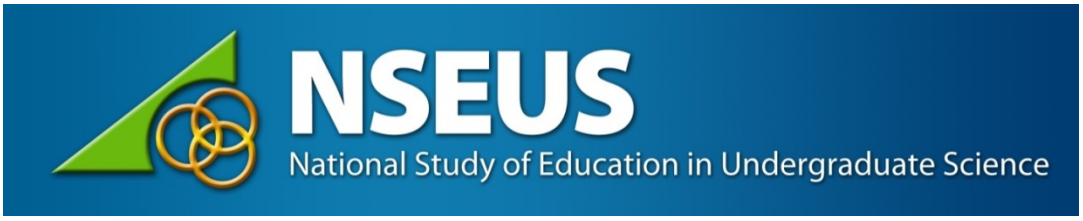

Background Research Paper No. 6

Measuring Differences in Student Perception of the Learning Environment in Undergraduate Entry-Level Science Courses

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The current study addresses four National Science Education Standards (National Research Council [NRC], 1996, pp 28ff and Siebert, & McIntosh, 2001) assumptions; what students learn is greatly influenced by how they are taught, the actions of teachers are deeply influenced by their perceptions of science as an enterprise and as a subject to be taught and learned, student understanding is actively constructed through individual and social processes, and actions of teachers are deeply influenced by their understanding of and relationships with students.

Science teaching requires specialized knowledge that is refined by faculty over time and through extensive experience (Loughran, Gunstone, Berry, Milroy, & Mulhall, 2000). We should expect to see differences among faculty instructors of science in our undergraduate science classrooms based on differences in their knowledge of teaching, its application to actual classrooms with students, and the context faculty find themselves in relating to their institution (Sorensen, Evans, & Andersen, 2009; Bland-Day, 1999). Shulman (1987) stated that teacher development of specialized teaching knowledge is even more critical in inquiry-based classrooms. For those undergraduate science courses involved in reforms set in interpreting the guidelines of the National Science Education Standards (p. 7), the knowledge of teaching science, as opposed to a person's knowledge of science, has a great impact on and is particularly important to, the teaching and learning of science by students (Mason, 1999; Gess-Newsome, 1999; Magnusson et al., 1999; Morine-Dershimer, & Kent, 1999; Shulman, 1987).

Research Question

Building on the existing research base, this study investigated undergraduate students' preferences and perceptions of the learning environment experienced in courses at 11 institutions of higher education selected from a US national population of institutions. These institutions, and one or more of their science courses, were involved in the NASA Opportunities for Visionary Academics (NASA/NOVA) faculty professional development program initiated in 1996. The multifaceted NASA/NOVA program was designed to foster reform in higher education through development and modification of entry-level, undergraduate science courses. A total of 103 institutions were involved in the program over a 10 year period.

This study addresses the overall problem, "*How do undergraduate entry-level science courses, differing in level of reform, affect students' perceptual understanding of the learning environment?"* Since significant professional development efforts are underway to enable higher education faculty to reform undergraduate courses, it is important to investigate key variables related to the problem.

Procedure

Building on the existing research base, the study investigated undergraduate student's perceptual understanding of the learning environment experienced in courses selected from a national population of higher education institutions. This study addressed the problem, "*How do undergraduate entry-level science courses, differing in level of reform, affect student perceptual understanding of the learning environment?"* Since significant professional development efforts are underway to enable higher education faculty to reform undergraduate courses, it is important to investigate important variables related to the problem (Sunal, et. al. 2001).

The study institutions, and one or more of their science courses, were involved in the NASA Opportunities for Visionary Academics (NASA/NOVA) faculty professional development program initiated in 1996 (NOVA, n.d.). The multifaceted NASA/NOVA program was designed to foster reform in higher education through development and modification of entry-level, undergraduate science courses. The study's population thus included faculty from a diverse national group of 103 institutions that had undergone reform over a 10 year period in one or more of their undergraduate science courses. The population surveyed ranged from tribal colleges to Doctoral/research universities-extensive (R-I) using the Carnegie (1994) classification, see Figure 1. A sample of faculty from eleven of these institutions was selected to participate in this study.

