CCTDI Assessment Report – Spring 2016

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1 INTRODUCTION

Florida SouthWestern State College's Quality Enhancement Plan goal is to permit first-time-in-college students to become independent learners proficient in critical thinking. Through course completion, students will be able to demonstrate their analytical and evaluation skills. One measurement for the achievement of that goal is the use of the California Critical Thinking Disposition Inventory tests (CCTDI). FSW has identified a set criterion for defining student advancement in the Cornerstone Experience course. The results of the overall means scores of the CCTDI are expected to statistically significantly improve in the following Critical Thinking Dispositions: Truth Seeking, Open-Mindedness, Analyticity, Systematicity, Inquisitiveness, Confidence in Reasoning, and Maturity of Judgment, as measured by the CCTDI. This report is the continued assessment of the FSW QEP.

Pre-test/post-test studies in small groups provide an assessment foundation for learning and skill set adoption under given criteria. While scores do yield some error related to the target subject such as grade level or demographic, many can be accounted for in small sub-samples (individual classes). Moreover, those correlative measures that cannot be accounted for can be better understood through assessment (Cole et al., 2011).

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2 STATISTICS

2.1 DESCRIPTIVE STATISTICS AND SIGNIFICANCE TESTING

During the spring 2016 semester, 375 total tests (pre- and post-) were administered to students. Of those, 225 of which were pre-/post- paired tests and 150 tests did not have counterparts. Pre-test and post-test mean scores for each dimension as well as the overall score are provided in Table 1. All dimensions exhibit improvements. The difference in the means from pre-to-post test scores for each dimension (Truth-seeking, Open mindedness, Inquisitiveness, Analyticity, Systematicity, Confidence in Reasoning, and Maturity of Judgment) was tested for significance using a paired means t-test according to standard methods (Davis, 1973; McDonald, 2009; Siegel, 1956; Wilkinson, 1999). The results of significance testing for each dimension are also shown in Table 1.

The paired means t-test results indicate that for Analyticity, Confidence in Reasoning and the overall score the results are statistically significantly different. In other words, we must reject the null hypothesis that the difference in the means of the pre- and post-test scores are equal to 0, and we can conclude this with a 95% confidence that the differences in scores are not solely due to chance.

For Analyticity and Confidence in Reasoning, which exhibits a statistically significant increase in mean score, it can be reasonably concluded that the average increase in score of the students as a group is a

result of some change in the students as a group. For the remaining dimensions, this cannot be stated or quantified.

Effect size was calculated using a method devised by Rosenthal and Rosnow (1991) for meta-analytical purposes in potential comparisons with other institutions (Lipsey and Wilson, 1993). The statistically significant results exhibit what Cohen (1988) would consider small-to-medium effect sizes ranging from 0.10 to 0.33 (Table 1). In other words, non-overlap from Pre-test scores to Post-test scores range from approximately 8% to 23%.

	Truth-seeking	Open Mindedness	Inquisitive-ness	Analyticity	Systematicity	Confidence in Reasoning	Maturity of Judgment	Overall
Pre-test Mean	36.0	42.1	49.4	45.3	42.2	45.6	41.1	297.5
Post-test Mean	36.8	42.5	49.4	46.4	42.7	47.6	41.4	306.6
Effect size	0.16	0.10	0.01	0.24	0.11	0.42	0.06	0.27
p-value	0.058	0.239	0.912	**0.004**	0.18	**9.05×10^{-7}**	0.436	**0.001**

Table 1. Comparison of mean scores for Pre/post test scores. Bold denote statistically significant difference. Positive effect sizes indicate a higher mean score for Post-test scores.

