ERGEBNISSE IM BIOLOGIE-LEHRPLAN

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### **Abstrakt:**

Ziel der Studie ist es, die Beziehungen zwischen dem biologischen Grundwissensniveau, dem Niveau der biologischen Anwendungsfähigkeiten und dem Niveau der biologisch kritischen Fähigkeiten in Bezug auf akademische Leistungsvariablen zu untersuchen. Der quasi-experimentelle quantitative Ansatz, der Test und zwei Cluster-Zufallsstichproben von Studenten wurden ausgewählt, um in der Studie verwendet zu werden. Die Studie ergab eine positive Korrelation zwischen dem biologischen Grundwissen, dem Niveau der biologischen Anwendungsfähigkeiten, dem Niveau der biologischen kritischen Fähigkeiten und den akademischen Leistungen. Es wurde auch festgestellt, dass die Gesamtvarianz der akademischen Leistungen, die durch das biologische Grundwissen, das Niveau der biologischen Anwendungsfähigkeiten und das Niveau der biologischen kritischen Fähigkeiten erklärt wird, für die Versuchsgruppe 66,7% und für die Vergleichsgruppe 86,3% beträgt.

**Schlüsselwörter:** Biologisches Grundwissen, biologische Anwendungsfähigkeiten, biologische kritische Fähigkeiten, akademische Leistungen

## **1. Introduction and literature review**

The biological basic knowledge level, biological application skills level, and biological critical skills level are meant to be the important variables that impact the academic achievements of students. The main aim of the research is to investigate the relationships between the biological basic knowledge level, biological application skills level, and biological critical skills level and academic achievements variables, as well as the impact of the biological basic knowledge level, biological application skills level, and biological critical skills level on academic achievements. The research questions are shown below: Is there a significant relationship between the biological basic knowledge level and academic achievements in the Biology curriculum? Is there a significant relationship between the biological application skills level and academic achievements in the Biology curriculum? Is there a significant relationship between the biological critical skills level and academic achievements in the Biology curriculum? Is the variance in the academic achievements explained by the biological basic knowledge level, biological application skills level, and biological critical skills level in the Biology curriculum?

### **1.1 The relationship between the biological basic knowledge level, biological application skills level, biological critical skills level, and academic achievements**

Investigating the factors that influence the academic achievements of students in High School is a challenging task. Previous work shows that students' academic achievements and performance depend on many different factors. Between those factors are listed socio-economic, psychological and environmental factors, availability of learning resources, students' profile, gender, age, the influence of peers and academicians, attendance in classes, time allocation for studies, parents' level of income, parent's age

and education, etc. (Gobaw, & Atagana, 2016; Hansen, 2000; Hijazi, & Naqvi, 2006). The process of skill development is an important requirement for tomorrow's society. Preparing students with a high level of achievement is a need and a mission of school today. The higher-order thinking skills, which are essential for absorbing knowledge in biology, are created by using innovative pedagogy methods and approaches which support teaching and learning goals. Deep knowledge and critical thinking skills are essential to get to the root of biological problems and find reasonable solutions for a global, and complex society of tomorrow (Živković, 2016; Karbalaei, 2012). Previous research shows the presence of a linear relationship between knowledge and application skills in biology and student academic achievements (Gobaw, & Atagana, 2016).

Research data shows also that the critical skills and reasoning ability of students have a greater impact on academic achievement in biology more than knowledge alone does. Improvement of reasoning during biology classes looks that better facilitate student achievements by reducing the differences between students in their academic achievements (Johnson, & Lawson, 1998; Jafar, 2018).