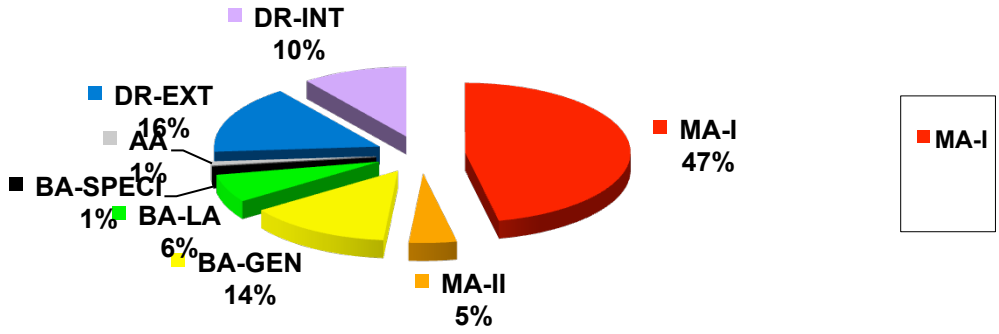

Figure 1: Carnegie classification of the population of higher education institutions in the survey.

The NOVA program invited the participation of undergraduate faculty concerned with improving entry level undergraduate science and mathematics courses between the years 1996 to 2006. Through NOVA, reform science courses were developed by collaborative teams of faculty in the sciences and education. Participation in NOVA included opportunities for, and commitment to, enhanced knowledge and skills through workshops, exemplary models, grant

funding, mentoring, evaluation site visits, and collaboration within and between higher education institutions. The NOVA professional development model was delivered in three *phases*: (1) *planning and preparation,* involving training, collaboration, and action planning for addressing baseline needs in faculty skills and knowledge enhancement; (2) *development and implementation*, involving initial course change, action research, mentoring, and sharing of expertise; and (3) *continuing development and long-term sustaining activity*, involving action research, networking, monitoring including site visits, and dissemination (Sunal et al., 2004).

In a survey of the population from which the sample was selected, it was found that the learning environment in reform courses at these institutions shared four common course features:

1) involving all students in an inquiry/investigative approach to learning science,
2) including fully integrated inquiry/investigative activities that involved the majority of a week's class time
3) using collaborative and cooperative learning groups during course activities,
4) using continuous alternative assessment, rather than using only a few traditional exams. (Sunal et al, 2008a, Sunal & Sunal, 2008b; Sunal, Sunal, Sundberg, Mason, & Lardy, 2008c; Sunal et al., 2008d; Sunal et al., 2008e; Sunal, Sunal, Mason & Zollman, 2008f)

The reformed courses in the sample were developed at various times between 1996 and 2005. All still are being offered at their respective institutions. Reform course student activities involving the science laboratory, during and outside of a class, included about two-thirds of the class time per week (see Table 1). The other one-third of class time involved interactive discussions, use of technology, and lecture. The instructional methods reported for these reformed courses contrast with the emphasis placed on similar course features in sampling of comparison undergraduate science courses at the same institutions (Sunal et. al., 2008d) (see Table 1).

Table 1
Instructional Methods Used in Reform and Comparison Courses

Instructional Method	Reform Course Average % of Time per Week	Comparison Course Average % of Time per Week
Lecture	15%	63%
Traditional Lab	03%	12%
Discussion/Interaction with student groups	10%	3%
Inquiry Based Integrated lab	68%	16%
Integrated use of technology	04%	06%

Faculty from two sets of courses, reformed and comparison were selected from the sample institutions. Pre and post testing along with on-site case study visits were completed with 19 faculty teaching entry level undergraduate science courses at the 11 higher education institutions. Two institutions were excluded because of low returns on the post-test data. The sample was geographically diverse, residing in nine states throughout the United States. The

higher education institutions, universities and colleges, range in size from 4000 to over 40,000 with an average student population of about 13,000. Carnegie designations of the sample institutions are six MA granting institutions, two research doctoral granting institutions, and three minority designated MA granting institutions. The 19 undergraduate science courses included in the institutional sample had an average class size of 35 students with a range of 18 to 70 students. Several were one section of a multiple section course with their own lecture/lab/and discussion periods. The course science disciplines included physics, astronomy, physical science, biology, integrated science, and geology.

