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Knowledge and Acceptance of Biological Evolution among College Students

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ABSTRACT

The importance of evolution is affirmed by both scientists and science educators. Despite this, the idea of evolution remains divisive among the general population. Learning evolutionary conceptions is still difficult, more than 150 years after they were first presented. Lack of evolution education, creationist teaching, and religious dogma clashes are the primary causes of low acceptance and knowledge of evolution among college students. This cross-sectional survey using inferential statistics mainly investigated the link between college students' knowledge and their acceptance of biological evolution. It established that knowledge of biological evolution varies greatly based on their academic backgrounds and family types and that those in the higher years were able to exhibit a greater degree of acceptance towards evolutionary processes. Correlation and regression analyses demonstrated a positive linear relationship existing between knowledge and acceptance and that the former is a significant predictor variable of the latter. This indicates that continued educational efforts may be able to enhance public perceptions of evolutionary theories.

Keywords: Evolutionary concepts, attitude towards evolution, higher education, relationship between knowledge and acceptance

INTRODUCTION

For more than 150 years, the modern Theory of Evolution has been expanding and progressing. Over the decades, new theoretical considerations based on novel methods and empirical data have been added to a more sophisticated

understanding of how evolution works within and beyond the biological world. It is at the heart of modern biological research because it provides a unifying framework within which biologists of many branches and subdisciplines can ask questions about the living world. As a result, biological education and scientific literacy require a fundamental comprehension of central evolutionary principles (Kuschmierz et al., 2020). Since Darwin's time, scientists from the fields of economics and sustainability science to linguistics and computer science have applied concepts from evolutionary theory to explain observable variation and change of features in populations (Hanisch & Eirdosh, 2020). The importance of evolution is affirmed by both scientists and science educators. In scientific education, an emphasis on understanding evolution is a major component of biology teaching (Dorner & Scott, 2016). Nevertheless, despite the support of different scientific and educational groups, the idea of evolution remains divisive among the general population, with acceptance ranging greatly around the world (Brown & Scott, 2016).

For those involved: instructors and students, evolution education, which includes teaching and learning about evolution, is extremely demanding. A lot of biological events and processes can only be comprehended with evolutionary background knowledge, which is a theoretical pivot point of modern biology and hence crucial to understanding biology as a scientific field (Scheuch & Rachbauer, 2019). Learning evolutionary theories is still difficult, more than 150 years after they were first presented; their understanding appears quite challenging for both those who reject them and those who accept them. This has been explained in several ways, one of these is the teachers' emphasis on details rather than broad principles and procedures, which results in the same degree of comprehension of the subject regardless of course length or number. Even convinced believers frequently demonstrate a lack of understanding of evolutionary processes and give erroneous interpretations (Mattsson & Mutvei, 2015). Public opinion polls continually show that a sizable segment of the population does not believe evolution has occurred or is occurring (Miller et al., 2006). Along the same vein, many students (in high school and college) are: 1) not receiving enough biological evolution training; 2) being taught incorrect biological evolution notions; and 3) being intentionally taught non-scientific material (e.g., creationism and intelligent design) in their science classes (Rice et al., 2015). The general poor understanding has been attributed to a wide variety of cognitive, epistemological, religious, and emotional factors (Alters & Nelson, 2002). These may lead to students having significant misconceptions regarding basic evolutionary principles such as

natural selection, adaptation, speciation, or phylogeny, which is a major problem in evolution education (Harms & Reiss 2019). Students have strong feelings about evolution but limited scientific comprehension of evolutionary processes. In addition to preconceptions about evolution, they may not grasp that scientific theory is based on strong evidence and support but is dynamic considering fresh, authenticated results. Consequently, students may have misconceptions about what constitutes a scientific theory, such as in the case of evolutionary theory, which may have an impact on their learning and comprehension of scientific issues (Cavallo et al., 2011)

This study offers additional insights into certain learner attributes that may explain the differences in the levels of knowledge and acceptance pertaining to concepts in biological evolution. Science educators will then be able to set a realistic level of expectancy and provide the appropriate amount of inputs and interventions to maximize the cognitive and affective abilities of the students. Furthermore, the establishment of a relationship between knowledge and acceptance of biological evolution would allow educational systems to put emphasis on strategies that develop both general and specific understanding of evolutionary processes. This will not only change the attitude of the learners in favor of biological evolution but it might also improve their view of science as a whole.

