Computer Simulations' Effect on Critical Thinking Levels of Entry-Level Athletic Training Students

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1. BACKGROUND:

Higher education is a dynamic process offering various instructional methods of educational material delivery to students. One of the main goals of healthcare educators is to help students to learn to think critically and to solve problems rather than simply identify correct answers (Starkey, Koehneke, Sedory, & Turocy, 2004). Solving a computer simulated clinical problem is a student-driven process promoting active learning (Barrows, 1990; Charlin & Mann, 1998). Computer simulations use a sample of real-world problems to provide students with an alternative form of educational material delivery. This learning process improves students' clinical reasoning (McGee, 2003). It increases the active learning process, allowing students to engage in a realistic problem (Heinrichs, 2002).

There has been a large increase in the diversity of education, which puts an increased workload on educators (Jeffries, 2001). Computer simulations accommodate diverse learning styles and offer students of varying cultural backgrounds a beneficial learning experience. This process also assists educators with their increased workload (Jeffries, 2001).

Computer simulation usage increased dramatically in medical education during the last decade. In healthcare education, computers are used for training, evaluation, and assisting in certification. The overall efficacy of computer-assisted learning is directly related to the students' involvement (Lewis, 2003). Interactive simulation can bridge the gap between the preclinical didactic and clinical application (Weller, 2004). It allows the students to practice, make mistakes, learn from the feedback given, and improve problem-solving and decision-making skills. Based on Weller's (2004) research, students are generally very enthusiastic about simulation-based learning.

Healthcare education is highly dependent on the patient presented during the students' clinical rotations, but students' exposure to patients has become limited (Jefferies, 2001). Thus, some students might not be exposed to unique conditions (Satava, 2001). The advantage of problem-solving via computer simulation is that students must work through a patient problem which enhances their problem-solving skills within the context of clinical practice (Abbey, 2002). Computer simulations are helpful in assuring that students have been exposed to uncommon conditions (Satava, 2001, Hammond et al., 2002) and provide performance data for assessment (Kneebone, 2003). It is assumed that students learn the best through active participation (Tomey, 2003). Mallott et al. (2005) reported that students enjoy working with the computer-case simulation because it allows them to exercise their knowledge and skills through a trial-and-error approach. Students want to make mistakes and see what consequences they would have to face. Computer-assisted instruction provides an effective type of instructional method producing a significant increase in knowledge over a four- to six-week period (Lynch et al, 2001).

Critical thinking includes problem-solving and decision making (Heinrichs, 2002). Many higher education curriculums have implemented case studies into their programs to promote critical thinking. Solving a clinical problem helps students think critically (Heinrichs, 2002). Students are actively involved during clinical problem solving, and this active learning improves critical thinking (Browne & Freeman, 2000). Castle (2000) stated that computer simulations improve athletic training students' critical thinking and decision making skills. The main goal of athletic training education is to help students become critical thinkers and healthcare professionals (Starkey et al., 2004).

The purpose of this study was to investigate if athletic training students' performance on computer simulations on evaluation of athletic injuries reflects their critical thinking level. The secondary purpose of this study was to investigate whether using self-directed learning utilizing computer simulations over a four week period affects student performance on computer simulations related to the physical evaluation of athletic injuries. The following questions were investigated: Do students who have lower levels of critical thinking skills perform the same on computer-simulations as students who have higher levels of critical thinking skills during a period of four weeks of self-directed learning? Do students with levels of higher critical thinking skills perform better on computer-simulations than students with a lower critical thinking skills level? When presented by computer-simulations as a self-directed learning tool for four weeks, do the students' performances on completing computer-simulations improve?

The California Critical Thinking Skills Test (CCTST) and Watson Glaser Critical Thinking Appraisal (WGCTA) are two primary instruments used in research that assess critical thinking abilities of college-age students (Adams, Stover, & Whitlow, 1999). Adams et al. (1999) evaluated prior research and stated that the CCTST reflects critical thinking abilities in allied health professions more accurately than does the WGCTA. Further current research states these are good critical thinking assessment tools (Staib, 2003). Although it is impossible to obtain direct measurement of critical thinking based on these tests, it is possible to evaluate critical thinking ability from these self-report assessments (Bers, 2005).