Data Collection Instruments

The *Constructivist Learning Environment Survey* instrument (CLES) was developed by Peter C. Taylor and Barry J. Fraser in 1997 to enable teachers of science to monitor their constructivist approaches to teaching. The CLES was intended to allow teachers to understand their students' perceptions of the extent to which the classroom learning environment enabled them to reflect on their prior knowledge, develop as autonomous learners, and negotiate their understandings with other students. The instrument contains five scales; (1) the *Personal Relevance Scale* measures how relevant students feel the course content is to their lives outside of the classroom, (2) the *Shared Control Scale* measures students' perceptions of their control over classroom learning, (3) the *Critical Voice Scale* measures students' perceptions of their ability to question the teacher's pedagogy, (4) the *Student Negotiation Scale* measures students' perceptions of their ability to share their ideas with other students in the classroom, and (5) the *Uncertainty Scale* measures students' perceptions of the level of inquiry based science knowledge in the classroom. Two versions of the instrument were given to the students during the semester. The first version involves participants in identifying the kind of classroom learning environment they prefer and is given during the beginning of the semester, preferences or expectations. The second version involves participants in identifying the classroom experience they have had as they perceive that experience and is given at the end of the semester, perceptions or perceptual understanding of experiences.

The CLES instrument has been used to determine if there was a difference in student perception of traditional versus constructivist and inquiry-oriented teaching at the higher education level. Several examples of the use of the CLES to monitor the development of constructivist practices at the secondary level can be found in the literature. Wright (2009) used the CLES to monitor student perceptions of traditional (comparison) vs. constructivist (experimental) treatments in a higher education level environmental studies course. Significant differences were found between the two groups with the constructivist treatment group having a higher positive perception of the classroom environment as inquiry oriented at the end of the semester indicating that the experimental groups experienced more constructivist learning than the traditional groups. Shin, Kim and Kim (2005) used the instrument to measure student's perception of the classroom environment before and after the implementation of a virtual reality module in an earth sciences class designed for pre-service teachers. Their results indicated this module increased students' perceptions (ratings) of the classroom environment as facilitative, in particular on the shared control scale.

In this study, the CLES was used to examine students' preferences (expectations) and perceptions (perceptual understanding) of the learning environment in the sample of undergraduate science classes that had undergone reform under the NASA/NOVA program in a population of 103 higher education institutions as compared to non-reformed classes at the same institutions. The NOVA courses were developed and offered at various times beginning in 1996 in a large professional development effort to create reforms in higher education undergraduate, entry-level science courses.

The CLES instrument was given twice during the first week and during the last two weeks the semester to undergraduate students in the selected courses at 11 institutions. The instrument was delivered online outside of the regular class time. After completing consent forms in class, students were instructed to respond to an email providing the Internet URL where the CLES could be completed. Students had not completed the instrument after a brief time were reminded on a periodic basis over a few days to complete the instrument. Students' data were stored electronically and could be downloaded for analysis. All analyses were conducted at the 95% confidence level. The CLES instrument uses a five point Likert-type scale with the categories of *almost always* (5 points), *often* (4 points), *sometimes* (3 points) *seldom* (2 points), and *almost never* (1 point). To measure differences in students' perceptions of learning in their classes, the students' responses were averaged to give a final score ranging from one to five. The scores among students were compared using the overall total score and then were compared on the separate scales of the CLES. Reported here are differences in students' overall perceptions of the classroom environment based on course, institution, or both variables.