FRAMEWORK

Scientific knowledge and understanding, critical thinking abilities, social and emotional elements, religious considerations, as well as demographic variables, are among the factors linked to evolution acceptance or rejection. Acceptance of evolution, for instance, is positively connected with the level of education, years of schooling, and attainment of a college diploma (Dorner & Scott, 2016). While evolution acceptance is a complicated subject, it must be addressed. It is indicated that one of the major contributors to the current situation is a lack of suitable training and proper teaching in the public education system. Many teachers start the profession with insufficient training and awareness of evolutionary principles, as well as the ability to firmly establish or offer scientific evidence to pupils who may be skeptical at first. Students join the higher education system with numerous preconceived opinions, which can become big obstacles in improving evolution acceptability. Their religious beliefs, as well as the beliefs of their parents, have a significant impact on their perceptions coupled

with inadequate or imprecise information they acquire in secondary school (Tolman et al., 2021). According to a study headed by Miller et al (2006), the evolutionary acceptance of the populace varies significantly among countries and social groups. As a result, one of the key subtopics of evolution education is research into the origins of such variances, as well as ways to raise acceptance and knowledge levels. Furthermore, empirical research has revealed that determining evolution acceptance is a difficult task that is likely multifaceted (Gefaell et al., 2020).

Religious affiliation, age, gender, education, and geographic region all contribute to a substantial number of people who do not comprehend or accept evolution. Several researchers have investigated what influences students' acceptance or comprehension of evolution theory. The elements that each study looked at differed from one to the next, such as the quantity of biology credit hours taken, the completion of an evolution course, cognitive tendencies, parents' educational level, and feelings of confidence. Furthermore, a thorough knowledge of the nature of science has been linked to learners' acceptance and understanding of evolutionary theory in multiple earlier research (Kim, 2016). The students' worldviews may be one of the most powerful variables in evolution acceptance. Students' ability to objectively assess scientific facts was demonstrated to be hampered by their beliefs, which was exacerbated when learned religious concepts clashed with the knowledge being taught. Additionally, before beginning their studies, a large number of students held non-scientific ideas such as creationism (Cavallo et al., 2011). This has been backed up by the findings of Brown & Scott (2016) that the lack of evolution education, creationist teaching, and religious dogma clashes are the primary causes of low acceptance and knowledge of evolution among entering college students. As a result, college students join science classes with the baggage of previous misconceptions about science and evolution, which might obstruct their understanding of the scientific explanations offered.

The formation of knowledge and the practice of science in the Philippines is multifaceted, involving the state, the economy, and a variety of institutions ranging from the family to universities. Many university academics easily confessed that their religious and scientific beliefs were intertwined. The public world of science and private religious beliefs are not considered as different domains. The blending of the private and public spheres is a significant characteristic of Philippine culture. Nature is rarely viewed by Filipinos as a raw truth that can be manipulated by humans. Instead, nature is frequently portrayed as animate, with its own set of goals. In fields of life such as art, music, literature, and religion, a