2. METHODS:

2.1 Participants:

Thirty-three junior- and senior- entry-level athletic training students from Pennsylvania State institution Athletic Training Program were asked to participate in this study, and 32 (97% of those recruited) completed this study. This number of participants was sufficient to obtain power $p = 0.8$ for five repeated measures with a size effect $\gamma = 0.4$.

Students participated in this study for a total of four weeks. During this time participants were given full rights to use the *higherlevelthinking.com* website, which provided them with unlimited access to computer simulations. Students were required to complete at least one specific simulation at the end of each week of the study, and students' scores for that simulation were recorded.

The participants consisted of 22 (68.8%) females and 10 (31.3%) males; 18 juniors (56.3%) and 14 seniors (43.8%). Participants ranged from 19 to 22 years of age with the mean of 20.94. The participants' mean overall cumulative grade point average (QPA) was 3.53 and grade point average in athletic training classes (ATGPA) 3.48 on the four-point scale.

Participants' protection was considered throughout this study. Permission from the Institutional Review Board was granted before the initiation of this study. Each participant signed an informed consent before participation.

2.2 Instrumentation:

All participants completed the Computerized Traditional Athletic Training Simulation Instrument (C-TATSI) before and at the conclusion of the four weeks. This instrument was developed by Dr. Ray Castle (Castle, 2000). It was not shown as a good predictor of students' success on the Board of Certification (BOC) exam; however, students' performances on C-TATSI were similar to their performance on the BOC exam (Castle, 2000). This instrument collected data to investigate the effect of participants' four weeks of self-directed learning.

Participants received unlimited access to computer case simulations through the www.higherlevelthinking.com website for the four-week testing period. This software also evaluated student performance on five specific simulations.

The first computer simulation was *Athletic Training Clinical Experience I,* which focused on evaluation skills related to various football injuries. The second case study completed at the end of the first week was *Head, Neck, and Cervical Spine Injuries.* During this computer simulation, students were tested on two scenarios related to head and cervical spine injuries. The third computer case study was the *NATABOC Mock Exam*, which included four case scenarios. This computer simulation prepared athletic training students for the BOC exam by giving them the opportunity to complete practice exams similar to the BOC exam and to identify their areas needing improvement. The fourth computer simulation completed at the end of the third week was the *Written Simulation Mock Exam.*

This computer simulation included four specific injury scenarios, where students could practice a portion of the former BOC exam. The final computer simulation, *Athletic Training Experience III*, was completed at the end of the fourth week. This simulation included evaluation of the head, cervical spine, and upper extremities.

2.3 Procedure:

All participants completed the CCTST, the pre- and post-test C-TATSI, five specific computer case studies, and also participated in self-directed learning over the Internet site www.higherlevelthinking.com. All participants completed several computer simulations as a part of their self-directed learning during this study. Students had unlimited access to these computer simulations and were allowed to take them at their convenience. They completed a required minimum of one per week. The average of completed computer simulations per week for all participants was (M = 2.87, SD = 2.93). The overall descriptive statistics for gender, class rank, and assigned critical thinking group are presented in Table 1.

All participants completed a demographic information sheet and took the CCTST at the beginning of the study. Their performance on CCTST was evaluated by California Academic Press via the Internet. The CCTST contained 34 multiple-choice questions. The scores participants received included: overall score; percentile ranking to other four-year college students; and subsection scores for induction, deduction, analysis, inference, and evaluation. Two groups emerged. Students in the 64th percentile (M = 72.65%) and above were placed into a *Higher Level Critical Thinking* group and students in less than the 64th percentile (M = 33.06%) were positioned in the *Lower Level Critical Thinking* group.