Results

Pre and Post CLES Results

The purposes for the administration of CLES were to determine if what students preferred for the classroom environment did occur, and to determine if students enrolled in a reformed vs. a comparison science class showed a difference in their perceptions of the classroom environment. The differences in classroom *preferences* between all students enrolled in the reformed and comparison courses were measured using the pre test version of CLES. Students enrolled in the reformed science courses (n = 189) had a mean score of 3.13 (*SD* = 0.827) on the preferred version of the CLES given at the beginning of the semester. Students enrolled in the non-reformed science courses (n = 148) had a mean score of 3.03 (*SD* = 0.784). There was insufficient evidence to indicate a statistically significant *(F* = 1.397; p = 0.238) difference in *preference* for the classroom environment between students enrolled in reformed or comparison science courses before instruction. Students enrolled in the science classes observed during the study had similar preferences for the learning environment before instruction began.

The differences in classroom *perceptions* between all students enrolled in the reformed and comparison courses were measured time using the post test version of CLES. After instruction, the students in the reformed science courses (n = 128) had an average score of 3.79 (*SD* = 0.686) and students enrolled in the comparison science courses (n = 128) had an average score on the post test version of CLES of 3.41 (*SD* = 0.762). There was sufficient evidence (*F* = 17.597, $p < 0.001$) to indicate a significant statistical difference in scores on CLES between

students in the reformed courses and comparison courses after instruction. Students enrolled in the reformed undergraduate science courses perceived more authentic experiences of the inquiry teaching and learning than did students enrolled in the comparison undergraduate science courses.

Comparisons of Pre and Post CLES

A paired *t*-test was performed to see if there was a statistical difference between the *preferred* test responses taken at the beginning of the semester and the *perceived* test responses taken at the end of the semester. A statistically higher score on the perceived version of the test indicates that the students preferred the method of instruction that occurred during the course (Taylor & Fraser, 1997; Cannon, 1997). The average score for the students in the study (n = 167) was 3.16 (*SD* = 0.813) before instruction and 3.62 (*SD = 0.*762) after instruction. The mean increase on the CLES from the beginning of the semester to the end of the semester was statistically greater than zero, providing evidence *(t* = -6.032, $p < 0.001$) that students' preference in regard to the inquiry classroom environment had been better met during the semester in the reformed class.

To determine if students enrolled in the reformed science courses showed a greater increase on CLES than students enrolled in the comparison science courses, the split file was used to divide the data into reformed or comparison groups, and a second paired *t*-test was run. Students enrolled in the reformed science courses (n = 93) had an average score of 3.17 (*SD* = 0.833) before instruction and an average score of 3.76 (*SD* = 0.715) after instruction. The mean increase on CLES was statistically greater than zero, providing evidence (t (92) = -6.130; $p <$ 0.001) that students reported that their preferred method of instruction was used in during the course. Students enrolled in the comparison science courses (n = 74) had an average score of 3.15 (*SD*= 0.792) at the beginning of the semester and an average score of 3.44 (*s* = 0.787) at the end of the semester. There was sufficient statistical data (t (73) = -2.442; p = 0.017) to suggest that the mean increase in score on CLES by students in the traditional science courses was greater than zero. Students in the comparison science courses reported that their preferred method of instruction was used during the course. Although students enrolled in both reformed and comparison science classes showed an increase in perception of the classroom environment in terms of constructivist inquiry orientation, the students in the reformed classes reported a significantly higher score. The students in the reformed courses perceived a higher level of constructivist reform in the classroom and that they perceived that their preferred method of instruction was used to a greater degree.

Comparison of CLES Results by Institution Type

The change in score on the CLES from the beginning of the semester to the end of the semester may have been dependent on the type of institution students attended. The institutions in the study vary from research intensive to tribal college. Institution demographics are shown in Table 2.