2.2   SUPPORTING EXPLORATORY DATA ANALYSIS

Since significance tests only provide information under the assumption the two groups are unchanged excepting for the learning in the classroom between pre-/post-tests, it is necessary to explore in detail each dimension using multiple standard processes for support of significance testing. In this way, the most effective assessment can be presented toward instructive improvement (Elder and Paul, 2007).
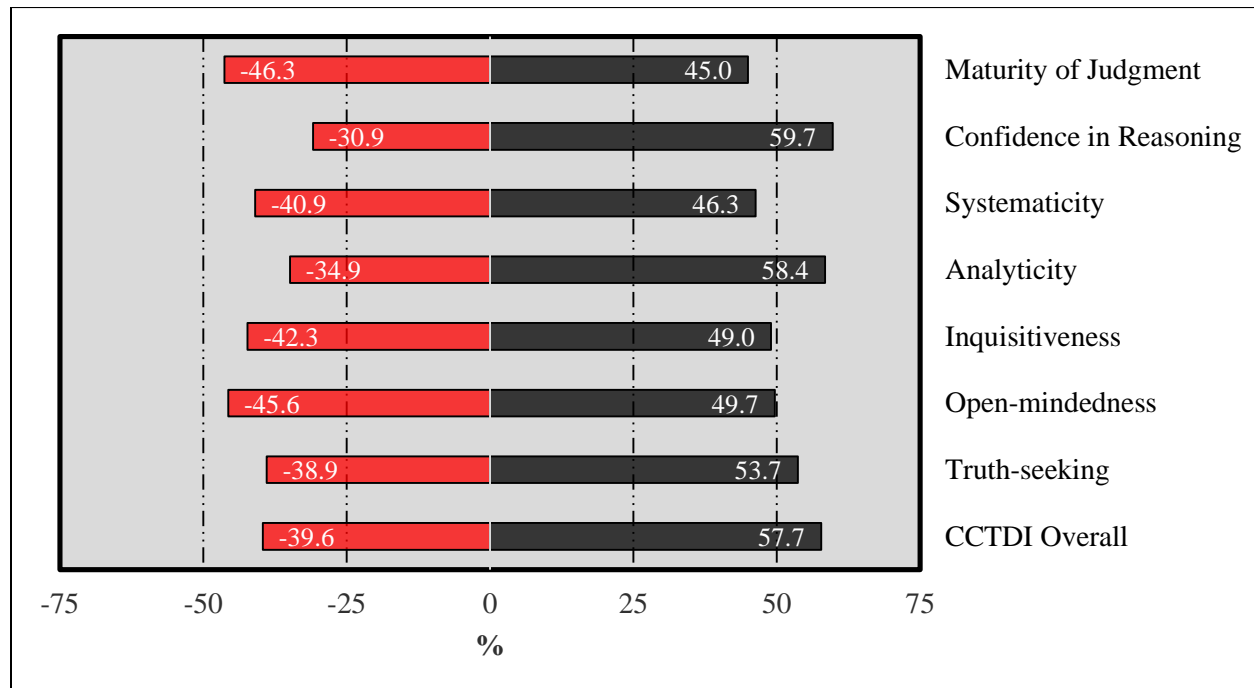

Figure 1. Percentage of students improved (black) vs. declined (red). Difference of the sum of increase and decline from 100 is the percentage of test takers that exhibited no change.

Figure 1 highlights the percentage of student test scores that improved and declined. The attributes of Confidence of Reasoning and Analyticity exhibit the greatest improvement percentages at 59.7% and 58.4%. By comparison, Maturity of Judgment shows the least improvement at 45.0%, which is actually lower than the decline percentage, 46.3%.

An empirical distribution (histogram) of each dimension is reported in Figures 2 through 8. Figure 2 depicts data distribution of the Truth-seeking dimension which exhibits a slight shift in the mode (central peak of the data) in conjunction with a slight decrease in kurtosis (peakedness of the curve).
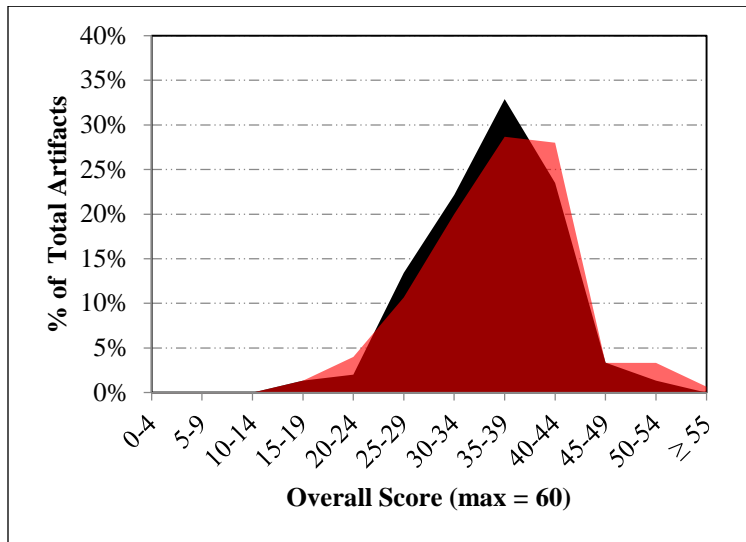

Figure 2. Truth-seeking dimension distribution of test scores for Pre- (black) and Post- (red).

Figure 3 depicts data distribution of the Open Mindedness which exhibits no discernable shift in the mode (central peak of the data) from pre-to-post test scores. When comparing pre-/post- scores, a decrease in the 35-39 and 45-49 scoring bins is coupled with increases in scoring bins 30-34 and 50-54.
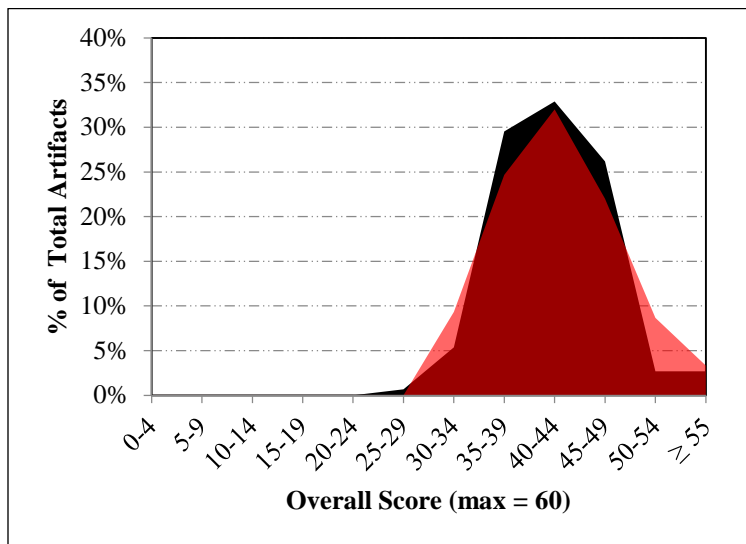

