OVERTLY TEACHING CRITICAL THINKING AND INQUIRY-BASED LEARNING: A COMPARISON OF TWO UNDERGRADUATE BIOTECHNOLOGY CLASSES

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Abstract

Some researchers have argued that science classrooms must move away from rote and passive applications of memorized concepts to the use of critical thinking skills as a primary component in facilitating learning. Yet few studies have examined the effect of overtly teaching for critical thinking on subsequent skill development. The purpose of this study was to assess if overtly teaching for critical thinking, as a teaching method, contributed to explaining increases in critical thinking skill scores of undergraduate students enrolled in agricultural biotechnology. One group of students were taught components of critical thinking and then asked to use the newly learned skills in class. A nonequivalent control group was instructed using the inquiry-based teaching method. The data exhibited significance between groups giving evidence that overtly teaching for critical thinking improves students' critical thinking skills as opposed to using the inquiry-based teaching method. Adding gender to the model did not significantly increase the explanation of variance in critical thinking skills. Also, a weak positive correlation was found between the total critical thinking skill score and the total critical thinking disposition score.

Introduction

Inquiry-based learning is one instructional method adopted by science and agriscience teachers alike, to foster students' abilities to make decisions and solve problems for the purpose of learning. Used in the classroom, inquiry-based learning facilitates higher levels of cognition among students who develop a process to better understand principles and concepts (Uno, 1999). Science instructors have many opportunities to employ inquiry-based learning in the classroom, however, Zoller, Ben-Chaim and Ron (2000) argue that science classrooms must move away from rote and passive applications of memorized concepts to the use of critical thinking skills as a primary component in facilitating learning. The implication is that even though the inquiry-based method of instruction is being used in many science classrooms, students are not necessarily using higher level thinking skills. An inhibiting factor of this movement discussed by Zoller et al. is that many teachers feel that teaching for critical thinking deprives students of the factual specifics students must learn to be competent in science. Fortunately, Gabel (1994) provides evidence that suggests students learn as much factual information when taught higher level thinking skills as they would in a traditional laboratory setting. However, does teaching for higher level thinking skills increase students' ability to utilize those skills? Researchers in the field of agricultural education have previously conducted research to determine

the levels of students' critical thinking skills in the classroom (Cano & Martinez, 1991; Rollins, 1990; Torres, 1993; Torres & Cano, 1995). Nevertheless, none of these studies have investigated if different instructional methods contribute to the explanation of higher levels of critical thinking among students. Does teaching students how to think critically increase their ability to use critical thinking skills?

Theoretical/Conceptual Framework

Critical thinking is often confused with other types of higher level thinking, such as problem solving, as well as specific components of Bloom's taxonomy of the cognitive domain (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956). The differences between critical thinking and problem solving can be assessed by examining their relationship with one another. For example, problem solving is a linear process of problem realization and solution finding, whereas critical thinking is an overlying set of abilities that facilitates the problem solving process (Hedges, 1991). Considering Bloom's taxonomy of the cognitive domain, the thinking skills of analysis and evaluation share the same name with critical thinking skills operationalized in this study as identified by Facione (1990). An examination of both analysis and evaluation does show each skill to be similar to its respective counterpart. The difference between the two classifications of thinking lies in how the thinking skills incorporate value and belief systems. Whereas thinking skills in Bloom's cognitive domain remain neutral of value judgments, critical thinking skills defined by Facione (1990) integrate values and beliefs into the formation of knowledge (Paul, 1985). This distinction among higher level thinking skills is necessary to prevent confusion and provide better understanding as to how critical thinking was taught and assessed in this study.

There was evidence in the literature indicating that a critical thinking disposition may affect one's use of critical thinking skills (Norris, 1994). Researchers have struggled in determining what facets compose a critical thinking disposition, but there is agreement that it is necessary for successful reasoning. Fortunately for students with a low critical thinking disposition, researchers believe it can be improved. Tishman and Andrade (1996) believe that teachers who model the behavior, explain their thinking, provide student interaction, and give feedback may improve critical thinking dispositions of their students. A disposition to think critically can be defined as consistent willingness, motivation, inclination and an intention to be engaged in critical thinking while reflecting on significant issues, making decisions and solving problems (Facione, Giancarlo, Facione, & Gainen, 1995).

