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ISSUE-BASED TEACHING OF BIOLOGY INTEGRATING RELIGIOUS CONCEPTS AND CRITICAL THINKING SKILLS DEVELOPMENT

by

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Abstract

This study determined the influence of issue-based teaching of biology integrating religious concepts on critical thinking skills development, and it sought to find out: (1) the difference in the performance of the respondents exposed only to science viewpoint (group A) and respondents exposed to both the science and religious viewpoints (group B) in the critical thinking skills test; (2) the impact of students' demographic characteristics on the performance of group A and group B in the critical thinking skills test, and (3) the belief systems reflected in the responses of the students to the pre-course questionnaire and post-course open-ended interview questions.

A quasi-experimental research design was adopted. The instruments used were: a researcher-constructed critical thinking skills test (used for pre- and posttest); a pre-course questionnaire and a post-course open-ended interview set of questions. These instruments were all content-validated and were pilot-tested. Data gathering was conducted for 6 weeks.

Paired-sample t-test was used to analyze the difference between the pre- and posttest mean scores of each group. Independent-sample t-test was used to analyze the mean gain scores of the two groups. ANCOVA (regression approach) was used to assess the impact of students' demographic characteristics (gender, social economic status, religious affiliation and religious practices) on their performance in the critical thinking skills test. Qualitative analysis and interpretation were done on the respondents' answers to the course questionnaire and the interview.

Statistically the t-test mean scores show no significant difference, but descriptively the posttest result is higher on each of the two groups (A and B) and group B achieved higher than group A. Results of the ANCOVA (regression approach) reveal the following: (1) in general, gender shows no significant impact; (2) on SES status, respondents whose parents have at least finished high school, who work as theologians, government employees or in business, who have middle to high economic status and who have fewer siblings have a significant scores; (3) religious affiliation, respondents who are Christians and have stay in their present religion longer have a significant scores; and (4) religious practices, respondents who obtain a significant scores in most of the skills are those who consider themselves as religious and those who attend church services more often.

Respondents prefer to use both the science and religious viewpoints in searching for answers and making decisions when faced with controversial issues. They believe that studying controversial issues and controversial issues integrated with religious concepts develop critical thinking skills. They agree that controversial issues in biology should be taught in the classroom.

Background of the Study

Beliefs are thought to be the best indicators of the decisions people make throughout their life. Since belief may affect actions, teacher's beliefs play a crucial role in restructuring science education (Lumpe *et al.*, 2000). Most of the literature on teachers' beliefs about the nature of science is based on two important assumptions: that what teachers believe about the nature of science affects (1) their behavior in the classroom and (2) their students' conceptions of the nature of science (Anderson and Helms, 2001).

Education has now gone well beyond the aim of transmitting knowledge to the next generation. The underlying aim of education becomes not only knowledge transmission but, through it, a preparation to take some point in the construction of society. There is a need for educational institutions to train teachers to be competent in teaching controversial issues. Teachers need to be properly trained. True general education should encourage the exploration of religious questions ... to encourage students to rethink assumptions and develop openness toward the questions the religions address. There is a need for creating spaces in the curriculum (especially in science classes) whereby students can explore, clarify, and possibly integrate their conflicting discourses (Brickhouse *et al.*, 2000).

Controversy should not be excluded from the science classroom, but should be one of the means used to give students a correct understanding of the processes of science. It is necessary that

controversial issues which arise in connection with the science curriculum be handled in the classroom in a way that helps all students, without compromising their personal beliefs, to mature in their understanding (Creation Science Research Center, 1996). Controversy promotes higher achievement, motivation and more accurate perspective than does concurrence seeking.

Controversial issues increase students' understanding of the following: content knowledge; discussion skills, problem solving and decision making skills; clear, logical and rational judgment; motivation to learn; self-esteem and intellectual independence. Foster motivation and learning, the assumption is that, if issues of significance are discussed and/or brought up in class, students would be more motivated to learn and participate in lessons.

Christian universities have long been criticized for being narrow-minded and not encouraging students to think critically (Vyhmeister, 2002). However, Christian education has recently begun to implement *critical thinking* as both a process of decision making and development (Vecellio, 2000). Critical thinking involves the application of criteria to make judgments. Critical thinking is not just logical thinking, because one has to have confidence in one's values, premises and beliefs before he can reason logically from them. Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning or communication, as a guide to belief and action.

Objective of the Study

It was believed that this study (on issue-based teaching of biology and the integration of religious concepts) may change or improve teachers' ideas/practices in teaching biology, with respect to particularly controversial issues, and ultimately result in the development of critical thinking in the student, to interpret the principles and apply them. The study is intended to make teachers, schools, community, and students realize that controversial issues are, by themselves, '*science*' and that science is holistic, encompassing and dynamic. Producing teaching resources that deal with controversial issues is an urgent task. Results of the critical thinking skills test may convince teachers and students to explore and undertake broader and deeper analysis of a controversy from various aspects of education, belief and culture and to enrich the biology/science education program in schools: policy making, supervisors, teacher educators, teacher training and curriculum development.

Hypothesis of the Study

This study sought to find out: (1) if there is significant difference in the performance of the respondents exposed only to science viewpoint (group A) and respondents exposed to both the science and religious viewpoints (group B) in the critical thinking skills test on the three issues discussed; (2) the impact of students' demographic characteristics on issue-based teaching on the performance of group A and group B in the critical thinking skills test, and (3) the belief systems reflected in the responses of the students to the pre-course questionnaire and post-course open-ended interview questions.

Research Design and Methodology of the Study

A quasi-experimental research design was adopted. Two sections (Biological Science class) taught by one professor were chosen. Three treatment packages or the controversial issues – *Origin of Life, Population Control* and *Embryonic Stem Cell Research* – were used. The science contents of the treatment packages were taken from several available biology books, and these were given to both groups as part of the treatment. However, in group B, the controversial issues discussed were integrated with three religious perspectives – *Christian, Buddhist* and *Islam.*

To find the effect of the issue-based teaching of biology and the integration of religious concepts on the respondents' critical thinking skills, the researcher constructed three critical thinking skills subtests used as a pretest and posttest, a pre-course questionnaire, and a post-course

open-ended interview set of questions. The instruments were content-validated and Cronbach's alpha was calculated to estimate the reliability of the tests' items. A dry-run (pilot study) of the instruments was conducted.