Figure 3. Open Mindedness dimension distribution of test scores for Pre- (black) and Post- (red).

Figure 4 depicts data distribution of the Inquisitiveness dimension which exhibits a discernable positive shift in the mode (central peak of the data) from pre-to-post test scores. As Inquisitiveness consistently exhibits the highest pre-test scores of any of the attributes, historically it is not uncommon to see little change from pre-to-post test scores in FSW studies typically the lowest change of the seven attributes (see Section 2.3 Longitudinal Studies). However, for this term, the Inquisitiveness attribute ranks 5th of 7 attributes in terms of improvement. When comparing pre-/post- scores, decreases in the 45-49 scoring bin is coupled with an increase in scorings bins 50-54 and ≥ 55.
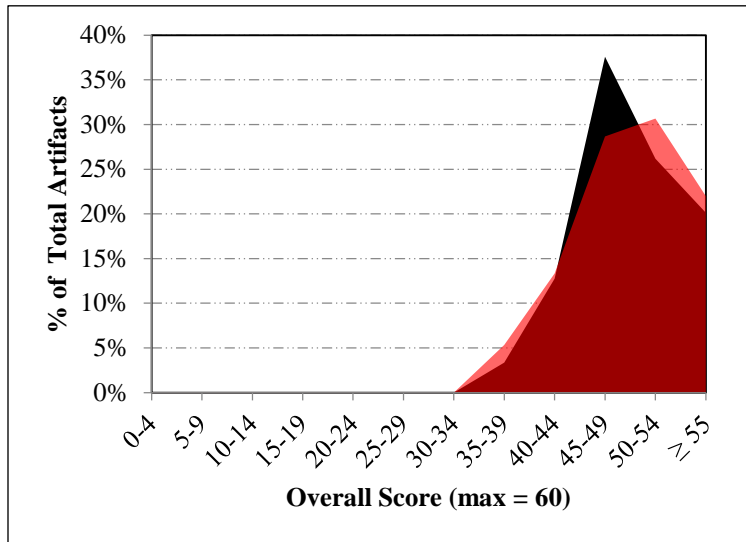

Figure 4. Inquisitiveness dimension distribution of test scores for Pre- (black) and Post- (red).

Figure 5 depicts data distribution of the Analyticity dimension which exhibits no shift in the mode (central peak of the data). When comparing pre-to-post scores, a net decrease in test scores in the 40-44 scoring bins is coupled with an increase in scoring bins 50-54 and above.
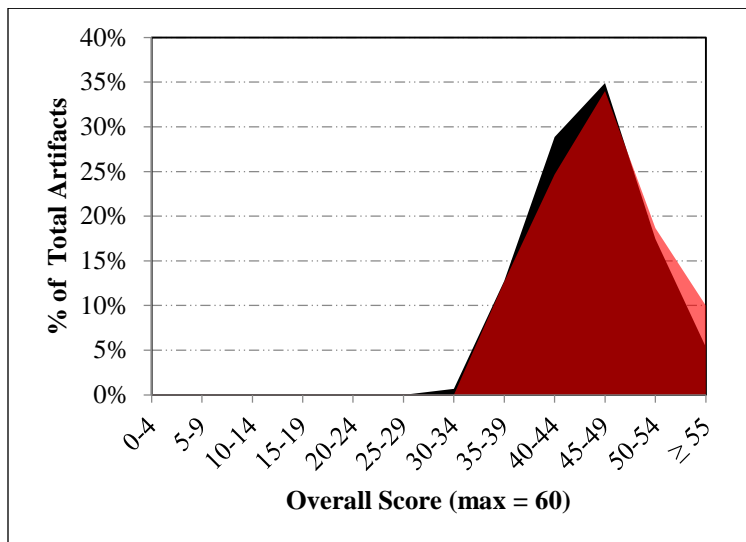

Figure 5. Analyticity dimension distribution of test scores for Pre- (black) and Post- (red).