Toward a Definition of Critical Thinking Skills

The study of critical thinking has led to many definitions among authors, but with common components. These shared components include identifying central issues, recognizing relationships, making judgments and conclusions, and evaluating conclusions based on credibility (Pascarella & Terenzini, 1991). A national Delphi study was conducted by Facione (1990) to provide clarity to the core constructs of critical thinking as a set of specific skills. From Facione's work, six critical thinking skills were identified: interpretation–clarifying meaning, analysis–examining arguments, evaluation–assigning value to claims, inference–drawing conclusions, explanation–presenting arguments, and self-regulation–self-examining biases. The validity of these skills was confirmed by the research conducted by Jones, Hoffman, Moore, Ratliff, Tibbetts and Glick (1995) and Giancarlo (1996). For this study, critical thinking skills were operationalized using these six core constructs. More detail to how these skills were taught and measured will be provided in subsequent discussion.

Correlates and Predictors of Critical Thinking

Facione and Facione (1997) conducted a five-year longitudinal investigation of 7,926 students from 50 different college programs to explore the relationships between critical thinking skill and critical thinking

disposition. Among different populations in the data, low positive correlations were found between total critical thinking skill and total critical thinking disposition, suggesting a relationship. However, not all scales of critical thinking skills were significantly correlated with scales of critical thinking disposition (Facione & Facione). For example, the thinking skill construct evaluation was not significantly correlated with the thinking disposition construct self-confidence (Facione & Facione). With such a large sample size, one would expect significant correlations between the two constructs. The findings indicate that scales of critical thinking skill could not be individually related with these corresponding scales of disposition, which implies disposition constructs are independent of skill constructs.

Again, there does seem to be a positive relationship between summative scores of critical thinking skill and summative scores of disposition. Facione (1998) summarized key findings in the literature and determined that a significant, but relatively low relationship existed between critical thinking skills and dispositions. Facione concluded that instruction incorporating critical thinking must include fostering the motivation to think as well as developing critical thinking skills. That is, a critical thinking instructional model must include facilitating both critical thinking skills and dispositions. This finding was supported by Zoller et al. (2000) who claim that a base-line critical thinking disposition is necessary for increasing students' usage of critical thinking skills.

The relationship between gender and critical thinking skills has been discussed frequently in the literature, but findings have been inconclusive. First examining critical thinking disposition, Costa and McCrae's and Sanchez's studies (as cited in Facione et al., 1995) examined the relationship between critical thinking disposition and personality. Findings for both studies included personality and gender contributing to students' critical thinking disposition. Results were interpreted as females being more open-minded and mature in their thinking, while males were more analytical (Facione et al., 1995). Rudd, Baker, and Hoover (2000) examined relationships between learning style and critical thinking disposition in a group of undergraduate agriculture students. No significant correlations were found between learning style and critical thinking disposition; however, there was a significant difference found in critical thinking disposition scores between males and females. The data suggested that females in the group had significantly higher total critical thinking disposition scores than males. On the contrary, Facione, Giancarlo, and Facione (1993) found that critical thinking disposition scores were not significant by gender. In a study examining Chinese undergraduate nursing students' disposition to think critically, there was no evidence that disposition scores were significantly different by gender (Ip, Lee, Lee, Chau, Wootton & Chang, 2000). Note that the same instrument, the California Critical Thinking Disposition Inventory (CCTDI) (Facione, Facione, & Giancarlo, 2001) was used to measure critical thinking disposition in all of the previous studies examining the relationship between disposition and gender.

For relationships between gender and critical thinking skills, Claytor (1997) found gender to be independent of critical thinking skills as measured by the Adult Medical Nursing Critical Thinking Instrument (AMNCTI). However, other studies have found a significant relationship between gender and critical thinking skills (Rudd et al., 2000; Walsh, 1996; Wilson, 1989). In these studies, the findings were interpreted as females having higher levels of critical thinking skills than males. To summarize the currently inconclusive literature regarding the relationship between gender and critical thinking, research suggests that either females tend to have higher levels of critical thinking, or gender has no relationship with critical thinking.

For age, the majority of the studies in the literature show age as having no relationship to critical thinking (Cillizza, 1970; Claytor, 1997; Facione, 1990; Facione, 1991; Feely, 1975; Jenkins, 1998; Rodriguez, 2000; Rudd et al., 2000). However, these studies have not focused on youth or the elderly when considering age as a significant variable.