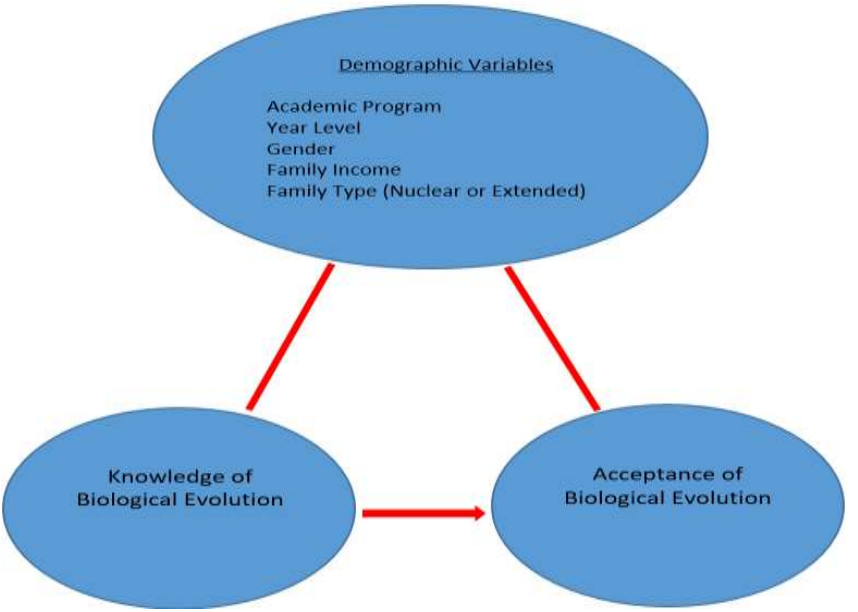
critical, aesthetic reflectivity blossomed, complementing natural science. Only particular perceptions of the world (e.g., regularity, predictability, falsifiability, etc.) are likely to lead to a scientific mindset (Pertierra, 2006).

Links were discovered between a person's understanding of biological evolution and their acceptance of it. This implies that to successfully teach biological evolution, we must address both a population's knowledge and acceptance of the concept (Rice et al., 2015). Trani (2004, as cited in Kim, 2016) goes on to say that the low level of acceptance of the evolutionary theory is due to a lack of knowledge of both the evolutionary theory and the fundamental nature of science.

A major focus of science education research is the relationship between attitudes toward evolution and knowledge about evolution. The evolution education community has yet to reach a consensus on the nature and scope of this relationship. The use of different measuring tools as well as the use of different names for the important constructs could be the main reasons for conflicting results in this domain (Kuschmierz et al., 2020).

Figure 1

A Schematic Presentation of the Interplay of Variables used in the Study



OBJECTIVES OF THE STUDY

The primary goal of this research is to investigate the link between college students' knowledge and their acceptance of biological evolution. Demographic factors that may account for the differences in the levels of knowledge and acceptance will be tested as well. This study was also guided by the following questions: (a) How do college students' knowledge of biological evolution differ according to their demographic profile?; (b) How do college students' views on biological evolution vary depending on their demographic profile?; (c) What relationship exists between college students' knowledge and acceptance of biological evolution?; and (d) To what extent does knowledge of biological evolution predict its acceptance?

METHODOLOGY

The study utilized a descriptive correlational research design with a researcher-made questionnaire comprising 3 sections that determine demographic context and assess the level of knowledge and acceptance of biological evolution. The knowledge test with 8 multiple choice questions covering general concepts that can be answered within 2 minutes while the acceptance measurement was carried out using a 5-point Likert scale with 13 items, which can be completed within 3 minutes. Reliability analysis gave a Cronbach's Alpha = 0.853. The objectives along with the guaranty of confidentiality and voluntary nature of the study make up the introductory portion of the questionnaire. There were 263 respondents who agreed to take part in the survey carried out by the researcher. All of them are bona fide college students from Higher Education Institutions (HEIs) in Mindanao across 5 classes of degree programs: Life Sciences; Health-Related; Arts and Social Sciences; Engineering and Mathematics; and Business and Accountancy. Participants were coming from 4 year-levels. The survey was conducted during October and November 2021.

Students were polled using the questionnaire encoded in Google Forms quiz, which they could access through a link provided via electronic mail or Meta Messenger chat once they consented to participate. The responses were extracted from the spreadsheet generated by Google Sheets that was coupled with the Google Forms quiz.

The responses in the spreadsheet were coded and migrated to the IBM SPSS Statistics 25 dataset. Characteristics of the demographic variables with respect to knowledge and acceptance scores were determined using Descriptive Statistics.

One-way ANOVA, Independent Samples t-test, and Tukey Post Hoc Test allowed the comparison of demographic variables in terms of the values obtained from the assessment of the participant's knowledge and acceptance of biological evolution. The linear association between knowledge and acceptance was measured using Pearson Product-Moment Correlation followed by Stepwise Linear Regression to quantify the relationship between knowledge as the predictor variable and acceptance being the response variable.