The researcher handled the teaching part of the intervention process. The questionnaire and pretest were given prior to the conduct of the intervention. The respondents, in groups of 5-8 students, were then given a handout, a case study related to the issue, scheduled for discussion. Each group chose its own discussion leader. The discussions were guided by the questions given in the handout. The guide questions set the parameters for discussion of the issue. The critical thinking skills test was then given as posttest after the treatment.

A descriptive analysis was done to describe the groups and the test results. Kurtosis and skewness was done to test the normality of the distribution of the data. In analyzing and interpreting the results of the critical thinking skills test, (1) a paired-samples t-test (one-tailed) was used to analyze the difference between the pre- and posttest mean scores of each group, (2) an independent-samples t-test (one-tailed) was used to analyze the mean gain scores of group A and group B and (3) Analysis of Covariance (regression approach) was used to assess the impact of the demographic characteristics (*e.g.*, gender, social economic status, religious affiliation and religious practices) on the performance in the critical thinking skills test.

For the qualitative part, 40 respondents (20 from each group) were randomly selected. The respondents were given four questions to determine their belief system as a result of the study.

Findings

A. Origin of Life

Table 1 shows the descriptive statistical information on the pretest and posttest of group A and group B. It shows that the mean score of the posttest is higher than the pretest. However, due to the insufficient statistical information, the performance of the respondents based on the mean scores of the critical thinking skills on the critical thinking skills test in group A and group B do not differ significantly at the $p < .05$ level (note: $p = .289$ and .057).

Table 1. Means for Pretest and Posttest on the Critical Thinking Skills Test of Group A and Group B in *Origin of Life*

Groups	Tests	Mean	Std. Deviation	Sig. (1-tailed)
A (N=35)	Pretest	2.7886	.5109	.289
	Posttest	**2.8400**	.4223	
B (N=39)	Pretest	2.5333	.4820	.057
	Posttest	**2.7026**	.4202	

Bold: Posttest > pretest

Through descriptive statistics, the table shows that the respondents' mean scores after the treatment (posttest) are greater than before the treatment (pretest).

Table 2 show the statistical analysis on the difference in the mean and the mean gain scores between group A and group B in the critical thinking skills of the critical thinking skills tests. The table shows that the mean score of group B is higher than of group A. However, due to the insufficient statistical information to reject the null hypothesis, the finding shows that the performance of the respondents in both groups, based on the mean gain scores of the critical thinking skills test, do not differ significantly at the $p < .05$ level (note: $p = .202$).

Table 2. Means for Group A and Group B on the Critical Thinking Skills Test in *Origin of Life*

	Groups	N	Mean	Std. Deviation	Sig. (1-tailed)
Critical Thinking Skills	A	35	.2571	2.7045	.202
	B	39	**.8462**	3.2569	

Bold: Group B > group A

Although the statistical analysis on the difference in the mean gain scores between group B and group A shows no significant differences, the descriptive statistic shows that group B has a higher mean gain score than group A.

B. Population Control

Table 3 shows the descriptive statistical information on the pretest and posttest of group A and group B. It shows that the mean scores of the posttest is higher than the pretest. The table also shows that the pretest and posttest mean scores of group A differ significantly at the $p > .05$ level (note: $p = .000$), but due to the insufficient statistical information the pretest and posttest mean scores of group B do not differ significantly at the $p < .05$ level (note: $p = .481$).

Table 3. Means for Pretest and Posttest on the Critical Thinking Skills Test of Group A and Group B in *Population Control*

Groups	Tests	Mean	Std. Deviation	Sig. (1-tailed)
A (N=30)	Pretest	2.3867	.4297	**.000**
	Posttest	**2.7133**	.4416	
B (N=38)	Pretest	2.3474	.5087	.481
	Posttest	**2.3526**	.5491	

Bold: Posttest > pretest

Through descriptive statistics, the table shows that the respondents' mean scores after the treatment (posttest) are higher than before the treatment (pretest).

Table 4 shows the statistical analysis of the difference of the mean and the mean gain scores between group A and group B in the critical thinking skills of the critical thinking skills test. The table shows that the mean scores of all of the skills in group A are higher than those of group B. They differ significantly at the $p > .05$ level (note $p = .014$).

Table 4. Means for Group A and Group B on the Critical Thinking Skills Test in *Population Control*

	Groups	N	Mean	Std. Deviation	Sig. (1-tailed)
Critical Thinking Skills	A	30	1.6333	2.0924	**.014**
	B	38	0.0263	3.4208	

Bold: Group B > group A

The statistical analysis on the difference in the mean gain scores between group A and group B shows significant differences.

C. Embryonic Stem Cell Research

Table 5 shows the descriptive statistical information on the pretest and posttest of group A and group B. The table shows that the posttest mean scores are higher than the pretest on both groups. The table also shows that the pretest and posttest mean scores of group A, due to the insufficient statistical information, do not differ significantly the $p < .05$ level (note: $p = .130$), but in group B they differ significantly at the $p > .05$ level (note: $p = .029$)

Table 5. Means for Pretest and Posttest on the Critical Thinking Skills Tests of Group A and Group B in *Embryonic Stem Cell Research*

Groups	Tests	Mean	Std. Deviation	Sig. (1-tailed)
A (N=26)	Pretest	2.6231	.5581	.130
	Posttest	**2.7462**	.4510	
B (N=32)	Pretest	2.3625	.4723	**.029**
	Posttest	**2.5563**	.5073	

Bold: Posttest > pretest

Table 6 shows the statistical analysis of the difference in the mean and the mean gain scores of group A and group B in the critical thinking of the critical thinking skills test. The table also shows that the mean scores of group B is higher than group A. However, due to the insufficient statistical information, the difference of the performance of group A and group B mean gain scores of the critical thinking skills on the critical thinking skills test do not differ significantly at the $p <$ .05 level (note: $p = .314$)

Table 6. Means for Group A and Group B on the Critical Thinking Skills Test in *Embryonic Stem Cell Research*

	Groups	N	Mean	Std. Deviation	Sig. (1-tailed)
Critical Thinking Skills	A	26	.6154	2.7141	.314
	B	32	**.9688**	2.7764	

Bold: Group B > group A

Although the statistical analysis of the mean gain scores of group A and group B in the critical thinking skills of the critical thinking skills tests do not all show significant differences. The descriptive statistics, however, show a practical significance where, in general, group B has higher mean gain scores than group A. The descriptive statistics of this study support and affirm earlier research findings that controversial issues increase students' understanding of the following: content knowledge; discussion skills, problem solving and decision making skills; clear, logical and rational judgment; motivation to learn; self-esteem and intellectual independence.