Figure 6 depicts data distribution of the Systematicity dimension exhibiting no discernible shift in the mode (central peak of the data) or change in skewness/kurtosis (shape of the curve). Decreses in the 35-39 and 45-49 scoring bins are coupled with increases in the 40-44 and 50-54 scoring bins. Similar cases in which systematicity did not significantly change following early testing have been reported (Beser and Kissal, 2009).
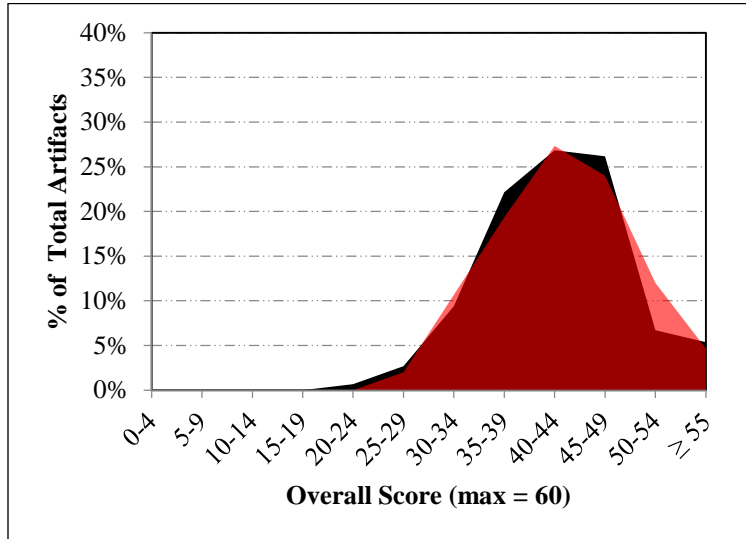

Figure 6. Systematicity dimension distribution of test scores for Pre- (black) and Post- (red).

Figure 7 depicts data distribution of the Confidence in Reasoning dimension. The post-test scores exhibit a shift in modality (central tendency of data) from 40-44 scoring bin in pre-test scores to 45-49 scoring bin in post-test scores. Additionally, a slight decrease in kurtosis (data more spread out) is also present. Net decreases in post-test scores in the number of scores in the 45-49 scoring bin and below can be seen coupled with net increases in post-test scores in both the 50-54 bin and above.
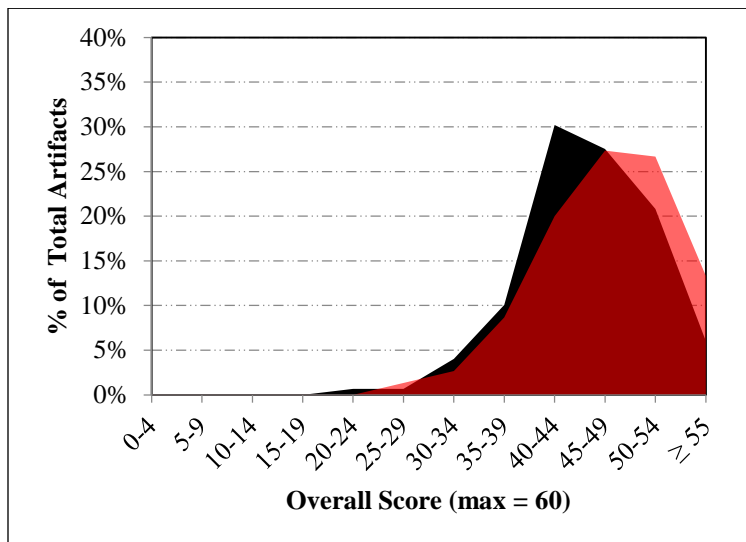

Figure 7. Confidence in Reasoning dimension distribution of test scores for Pre- (black) and Post- (red).

Figure 8 depicts data distribution of the Maturity of Judgment. The post-test distribution has a noticeably diminished kurtosis (smaller peak to the data). Large decreases in the 30-44 scoring bins from pre-to-post are coupled with large increases in the 25-29 and 45-49 and above scoring bins.
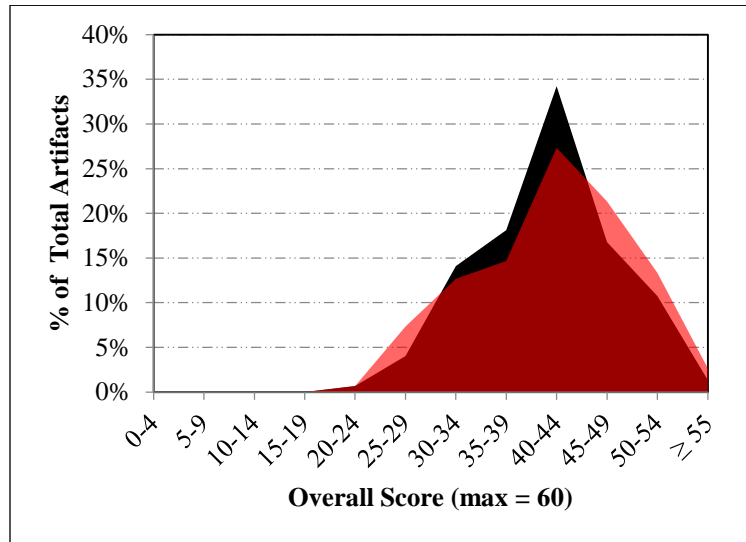

Figure 8. Maturity of Judgment dimension distribution of test scores for Pre- (black) and Post- (red).