The Critical Thinking Instructional Model

In 2000, a federally-funded grant project was initiated to develop an instructional model and skills assessment instrument for the teaching and evaluation of critical thinking in an undergraduate general education course in plant biotechnology at the University of Florida. The attempt to focus and integrate the teaching of critical thinking within a specific discipline was based on the work of researchers such as Huitt (1998), who have argued that rather than a set of generalized skills, critical thinking is a *process.* The rationale for the project was based on evidence that showed that although there was significant research on the teaching of critical thinking and its components as a set of skills or standards, few researchers, up to that point, had focused on the development of critical thinking within a specific content area (Carr, 1990; Hichey, 1990; Mertes, 1991). Furthermore, a valid and reliable discipline specific test of critical thinking skills did not exist.

The first stage of the project was to develop a set of specific teaching methods and instructional strategies designed to focus on each of the critical thinking skills and sub-skills identified by Facione (1990) and establish their relationships.

Instructional methods and strategies then were applied to the instructional content in the development phase. Specifically, each critical thinking skill was incorporated into assignments as follows: 1) Interpretation–factual knowledge to include definitions of scientific terms. Practice and discussion of information was facilitated through use of weekly electronic journals and online self-quizzes. 2) Analysis–visual representation modeling techniques were used to examine how a genetically-engineered crop moves from the research laboratory to the marketplace. 3) Evaluation–assessments of case studies and role-playing were utilized to teach socio-political aspects of biotechnology such as labeling and patent issues. In order to facilitate case analysis and deeper interpretation of decision-makers' reactions and motivations by students, cases and role-playing guides were developed utilizing multi-media production techniques including Web and digital video. 4) Inference–the concept of action learning was employed through engaging students in a project to develop a genetically-engineered food product from inception through marketplace distribution. 5) Explanation–pre-recorded videos of discussions and presentations by proponents and opponents of food biotechnology were used to initiate interactive student debates. 6) Self-Regulation–self-directed questioning and moderated focus group discussion techniques were utilized to enable students to engage in self-examination with respect to understanding the basis of their own ethical and social perspectives and draw on logic, and reasoning to make informed decisions about food biotechnology.

Purpose and Objectives

Thinking skills learned through inquiry-based learning include "…identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations" (National Research Council, 1996, p. 23). Although critical thinking skills are taught through inquiry-based instruction, would students improve their critical thinking skills if they were identified within context and overtly taught within class assignments? The purpose of this study was to assess the relationship between critical thinking skills and different instructional methods within the context of agricultural biotechnology. Specifically, the objectives of the study were to:

1. Determine selected demographic information of undergraduates enrolled in the courses AGR 2612 Seeds of Change and PLS 2003 Plants that Feed the World.
2. Determine undergraduate level of critical thinking skills and critical thinking dispositions and explore differences between the two groups.
3. Determine the relationship between overtly teaching critical thinking skills and selected demographics with the posttest critical thinking skills of participants.
4. Determine the relationship between critical thinking skills and critical thinking dispositions.

Procedures

Students enrolled in AGR 2612 Seeds of Change and PLS 2003 Plants that Feed the World during the spring 2004 semester were utilized for this study. These two courses were selected as two similar agri-science courses covering biotechnology concepts in which two types of instructional methods could be applied, overtly teaching for critical thinking and inquiry-based learning. The research design for this study was a nonequivalent control group as defined by Campbell and Stanley (1963). Students enrolled in AGR 2612 were instructed with methods overtly teaching critical thinking skills developed from the work of Facione (1990). That is, students were taught components of critical thinking and then asked to use the newly learned skills in class. Students enrolled in PLS 2003 were instructed using inquiry-based learning teaching methods as described by the National Science Education Standards (National Research Council, 1996). Typical assignments included interpreting information, assessing experimental evidence, questioning assumptions and offering alternative explanations and completing laboratory activities. Students of both groups were administered the University of Florida Engagement, Maturity and Innovativeness test (UF-EMI) to measure critical thinking disposition and the University of Florida Critical Thinking Skills test for Plant Biotechnology (UF-CTS) to measure critical thinking skills at the beginning of the semester. The UF-CTS was again administered as a posttest to both groups to determine if critical thinking skills improved during the semester.

Instrumentation

UF-CTS was developed by the researchers to measure the discipline specific skills of analysis, evaluation and inference by using scenario-based questions specific to biotechnology with scaled responses to each item. Prior to the study, a panel of experts in critical thinking and plant biotechnology checked the multiple-choice skills test for content and face validity. The UF-CTS only measures the critical thinking skills constructs analysis, evaluation and inference as Facione (1991) found that measuring only these three constructs gives an accurate measure of critical thinking skill abilities. The UF-CTS was pilot tested in the first year of the three project period, and refined for administration in the current study. Demographic items were added to the UF-CTS to attain objective one. Items were chosen by the researchers based on literature concerning critical thinking skills and dispositions (Rudd, Baker, and Hoover, 2000).