The findings of this study are also in line with the thought of Kant (as cited in Dewhurst, 1992) where he said that the incorporation of controversial issues has the potential to foster intellectual independence and autonomous judgment for what might be termed enlarged thinking as well as the stand of other researchers that controversial issues give students a correct understanding of the processes of science and the chance to mature in their understanding (Reiss, 1993; Creation Science Research Center, 1996; Dagher and BouJaoude, 1997); that it develops decision making (Cross and Price, 1996); that it improves the mental state of the students (Loving and Foster, 2000); that it influences the students' scientific decision (Van Rooy, 1993); that it fosters motivation and promotes higher achievement, motivation and more accurate perspective (Johnson, *et al.*, 1985).

Students' Demographic Characteristics and Critical Thinking Skills Test

The following set of data shows the findings on the impact of the various intervening variables on the critical thinking skills of the respondents in the critical thinking skills test in the three treatments. Since the degree of the input (covariance) or the goodness of fit of the model is significant (.000) or acceptable, thereby justifying the use of regression analysis.

A. Origin of Life

Table 7 shows the prediction of impact of the various intervening (covariates) variables on the overall critical thinking skills of the respondents in the critical thinking skills test in Origin of Life. The findings are as follows:

(1) The finding shows that male and female respondents have the same scores and impact.
(2) The finding shows that the respondents (a) whose fathers finished high school, (b) whose mothers finished college, (c) whose fathers work as seminarians or preachers and government employees and (d) whose mothers work as seminarians or in religion-related jobs, government employees and businesswomen and (e) who have fewer siblings in the family have higher scores and have a significant impact.
(3) There is no sufficient statistical information on the religion affiliation of the respondents to reject the null hypothesis; in other words, regardless of the family and respondents' religious affiliation and the length of time they have been in their present religion, the respondents have the same score and impact.

(4) There is no sufficient statistical information on the religious practices of the respondents to reject the null hypothesis; in other words, regardless of their perception of their religious belief, the frequency of and their attitude toward attending church services and their knowledge of the school's belief, the respondents have the same score and impact.

Table 7. Regression of Students' Demographic Characteristics on the Critical Thinking Skills of the Critical Thinking Skills Test in *Origin of Life*

	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
Father's education (4)	2.572	1.085	.268	2.371	.021
Mother's education (5)	3.172	1.000	.465	3.172	.002
Mother's education (6)	2.277	.862	.373	2.641	.011
Father's occupation (3)	3.143	1.567	.238	2.006	.049
Father's occupation (4)	-6.502	1.629	-.638	-3.991	.000
Mother's occupation (2)	-6.731	2.934	-.261	-2.294	.025
Mother's occupation (4)	8.123	2.182	.616	3.723	.000
Mother's occupation (5)	1.534	.681	.257	2.253	.028
Number of siblings	-.701	.199	-.369	-3.516	.001

Dependent Variable: Critical Thinking Skills
Numbers: Categorical level

B. Population Control

Table 8 shows the prediction of impact of the various intervening (covariates) variables on the critical thinking skills of the respondents in Population Control. The findings are as follows:

(1) The finding of this study shows that female respondents have higher scores and have a significant impact than the male respondents on their critical thinking skills.

(2) Statistical information on the fathers' and mothers' educational attainment and occupation, family monthly income and number of siblings in the family rejects the null hypothesis. The finding shows that the respondents (a) whose fathers finished high school, (b) whose mothers reached college, (c) who belong to the medium (US$300.00 – 400.00), upper medium (US $450.00 – 550.00) and high (more than US$ 600.00) monthly family income and (d) who have fewer siblings in the family have higher scores and have a significant impact.

(3) Statistical information on family religion and length of time in the present religion rejects the null hypothesis. The finding shows that respondents whose family are Adventist, Catholic, Christian and Muslim, who have been in their present religion longer, meaning the respondents' religion is not the same as that of the family have higher scores and a significant impact.

(4) Statistical information on the respondents' frequency of and attitude toward attending church services and their knowledge of the school's belief rejects the null hypothesis. The finding of this study shows that respondents who attend church services 4-6 times a month and attend church services because they want to, have higher scores and a significant impact.

Table 8. Regression of Students' Demographic Characteristics on the Critical Thinking Skills of the Critical Thinking Skills Test in *Population Control*

	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
Gender	2.143	.624	.337	3.435	.001
Father's education (4)	-2.766	.950	-.315	-2.910	.005
Mother's education (5)	-2.068	.770	-.288	-2.686	.010
Family income (4)	-2.591	.988	-.332	-2.621	.012
Family income (5)	-3.184	.892	-.453	-3.568	.001
Family income (6)	-2.365	.805	-.371	-2.939	.005
Mother's occupation (2)	-10.116	2.296	-.409	-4.406	.000
Number of siblings	-.681	.182	-.379	-3.737	.000
Family religion (2)	8.780	2.091	1.395	4.199	.000
Family religion (3)	6.181	2.021	.839	3.059	.004
Family religion (4)	5.215	2.187	.497	2.385	.021
Family religion (5)	-12.723	5.078	-.514	-2.506	.016
Length in religion	.900	.334	.618	2.695	.010
Freq. in attending church (3)	3.273	.735	.476	4.454	.000
Attitude in attending church	1.236	.592	.207	2.086	.042

Dependent Variable: Critical Thinking Skills
Numbers: Categorical level

C. Embryonic Stem Cell Research

Table 9 shows the prediction of impact of the various intervening (covariates) variables on the critical thinking skills of the respondents in Embryonic Stem Cell Research. The findings are as follows:

(1) The finding shows that male and female respondents have the same score and impact.
(2) Statistical information on the fathers' and mothers' educational attainment and occupation rejects the null hypothesis. The finding shows that the respondents (a) whose fathers finished college, (b) whose mothers finished high school, (c) whose fathers work as government employees and businessmen and (d) whose mothers work as seminarians in a religion-related job, teachers and government employees have higher scores and have a significant impact.
(3) Statistical information on the length of time the respondents have been in their present religion rejects the null hypothesis. The finding shows that the longer the respondents have stayed in their present religion, meaning the respondents' religion is not the same as that of the family have higher scores and have a significant impact.
(4) There is no sufficient statistical information on religious affiliation to reject the null hypothesis; in other words, the finding shows that the respondents' perception of their religious life, the frequency of and their attitude toward attending church services and the school's belief have the same score and impact.