Table 2: **Institution Demographics**

Institution	Carnegie Designation	Student Population	Average Sample Course Size
100	DR-EXT	29,000	40
200	MA-I (Tribal)	4,000	15
300	BA-GEN	3,500	20
500	MA-I	7,500	24
700	MA-I	21,500	48
800	DR-INT	40,400	50
900	MA-I	20,500	40
1000	MA-I	2,000	18
1100	MA-I	4,300	28

Undergraduate student preferences and perceptions of the classroom environment may be influenced by environmental factors outside of the classroom that are not controlled by the course instructor. Students attending smaller institutions may have different expectations and perceptions of the learning environment than students attending larger institutions. Students in smaller classes may have different perceptions of the learning environment than students in larger classes. Faculty may feel restricted in the type of learning environment implemented by the size of the class. The differences may be influential when trying to make a comparison between courses using different levels of reform in the sample. To determine if there were any differences in mean score between the types of institutions, the CLES scores were compared based on institution. The results of these comparisons are shown in Tables 3 and 4. As depicted in Table 3, at the 95% confidence level, there was significant statistical evidence to suggest that the difference between the pre- and post-CLES score was greater than zero for five institutions (100, 200, 300, 700, and 1100). There was insufficient statistical evidence at the 95% confidence level to suggest that the difference between the pre- and post-test scores was greater than zero at four institutions (500, 800, 900, and 1000). *Institution type* was not an important factor in determining change in scores reported on the CLES. Other factors such as academic major, student attitude for science, or number of science classes taken may be factors, in addition to reform variables, influencing differences in CLES score at institutions where no difference between pre- and post-CLES score was found.

Table 3: Paired *t*-test Comparing Students' Pre- and Post-test Scores at Individual Institutions.

Institution	Variable	Mean	N	Standard Deviation	*t*	Sig
100	Pre-CLES	2.98	33	0.575	-2.232	0.033
	Post-CLES	3.36	33	0.888		
200	Pre-CLES	3.30	18	0.882	-3.632	0.002
	Post-CLES	3.96	18	0.568		
300	Pre-CLES	3.11	21	0.787	-3.822	0.001
	Post-CLES	3.76	21	0.563		
500	Pre-CLES	3.06	21	0.877	-2.017	0.057
	Post-CLES	3.51	21	0.616		
700	Pre-CLES	2.76	17	0.885	-3.428	

	Post-CLES	3.81	17	0.813		0.003
800	Pre-CLES	3.01	11	0.752	-1.408	0.189
	Post-CLES	3.35	11	0.941		
900	Pre-CLES	3.60	28	0.686	1.343	0.191
	Post-CLES	3.39	28	0.801		
1000	Pre-CLES	3.50	6	0.422	-1.836	0.126
	Post-CLES	3.96	6	0.335		
1100	Pre-CLES	3.21	12	0.839	-3.180	0.009
	Post-CLES	4.16	12	0.469		

The data were split by institution and course for analysis to determine if there was a difference between students based on institution and course. The results are shown in Table 4. The students enrolled in the science courses in the study showed an increase in their scores on the CLES, except for students in courses at institution 900, where the score remained the same for the reformed science course and decreased for the comparison course. Students at institutions 100, 200, 300 and 1000 reported a statistically significant difference between mean scores of the pre- and post-tests in the reformed course only. Institution 700 showed a statistically significant difference between the pre-test and the post-test in the comparison course only. Institutions 500, 800, and 900 remained the same. The results suggest that in general, students enrolled in the reformed courses reported the perception of a greater inquiry orientation of the classroom environment than students enrolled in comparison science courses. In the instance where the students in the comparison course had a higher perception of the classroom environment, other factors not considered in this report may have been influential. At institutions 500, 800, and 900 factors not examined in this study may have influenced the students' perceptions of the classroom environment.