Improving student's academic achievement through building up critical, analytical, application knowledge and skills are one of the goals of the education system in today's world. The education system is seriously trying to empower critical and creative thinking skills and learning outcomes by using innovative learning methods and strategies (Fatmawati, Zubaidah, & Mahanal, 2019; Thompson, 2011; Kurniawati, Zubaidah, & Mahanal, 2015). Knowledge, application, analysis, and critical skills play an important role in preparing students to strongly co-develop their achievements in psychomotor, cognitive, and affective domains to have better academic performance in biology. On the other hand, learning biology also helps students in developing socially acceptable behavior (Shaheen, & Kayani, 2015; Boddy, Watson, & Aubusson, 2003). Other studies present important data that shows an evident correlation between critical and creative thinking skills of students, with their level of the learning outcomes achievements (Fatmawati, Zubaidah, & Mahanal, 2019; Thompson, 2011; Falah, Sistiana, & Suhendar, 2018). Based on research data improvement of critical thinking knowledge, and skills is possible to be achieved through purposeful learning activities and repeated practice that encourages critical thinking abilities and nourishes the knowledge at individual and collective levels by direct effect in student performance (Shaheen, & Kayani, 2015; Karbalaei, 2012).

The research data shows also that the teaching method used during the learning process that focuses on the utilization of the concepts gained from students in the past plays an important and vital role in students' academic achievements based on *knowledge, application, analysis, and critical skills*. This approach affects the construction of more sustainable knowledge which directly affects the level of student achievement (Shaheen, & Kayani, 2015; Alparslan, Tekkaya, & Geban, 2003). Developing creative and critical skills seems to help students in their achievements in biology subjects during high school. There is a correlation between a student's level of academic achievements and the number of skills they use during the learning process (Fazal, Hussain, Majoka, & Masood, 2012).

Critical thinking helps students to build up a form of thinking that is based on goals is autonomous and can produce decision-making that involves active analyses, interpretation, and evaluation (Kanbay, Isik, Aslan, Tektas, & Kiliç, 2017; Facione, 1990).

Through knowledge, application, analysis, and critical skills biology teachers can help their students to overcome their struggle with concepts, to find meaning, to distinguish bias, and to use logic in arguments so they may gain a deeper understanding of the world in which they live (Karbalaie, 2012).

Thus, based on the literature review, there is a gap in studying the relationship between the biological basic knowledge level, biological application skills level, biological critical skills level, and academic achievement variables. Therefore, it is mainly hypothesized that:

**H<sub>0</sub>:** Higher scores of the biological basic knowledge level, biological application skills level, biological critical skills level associate with higher scores of academic achievements (Main Hypothesis).

Based on the main hypothesis, operational hypotheses have been formulated as follows:

**H<sub>1</sub>:** There is a significant positive relationship between the biological basic knowledge level and academic achievements in the biology curriculum.

**H<sub>2</sub>:** There is a significant positive relationship between the biological application skills level and academic achievements in the biology curriculum.

**H<sub>3</sub>:** There is a significant positive relationship between the biological critical skills level and academic achievements in the biology curriculum.

**H<sub>4</sub>:** The variance in the academic achievements is explained by biological basic knowledge level, biological application skills level, and biological critical skills level in the biology curriculum.

## 2. Methodology

### 2.1 Method and design

The method used in the research was the quantitative approach. The quasi-experimental research design was used to test the research hypothesis. The non-equivalent comparison group posttest only design was selected to be used in the study. The experimental and comparison groups of respondents were selected using existed students in higher secondary education schools in urban and rural parts of the capital city.

### 2.2 Sample and data collection

The cluster samples of the research have been compounded by higher secondary students' experimental group (N=96) of urban schools of the capital city, and higher secondary students' comparison group (N= 96) of rural schools of the capital city. A breakdown of the cluster random sample of the experimental group included 58 females (60.4%), and 38 (39.6%) males; meanwhile, the cluster random sample of the comparison group is composed of 49 females (51.3%), and 47 (49%) males.

A comprehensive test was used to gather data for biological basic knowledge level, biological application skills level, biological critical skills level, and academic achievement variables.