Table 9. Regression of Students' Demographic Characteristics on the Critical Thinking Skills of the Critical Thinking Skills Test in *Embryonic Stem Cell Research*

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Father's education (6)	-1.720	.755	-.318	-2.279	.027
Mother's education (4)	-3.388	.957	-.432	-3.539	.001
Father's occupation (4)	-4.379	1.348	-.454	-3.249	.002
Father's occupation (5)	-2.197	.720	-.381	-3.052	.004
Mother's occupation (2)	-8.237	2.243	-.396	-3.673	.001
Mother's occupation (3)	-3.339	1.074	-.402	-3.108	.003
Mother's occupation (5)	-3.412	.668	-.627	-5.108	.000
Length in religion	.367	.129	.299	2.838	.007

Dependent Variable: Critical Thinking Skills
Numbers: Categorical level

The finding of this study indicates that higher SES (Social Economic Status), in terms of parents' educational attainment and occupation, family monthly income and fewer siblings in the family do significantly predict the impact of relationship between the groups and critical thinking skills development.

On the religious affiliation and practices, the finding of this study indicates that respondents who are Christians, in general, significantly predict the impact of relationship between the groups and critical thinking skills development. The findings also show that almost all respondents who belong and whose family belongs to either Adventist or Catholic and the longer they have been in their religion have a strong stand on the issues discussed. Respondents' perception of their religious conviction as someone considered as a religious person, the higher the frequency of attending church services and who do not know the school's belief, generally, have a significant impact. This study supports earlier findings that students associate many of their problems in learning science with the irreconcilable conflicts between the religious discourses learned at home from parents and in church and the scientific discourse to which they were introduced at school, where they come to classrooms to understand concepts (Cobern, 1994); that one's beliefs are acquired at an early age, when children have a strong tendency to form beliefs for irrational reasons (Scriven and Paul, n.d); and that some students believe that science opposes religious belief, especially since some scientists deny the role of God in creation (Roth and Alexander,1997).

The findings of this study also affirms the thought that "Instructional strategies for teaching about religion include natural inclusions, fairness and balance, respect for differences, use of religious scriptures, role playing, rights, responsibility and respect if they [students] would have a complete education; knowledge about religions is not only a characteristic of an educated person, but is also necessary for understanding and living in a world of diversity."

Although the data show no regular, fixed or predicted pattern of significant impact, the finding affirms the results of the study of Pascarella *et al.*(2001) where they found that students' involvement in various experiences during college have statistically significant positive effects on their score in an objective and standardized measure of critical thinking skills. However, a variety of experiences influence the critical thinking of students in subgroups based on gender and ethnic background at different points in their college experience.

Respondents' Belief Systems

Table 10 shows the descriptive result of the responses on the 4-point rating scale of the pre-course questionnaire. The twelve questions were intended to seek the respondents' religious conviction, their knowledge and understanding of the three issues.

Table 10. Pre-course Questionnaire Mean Score for Student's Knowledge and Understanding on Religion and Science

Question Items	A				B			
	Origin of Life	Population control	ESCR	Mean	Origin of Life	Population control	ESCR	Mean
God as the creator of life	4.00	3.87	4.00	3.96	3.95	3.95	3.94	3.95
Science and religion relationship	2.23	2.00	2.19	2.14	2.18	2.21	2.16	2.18
Religion and scientific concepts /procedures	2.49	2.47	2.65	2.54	2.33	2.34	2.38	2.35
Religion: guideline for decisions on controversies	3.31	3.33	3.42	3.35	3.05	3.08	3.03	3.05
Teaching controversial issues in biology	3.43	3.30	3.46	3.40	3.31	3.32	3.31	3.31
Beliefs and decision-making in controversial issues	2.57	2.50	2.65	2.57	2.44	2.42	2.34	2.40
Understanding abortion issue	3.63	3.50	3.54	3.56	3.23	3.21	3.16	3.20
Abortion and overpopulation: advantages or disadvantages	1.57	1.60	1.58	1.58	2.23	2.21	2.22	2.22
Life originated and evolved from nonliving matter	1.51	1.47	1.50	1.49	1.77	1.74	1.81	1.77
Understanding biotechnology: advantages or disadvantages	2.40	2.30	2.42	2.37	2.62	2.61	2.72	2.65
Understanding embryonic stem cell research	1.97	1.93	2.04	1.98	1.97	1.98	2.00	1.98
Embryonic stem cell research and incurable diseases	2.34	2.23	2.31	2.29	2.13	2.13	2.22	2.16

The legend: ① Not at all, ② Sometimes, ③ Often and ④ Very often/strongly

Controversial Issues and Critical Thinking Skills Development

Below are the four post-course open-ended interview set of questions and the responses of the students to the question in regards to their perception of the usefulness of learning controversial issues in the development of their critical thinking skills.

A. "In What Ways Do You Think Learning Controversial Issues in the Classroom Helps You in the Development of Your Critical Thinking Skills?"

1. Developing Knowledge.

Learning controversial issues in the classroom is very much perceived by the respondents as a process of developing knowledge and understanding.

2. Decision making.

Learning controversial issues makes the respondents think and then make the right decision in accordance to what they believe.

3. Making Judgment.

Learning controversial issues helps students develop better understanding and skill in analyzing and judging them.

4. Ability to Analyze.

The ability to analyze is an important characteristic of critical thinking. When presented with controversial issues in the classroom, the students respond positively and affirmatively.

5. Ability to Participate in Discussions.

Critical and logical thinking skills can be achieved through learning controversial issues, because this requires skill in asking and answering questions and the ability to participate in discussions.