RESULTS AND DISCUSSION

A one-way ANOVA was performed to compare the knowledge and acceptance scores of the participants when clustered according to the Academic Program they are currently enrolled in, Gender, Income, and Year Level (Table 1). The analysis shows that there was no statistically significant difference in both knowledge and acceptance for groups under Gender and Income. However, regarding Academic Program, it was revealed that there was a significant difference between at least two groups [$F(4, 258) = 4.43$, $p = 0.002$] under the knowledge measure. Tukey's HSD test for multiple comparisons found that the mean value of knowledge was significantly different between Health-related and Arts and Sciences ($p = 0.012$, 95% C.I. = 0.1187, 1.4465); and between Health-related and Business and Accountancy ($p = 0.040$, 95% C.I. = 0.0307, 2.1916). Life sciences scored highest in the knowledge test ($M = 6.1154$, $SD = 1.3951$) with Business and Accountancy ($M = 4.8889$, $SD = 2.2723$) getting the lowest. As for the Year level, a statistically significant difference among the acceptance mean scores was observed [$F(3, 259) = 1.28$, $p = 0.039$]. Third-year participants topped the acceptance measurement ($M = 3.4646$, $SD = .4046$), and the freshmen were at the other end of the spectrum ($M = 3.2750$, $SD = .4316$). Taken as a whole, the students were inclined to accept biological evolution but tended to stay neutral about it ($M = 3.3322$, $SD = .4329$, $Mdn = 3.000$).

Table 1

One-Way ANOVA of Knowledge and Acceptance of Biological Evolution by Academic Program, Gender, Income, and Year Level

	Academic Program n=258		Gender n=260		Income n=256		Year Level n=259	
Measure	***F***	***p***	***F***	***p***	***F***	***p***	***F***	***p***
Knowledge	$F = 4.43$	.002**	$F = .34$	.710	$F = 1.28$	.267	$F = 2.58$	.054
Acceptance	$F = 1.29$	.274	$F = .37$	.255	$F = .59$	.739	$F = 1.28$	.039*

**. Significant at 0.01 level
*. Significant at 0.05 level

Note. Academic Program: Life Sciences; Health-Related; Arts and Social Sciences; Engineering and Mathematics; Business and Accountancy
Gender: Female; Male; Others
Income: Poor; Low Income; Low Income; Lower Middle Class; Middle Class; Upper Middle Income; High Income; Rich
Year Level: 1st Year; 2nd Year; 3rd Year; 4th Year

A significant difference was seen in knowledge between the nuclear family (M = 5.894, SD = 1.392) and extended family (M = 5.228, SD = 1.846); t(257) = -3.198, p = 0.041 when the researcher ran a two samples t-test to compare knowledge and acceptance (Table 2).

Table 2

Independent Samples t-test Comparing Knowledge and Acceptance of Biological Evolution Between Nuclear and Extended Families

	Nuclear Family		Extended Family				
	M	SD	M	SD	t	df	*p*
Knowledge	5.894	1.392	5.228	1.846	-3.198	257	.041*
Acceptance	3.361	.440	3.274	.422	-1.486	257	.516

*. Significant at 0.05 level

Note. M = Mean, SD = Standard Deviation

Pearson correlation coefficient was computed to assess the linear relationship between knowledge and acceptance of biological evolution as shown in Table 3. It was determined that there was a positive correlation between the two variables, r(261) = .310, p = .000. A scatterplot summarizes the results along with the

line of best fit and coefficient of determination (Figure 2). Hence, increases in knowledge of biological evolution correlate with increases in its acceptance.