2.3 LONGITUDINAL STUDY

The results of paired means t-test of pre-/post- test scores for all semesters from fall 2012 through spring 2016 are shown in Table 2. Truth-seeking, Open-Mindedness, Analyticity, and Confidence in Reasoning exhibit improvements from pre-test to post-test in all terms, although not all improvements are statistically significant. The Confidence in Reasoning attribute has exhibited statistically significant improvements in all 10 terms. Analyticity exhibits a similar rate, with statistically significant improvement in 9 of 10 terms. The Truth-seeking attribute also demonstrates strong results with 7 of 10 terms exhibiting statistically significant improvement.

	Truth-seeking	Open Mindedness	Inquisitiveness	Analyticity	Systematicity	Confidence in Reasoning	Maturity of Judgment
Fall '12	1.1	0.7	0.7	1	0.8	1.6	1.2
Spring '13	0.4	0.7*	0.1	1.2	0.8*	1.8	1.1
Summer '13	0.8	0.4	0.4	1.1	1.1	2.6	0.0
Fall '13	0.5	0.0	-0.6	0.4*	0.0	1.4	-0.1
Spring '14	1.1	0.8	0.0	1.2	0.8	1.7	1.1
Summer '14	0.8*	0.5	0.2	1.2	1.6	1.8	0.1
Fall '14	0.8	0.4*	-0.3	0.7	0.2	1.7	-0.2*
Spring '15	0.9	1.0	0.1	1.3	0.4*	2.3	-0.0
Fall '15[#]	0.0	0.0	-0.4	0.5	-0.5	1.3	0.3
Spring '16[#]	0.8	0.4	0.0	1.1	0.6	2.0	0.3

*Table 2. SLS 1515 CCTDI Pre-/Post- test results mean difference. Comparison of significance test results for mean difference of pre-/post-test scores for Fall 2012 through Fall 2015. Shaded cells indicate statistically significant differences in the mean at the 95% confidence level. Red text denotes decrease from pre-to-post. *Denote marginal significance as defined by Johnson (2013). [#]Indicate scores originate from a random sample of the full SLS 1515 population.*

Table 3 provides additional information regarding the paired means t-test including the observed t-statistic (t_{obs}) and probability of difference due to chance (p-value) with respect to the degrees of freedom for each study. No effect size is reported since the method of calculation for this study has not been consistent historically (Rosenthal and Rosnow, 1991; Dunlop et al., 1996).

	Truth-seeking	Open Mindedness	Inquisitiveness	Analyticity	Systematicity	Confidence in Reasoning	Maturity of Judgment
Fall 2012 t_{crit} = 1.97	t(365)=4.00, p<0.05	t(365)=2.67, p<0.05	t(365)=2.40, p<0.05	t(365)=4.18, p<0.05	t(365)=2.81, p<0.05	t(365)=5.97, p<0.05	t(365)=3.73, p<0.05
Spring 2013 t_{crit} = 1.97	t(204)=1.09, p=0.275	t(204)=2.24, p=0.026*	t(204)=0.24, p=0.813	t(204)=3.46, p=0.0007	t(204)=2.08, p=0.039*	t(204)=5.28, p<0.001	t(204)=2.89, p=0.004
Summer 2013 t_{crit} = 1.98	t(145)=1.71, p=0.090	t(145)=0.94, p=0.347	t(145)=0.95, p=0.345	t(145)=2.92, p=0.004	t(145)==2.69, p=0.008	t(145)=5.79, p<0.001	t(145)=0.03, p=0.980
Fall 2013 t_{crit} = 1.97	t(859)=2.69, p=0.007	t(859)=0.07, 0.941	t(859)=3.10, p=0.002	t(859)=2.26, p=0.024*	t(859)=0.05, p=0.963	t(859)=7.71, p<0.001	t(859)=0.54, p=0.590
Spring 2014 t_{crit} = 1.97	t(407)=3.91, p=1.09x10^{-4}	t(407)=3.36, p=8.56x10^{-4}	t(407)=2.83, p=0.907	t(407)=5.00, p=8.72x10^{-7}	t(407)=2.83, p=0.005	t(407)=6.02, p=2.95x10^{-9}	t(407)=3.47, p=5.79x10^{-4}
Summer 2014 t_{crit} = 1.97	t(173)=2.14, p=0.034*	t(173)=1.34, p=0.183	t(173)=0.57, p=0.570	t(173)=3.84, p=1.70x10^{-4}	t(173)=4.19, p=4.44x10^{-5}	t(173)=4.98, p=1.52x10^{-6}	t(173)=0.31, p=0.755
Fall 2014 t_{crit} = 1.97	t(1848)=5.82, p=7.88x10^{-8}	t(1848)=2.57, p=6.74x10^{-9}	t(1848)= -2.78, p=0.010	t(1848)=6.01, p=0.005	t(1848)=0.55, p=2.30x10^{-9}	t(1848)=13.80, p=2.77x10^{-41}	t(1848)=-2.20, p=0.028*
Spring 2015 t_{crit} = 1.97	t(764)=4.36, p=7.44x10^{-12}	t(764)=5.46, p=1.51 x10^{-5}	t(764)=0.51, p=0.608	t(764)=7.58, p=9.82x10^{-14}	t(764)=2.26, p=0.024	t(764)=11.79, p=1.41x10^{-29}	t(764)=-0.06, p=0.954
Fall 2015 t_{crit} = 1.97	t(268)=0.03, p=0.974	t(268)=0.08, p=0.936	t(268)=-1.11, p=0.178	t(268)=1.61, p=0.108	t(268)=-1.65, p=0.101	t(268)=4.11, p=5.26x10^{-5}	t(268)=0.80, p=0.422
Spring 2016 t_{crit} = 1.97	t(148)=1.91, p=0.058	t(148)=1.18, p=0.239	t(148)=0.11, p=0.912	t(148)=2.93, p=0.004	t(148)=1.35, 0.180	t(148)=5.13, p=9.05x10^{-5}	t(148)=0.78, p=0.436