Based on the responses to the first question of the post-course interview, three critical thinking skills are employed by the respondents in learning controversial issues. These are (1) judging, (2) analyzing and (3) decision making. This finding confirms what Schafersman (1998) wrote, where he described critical thinking as scientific thinking applied to questions and problems of everyday life. It also confirms what Ommundsen (1999) wrote, where he described critical thinking as seeking reliable knowledge. Practice in critical thinking prompts thoughtful examination of the role of science in society. This is an important outcome of biology education, and brings us closer to addressing the Socratic dictum *"The unexamined life is not worth living."*

The characteristics of critical thinking extracted from this question are in accord with the ideas of (a) Ennis (1962, 1987) who described critical thinking as a reasonable reflective thinking that is focused on deciding what to believe or do and (b) Paul *et al.* (1990) who described critical thinking as the ability to think interdependently on the different dimensions of critical thought.

Judging the credibility of sources and the quality of arguments based on the acceptability of their reasons, assumptions and evidences strongly indicate critical thinking. It tends to improve the performance of the respondents in their study. This confirms what Scriven and Paul (n.d.) wrote, that reasoned judgments may arise in countless kinds of situation including evaluating theories or how to act in a delicate social situation, and what Van Rooy (1993) wrote, that controversial issues in science are open to various viewpoints, interpretation and judgment.

Analyzing (while being open-minded, trying to be well informed or updated, defining issues in a way appropriate to one's belief and asking appropriate clarifying questions) is another strong evidence of critical thinking. This finding confirms (1) the report study of Van Rooy (1993) where she finds that controversial issues give science methodology and the process of science an added dimension, a critical examination of second-hand data and (2) to the report of Siegel (1985) where he said that a critical thinker is moved by reason and able to assess the forces of reasons in many contexts. The same is true with the report of Paul (n.d.) where he described a critical thinker as one who evaluates goals and how to achieve them. He can pinpoint specifically where opposing arguments or views contradict each other, distinguishing the contradictions from compatible beliefs, thus focusing the analysis of conflicting views.

Decision making after (1) identifying assumptions, reasons and conclusions, (2) developing and defending a position on an issue, and (3) drawing conclusions when warranted but with caution is the critical part a person does particularly in dealing with controversial issues. It aims toward the development of critical thinking skills. This finding confirms Scriven and Paul (n.d.) claim that critical thinking involves thinking through problematic situations about what to believe and how to decide or act. It is in accord with the thought of many educators or psychologists who report that controversial issues increase students' content knowledge and improve their discussion, problem solving and decision-making skills. It also agrees with Van Rooy (1993) that controversial issues influence the students' scientific decision.

Beside the learning factor (*i.e.*, learning the issues) in developing critical thinking skills through controversial issues, the respondents also touched on the teaching factor. They described the proper way of teaching, (*i.e.*, discussion or interactive lecture, asking questions and debate) that helps in developing of critical thinking skills. This affirms Larson's (1997 in Hess, 2001) claim that teaching with discussions extends to such considerations as the need to develop understanding of a specific issue, to enhance critical thinking skills and to improve interpersonal skills. The outcomes of this type of instruction are students who become highly skilled discussants.

B. "Regarding the Development of Critical Thinking Skills through Controversial Issues, Which Do You Think is Better, through the Science Viewpoint only, through the Religious Viewpoint only, or through both Viewpoints? And why?

1. ***Science Viewpoint***
   "*To see is to believe*", things that can be seen, touched and felt are often perceived as real and concrete. In the development of critical thinking skills through the study of controversial issues, some respondents perceive the science viewpoint to be better since science present facts.
2. ***Religious Viewpoint***
   Respondents believe that developing critical thinking skills through the study of controversial issues is better from the religious perspective, because God created science, and so, the religious perspective that believes in God is better.
3. ***Both Viewpoints Because:***
   a. ***Both Improves Understanding***
      With regard to this particular question, majority of the respondents answered that, in developing critical thinking skills through controversial issues, it is better to know, learn and understand both the science and religious viewpoints.
   b. ***Both Develop Knowledge and Critical Skills***
      Some respondents agree that learning the two viewpoints widen their knowledge and develop critical thinking skills.
   c. ***Both Affirm Their Religious Belief***
      Although majority of the respondents agree that the development of critical thinking skills through the study of controversial issues is better using science and religion, a fraction of this majority says that it is because the two perspectives strengthened their religious conviction and belief in God.
   d. ***Both Develop Analysis Skills***
      A few respondents are of the opinion that a complete analysis of an issue is possible only with both viewpoints.

Based on the responses from both group A and group B to the second question of the post-course interview, both the science and religious perspectives are perceived to be the better option for developing critical thinking skills when studying controversial issues. This confirms Scriven and Paul's (n.d.) statement that critical thinking, when grounded in selfish motives, is often manifested in the skillful manipulation of ideas in the service of one's own or one's groups' vested interest. As such it is typically intellectually flawed, however pragmatically successful it might be, but when it is grounded in fair-mindedness and intellectual integrity, it is typically of a higher order intellectually. Still on the subject, Medado (1996) describes critical thinking as engaging the mind to ask questions from multiple perspectives; thus helping one solve problems of varying complexity; Ennis (1962, 1987) describes critical thinking as a reasonable reflective thinking that is focused on deciding what to believe or do, *i.e.*, to be open-minded, trying to be well informed and judging the credibility of sources and quality of arguments and Scriven and Paul (n.d.) describes critical thinking as being responsive to various subject matters, issues and purposes, and is incorporated in a family of interwoven modes of thinking; critical thinking can be seen as a set of information, belief generating and processing skills.

C. "Knowing that there are Controversial Issues in Biology, Will You Search for the Answer from the Science Perspective Only? Religious Perspective Only? Both Sciences and Religious Perspectives? Why?"

1. ***Science Viewpoint***
   The science viewpoint is preferred in searching for answers because science deals with facts through experimentation. However, with questions that science cannot answer, one respondent said the Bible can help.