Table 4: Paired *t*-test Comparing Students' Pre- and Post-test Scores at Individual Institutions Based on Course Enrollment

Institution	Course	Variable	Mean	N	Standard Deviation	*t*	Sig
100	Reform	Pre-CLES	3.02	20	0.843	-2.359	0.029
		Post-CLES	3.58	20	0.884		
	Comparison	Pre-CLES	2.91	13	0.626	-0.468	0.647
		Post-CLES	3.02	13	0.810		
200	Reform	Pre-CLES	3.41	15	0.843	-3.522	0.003
		Post-CLES	4.06	15	0.506		
	Comparison	Pre-CLES	2.72	3	1.02	-0.997	0.423
		Post-	3.41	3	0.635		

		CLES					
300	Reform	Pre-CLES	2.46	8	0.632	-4.026	0.005
		Post-CLES	3.48	8	0.313		
	Comparison	Pre-CLES	3.51	13	0.583	-2.021	0.066
		Post-CLES	3.92	13	0.624		
500	Reform	Pre-CLES	2.74	2	0.311	-1.400	0.394
		Post-CLES	3.44	2	0.395		
	Comparison	Pre-CLES	3.09	19	0.914	-1.743	0.098
		Post-CLES	3.51	19	0.642		
700	Reform	Pre-CLES	3.07	6	1.125	-1.785	0.134
		Post-CLES	4.21	6	0.772		
	Comparison	Pre-CLES	2.59	11	0.729	-2.894	0.016
		Post-CLES	3.58	11	0.777		
800	Reform	Pre-CLES	3.01	11	0.752	-1.408	0.189
		Post-CLES	3.35	11	0.941		
900	Reform	Pre-CLES	3.59	13	0.807	-0.016	0.987
		Post-CLES	3.60	13	0.610		
	Comparison	Pre-CLES	3.61	15	0.591	1.631	0.125
		Post-CLES	3.20	15	0.916		
1000	Reform	Pre-CLES	3.50	6	0.422	-1.835	0.125
		Post-CLES	3.96	6	0.334		
1100	Reform	Pre-CLES	3.21	12	0.839	-3.180	0.008
		Post-CLES	4.15	12	0.469		

Comparison of CLES Results by Course Size: Reformed and Comparison

A one-way Analysis of Variance (ANOVA) was performed to compare the reformed courses to each other and the comparison courses to each other. A difference in means in the CLES was seen in the reformed and comparison courses, both at pre- and post-instruction times as shown in Table 5. These findings suggest that factors other than course of enrollment might have influenced the way students perceived their classroom environment.

Table 5: **Group Statistics for One-Way ANOVA Comparing Reformed Courses with Each Other and Comparison Courses with Each Other**

Variable	Code	N	Mean	Std. Deviation
Pre-CLES Average	reform	189	3.13	.827
	comparison	148	3.03	.784
Post-CLES Average	reform	128	3.79	.686
	comparison	128	3.41	.762

Table 6: **One-Way ANOVA Comparing Reformed Courses with Each Other and Comparison Courses with Each Other**

Code			df	*F*	Sig.
Reform	Pre-CLES Average	Between Groups	8	2.139	.034
		Within Groups	180		
		Total	188		
	Post-CLES Average	Between Groups	8	4.570	.000
		Within Groups	119		
		Total	127		
Comparison	Pre-CLES Average	Between Groups	5	2.713	.023
		Within Groups	142		
		Total	147		
	Post-CLES Average	Between Groups	5	4.140	.002
		Within Groups	122		
		Total	127		

A Least Significant Difference (LSD) post-hoc test was performed to determine where differences between the courses occurred at the institutions studied. Knowing where the differences lie would allow insight into institutional factors that may lead to differences in students' perceptions of the classroom environment of the science classes observed. It also

allows for questioning concerning what these instructors did that was different from other instructors in the study. The results are summarized in Tables 7 to 10; for brevity, only those instances where there are significant differences are shown. Table 7 reports the results from multiple comparisons of the mean score on the CLES of the reformed classes on the preferred (pre test) version of CLES. At the 95% confidence level, there was sufficient data to suggest that at the beginning of the semester, students enrolled in the reformed science courses at institutions 900 and 1000 were different from students at institutions 100, 300, 500, and 1100. No other difference in mean CLES score was found. Students at institution 900 reported that their preferences for the inquiry orientation classroom environment occurred more than students at institutions 100, 300, 500, and 1100. Students at institution 1000 perceived that their classroom environment preference occurred more often during the semester than students at institutions100, 300, 500, and 1100,