### 2.3 Analysis

The central tendency and frequency values were used to describe the biological basic knowledge level, biological application skills level, biological critical skills level, and academic achievements for both, experimental and comparison groups. The relationship between biological basic knowledge level, biological application skills level, biological critical skills level, and academic achievements was investigated for the experimental and comparison group using Pearson's *r* correlation coefficient. The prediction of the academic achievements by the biological basic knowledge level, biological application skills level, and biological critical skills level was investigated by linear bivariate regression. The assumption testing was conducted to check for normality, linearity, outliers, as well as the homogeneity of variance-covariance matrices and multicollinearity, with no violations noted.

**Table 1:** Biological basic knowledge level frequencies

		Experimental group		Comparison group	
		Frequency	Percent	Frequency	Percent
Valid	Very low level	20	20.8	16	16.7
	Low level	7	7.3	3	3.1
	Medium level	33	34.4	26	27.1
	High level	11	11.5	6	6.3
	Very high level	25	26.0	45	46.9
	Total	96	100.0	96	100.0

Biological basic knowledge level variable frequencies showed that 28.1% of the experimental group and 19.8% of the comparison group are reported to have a very low or low level of biological basic knowledge; 34.4% of the experimental group and 27.1% of the comparison group medium level; and 37.5% of the experimental group and 53.2% of the comparison group are reported to have a high or very high level of biological basic knowledge. Central tendency values, for experimental group ( $M = 2.14$ ;  $DS = 1.43$ ), as well as for comparison group ( $M = 2.63$ ;  $DS = 1.50$ ) confirm the same tendency. Therefore, the experimental group of high school students to whom the competency-based-test is used reported lower levels of biological basic knowledge compared to the comparison group of high school students to whom the knowledge-based-test is used. In conclusion, the teaching in the biology curriculum in high school is more focused on knowledge acquisition than on competency and skills construction.

**Table 2: Biological application skills level frequencies**

		Experimental group		Comparison group	
		Frequency	Percent	Frequency	Percent
Valid	Very low level	25	26.0	21	21.9
	Low level	14	14.6	5	5.2
	Medium level	32	33.3	23	24.0
	High level	24	25.0		
	Very high level	1	1.0	47	49.0
	Total	96	100.0	96	100.0

Biological application skills level variable frequencies showed that 40.6% of the experimental group and 27.1% of the comparison group are reported to have a very low or low level of biological application skills; 33.3% of the experimental group and 24% of the comparison group medium level; and 26% of the experimental group and 49% of the comparison group are reported to have a high or very high level of biological application skills. Central tendency values, for experimental group ( $M = 1.60$ ;  $DS = 1.15$ ), as well as for comparison group ( $M = 2.48$ ;  $DS = 1.63$ ) confirm the same tendency. Thus, the experimental group of high school students to whom the competency-based-test is used reported lower levels of biological application skills compared to the comparison group of high school students to whom the knowledge-based-test is used. In conclusion, the teaching in the biology curriculum in high school is more focused on knowledge acquisition than on competency and application skills construction.

**Table 3: Biological critical skills level frequencies**

		Experimental group		Comparison group	
		Frequency	Percent	Frequency	Percent
Valid	Very low level	46	47.9	42	43.8
	Low level	15	15.6	2	2.1
	Medium level	27	28.1	25	26.0
	High level	3	3.1	6	6.3
	Very high level	5	5.2	21	21.9
	Total	96	100.0	96	100.0

Biological critical skills level variable frequencies showed that 63.5% of the experimental group and 45.9% of the comparison group are reported to have a very low or low level of biological critical skills; 28.1% of the experimental group and 26% of the comparison group medium level; and 8.3% of the experimental group and 28.2% of the comparison group are reported to have a high or very high level of biological critical skills. Central tendency values, for experimental group ( $M = 1.02$ ;  $DS = 1.16$ ), as well as for comparison group ( $M = 1.60$ ;  $DS = 1.60$ ) confirm the same tendency. Hence, the experimental group of high school students to whom the competency-based-test is used reported lower levels of biological critical skills compared to a comparison group of high school students to whom the knowledge-based-test is used. In conclusion, the teaching in the biology

curriculum in high school is more focused on knowledge acquisition than on competency and critical skills construction.