*Table 3. Additional significance testing statistics for attributes including observed t-stat (t_{obs}), probability of difference due to chance (p-value), degrees of freedom (df), and critical t-stat. In some cases, earlier reports did not include p-value when p<0.05 or in later studies, p<<0.001 and are indicated where applicable. Mean difference of pre-/post-test scores are reported in Table 3. *Denote marginal significance as defined by Johnson (2013).*

Figure 9 is a graphical representation of the difference in mean scores of attributes across all semesters. The consistently strong improvement in scores from pre-to-post tests of the Confidence in Reasoning attribute is clearly visible (see consistent red zones in Figure 9). Analyticity exhibits the second strongest improvement over time followed by Truth-seeking.

By comparison, the attribute with minimal results across all semesters is Inquisitiveness (see consistent white or blue zones in Figure 9). This dimension has the lowest mean score difference across all but one semester (summer 2013) and exhibited a decline from pre-to-post scores in the fall 2013, fall 2014, and fall 2015 semesters.

In terms of variability, Systematicity exhibits the widest variation of any indicator, as high as +1.6 in summer 2014, and as low as -0.5 in fall 2013, a range of 2.1. The Inquisitiveness attribute also exhibits substantial variability from as high as +1.4 in summer 2013 to as low as -0.6 in fall 2013, a range of 1.9. Analyticity is the most stable of all attributes with a range of just 0.9 from highest (+1.3) in spring 2015 to lost (+0.4) in fall 2013.
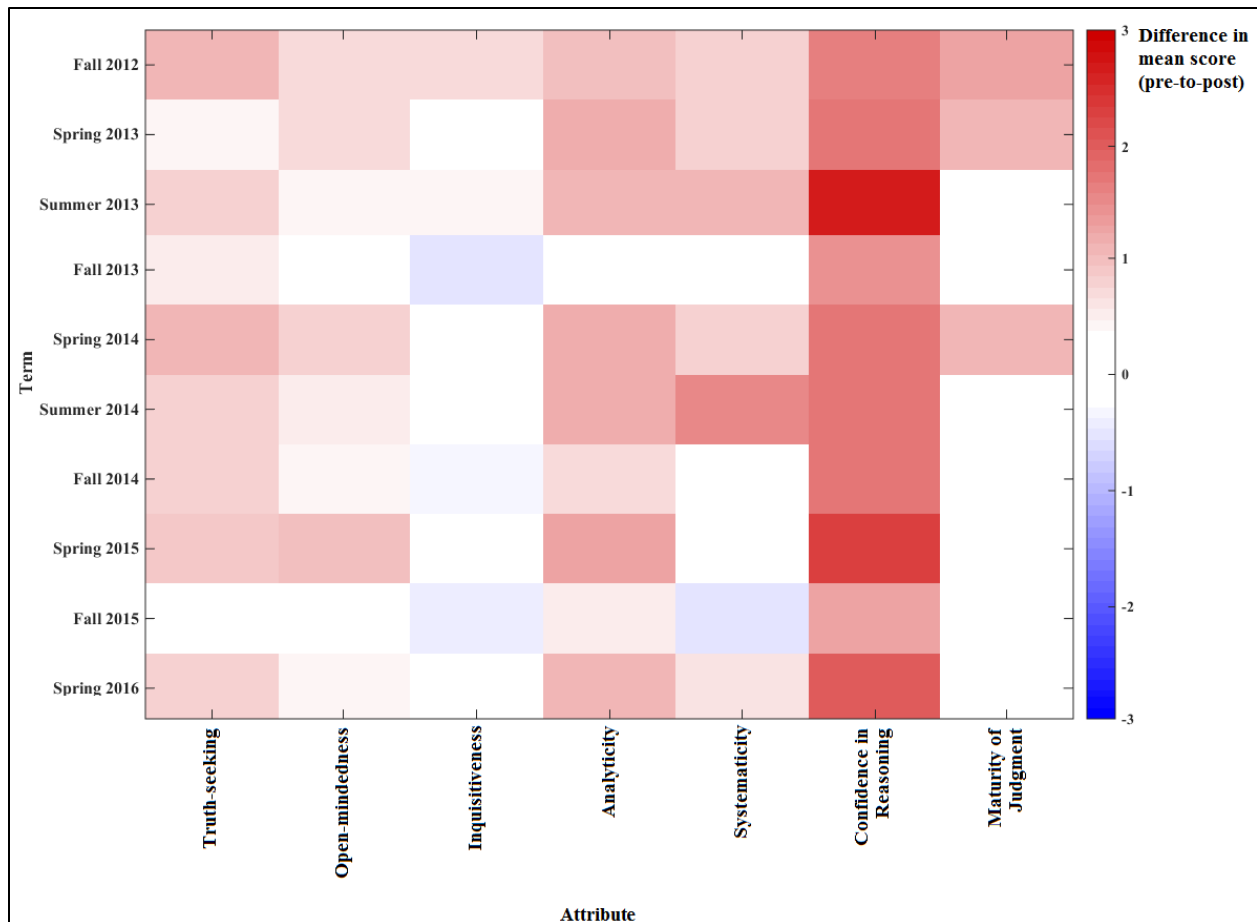
Figure 9. Colormap comparison of the difference in mean scores from pre-to-post tests across semester by attribute. White areas denote results that have never been statistically significant (approximately +/- 0.35). Color bar represents maximum range of changes in the mean from pre-test to post-test with strongest positive changes in the mean denoted by darker reds and strongest negative changes in the mean denoted by darker blues.