Table 7: Multiple Comparisons of Pre-CLES Results by Students in Reformed Courses at Institutions Included in Study

Code	Dependent Variable	(I) institution	(J) institution	Sig.
Reform	Pre-CLES Average	100	900	.009
			1000	.030
		300	900	.014
			1000	.030
		500	900	.017
			1000	.030
		900	100	.009
			300	.014
			500	.017
			1100	.008
		1000	100	.030
			300	.030
			500	.030
			1100	.027
		1100	900	.008
			1000	.027

Table 8 reports the results from multiple comparisons of the perceived (post test) mean score on the CLES of the *reformed classes* at the end of the semester. At the 95% confidence level, institution 100 differed from institutions 200, 700, and 1100. Institution 100 had a lower mean score on the perceived version of the CLES indicating that the students in the reformed course at institution 100 perceived that their preferences for the classroom environment occurred less often than at institutions 200, 700, and 1100. At the 95% confidence level, institution 200 was different from institutions 300, 800, and 900. Institution 200 had a higher mean score on the perceived version of the CLES indicating that the students in the reformed course at institution 200 reported that their preferences for the inquiry orientation classroom environment occurred more often than at institutions 300, 800, and 900. Institution 300 differed from institutions 700 and 1100. Institution 300 had a higher mean score on the perceived version of the CLES indicating that the students in the reformed course at institution 200 reported that their preferences for the inquiry orientation classroom environment occurred more often than at institutions 700, and 1100. Institution 500 and 700 were found to be significantly different at the 95% confidence level. Institution 500 had a higher mean score on the perceived version of the CLES indicating that the students in the reformed course at institution 500 reported that their preferences for the inquiry orientation classroom environment occurred more often than at institution 700. Institution 700 was found to be significantly different from institution 800 and 900. Institution 1100 and was found to be significantly different from institutions 800 and 900 at the 95% confidence level. Institution 700 and 1100 had a lower mean score on the perceived version of the CLES indicating that the students in the reformed course at institution 200 reported that their preferences for the inquiry orientation classroom environment occurred less often than at institutions 800 and 900. The interpretation of factors affecting student perception after instruction is complex and may be influenced by other factors not included in this report such as the number of science classes a student has taken, academic major, and whether a student likes science, and instructor's level of pedagogical content knowledge. Each of these factors can affect how a student feels about the classroom environment.

Table 8: Multiple Comparisons of Post-CLES Results by Students in Reformed Courses at Institutions Included in Study

Code	Dependent Variable	(I) institution	(J) institution	Sig.
Reform	Post-CLES Average	100	200	.018
			700	.000
			1100	.029
		200	100	.018
			300	.007
			800	.000
			900	.024
		300	200	.007

		700	.000
		1100	.010
	500	700	.011
	700	100	.000
		300	.000
		500	.011
		800	.000
		900	.001
	800	200	.000
		700	.000
		1100	.001
	900	200	.024
		700	.001
		1100	.034
	1100	100	.029
		300	.010
		800	.001
		900	.034

Table 9 reports the results from multiple comparisons of the mean score on the preferred (pre test) version of the CLES of the comparison courses. At the 95% confidence interval, the comparison course at institution 300 was statistically different from institutions 100, 200, 500, and 700, and institutions 700 and 900 were found to be statistically different from each other. Institution 300 had a higher mean score on the preferred version of the CLES indicating that the students in the more traditional non-reformed comparison course at institution 300 had different preferences for the classroom environment than at institutions 100, 200, 500, and 700. Institution 700 had a lower mean score on the preferred version of the CLES, indicating that the students in the non-reformed comparison course at institution 300 had different preferences for the classroom environment at institution 900. The comparison courses at institutions 200, 300, 500, and 900 were non-majors science courses. Differences in classroom environment preference at the beginning of the course may have been due to course content, students not liking science, or pre-conceptions of sciences classes that they had before entering the classroom. The courses at institutions 100 and 700 were introductory level science courses for majors and non-majors. The student population in these courses may have had different preferences for the classroom environment because many of the students were science majors.