2. ***Both Viewpoints Because Both:***
   a. ***Affirm Their Religious Belief***
   Almost all of the respondents in group A agree that using both the science and religious perspectives is the best way in searching for answers to the questions raised, although with various reasons. Some respondents use both the science and religious viewpoints while still holding on to their religious beliefs as the more important source.
   b. ***Are Useful in Finding Answers and Making Decisions***
   Respondents believe that using both viewpoints enables them to get the right answers to questions on controversial issues.
   c. ***Improves Understanding***
   The perception of the respondents in using both viewpoints is that they give or lead to a better understanding in the ability to reason or explain.
   d. ***Lead to Balanced Assessment***
   Some respondents propose using both viewpoints so that one can act fairly (not biased) in the search.

Based on the responses to the third question of the post-course interview, both the science and religious perspectives are employed by all the respondents in group A and by almost all respondents in group B in searching for answers regarding controversial issues, although for various reasons.

These findings confirm the reports of a number of authors regarding the handling of controversial issues. Students come to class to find out the ideas that the opposite views expound. But they do not want to be told which is "right" or what to believe in. Cobern (1994) believes students come to the classroom wanting simply to understand concepts of the two sides of an issue. It is on these concepts that they will later decide on which side they will accept. Rinehart (2003) claims that students need to explore underlying issues, recognize core problems, engage in analyzing cases, problems and issues reflecting decision-making situations. Hokanson (2003) considers it important that students are encouraged to explore ideas and combine, integrate and reconstruct them; independent thought is not only acceptable; new ideas must be developed.

D. "In Making a Decision, Whether to Believe/Accept or Not a Controversial Issue, which Dominates Your Decision, Your Scientific Understanding? Your Religious Belief? Both the Science and Religious Views? Why?

1. ***Science Viewpoint.***
   Only one respondent admits that it is the science concept that dominates his decision on controversial issues, since science gives clear proofs.
2. ***Religious Viewpoint***
   Decision making is crucial in the study of controversial issue, since it reflects one's belief system. When asked which viewpoint dominates their decision making, many respondents claim that it is their religious belief.
3. ***Both Viewpoints:***
   a. ***But Still Holding on to Their Religion***
   Several respondents answered that both the science and religion influence their decision making on controversial issues. However, they still depend on their religion and believe in God.
   b. ***For a Balanced and Fair Answer***
   In making a decision on whether or not to believe a controversial issue, two respondents chose both viewpoints. The reason is to balance things and thus make a fair decision.

Based on the responses to the fourth question of the post-course interview, both the science and religious perspectives are employed by most of the respondents in group A and group B, although for various reasons.

These findings confirm Rinehart's (2003) thoughts on decision making in which he claims that students need to explore underlying issues, recognize core problems, engage in analyzing cases, problems and issues reflecting decision-making situations. They also confirm the thoughts of Thomasma (1996 in Shelp, 1996) on religious belief in which he believes that faith itself can be enriched by this diversity of views. For one thing, as a science venture advances (*e.g.,* ES cell research), people's attention tends to be captivated by such advancement to the neglect of its moral value. Hence, while the scientific venture may not necessarily be immoral, people become less concerned with its moral dimension.

A few respondents in group A admitted that, with the discussion of controversial issues in class, they became more confused. They cannot reconcile what they learned about the scientific developments involved in the controversial issues with their religious beliefs. This observation confirms the findings of Roth and Alexander (1997) that conflicts do arise in both teachers and students of science because of their religious training at home and in church *vis-à-vis* the scientific discourse to which they are introduced in school.

Most of the respondents, however, decided to use the two opposing viewpoints as a way to strengthen their religious belief or what they believe as true. They declared that having the chance to discuss and debate on the controversial issues gave them a greater ability to explore, clarify and integrate the issues and thus facilitated their decision making. This finding supports the recommendation of Brickhouse *et al.* (2000) regarding the need to create spaces in the curriculum (especially in science classes) where students can explore, clarify, and possibly integrate their conflicting ideas.

Summary

A qualitative analysis and interpretation was done on the respondents' answers to the questionnaire and the interview questions.

The general findings of this study are as follows:

Problem 1: Difference in the performance of group A and group B on the critical thinking skills test

A. Effectiveness of the two teaching model – Issue-based Teaching (IBT) and Issue-based Teaching Integrated with Religion (IBT+R) – described separately
   a. Regarding the issue-based teaching model (Group A), results of the paired t-test on the pre- and posttest mean scores show that, in Origin of Life and Embryonic Stem Cell Research, statistically there is no significant difference. But in Population Control, there is a significant difference. However, for practical significance, the data show that the posttest mean scores of the three subtests, in general, are actually higher than the pretest mean scores.
   b. Regarding the Issue-based teaching model integrated with religious viewpoint model (Group B) results of the paired t-test on the pre- and posttest mean scores show that, in Origin of Life and population Control, statistically there is no significant difference, but in Embryonic Stem Cell Research, there is a significant difference. However, for practical significance, the data show that the posttest mean scores of the three subtests, in general, are actually higher than the pretest mean scores.

B. Comparing the IBT model (Group A) and the IBT+R model (Group B)

Results of the independent t-test on the mean gain scores of the two groups show that, in Origin of Life and Embryonic Stem Cell Research statistically there is no significant differences. But in Population Control, there is a significant difference in the mean gain scores.

For practical significance, the data show that the mean gain score of group B, in general, is higher than of group A, but the differences are not statistically significant. These results might be explained by the fact that both group A and group B have a very strong religious background

considering that the study site is a sectarian university. The intervention period of one term (6 weeks) might have been too short to really make any considerable change in their belief system. If the study were conducted in a nonsectarian university, the results might have been different. Another possible explanation of these results is the fact that both models utilize issue-based teaching which research has proven time and again to promote critical thinking.

However, the data showed that, descriptively, there are differences, which are an increase in the students' critical thinking tests after the treatment and after the integration of religious viewpoints. This finding shows the advantage of religious concepts in science classes, particularly in Biology where this study was conducted.

Problem 2: Possible impact of demographic characteristics on the issue-based teaching integrated with religious viewpoint model on the respondent's performance in the critical thinking skills test

Results of the ANCOVA (regression approach), in general, reveal the following:

a. **Gender**

In Origin of Life and Embryonic Stem Cell Research, both female and male performed no significant difference in the critical thinking skills test scores. While in Population Control, male obtained significant scores than female respondents. In other words, male performed better than female in the critical thinking skills test.

b. **Social Economic Status (SES)**

Respondents whose parents have at least finished high school, who work as theologians, government employees or businessmen/businesswomen, who have middle to high economic status and who have fewer siblings obtained significant scores.

c. **Religious Affiliation**

The respondents who are Christians, whose family is either Adventist or Catholic and who have stayed in their present religion longer obtained significant scores in most of the skills in the three subtests.

d. **Religious Practices**

The respondents who obtained significant scores in most of the skills in the three subtests were those who considered themselves as religious and who attended church services more often.