The intent was to divide the participants into two groups with a cut off equal to median value. However, this was impossible due to a small cluster of participants scoring the same score close to the median. Thus, the group with higher level of critical thinking included 18 students: 12 females and six males; with a mean age of 21 years; a mean QPA of 3.647; and a mean ATGPA of 3.631. The lower-level critical thinking group had 14 students: 10 females and four males and the mean age for this group was 20.86 years. Their mean QPA was 3.377 and mean ATGPA was 3.277 (See Table 2).

Data were analyzed using a repeated measure analysis of variance (ANOVA) with the level of critical thinking groups (higher and lower level critical thinking groups) as the independent variable and the five computer simulations scores as the dependent variables. Additional data analyses focused on critical thinking levels and the supplementation of computer simulations to traditional lecture teaching methods. The data were analyzed to investigate the relationship between participants' QPA and ATGPA according to their level of critical thinking. Analyses were also conducted to examine the effect of participants' QPA and ATGPA on the five specific computer simulation scores.

The numbers of completed practice computer simulations per each week were analyzed, and the participants were placed into two groups: high number of completed simulations and low number of completed simulations. Their pre-test and post-test C-TATSI performances were analyzed using a repeated measures ANOVA with groups serving as an independent variable and C-TATSI performance as a dependent variable. A final analysis compared junior and senior students' scores on the CCTST as well as their performance compared to students from other four-year colleges.

3. RESULTS:

An independent t-test was conducted to evaluate the difference between the QPA and ATGPA of the higher-level and lower-level critical thinking skills groups. The test was significant for QPA t (-2.63), p = .015. This suggests students in the higher-level critical thinking groups had significantly higher QPA than students in the lower-level critical thinking group.

The test was also significant for ATGPA t (-3.142), p = .005 suggesting that students in the higher-level critical thinking groups had significantly higher ATGPA than students in the lower-level critical thinking group (See Table 4).

The California Critical Thinking Skills Test provides test-takers with two scores following the exam. The first score is based on their responses to the questions, whereas the second score is their relative percentile ranking to other four-year college students. The mean score for four-year college students is 16.8 with a maximum score possible of 34 points. The average first score for this population was (M = 17.53, SD = 3.64).

Table 5 summarizes the scores by grade level and critical thinking group. The average score for the group of students with higher-level critical thinking skills was (*M* = 20.11, *SD* = 2.37). The average score for the group of students with lower-level critical thinking skills was (*M* = 14.21, *SD* = 1.76).

The second score reported is the overall relative ranking score to other four-year college students. This score compares the participants' performances from this study to other four-year college and university students. The participants of this study were placed at the 55th percentile of four-year college students (*M = 55.26, SD = 23.35*). Table 6 presents a complete breakdown.

The higher-level and lower-level critical thinking participants' pre-test and post-test C-TATSI scores were analyzed using a one-way ANOVA repeated measures within and between subjects factors. Using the Wilks' Lambda criterion, the participants' pre-test and post-test performance was not affected by their level of critical thinking, Wilks' Lambda = .975, *F* = (1,30) = .775, *p* =.386, multivariate η_p^2=.025. No significant difference was found between the higher-level and lower-level critical thinking groups' pre-test and post-test performance. Table 7 and Figure 2 present the data.

Pre- and post-test C-TATSI performance data were collected and analyzed using a one-way ANOVA repeated measures within and between subjects factors. Using the Wilks' Lambda criterion, the participants' pre-test and post-test performance was not affected by the amount of completed practice simulations, Wilks' Lambda = .971, *F* = (1,30) = .905, *p* =.349, multivariate η_p^2=.029. Therefore, no significant difference existed in the pre-test and post-test performance of the low practice group and the high practice group. Table 3 and Figure 1 outline the results of this analysis.