Table9: Multiple Comparisons of pre-CLES results by students in Comparison Courses at Institutions included in study

Code	Dependent Variable	(I) institution	(J) institution	Sign.
Comparison	Pre-CLES Average	100	300	.007
		200	300	.042
		300	100	.007
			200	.042
			500	.015
			700	.002
		500	300	.015
		700	300	.002
			900	.040
		900	700	.040

Table 10 shows the results from multiple comparisons of the mean score on the CLES of the comparison classes on the perceived (post test) version of the CLES. After instruction, institution 100 was found to be statistically different from institutions 300, 500, and 700. Institution 100 had a lower mean score on the perceived version of the CLES indicating that students in the comparison course at institution 100 perceived that their preferences for the classroom environment occurred less often than at institutions 300, 500, and 700. Institution 200 was found to be different from institution 300 and 500. Institution 200 had a lower mean score on the perceived version of the CLES indicating that students in the non-reformed comparison course at institution 200 perceived that their preferences for the classroom environment occurred less often than at these institutions 300 and 500. Institution 300 was found to be different from institution 900. Institution 300 had a higher mean score on the perceived version of the CLES indicating that the students in the non-reformed comparison course at institution 300 perceived that their preferences for the classroom environment occurred less often than at institution 900. Differences in students' perceptions of the classroom environment may have been influenced by differences in the student population.

Table 10: Multiple Comparisons of post-CLES results by students in Comparison Courses at Institutions included in study

Code	Dependent Variable	(I) institution	(J) institution	Sig.
Comparison	Post-CLES Average	100	300	.001
			500	.001
			700	.006

	200	300	.025
		500	.048
	300	100	.001
		200	.025
		900	.041
	500	100	.001
		200	.048
	700	100	.006
	900	300	.041

The study indicates that students have similar preferences for the classroom learning environment and that students enrolled in reformed classrooms perceive their preferences to occur at a higher level. Whether the course was a reformed or a comparison course seemed to be the factor accounting for the biggest difference in mean score on the CLES in this investigation. In cases where a difference in mean was found, the reformed science class had a higher mean score than the comparison course, indicating that reform in the science classroom impacts student perception of the classroom.

In this study, institution type did not seem to be a factor in determining the difference in mean CLES score. Students attending smaller colleges did not consistently have higher means on the CLES than students attending larger universities, but this may be because the majority of the institutions examined were MA-I type institutions, only three were not. It is possible that institution type does influence the way students perceive the classroom learning environment. There is little research on students' perception of the science course learning environment based on the type of institution they attend. A review of the literature finds researchers looking at differences between institution types tended to focus on race or gender. Additional research is needed investigating differences between students perception of the classroom environment based on type of institution, especially for lower division students.

Further NSEUS studies are underway to investigate differences based on content, department offering the course, class size, academic major, number of science courses taken, and over all perception of science.

Conclusion

Effective undergraduate science teaching is a complex process requiring specialized knowledge and skills to do it well and facilitate student learning. Reforms in entry-level undergraduate science courses impact all students in higher education. There is a need to assure that science instructors transform science content knowledge and represent it in a way to promote student learning based on research based strategies (Sorensen, Evans, & Andersen, 2009; DeJong et al., 2005; Loughran et al., 2000; Van Driel et al., 1998). It is important to investigate current efforts underway in undergraduate science course reform through the knowledge faculty members have available to implement reforms that impact the course learning environment and to study the impact of such actions on student outcomes in those courses.

The current study of a small national and diverse sample investigated the learning environment existing in undergraduate entry level science courses. Results in this study identified variations and significant relationships between courses that were involved in attempts at reform and other comparison courses at the same institutions. Faculty instructors who taught reform undergraduate science course(s) were rated higher by their students than other faculty. The level of reform found in the courses were found to vary along a continuum from reformed to traditional instructor orientation and this context significantly affected student perceptions of the learning environment. Other factors were not related to perceptions reported by the students.

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