Table 3

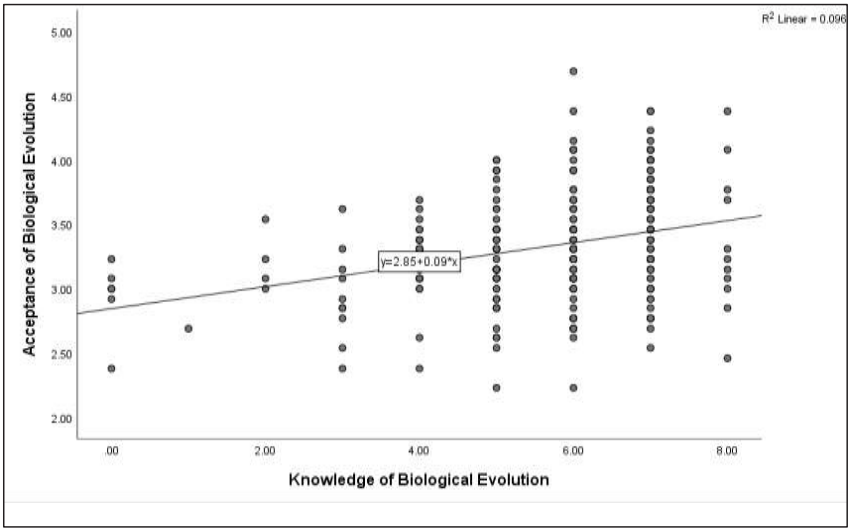
Correlation Coefficient for the Relationship Between Knowledge and Acceptance of Biological Evolution

		Acceptance	Knowledge
Knowledge	Pearson Correlation (*r*)	.310**	1
	p	.000	
	SS	55.271	646.433
	Covariance	.211	2.467
	N	263	263

**. Correlation Significant at 0.01 level (1-tailed)

Figure 2

*Relationship between Knowledge and Acceptance of Biological Evolution. Pearson's r = .310***



Note. **. Correlation Significant at 0.01 level (1-tailed)

Knowledge score was tested if it could significantly predict acceptance of biological evolution using linear regression (Table 4). The fitted regression model was: Acceptance = 2.85 + .09 * (Knowledge). The overall regression was statistically significant (r2 = .096, F(1, 262) = 27.794, p < .01). About 10% of the variability that may occur in the acceptance of biological evolution can be explained by knowledge of the same. It is apparent that knowledge of biological evolution significantly predicts its acceptance (B = .09, p < .01).

Table 4

Regression Analysis Summary for Knowledge Predicting Acceptance

	Unstandardized Coefficients		**Standardized Coefficients**	r^2	**t**	***Sig.***
	B	**Std. error**	β			
Constant	2.846	.096				
Knowledge of Biological Evolution	.086	.016	.310	.096	5.272	.000**

**. *p < .01*
Predictors: (Constant), Knowledge of Biological Evolution
Dependent Variable: Acceptance of Biological Evolution

The higher scores in the knowledge test obtained by those who were in life sciences and health-related academic programs can be partially explained by the extent of evolutionary themes in their respective curricula. CMO No. 49 Series of 2017 classifies Evolutionary Biology as a fundamental course for the BS Biology Program. There is no similar offering in other collegiate programs in the Philippines. Although some broad concepts in evolution are to be introduced on the topics of biodiversity, Genetically Modified Organisms, and Gene Therapy for Science, Technology, and Society that is a General Education Course. For Health-related programs, the lack of a dedicated course in evolution is sufficiently compensated with courses that build skills and attitudes that strengthen their knowledge and appreciation of the nature of science. This allows them to build around related scientific concepts.

In a similar study conducted to measure the level of evolution knowledge among European university students, results differ across and within the area of study. From those various non-biology-related study programs, knowledge of evolution was very low in languages and mathematics (Kuschmierz et al.,

2020; Annaç & Bahçekapili, 2012) and low in chemistry, languages, and history (Beniermann, 2019, as cited in Kuschmierz et al., 2020; Gefaell et al. 2020). Biology-related and biology majors exhibit knowledge increase correspondingly with year level. A significant association between knowledge and year level was not observed in this study.

It can be fairly said that the K-12 Science Curriculum Guide of the Department of Education has integrated Biodiversity and Evolution as key learning areas from Grades 3 to 10. However, the results of this study imply that it's the academic degrees that they are pursuing in college that could influence their knowledge of biological evolution. More evolution-focused content introduced into the curricula is therefore needed to improve evolution knowledge.