**Table 4:** Academic achievements level frequencies

		Experimental group		Comparison group	
		Frequency	Percent	Frequency	Percent
Valid	Very low level	16	16.7	10	10.4
	Low level	37	38.5	32	33.3
	Medium level	33	34.4	23	24.0
	High level	7	7.3	13	13.5
	Very high level	3	3.1	18	18.8
	Total	96	100.0	96	100.0

Academic achievements variable frequencies showed that 55.2% of the experimental group and 43.7% of the comparison group are reported to have a very low or low level of biological critical skills; 34.4% of the experimental group and 24% of comparison group medium level; and 10.4% of the experimental group and 32.3% of the comparison group are reported to have a high or very high level of biological critical skills. Central tendency values, for experimental group ( $M = 6.69$ ;  $DS = 1.65$ ), as well as for comparison group ( $M = 7.42$ ;  $DS = 1.89$ ) confirm the same tendency. Therefore, the experimental group of high school students to whom the competency-based-test is used reported lower levels of academic achievements compared to the comparison group of high school students to whom the knowledge-based-test is used. In conclusion, the teaching in the biology curriculum in high school is more focused on knowledge acquisition than incompetency and application, and critical skills construction.

## 2.4 Testing of hypothesis

The results of inferential analyses to investigate the relationship between biological basic knowledge level, biological application skills level, biological critical skills level, and academic achievement variables are shown below.

**Table 5:** Correlation outputs of the relationship between biological basic knowledge level, biological application skills level, biological critical skills level, and academic achievements variables

Correlations					
Experimental group					
		Academic achievements	Biological basic knowledge level	Biological application skills level	Biological critical skills level
Pearson Correlation	Academic achievements	1.000	.240	.597	.786
	Biological basic knowledge level	.240	1.000	.092	.149

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	Biological application skills level	.597	.092	1.000	.567
	Biological critical skills level	.786	.149	.567	1.000
<b>Correlations</b>					
<b>Comparison group</b>					
		<b>Academic achievements</b>	<b>Biological basic knowledge level</b>	<b>Biological application skills level</b>	<b>Biological critical skills level</b>
Pearson Correlation	Academic achievements	1.000	.706	.757	.817
	Biological basic knowledge level	.706	1.000	.468	.703
	Biological application skills level	.757	.468	1.000	.451
	Biological critical skills level	.817	.703	.451	1.000

**H1:** There is a significant positive relationship between the biological basic knowledge level and academic achievements in the biology curriculum.

The outputs of the Pearson correlation indicate that there is a low positive correlation between biological basic knowledge level and academic achievement variables,  $r = .240$ ,  $n = 96$ ,  $p < .005$  for the experimental group. Meanwhile, there is a high positive correlation between biological basic knowledge level and academic achievements variables for comparison group:  $r = .706$ ,  $n = 96$ ,  $p < .005$ . The value of correlation, for the experimental and comparison group, points out that increasing biological basic knowledge level values would increase the academic achievements level, although there are differences between the experimental and comparison group. So, there is a low positive correlation between biological basic knowledge level and academic achievements referring to an experimental group of high school students to whom the competency-based-test is used compared to a high positive correlation referring to a comparison group of high school students to whom the knowledge-based-test is used. The result was consistent with previous literature works, who argued that biological basic knowledge level influences the academic achievements of high school students.

Therefore, hypothesis 1: *There is a significant positive relationship between the biological basic knowledge level and the academic achievements in biology curriculum*, is been supported



**H2:** There is a significant positive relationship between the biological application skills level and academic achievements in the biology curriculum.