Pre-test and post-test C-TATSI scores were also compared based on participants' QPA and their ATGPA. A repeated-measures ANOVA was used to analyze these data. Using the Wilks' Lambda criterion, the participants' pre-test and post-test performance was not affected by their QPA, Wilks' Lambda = 1.0, *F* (1,30) = .002, *p* = .964. Neither was it affected by their ATGPA, Wilks' Lambda = .997, *F* (1,30) = .104, *p* =.749, multivariate η_p^2=.003. Therefore, the participants' QPA and ATGPA does not play an effect in the difference between participants' pre- and post-test C-TATSI. Data divided by subjects' ATGPA and QPA are presented in Table 8.

4. CONCLUSION:

This study investigated athletic training students' levels of critical thinking in relation to performance on computer simulations. In addition, this study investigated the use of computer simulations as a tool for self-directed learning over a four-week period and its effects on students' performances. The results of this study are specific to the CAATE-accredited entry-level athletic training program at a Pennsylvania State institution.

The goal of this research was to contribute to the athletic training literature related to teaching methods, computer simulations, and critical thinking. The sample consisted of thirty-two athletic training students. All of the participants (18 juniors and 14 seniors) had completed the Physical Evaluation of Athletic Injuries class before participating in the study.

There was no significant difference in the performance on the computer simulations between the two critical thinking groups (higher and lower level). It appears that both groups of students performed similarly on the computer simulations. Although overall performance on computer simulations was not affected by participants' critical thinking level, there was a significant correlation between the critical thinking and case simulation number five *Athletic Training Clinical Experience III.* This may be caused by the simulation questions in this scenario requiring more in-depth thinking than the other computer case simulations.

Although the groups' performances on the computer simulations were not significantly different, students with higher levels of critical thinking outscored students with lower levels of critical thinking on three out of the five computer simulations. This may be due to higher QPA and ATGPA scores of the higher level critical thinking group. The other two computer simulations were completed with a similar score for both groups.

Direct application of this finding may include that traditional written exams, and computer simulations can be used in the assessment of athletic training students' knowledge and decision-making skills. Computer-simulated instructions are as good as, and sometimes even better than traditional lectures (Littlefield et al., 2003; Rouse, 2000; Satava, 2001; Shim et al., 2005). However, based on the results of this study, computer simulations presented via C-TATSI should not be used as an indicator of entry-level athletic training students' ability to think critically.

The results of the ANOVA repeated measures indicated that there was no significant performance difference in the overall means of computer simulations performance between the two groups. Students with higher levels of critical thinking outscored the students with lower levels of critical thinking in three of five computer simulations. They also outscored them with a mild difference in the overall mean for all five computer simulations scoring $M = 64.45\%$ compared to $M = 61.3\%$ of the lower level critical thinking group. This is not a significant difference and might be due to chance. Another important factor that might play a role in these results is a low number of participants and an unequal number of subjects in each group.

It is impossible for the athletic training students to be able to observe every possible and unique injury during their clinical education. Thus, computer simulation programs might serve as a learning and assessment tool to recognize weaknesses in students' knowledge (Bennett, 2002). Computer simulations used in C-TATSI may be used as a motivational (Heinrichs, 2002; Jeffries, 2001; Mensch & Ennis, 2002) and self-directed learning instrument (Shim et al., 2005), but given the data collected in this study, these simulations should not be used for assessing athletic training students' abilities to think critically.

Critical thinking is beneficial to healthcare professionals and their patients. Thus it is a necessary skill for athletic training students to master (Rauen, 2001). Many healthcare education programs use computer simulations as a supplement to their lectures to provide students with opportunities to apply their knowledge, skills, and critical thinking (Rauen, 2001). It is vital for the students to be able to assess the situations and recognize the correct answers; however, they need to be able to evaluate the thinking process behind their decisions (Pithers & Soden, 2000). Simulations allow students to learn from harmless, self-generated feedback and assure that they have been exposed to uncommon conditions feedback (Bernstein, Scheerhorn & Ritter, 2002). Simulations promise to decrease possible inconsistencies in athletic training education (Hammond et al., 2002; Satava, 2001).