The attributes of the CCTDI exhibit a wide range of scores from pre-test to post-test. In some cases, the post-test scores of one attribute are lower than the pre-test scores of another. A review of this comparison can be helpful in determining if there is further room for improvement in that attribute as well as if minimal improvements are a result of an already strong attribute score. Figure 10 compares time-averaged pre-test mean scores from fall 2012 through the present to time-averaged post-test mean scores. Note that the highest pre-test scoring attribute, Inquisitiveness, also exhibits the smallest improvement from pre-to-post test with an improvement that barely registers on the graph. By comparison, the second highest pre-test attribute, Confidence in Reasoning, exhibits the largest improvement. For more clarity, see Figure 11 which displays time-averaged pre-test scores with time-averaged improvements from pre-test to post-test.
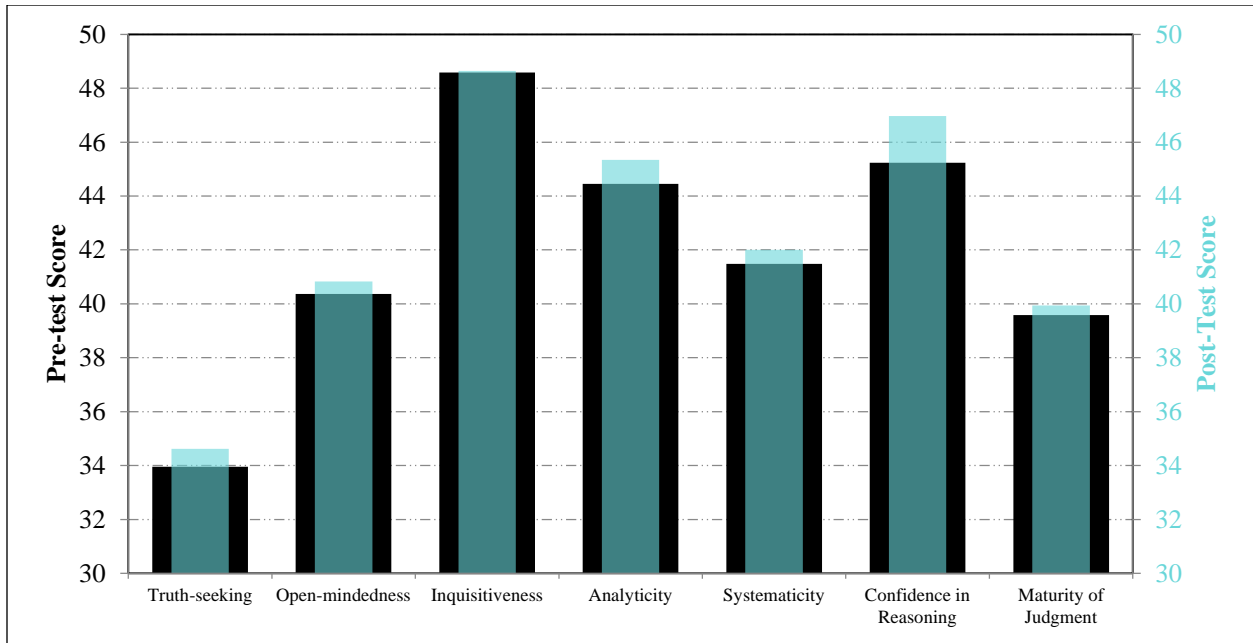
Figure 10. Average through time of the CCTDI mean scores from pre-test (black) to post-test (teal) from fall 2012 through the present.
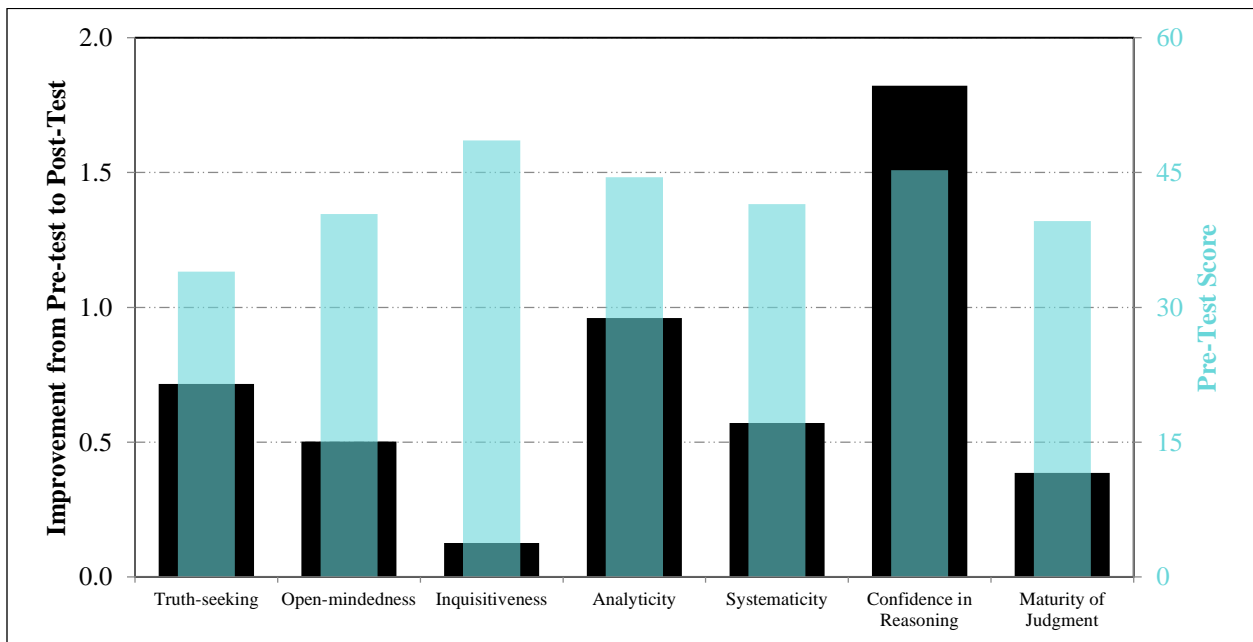