Evans (2010) pointed out that our reasoning processes are always influenced by the intuitive mind, but this influence on thinking maybe disguised from science students and professors. Curricular examples could be used to show students how intuitive sensations can be deceiving and contradict their own deliberate reasoning attempts in some circumstances. As a result, activities that draw students' attention to intuitive impulses and deliberate reasoning may aid in the development of a more comprehensive understanding of scientific thought.

Consideration of the fact that intuition may compete with the outputs of students' rational, introspective, and intentional reasoning may also help science instruction. The vast literature on students' naive science beliefs may have special importance for intuitive cognitive processing. Consequently, intellectual and emotional efforts aimed at conceptual change may not reach intuitive cognitions (Ha et al., 2012).

Although in the study of Gefaell et al. (2020), it was shown that the academic program of choice appears to influence the level of acceptance, it was not observed on this occasion. Rather, it was the year level that determined such an extent with third-year and fourth-year students showing a higher degree of acceptance compared to their first-year and second-year counterparts. This may somewhat reflect the findings of Nadelson & Sinatra (2009) and Ha et al. (2015), albeit the studies being conducted on educators, that evolution acceptance may depend on the level of education. The findings of Kim (2016) also contrast with those in this study wherein acceptance scores did not go up with the increase in grade levels.

Brem (2003, as cited in Hanisch & Eirdosh, 2020) mentioned that issues in acceptance of evolution could be ascribed to emotional and motivational barriers. One of these roadblocks appears to be the fear of evolutionary theory's negative consequences in personal life and society. For example, the concepts of

competitiveness, extinction, and violence in nature may cause "existential anxiety" in kids (Legare et al., 2018 as cited in Hanisch & Eirdosh, 2020). Moreover, evolutionary theories of life, including the origins of people, might conflict with religious views and other aspects of personal identity, posing a substantial issue.

Family structure has been recognized through studies to have an influence on the academic performance of students (Ginther & Pollack, 2004; Nato, 2016; Suleman et al., 2012) with children raised in nuclear families significantly performing better. Pertierra (2006) attributed the formation of scientific knowledge and practice among Filipinos to the family among other institutions and factors. Although admittedly, there are confounders that affect this trend such as support, economics, sense of security, and stress. The researcher looks into the possible influence of grandparents and other family members who possess moral ascendancy over the students on their religiosity. This might impact their interest in acquiring substantial learning about biological evolution. This information should be put into proper perspective since the significant difference in knowledge test scores could just be a subset of the whole cognitive performance of the students and does not necessarily be confined to circumstances affecting solely knowledge of biological evolution.

The existence and strength of significant association between knowledge and acceptance of evolution vary among different studies. From no significant correlation for primary and secondary education students to a weak positive correlation for secondary education and university students (Beniermann, 2019, as cited in Kuschmierz, et al., 2020). In this study, the correlation coefficient of $r = .310$ may be interpreted as a weak positive linear relationship. In terms of acceptability, curricula, in addition to the national socio-cultural background and denominations, appear to play a big influence in this case, as a lack of evolution in the curriculum has been linked to a rejection of evolution in several countries.

It was also found that even university faculty members' understanding, and acceptance of biological evolution are connected. Across a sample of university teachers, more knowledge of biological evolution is associated with greater acceptance of biological evolution. These findings were anticipated, but they highlight the fact that biological evolution knowledge and acceptance are linked. If boosting public acceptance of evolution is a goal for science educators, this connection lends credence to the perception that successful biological evolution education is a viable option (Rice et al., 2015).

The presence of positive association across different variables shows that, regardless of one's academic specialization, academic year level, family type and income, or gender, one's understanding of biological evolution and acceptance of

biological evolution can be increased simultaneously.

Because emotional variables frequently cannot be isolated from conceptual learning, and many scholars believe that learning includes affective and motivational characteristics, there are complicated linkages between obstacles of comprehension and acceptance. This is why evolution education has focused on the apparent difficulty that students' grasp of evolution does not appear to correspond to their acceptance, motivation, or perceived significance of evolution. Inquiry-based learning, the use of models, games, and simulations, and using metacognitive tools for students to explore their own conceptual change and understanding have all been demonstrated to increase comprehension and acceptance of evolution (Hanisch & Eirdosh, 2020).