Active learning is important for critical thinking to take place (Browne & Freeman, 2000). Using computer simulations forces students to become active learners and make decisions on their own. Based on the consequences students learn to view the material presented more critically. However, based on this study computer simulations presented via C-TATSI do not evaluate the thinking process behind the decision making, and thus, should not be used as an evaluation tool for assessing critical thinking.

According to Kulik and Kulik (1991), students' performances on computer simulations peak in four weeks. However, athletic training students participating in this study completed the most computer simulations during the second week of self-directed learning, which might be possibly due to "Hawthorne Effect" (motivation to participate in a new treatment). However, their performances on computer simulations did not continue to change over the period. Their scores reached the peak at the end of the second week of the study on the *NATABOC Mock Exam* computer simulation.

Students' cumulative grade point averages and grade point averages of athletic training classes do correlate with their ability to think critically. This positive finding shows higher education programs help students with critical thinking. Students respond positively to computer-assisted learning with increased motivation towards learning.[6] Thirty-two of thirty-three students who were asked to participate finished the study. The one student did not participate due to not attending the institution at the time of data collection. All participants were enthusiastic to participate in the study and test their knowledge on computer simulations. Computer simulations are not part of the curriculum at this institution; many participants responded with positive feedback to include computer simulations over a variety of subjects. Additional feedback given by participants was that they enjoyed completing computer simulations because it was something new and challenging.

Many seniors stated that they approached these computer simulations as a preparation tool for their BOC exam. Junior level students expressed their interest in using computer simulations as their self-directed learning for the next year. Sophomore level students who were not involved in this study expressed their interest to participate in a similar study using computer simulations next year. Therefore, this study has generated a large amount of interest among athletic training students at this institution in using computer simulations as a learning tool.

Six out of seven (86%) seniors from the higher-level critical thinking group passed the BOC examination on the first trial. Two out of five (40%) from the lower level critical thinking group passed the BOC exam on the first trial. Future study may investigate the effect of critical thinking on students' performances on the BOC examination.

Although critical thinking is a necessity for healthcare professionals, based on this study athletic training students' performances on the computer simulations presented via C-TATSI do not reflect their level of critical thinking.

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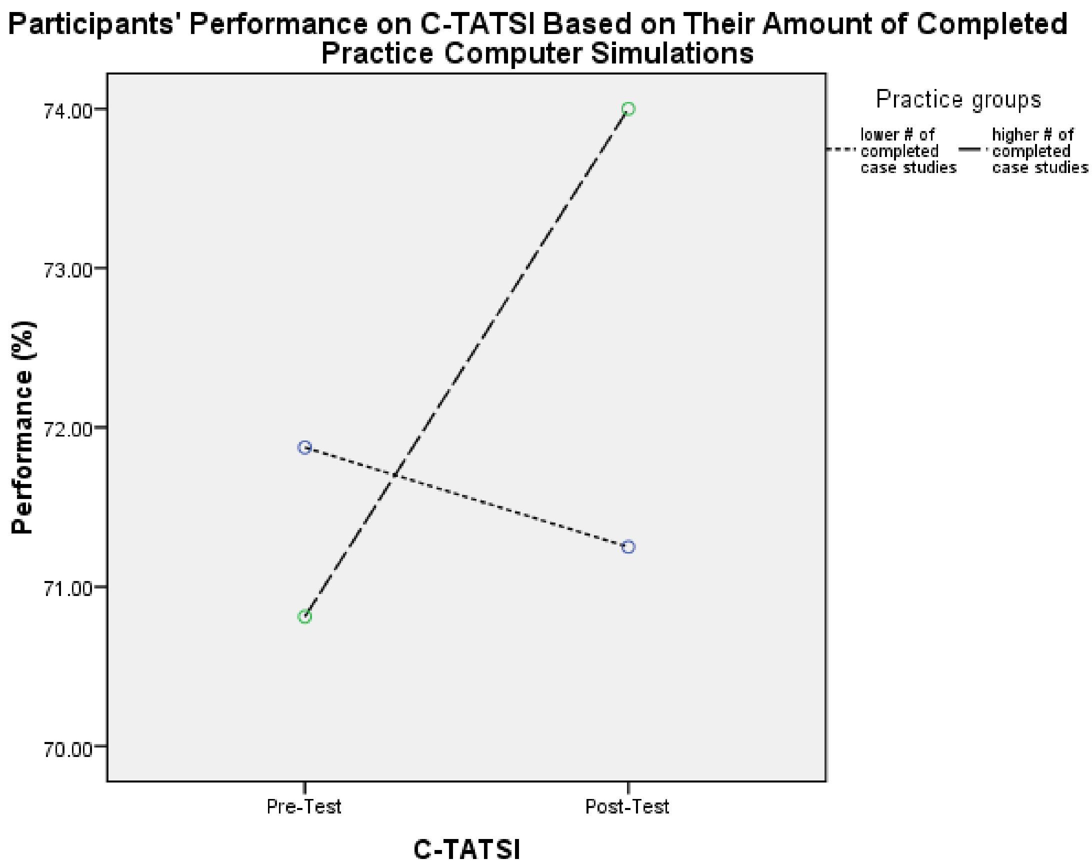