Problem 3: Respondents' belief system derived from the questionnaire and interview

a. The responses indicate that, in general:
   1) the respondents have a very strong belief in their religion, believing that God is the creator of life;
   2) they know that there are conflicts between science and religion, and that their religion hardly supports scientific concepts and procedure;
   3) when facing controversies, they use the tenets of their religion as guide in making decisions. However, they agree that controversial issues in biology should be taught in the classroom;
   4) because of their strong belief in God as the creator of life, the issue of Origin of Life from the science perspective is something they do not accept;
   5) the respondents are familiar with the abortion issue, and they believe that abortion practices have more disadvantages to society than advantages; and
   6) they have very little knowledge about Embryonic Stem Cell Research, and they do not think that embryonic stem cell research can solve the problem of incurable diseases. Besides, it also kills life (*e.g.*, embryo).

b. Majority of the respondents prefer to use both the science and religious viewpoints in searching for answers and making decisions when faced with controversial issues. They

believe that studying controversial issues develop judging, analyzing and decision-making skills, which are components of critical thinking.

Conclusions

Based on the foregoing findings, the following conclusions are made.

1. Since the difference, in general, between the posttest mean scores of the students in group A and their pretest mean scores; the posttest mean scores of the students in group B and their pretest mean scores; and the mean gain scores of group B and those of group A in the critical thinking skills test is not significant, it can be said that, in this particular sample, the issue-based teaching integrated with religious viewpoint model does not offer a distinct advantage over the issue-based teaching model. As cited earlier, this result might be due to the combination of two factors: (a) the very strong religious conviction of **both** experimental and control groups and (b) the intervention period and limited number of controversial issues discussed.
2. Gender, social economic status, religious affiliation and religious practices, in general, have a significant impact in the effect of the issue-based teaching integrated with religious viewpoints model on critical thinking skills development.
3. In general, the respondents believe that studying controversial issues in biology develops critical thinking, particularly the skills of judging, analyzing and decision making.
4. In general, the respondents are of the opinion that, in searching for answers to and making decision on controversial issues (in brief, for the development of critical thinking), it is preferable to use both the science and religious viewpoints.
5. In general, the findings of this research lead to facts that the integration of religious concepts or viewpoints help the student in their critical thinking skills and improve their understanding and knowledge.

Recommendations

Based on the foregoing findings and conclusions the following recommendations are hereby offered:

1. Results of this study support the findings of other studies cited in the survey literature regarding the positive affect of issue-based teaching on the development of critical thinking skills. It is, therefore, recommended to school administrations that issue-based teaching be encouraged in biology classes. And training on this teaching strategy should be made available to biology teachers.
2. This study shows that integration of religion in issue-based teaching resulted in a higher gain mean score in group B (IBT+R model) than in group A (IBT model). It is, therefore, recommended that:
   2.1) a similar study be conducted involving a greater number of controversial issues and a longer intervention period;
   2.2) the study be replicated in nonsectarian schools or in other sectarian schools (*i.e.*, of other cultural background).

The educational impact of issue-based teaching or the study of controversial issues in biology and some other subjects has been investigated a number of times in the past. And the integration of religion in science education has been tried in all cultures. But there has been no formal study on the integration of religion in issue-based teaching in biology. This is the major contribution of this study to biology education in particular and to science education in general. The feedbacks from the students, their frank and honest responses to the researcher's questions, are fresh ideas from which teachers and researchers can drive valuable insights with educational implications.

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(Note: Below is the Critical Thinking Test, subtest **Origin of Life,** *used in the study. For further inquiry on the study please email the researcher: jhltobing@yahoo.co.uk or joshuahltobing@unai.edu)*

CRITICAL THINKING TEST

"Issue-based Teaching of Biology, Integrating Religious Concepts and Critical Thinking Skills Development" (Origin of Life)

Joshua H.L Tobing © 2004

Test 1: Inferences

An ***inference*** is a conclusion that a person draws from certain observed supposed facts. For example, from the light visible behind the window shades and from the sound of music in a house, a person might infer that someone is at home. But this inference may or may not be correct. Possibly the people in the house went out leaving the lights on, and the music could be coming from a radio or tape recorder they left playing.

Directions. In this test, each exercise begins with a statement of supposed facts which you are to regard as true. After each statement of supposed facts you will find several possible inferences, that is, "conclusions" which one might make from the supposed facts. Examine each inference separately, and make a decision as to its degree of truth or falsity.

For each inference you will find spaces on the answer sheet labeled T, PT, ID, PF, and F. For each inference darken the circle on the answer sheet under the appropriate label as follows.

T – If you think the inference is definitely TRUE.
PT – If you think the inference is PROBABLY TRUE.
ID – If you think that there are INSUFFICIENT DATA.
PF – If you think the inference is PROBABLY FALSE.
F – If you think the inference is definitely FALSE.

Sometimes, in deciding whether an inference as probably true or probably false, you will have to use certain commonly accepted knowledge of information which practically every person has.

Statement No. 1: In science there are two major theories regarding the origin of life, one holds that life on earth originated from extraterrestrial life (biogenesis) and the other say that life originated from the ocean of organic soup through the process of chemical evolution (abiogenesis). However, it is also important to recognize that we will probably never know for sure how life on earth came to be.

Proposed inferences:

1. The search for the origin of life on earth is still going on.
2. No concepts or beliefs give a definite answer to the question on the origin of life.
3. Only the Bible is true about the origin of life.

Statement No. 2: We have a choice between two opposing concepts to explain the origin of our universe, origin of life and origin of man. The evolutionary theory says that natural means alone were required, but the creation concept says that natural means alone are insufficient; so in addition, a supernatural means (creator) was required. Only one of these alternative concepts on the origin of our universe can be true.

Proposed inferences:

4. Science is against religion since it believes that life was formed from the evolution of inorganic matter.
5. God does exist; therefore, religious concept on the origin of life is true and should be the foundation of our belief.