In the study by Gefaell et al. (2020), evolution acceptance was similarly influenced by the degree studied and, under the regression model, evolution knowledge. Such a study in the regression model revealed that knowledge as a component ranks higher than religiosity. Apart from the comparatively low influence of religiosity apparently, it is also independent of evolution knowledge. Hence acceptability of evolution can be analyzed by focusing on knowledge as a discrete factor.

Brown & Scott (2016) measured the level of acceptance concerning the theory of Evolution among community college students in Texas. Regression analysis proposed that exam scores in the knowledge of evolution were able to strongly predict the measurement of evolutionary theory acceptance. This infers that when individuals acquire a substantial amount of knowledge about evolutionary concepts, they are more likely to accept them.

An inevitable recommendation is to dedicate more time to evolution education and to include it in all biology classes. To expand the knowledge base of evolution for future educators who aspire to teach science, more revisions to university curricula would be beneficial. Evolution should be taught at all levels of education, using more effective approaches that account for existing knowledge and provide teaching methods that actively engage students. Thus, careful selection of workshop activities for students may turn evolution into a dynamic experience, allowing them to move from passive reading to experimental study, assisting them in discovering the fascinating story of biological evolution.

Hanisch & Eirdosh (2020) suggested several ways to deal with the challenges of evolution acceptance such as: (1) Putting more emphasis on observable cultural evolutionary dynamics of human behavior, cognition, and culture will have a significant impact on students' worlds and issues of sustainable development. Increasing emphasis on integrating student intuitive concepts about change will

help to address challenges related to the perceived relevance of evolution; (2) Focusing more on the evolution of cooperative traits in humans and other species, the impact of social interdependence on evolutionary trajectories across levels of organization, and looking at the self as a population as an example of how evolution can favor cooperation among interacting elements; (3) Highlighting the randomness and passiveness of organisms by putting a stronger emphasis on the causal role of goal-directed behavior in shaping evolution, as well as exploring the evolution and development of our everyday experiences, such as our sense of purpose, agency, belonging, intention, emotions, explicit goals, and values; (4) Putting a greater emphasis on the complex developmental causes of human behavior, cognition, and culture, building on students' intuitive concepts of adaptation, and relating to oneself as an evolving system or population; and (5) Focusing on historic and current cultural evolutionary dynamics that do not necessarily conflict with religious beliefs about the past, and exploring the evolution of religion and morality, as well as other valued behavioral and cultural traits, to address challenges of evolution acceptance due to religious beliefs.

CONCLUSIONS

It has been determined in this study that knowledge of biological evolution differs significantly among students depending on their chosen academic fields or family type. Those who are into life sciences and health-related curricula have higher cognitive scores opposite arts and social science, engineering and mathematics, and business and accountancy. Participants raised in a nuclear family scored significantly higher on the knowledge test compared to those in extended families. The degree of acceptance was found to vary along the year levels with those in their third or fourth year better able to acknowledge evolutionary processes at work. The correlation test demonstrated that acceptance of evolution improves along with knowledge, furthermore, the regression model illustrates that the latter has a significant impact on the former. This shows that exposure to concept-specific content can help people accept it by helping them understand the information offered. Accordingly, educators who teach any relevant course in biological or social sciences are encouraged to include elements of evolution-based explanations so that students develop a more profound awareness of this viewpoint.

The researcher feels that any effort to improve people's understanding should focus not only on enhancing general awareness of evolutionary theory but also on imparting a more realistic view of modern scientific procedures and

how science generates information. Furthermore, it is recognized that teaching evolution should not be limited to formal schooling, especially because even biology academics have numerous misconceptions about the subject. A variety of educational experiences, such as television shows, online videos, and educational field tours, may help bridge this gap by providing fascinating and effective means for imparting evolutionary theory subjects.

Knowledge was expected to predict acceptance to some extent, and this study backs that up. A greater understanding of evolution may lead to opinions that are more in line with scientific agreement, but it's also plausible that people who believe in evolution are more willing to learn about it. Optimistically, this indicates that continued educational efforts may be able to enhance public perceptions of evolutionary theory.

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