Figure 1. Comparison of the means on pre-test and post-test C-TATSI between higher practice and lower practice groups.

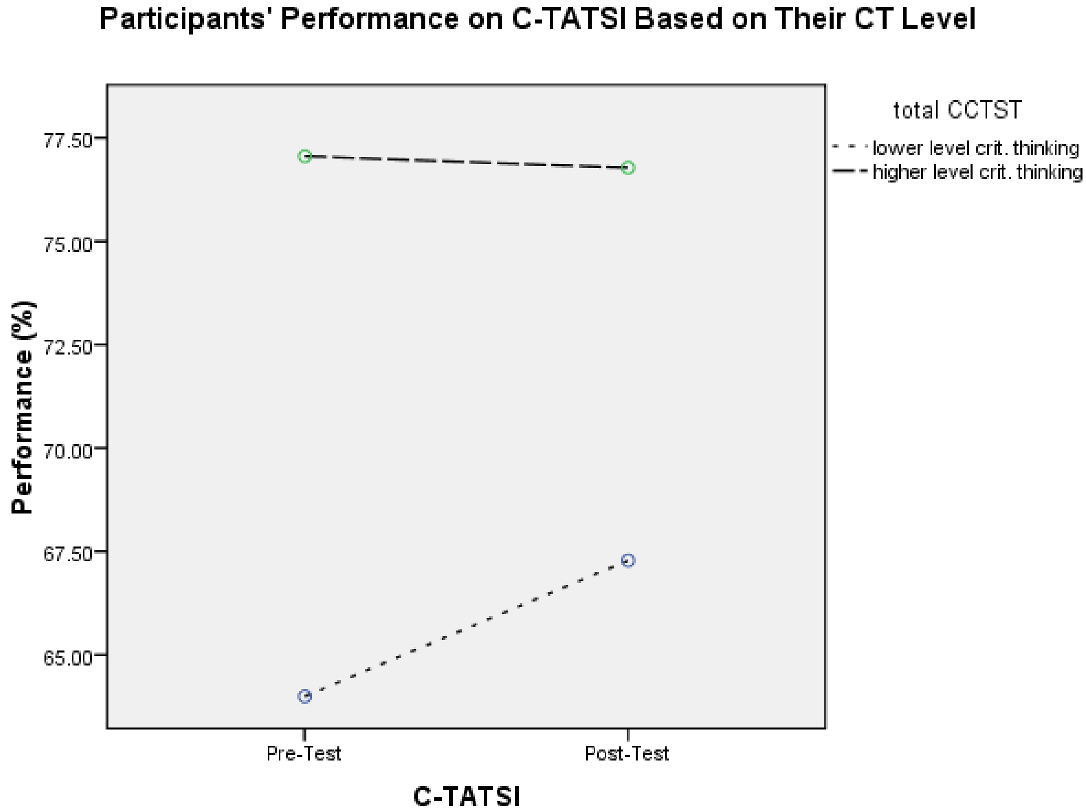

Figure 2. Comparison of the means on the pre-test and post-test C-TATSI between the higher and lower level critical thinking groups.