The outputs of the Pearson correlation indicate that there is a medium positive correlation between biological application skills level and academic achievement variables,  $r = .597$ ,  $n = 96$ ,  $p < .005$  for the experimental group. Meanwhile, there is a high positive correlation between biological application skills level and academic achievements variables for comparison group:  $r = .757$ ,  $n = 96$ ,  $p < .005$ . The value of correlation, for the experimental and comparison group, indicates that increasing biological application skills level values would increase the academic achievements level, although there are differences between the experimental and comparison group. Thus, there is a medium positive correlation between biological application skills level and academic achievements referring to an experimental group of high school students to whom the competency-based-test is used compared to a high positive correlation referring to a comparison group of high school students to whom the knowledge-based-test is used. The result was consistent with previous literature works, who argued that biological application skills level impact the academic achievements of high school students.

Therefore, hypothesis 2: *There is a significant positive relationship between the biological application skills level and the academic achievements in biology curriculum*, is been supported.

**H3:** There is a significant positive relationship between the biological critical skills level and academic achievements in the biology curriculum.

The outputs of the Pearson correlation indicate that there is a high positive correlation between biological critical skills level and academic achievement variables,  $r = .786$ ,  $n = 96$ ,  $p < .005$  for the experimental group. Meanwhile, there is also high positive correlation between biological critical skills level and academic achievements variables for comparison group:  $r = .817$ ,  $n = 96$ ,  $p < .005$ . The value of correlation, for the experimental and comparison group, points out that increasing biological critical skills level values would increase the academic achievements level, although there are differences between the experimental and comparison group. Hence, there is a high positive correlation between biological critical skills level and academic achievements referring to an experimental group of high school students to whom the competency-based-test is used, as well as related to a comparison group of high school students to whom the knowledge-based-test is used. The result was consistent with previous literature works, who argued that biological critical skills level influences the academic achievements of high school students.

Therefore, hypothesis 3: *There is a significant positive relationship between the biological critical skills level and the academic achievements in the biology curriculum*, is been supported.

**H4:** The variance in the academic achievements is explained by biological basic knowledge level, biological application skills level, and biological critical skills level in the biology curriculum.

**Table 6:** R Square values of the relationship between biological basic knowledge level, biological application skills level, biological critical skills level, and academic achievements variables

Model Summary									
Experimental group									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.817 <sup>a</sup>	.667	.656	.97030	.667	61.471	3	92	.000
a. Predictors: (Constant), Biological critical skills level, Biological basic knowledge level, Biological application skills level									
Model Summary									
Comparison group									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.929 <sup>a</sup>	.863	.859	.71182	.863	193.989	3	92	.000
a. Predictors: (Constant), Biological critical skills level, Biological application skills level, Biological basic knowledge level									

The regression outputs show that the total variance of academic achievements explained by biological basic knowledge level, biological application skills level, and biological critical skills level is 66.7%,  $F(3, .667)$ ,  $p < .005$  for the experimental group, and 86.3%,  $F(3, .863)$ ,  $p < .005$  for the comparison group. The other variance may be explained by other variables. The control measure in the model is statistically significant with higher standardized beta values for experimental group:  $\beta = -.129$ ;  $p < .005$ ), and for comparison group: ( $\beta = .321$ ;  $p < .005$ ). There is no huge difference in the total variance of academic achievement levels explained by biological critical skills level, biological application skills level, biological basic knowledge level between experimental and comparison group, while there is the same tendency. Therefore, biological basic knowledge level, biological application skills level, and biological critical skills level predict academic achievements.

Beta Standardized coefficient .122 of biological critical skills level explains 12.2% of the variance; .465 of biological application skills level explains 46.5% of the variance, and .521 of biological basic knowledge level explains 52.1% of the variance of academic achievements. The result was consistent with previous literature works, who argued that biological basic knowledge level, biological application skills level, and biological critical skills level predict the academic achievements of high school students.