The UF-EMI was developed by the researchers and consists of 26 Likert-type items that correspond to three constructs that determine critical thinking disposition including: engagement, cognitive maturity, and innovativeness. This instrument was developed after a factor analysis of the CCTDI indicated that identified constructs were not confirmed (Moore, Rudd, & Penfield, 2002). The UF-EMI was the result of the factor analysis with three constructs formed from the original seven constructs of the CCTDI.

Data Analysis

Descriptive statistics were used to analyze demographic information. Analysis of covariance (ANCOVA) was used to determine differences between the two courses utilized in the study while controlling for pretest variation between groups. An ANCOVA is a statistical tool used to reduce error variance, remove preexisting pretest differences and give a less biased estimate of group effects on the dependent variable (Agresti & Finlay, 1997). Bivariate correlation was used to determine the relationship between critical thinking skills and critical thinking dispositions.

Findings

The UF-EMI had acceptable post-hoc reliability alpha coefficients for the constructs of engagement (α = .91), cognitive maturity (α = .79) and innovativeness (α = .80). However, the UF-CTS suffered from poor reliability with lower alpha coefficients in analysis (α = .61), evaluation (α = .46), and inference (α = .78). The researchers discriminated and

removed two items measuring analysis and three items measuring evaluation that had low internal consistency, the majority of which were reverse coded. After these items were removed, the UF-CTS had improved post-hoc reliability alpha coefficients for the constructs of analysis (α = .68), evaluation (α = .70) and inference (α = .78).

The first objective addressed by this study was to determine selected demographic information of undergraduates enrolled in courses AGR 2612 Seeds of Change and PLS 2003 Plants that Feed the World. There were 20 students in AGR 2612 who participated in the study, of which 10 were female and 10 were male. The mode age of the participants in this course was 19 years. Participants in this course were 45% Caucasian and 15% Hispanic with the remaining students described as African American, and European. The group included 17 majors of which there was no sizable difference. Students' mean GPA was 3.88 with a total of 60% of the participants self-reporting their cumulative GPA at or above a 3.50. Eleven students in this course were enrolled in the University of Florida Honors Program.

For the PLS 2003 course, 38 students participated in the study, of which 22 were female and 16 were male. The mode age of the participants was also 19 years. The group was 52.6% Caucasian and 23.7% Hispanic with the remaining students described as Asian or African American. A total of 14 majors were represented with 31.6% working toward a business degree. No other major represented more than 10% of the group. The mean GPA for responding students enrolled in PLS 2003 was 3.28 with 75% of the students self-reporting their GPA above a 3.00. In this course, three students were enrolled in the University of Florida Honors Program.

The second objective addressed by this study was to determine undergraduate level of critical thinking skills and dispositions and explore differences between the two groups. Because of missing data, eight participants in the PLS 2003 course were removed from the data analysis; these participants did not answer specific questions which led to the inability to calculate construct scores of critical thinking skill. Overall, critical thinking skill scores of students enrolled in AGR 2612 had little change between pretest and posttest critical thinking mean scores across constructs, except for a 7.15 point increase in the evaluation mean score. This gain helped contribute to the increase of students' total posttest critical thinking skill mean score (M = 196.15) of 8.60 points from the pretest total mean score (M = 187.55) (Table 1).

In the PLS 2003 course, student respondents' pretest critical thinking skill mean score (M = 171.50) was 16.05 points lower than students enrolled in AGR 2612. Students in PLS 20003 also had a lower total posttest mean score (M = 171.83) of 24.32 points. Note that the increase from pretest to posttest of the total critical thinking skill mean score for PLS 2003 students was less than one point (Table 2).

Table 1
Critical Thinking Skills Scores of AGR 2612 (n = 20)

Critical Thinking Skill	*M*	*SD*	Min	Max
Pretest				
Analysis	64.55	8.54	51	78
Evaluation	48.80	7.44	38	62
Inference	74.20	8.18	54	89
Total skill score	187.55	19.45	145	225
Posttest				
Analysis	64.85	9.15	44	76
Evaluation	55.95	8.97	39	70
Inference	75.35	9.01	52	90
Total skill score	196.15	23.48	135	231

Note. Possible Ranges: Analysis–8 to 80; Evaluation–7 to 70; Inference–10 to 100; Total Score–25 to 250.