Table 1
Completed Practice Computer Simulations

Groups	Week 1		Week 2		Week 3		Week 4	
	M	SD	M	SD	M	SD	M	SD
Total	3.03	2.83	5.03	4.84	1.59	1.76	1.84	2.29
Juniors	3.17	2.94	5.11	4.24	1.39	1.50	1.44	1.29
Seniors	2.86	2.77	4.93	5.69	1.86	2.07	2.36	3.13
LLCT	2.57	2.44	4.64	4.50	1.71	2.02	2.00	2.63
HLCT	3.39	3.11	5.33	5.20	1.50	1.58	1.72	2.05
Females	2.68	2.64	4.05	3.85	1.23	1.41	1.64	1.99
Males	3.80	3.19	7.20	6.22	2.40	2.22	2.30	2.91

Table 2
California Critical Thinking Skills Test (CCTST) Groups' Demographics

CCTST Group	Age	Female	Male	Seniors	Juniors	QPA	ATGPA
HLCT	21.00	12	6	8	10	3.65	3.63
LLCT	20.86	10	4	6	8	3.38	3.28

Table 3

Pre-Test and Post-Test Performance on C-TATSI for Low Practice and High Practice Groups

Groups	N	M	SD
Pre-Test			
Low Practice	16	71.88	15.19
High Practice	16	70.81	14.02
Post-Test			
Low Practice	16	71.25	16.91
High Practice	16	74.00	9.68

Table 4

Participants' Cumulative Grade Point Average and Grade Point Average in Athletic Training Classes

Group		N	M	SD
QPA				
	HLCT	18	3.65	.23
	LLCT	14	3.38	.33
ATGPA				
	HLCT	18	3.63	.23
	LLCT	14	3.28	.37

Table 5

California Critical Thinking Skills Test Score

Groups	N	M	SD
Juniors	18	17.67	3.73
Seniors	14	17.36	3.65
HLCT	18	20.11	2.37
LLCT	14	14.21	1.76

Table 6

Mean and Standard Deviation of Percentile Rank of California Critical Thinking Skills Test Score

Groups	N	M	SD
Juniors	18	55.81	23.21
Seniors	14	54.70	23.48
HLCT	18	72.65	11.24
LLCT	14	33.06	11.94

Table 7

Pre-Test and Post-Test Performance on C-TATSI for Higher-Level and Lower-Level Critical Thinking Groups

Groups	N	M	SD
Pre-Test			
LLCT	14	64.00	.15
HLCT	18	77.06	.11
Total	32	71.34	.14
Post-Test			
LLCT	14	67.29	.16
HLCT	18	76.78	.11
Total	32	72.63	.14

Table 8

Pre-Test and Post-Test Performance on C-TATSI Based on Participants' ATGPA and QPA

Groups	N	M	SD
Pre-Test			
ATGPA<3.5/4.0	16	67.56	14.94
ATGPA>3.5/4.0	16	75.12	12.35
Total	32	71.34	14.02
Post-Test			
ATGPA<3.5/4.0	16	69.50	16.60
ATGPA>3.5/4.0	16	75.75	9.34
Total	32	72.63	13.63
Pre-Test			
QPA <3.6/4	16	67.81	14.92
QPA>3.6/4.0	16	74.88	12.52
Total	32	71.34	14.02
Post-Test			
QPA <3.6/4	16	69.00	16.59
QPA>3.6/4.0	16	76.25	8.99
Total	32	72.63	13.26