**Table 7:** Multivariate regression outputs of the relationship between biological basic knowledge level, biological application skills level, biological critical skills level, and academic achievements variables

Coefficients <sup>a</sup>									
Experimental group									
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	4.954	.218		22.711	.000			
	Biological basic knowledge level	.143	.070	.124	2.043	.044	.240	.208	.123
	Biological application skills level	.317	.105	.222	3.035	.003	.597	.302	.183
	Biological critical skills level	.909	.104	.642	8.737	.000	.786	.673	.526
a. Dependent Variable: Academic achievements									
Coefficients <sup>a</sup>									
Comparison group									
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	4.693	.162		28.898	.000			
	Biological basic knowledge level	.154	.070	.122	2.185	.031	.706	.222	.084
	Biological application skills level	.539	.052	.465	10.456	.000	.757	.737	.403
	Biological critical skills level	.615	.065	.521	9.434	.000	.817	.701	.363
a. Dependent Variable: Academic achievements									

Therefore, hypothesis 4: *The variance in the academic achievements is explained by biological basic knowledge level, biological application skills level, and biological critical skills level in the biology curriculum*, is been supported.

#### 4. Conclusion and implications

The study aimed to investigate the relationship between the biological basic knowledge level, biological application skills level, and biological critical skills level on academic achievement variables. The prior assumption was that the biological basic knowledge level, biological application skills level, and biological critical skill level predict students' academic achievements.

The study found that the experimental group of high school students to whom the competency-based-test is used reported lower levels of biological basic knowledge

compared to the comparison group of high school students to whom the knowledge-based-test is used. It is also found that the experimental group of high school students to whom the competency-based-test is used reported lower levels of biological application skills compared to the comparison group of high school students to whom the knowledge-based-test is used. The study revealed that the experimental group of high school students to whom the competency-based-test is used reported lower levels of biological critical skills compared to the comparison group of high school students to whom the knowledge-based-test is used. It is also revealed that the experimental group of high school students to whom the competency-based-test is used reported lower levels of academic achievements compared to the comparison group of high school students to whom the knowledge-based-test is used. In conclusion, the teaching in the biology curriculum in high school is more focused on knowledge acquisition than on competency and application, and critical skills construction.

The study found a low positive correlation between biological basic knowledge level and academic achievements referring to an experimental group of high school students to whom the competency-based-test is used compared to a high positive correlation referring to a comparison group of high school students to whom the knowledge-based-test is used.

It is also found that there is a medium positive correlation between biological application skills level and academic achievements referring to the experimental group of high school students to whom the competency-based-test is used compared to a high positive correlation referring to the comparison group of high school students to whom the knowledge-based-test is used.

The study indicated a high positive correlation between biological critical skills level and academic achievements referring to an experimental group of high school students to whom the competency-based-test is used, as well as related to a comparison group of high school students to whom the knowledge-based-test is used.

It is also showed that the total variance of academic achievements explained by biological basic knowledge level, biological application skills level, and biological critical skills level is 66.7% for the experimental group, and 86.3% for the comparison group. Therefore, biological basic knowledge level, biological application skills level, and biological critical skills level predict academic achievements. The study showed that the biological critical skills level explains 12.2% of the variance, biological application skills level explains 46.5% of the variance, and biological basic knowledge level explains 52.1% of the variance of academic achievements. Therefore, teachers, as well as the schools should increase their work to support high school students in the application, and critical skills construction during the teaching activities in the biology curriculum to influence students' academic achievements.

### **Conflict of Interest Statement**

The authors have no conflicts of interest to declare. All co-authors have agreed with the contents of the manuscript and there is no financial interest to report. We certify that the submission is our original work and is not under review at any other publication.

### **About the Authors**

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**Prof. Dr. Anila Papparisto** has about 25 years of experience in scientific research and projects in the field of Animal Biology and Education and teaching Biological Sciences. During her academic career Prof. Papparisto has been involved in national and international research and science projects in the field of entomology, systematic and biodiversity, invasive species, insects as bio-indicators of river pollution and biological education. Her scientific research results are published in numerous national and international journals.

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