Table 2
Critical Thinking Skills Scores of PLS 2003 (n = 30)

Critical Thinking Skill	*M*	*SD*	Min	Max
Pretest				
Analysis	56.83	9.01	42	77
Evaluation	47.20	9.90	28	70
Inference	67.47	10.84	46	90
Total skill score	171.50	24.30	131	231
Posttest				
Analysis	56.66	8.38	43	75
Evaluation	48.41	8.24	36	63
Inference	66.76	13.31	45	90
Total skill score	171.83	24.58	131	222

Note. Possible Ranges: Analysis–8 to 80; Evaluation–7 to 70; Inference–10 to 100; Total Score–25 to 250.

For critical thinking disposition, students enrolled in AGR 2612 and PLS 2003 had similar mean scores among constructs and in total score. However, students in AGR 2612 did have a slightly higher critical thinking disposition mean score (M = 105.55) than the responding PLS 2003 students' disposition mean score (M = 104.12). However, note that students in PLS 2003 had total disposition mean scores both lower and higher than students enrolled in AGR 2612 (Table 3).

Table 3
Critical Thinking Disposition Scores of AGR 2612 (n = 20) and PLS 2003 (n = 30)

Critical Thinking Disposition	*M*	*SD*	Min	Max
AGR 2612				
Engagement	45.95	5.58	36	55
Cognitive Maturity	31.10	3.97	22	38
Innovativeness	28.50	3.28	23	34
Total Disposition Score	105.55	11.36	89	125
PLS 2003				
Engagement	44.38	5.72	36	55
Cognitive Maturity	32.17	3.55	25	40
Innovativeness	27.70	3.81	19	35
Total Disposition Score	104.12	12.43	76	130

Note. Possible Ranges: Engagement–11 to 55; Cognitive Maturity–8 to 40; Innovativeness–7 to 35; Total Score–26 to 130.

The third objective addressed by this study was to determine the relationship between overtly teaching critical thinking skills and selected demographics with the posttest critical thinking skills of participants. An ANCOVA was employed to determine significant differences of critical thinking scores between the two groups using pretest total critical thinking scores as a covariate and total critical thinking posttest scores as the dependent variable. To make this comparison, the two courses of interest were dummy coded to distinguish between groups and used as the independent variable. Levene's Test of Equality of Error Variances was used to test the null hypothesis that the error of variance of posttest critical thinking skill score was equal across groups. The test indicated to fail to reject the null hypothesis, (F = 2.49, p = .12) with alpha set a priori at .05. The researchers concluded that the assumption of the homogeneity of the variances was met.

Data analysis from the ANCOVA provided evidence that there was a significant difference between groups (F = 5.07, p = .03) indicating that in the examined classes, overtly teaching critical thinking skills contributed to explaining the increase of students' critical thinking skills. Furthermore, the R^2 value was .73 indicating that 73% of the variance in critical thinking scores was explained by the model (Table 4).

Table 4
ANCOVA of AGR 2612 and PLS 2003; Explanation Critical Thinking Skills by Group (n = 50)

Source of Variance	Adjusted SS	*df*	*MS*	*F*	*p*
Between Groups	981.87	1	981.87	5.07	.03*
Within Groups	8911.97	47	193.74		
Total	9893.84	48			

Note. Adjusted R^2=.73.
* $p < .05$

In a second ANCOVA, the researchers selected gender as a second independent variable in addition to group, as previous research has been inconclusive to if gender is a contributing variable to higher critical thinking skills. The data again provided evidence of significance between groups (F = 4.22, p = .05), but provided no evidence to support gender as a significant contributor to explaining total critical thinking skill scores (F = .69, p = .41, R^2 = .73). Note there was no change in the R^2 value in the second model. These findings indicate that gender did not contribute to the explanation of critical thinking skills in these two courses (Table 5).

Table 5
ANCOVA of AGR 2612 and PLS 2003; Explanation of Critical Thinking Skills by Group and Gender (n = 50)

Sources of Variance	Adjusted SS	*df*	*MS*	*F*	*p*
Between Groups	830.64	1	830.64	4.22	.05*
Between Genders	135.61	1	135.61	0.69	.41
Group * Gender	73.53	1	73.53	0.37	.54
Within Groups	8658.36	45	196.78		
Total	9698.14	48			