Test 2: Recognition of Assumptions

An ***assumption*** is something that is to be accepted as true without proof or demonstration. When someone says, *"I'll graduate in March,"* he assumes that he will finish his study and the school will judge him to be eligible for graduation in March.

Direction. Below are a number of statements. Each statement is followed by several proposed assumptions. You are to decide for each assumption whether a person, in making the given statement, is really making that assumption.

If you think the given assumption in the statement is **accepted** as true without proof, darken the circle under "ASSUMPTION MADE" on the answer sheet.

If you think the given assumption in the statement is **not accepted** as true without proof, darken the circle under "ASSUMPTION NOT MADE" on the answer sheet.

Statement No. 3: The Bible says "In the beginning God created the heaven and the earth, and God created living things out-of-nothing."
Proposed assumptions:

6. The religious concept has the true and definite answer on the question of the origin of life.
7. God is definitely the only source and origin of life on earth.
8. Life exists on other planets.

Statement No. 4: "Mars exploration is intended to find evidence of life and scientists said that water once exist in that planet."
Proposed assumptions:

9. Mars is older than earth. "Extraterrestrial origin" (biogenesis) may answer the question of the origin of life on earth.
10. Scientifically, it is difficult to prove and accept the concepts of creation.

Test 3: Deduction

A ***deductive reasoning*** means, "the assumed truths of the premises supposedly justify the truth of the conclusion."

Directions. Each exercise consists of two statements (premises) followed by several suggested truth (true without exemption) or conclusions. Read and judge the conclusions beneath the statements. Try not to let your prejudices influence your judgment, just stick to the given statements (premises) and judge each conclusion as to whether it necessarily follows from them.

If you think it is a conclusion from the given statements, darken the circle under "CONCLUSION FOLLOWS" on the answer sheet.

If you think it is not a conclusion from the given statements, darken the circle under "CONCLUSION DOES NOT FOLLOW," even though you may believe it to be true from your personal knowledge.

Statement No. 5: Organic compounds, which include amino acids, peptides, and proteins, are said to be the building blocks of life. Scientists through laboratory experiments claim that they are able to produce these compounds, therefore –

Proposed conclusions:

11. Laboratory experiments may produce life.
12. Scientists do not believe that God created life.
13. Having the simplest component of life, one-celled animal can then evolve into any complex form of life.

Statement No. 6: Biogenesis is a concept says that 'life-begets-life'. Many religions and beliefs teach that God is the creator of life, therefore –

Proposed conclusions:

14. Life existed earlier in the other planets (extraterrestrial) and migrated to earth.
15. Biogenesis is true if it considers God as the source of life.

Test 4: Interpretation

An ***interpretation*** is to give one's own conception of, to place in the context of one's own experience, perspective, point of view, philosophy in clarifying meanings or decoding significances of experiences, situations, data, events, judgments, and beliefs.

Directions. Each exercise below consists of a short statement followed by several proposed conclusions. Assume that everything in the short statement is true.

If you think that the proposed conclusion follows the reasoning of the short statement (even though it may not follow absolutely and necessarily), darken the circle under the "CONCLUSION FOLLOWS" on the answer sheet.

If you think that the proposed conclusion does not follow beyond the reasoning of the short statement, darken the circle under "CONCLUSION DOES NOT FOLLOW" on the answer sheet.

Statement No. 7: One hypothetical scenario for the origin of life, as perceived by some scientists, portrays the first organisms as products of a chemical evolution in four stages: (1) the abiotic (nonliving) synthesis evolution of small organic molecules, such as amino acids and nucleotides; (2) the joining of these small molecules (monomers) into polymers, including proteins and nucleic acids; (3) the origin of self-replicating molecules that eventually made inheritance possible; and (4) the packaging of all these molecules into "protobionts", droplets with membranes that maintained an internal chemistry different from the surroundings.

Proposed conclusions:

16. Given the needed organic molecules, life form can be produced.
17. Evolution answers the question on how life originated.
18. Genetics is not the answer to the question on the origin of life but on how life is being sustained and inherited.

Statement No. 8: The origin of life on planet Earth has long baffled the scientific community. Science believes that the earth's early/primitive atmosphere gases are methane, hydrogen, ammonia, and steam. These gases electrically charged by lightning turn into organic compounds. Organic compounds, which include amino acids, are recognized as the buildingblocks of life. However, scientists acknowledge that simple single-celled organisms are more complex than the organic compounds that were 'formed'. Scientists theorized that, "natural processes" explaining the origin of life are far too complex. However, these theories contradict the Biblical Genesis perspective, where life can only propagate *"according to their kinds"*, and it contradicts the concept of life arising from nonliving matter. As conclusion, the overall transformation from lifeless matter to living creatures over time is just cannot be accepted.

Proposed conclusions:

19. The religious concept stated that Biblical Genesis is the only logically acceptable principles on the origin of life.
20. The Bible and Science tend to unite in a common acceptance that life gives birth to life.

Test 5: Evaluation of Arguments

An ***argument*** is a reason for or against something. To argue is to use logic and reason, and to bring facts to support or refute a point. It is done in a spirit of cooperation and good will. An argument, considers as strong, must be both important and directly related to the question. An argument, considers as weak, if it is of minor importance or not directly related to the question, even though it may be of great general importance.

Directions. Below is a series of questions. Each question is followed by several arguments. For the purpose of this test you are to regard each argument as true. Darken the circle on the answer sheet under "STRONG" if you think the argument is strong, or under "WEAK" if you think the argument is weak. Judge each argument separately on its own good point; try not to let your personal attitude toward the question influence your evaluation.

Statement No. 9: Should Biblical Genesis on "creation of life" be absolutely accepted as truth, despite the claim of science that life originated and evolved from nonliving materials, since God is the creator?

Proposed arguments:

21. Yes, science and religion never come into any common agreements.
22. No, Science gives more physical evidences and proofs on the origin of life.
23. Yes, God is the creator and author of life.

Statement No. 10: Should the genetic concept that "life begets life" be the primary belief of science on the origin of life?

Proposed arguments:

24. Yes, the facts of science indicate that only living organisms can reproduce.
25. No, genetics does not deal with the origin of life.