Figure 11. Time-averaged CCTDI mean improvement from pre-to-post test (black) compared with time-averaged mean scores from pre-test (teal).

3   CONCLUSIONS

In Florida SouthWestern State College's QEP assessment, students are expected to improve in the seven Critical Thinking Dispositions: Truth Seeking, Open-Mindedness, Analyticity, Systematicity, Inquisitiveness, Confidence in Reasoning, and Maturity of Judgment based on exposure to these topics in the SLS 1515 *Cornerstone Experience* course. These dispositions are measured using the California Critical Thinking Disposition Inventory tests (CCTDI) and analysis between pre-test (first three weeks of semester testing date) and post-test (last three weeks of semester testing date) is performed.

A drilldown of the results of the CCTDI spring 2016 assessment are as follows:
1. The means of post-test scores exhibit statistically significant improvement over means of pre-test scores in the Confidence in Reasoning and Analyticity attributes although all attributes exhibit improvement.
2. In a comparison of students who improved from pre-to-post and those that didn't, all attributes exhibit a greater population of students who improved from pre-to-post test scores than declined.   Confidence of Reasoning and Analyticity exhibit the greatest improvement percentages at 59.7% and 58.4%.
3. In a longitudinal study, since comparisons began in fall 2012 the three attributes that have consistently exhibited the largest improvement in scores from pre-/post-test scores are 1) Confidence in Reasoning, 2) Analyticity and 3) Truth-seeking, in that order. All three dimensions have exhibited increases in mean score across all semesters although in the case of the latter two, some were not statistically significant.
4. In the same longitudinal study, the attribute with minimal results across all semesters is Inquisitiveness and exhibits a decline from pre-to-post scores in fall 2013, fall 2014, spring 2015, and fall 2015.
5. In the same longitudinal study, a comparison between time-averaged pre-test mean scores from fall 2012 through the present to time-averaged post-test mean scores exhibits he highest pre-test scoring attribute, Inquisitiveness, also exhibits the smallest improvement from pre-to-post test with an improvement that barely registers on the graph. Meanwhile, the second highest pre-test attribute, Confidence in Reasoning, exhibits the largest improvement.

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