Note. Adjusted R^2=.73.
* $p < .05$

Given the lack of group size, it was not possible to add another independent variable to the above model. However, the literature asserts there should be a relationship between critical thinking skills and critical thinking dispositions. The fourth objective addressed by this study was to determine the relationship between critical thinking skills and critical thinking dispositions. A moderate and positive relationship (r = .37, $p < .05$) was found between the total critical thinking skill posttest scores and the total critical thinking disposition scores indicating that the UF-CTS and UF-EMI were related. Considering the constructs of critical thinking skills and critical thinking disposition, all relationships were positive. Generally, moderate correlations (r = .30, $p < .05$ to r = .42, $p < .05$) were found throughout critical thinking skill constructs

and critical thinking disposition constructs. However, the critical thinking disposition construct cognitive maturity did not correlate significantly with any critical thinking skill scale. Note that the cognitive maturity construct also had a lower post-hoc reliability coefficient which indicated item inconsistency for this scale. The critical thinking skill evaluation did not correlate significantly with any disposition scales except a moderate correlation with innovativeness (r = .30, p < .05). These positive correlations indicate an increase in students' thinking disposition scores was associated with an increase in thinking skill scores (Table 6).

Table 6
Correlations of Critical Thinking Dispositions and Critical Thinking Skills (n = 50)

	Critical Thinking Skill			
Critical Thinking Disposition	Analysis	Evaluation	Inference	Total Skill Score
Engagement	.37*	.19	.34*	.35*
Cognitive Maturity	.13	.13	.23	.20
Innovativeness	.39*	.30*	.39*	.42*
Total Disposition Score	.34*	.23	.36*	.37*

* p < .05

Conclusions

The courses AGR 2612 and PLS 2003 adequately served to assess if overtly teaching for critical thinking as an instructional method contributed to explaining critical thinking skill scores of undergraduate students enrolled in agricultural biotechnology. Overall, the students participating in this study had a mode age of 19 years and represented a broad range of majors. The AGR 2612 course composed of 10 females (50%) and 10 males (50%) with the highest ethnicity group being Caucasian (45%). Students in this course, of which 11 were honors students, held a relatively higher self-reported cumulative GPA, with a mean of 3.88. Students enrolled in PLS 2003 consisted of 22 females (58%) and 16 males (42%) with Caucasian (52.6%) being the largest ethnic group. Students in PLS 2003, of which 3 were honors students, held a self-reported cumulative GPA of 3.28.

In the AGR 2612 group there was a mean score increase of 7.15 in the critical thinking skill construct of evaluation between pretest and posttest. There was little change in the constructs of analysis and inference between the AGR 2612 pretest and posttest. Overall, critical thinking mean scores in AGR 2612 were higher than PLS 2003 scores. Also, students in PLS 2003 had little change in critical thinking skills from pretest to posttest. In terms of critical thinking disposition mean scores, there was little difference between groups.

The data suggests that students in AGR 2612, all of whom were overtly taught the components of critical thinking, had significantly higher levels of critical thinking skills (F = 5.07, p = .03). Furthermore, the effect of overtly teaching critical thinking skills explained a large portion of total variance (Adjusted R^2 = .73) of students' posttest critical thinking skill scores. The addition of gender to the model was not significant (p = .41) in predicting critical thinking posttest scores and did not add to the total variance of posttest critical thinking scores. This gives auxiliary support to the debate that gender does not influence critical thinking skills (Claytor, 1997; Facione et al., 1993; Ip et al., 2000).

There was a weak positive correlation (r = .37) between total critical thinking skill score and total critical thinking disposition score. Moderate correlations were found between constructs of critical thinking skills and critical thinking dispositions. However, not all critical thinking skill constructs significantly correlated with disposition constructs. This finding mimics the results of Facione and Facione (1997), indicating that some constructs of critical thinking skills have no correlation with constructs of critical thinking disposition.

Recommendations and Implications

In this study, overtly teaching critical thinking skills within a specific knowledge domain did significantly facilitate the increase of total critical thinking skills scores with emphasis in the thinking skill evaluation (Huitt, 1998), more so than inquiry-based learning. The authors caution the reader, as findings were limited due to the nature of nonrandomized samples. This study should be replicated to affirm the results and more research should be conducted to discover how to better increase students' use of analysis and inference thinking skills.

Moderate positive correlations were found throughout the constructs of critical thinking skills and critical thinking dispositions, except for the constructs cognitive maturity and evaluation. Why does this exist? Granted that the findings are similar to that of Facione and Facione (1997), the lower reliability coefficient of the cognitive maturity scale suggests more research is needed to be better able to measure critical thinking disposition. Specific recommendations stemming from this study would therefore include more research into the measurement of these skill constructs, combined with further exploration of the role that overtly teaching for critical thinking plays in terms of student learning outcomes.

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