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ABSTRACT

This study examined three instruments developed for studying anchored science learning environments. The evaluated instruments (Science/Space Task Interest Survey, Science/Space Attitude Survey, and Science/Space Activity Survey) were developed to be used to study any space-related school science environment in middle and upper grades. The instruments were administered to 470 seventh-graders at two middle schools. The reliabilities of the scales in terms of internal consistencies and test-retest reliability were very high, and all instruments were useful for identifying meaningful differences in two populations. Copies of the instruments are not included in this document. (PR)

# Middle-Schoolers' Interest in Science and Space Science: Dimensions of Content, Context, & Actualization

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## Middle-Schoolers' Interest in Science and Space Science: Dimensions of Content, Context, Actualization

Our reseacch group has been developing a prototype middle school learning environment known as the *Mars Mission Challenge* (Hickey, Pellegrino, & Petrosino, 1991, Hickey, Petrosino, Pellegrino, Goldman, Bransford, Sherwood, & CTGV, in press & 1992). This environment presents K-12 math, science, and cross-curricular content in the context of planning a human mission to Mars. The *Mars Mission Challenge* exemplifies the contemporary *generative* approaches to instruction that our group has been refining over the past several years (e.g., Cognition & Technology Group at Vanderbilt, 1990; 1991a; 1992c). We refer to the class of generative environments that our group is developing as *Anchored Instruction* (CTGV, 1991). Based on contemporary cognitive theory, (e.g., Bransford, Franks, Vye, & Sherwood, 1989; Brown, Collins, & Duguid, 1989), this approach anchors (or "situates") school content within meaningful and authentic problem solving activities.

One goal of our research program has been developing a framework for studying the role of motivation and affect in students' skill and knowledge acquisition in these new learning environments. Another goal has been evaluating their impact on students' interests and attitudes regarding the academic content incorporated into these learning environments. A substantial effort has been directed at developing new approaches for assessing anchored instruction, including performance asssessment and teacher-driven formative evaluation (e.g., Barron, et al., 1994, CTGV, in press). However, the research effort described here has focused on methods suitable for large-scale administration using machine-readable instruments, and using more conventional psychometric methods. In particular, we are attempting to develop a research framework which affords the use of structural equation modeling methods.

Our search for a compatible theoretical framework for studying motivation and anchored instruction quickly led us to the new synthesis of research on interest and interestingness (e.g., Hidi, 1990; Renninger, Hidi, & Krapp, 1992; Schiefele, 1991). We have found that a focus on the interestingness of learning settings, as in the "situational interest" research (e.g., Anderson, Shirey, Wilson, & Fielding, 1987; Hidi & Anderson, 1992; Hidi & Baird, 1988) presents a useful way to think about developing and improving anchored instruction environments. These researchers have argued that learning environments which are high in situational interest will positively impact learners' personal interest regarding the topics presented in that environment (See Mitchell, 1993; Mitchell & Prion, 1994). We believe that learning environments which *authentically* anchor instructional content to exciting real world-contexts can afford very high levels of situational interest. Studies with the *Adventures of Jasper Woodbury* Mathematical Problem Solving Series have shown that this particular anchored instruction environment supports extended high-level cognitive engagement in complex mathematical problem solving (CTGV, 1992b; Hickey, Pellegrino, Goldman, et al., 1993; Pellegrino, et al., 1992; Van Haneghan, et al., 1992). Many studies have shown that higher levels of personal interest in a domain positively impacts learning and motivation in students' encounters with that domains (see, for example, Schiefele, Krapp, &Winteler's, 1992, metanalysis). Our studies with the Jasper materials demonstrated that middle schooler's whose math curriculum included the Jasper materials demonstrated significantly improved interest in math and math problem solving during the school year, compared to control students (Hickey, Pellegrino, Goldman, et al., 1993; Pellegrino et al., 1992).

We have found that focusing on learner's interest in instructional content, as in the "personal interest" research (e.g., Nenninger, 1992; Schiefele, 1992) is a useful way to conceptualize the impact of these environments on student attitudes. The focus on fundamentally domain-specific constructs in interest research is highly compatible with the contemporary models of cognition which underlie anchored instruction. Such a focus is particularly important in maximally generative environments such as our *Mars Mission Challenge*, because different students are expected to focus on different, relatively idiosyncratic aspects of the larger activity. This absence of an easily specified body of outcomes across students presents new challenges for evaluating these environments. The following paper describes an initial research framework which follows from recent interest research, drawing particularly from European research associated with *person-object theories* (e.g., Prenzel, 1992; Prenzel, Krapp, & Schiefele, 1986) and *content-oriented personal interest* (e.g., Nenninger, 1992). We developed this research framework and the corresponding instruments while carrying out an evaluation the *M.A.R.S (Mission Assignment: Relief and Supply)* learning activity developed by the Challenger Learning Centers for Space Sciences. This activity, which contextualizes middle school science content within the larger context of Mars mission, consists of 5-10 periods of classroom learning activities which prepare students for a two-hour simulated mission at a museum-based learning center. While not an anchored instruction program *per se,* the learning activities supported by the 27 Challenger Centers incorporate many of the same features as anchored instruction. This includes realistically situating academic content in meaningful tasks, having groups of students pursue individual goals oriented towards a larger common goal, and supporting meaningful collaboration within and between those groups.

### *Study Overview*

The findings of our pilot Challenge Center evaluation are detailed elsewhere (Hickey, Petrosino, & Pellegrino, 1993, 1994). Three of the instruments developed for evaluating the impact of this program (*Science /Space Task Interest Survey, Science/Space Attitude Survey, and Science/Space Activity Survey*) could be used to study any space-related school science environment in middle and upper grades. The goals of the present study include (1) establishing the reliability of these measures, (2) comparing their sensitivity to group differences, and (3) examining their disc iminant validity regarding several theoretically derived constructs

### *Method*

The three instruments, along with a background questionnaire, were administered to 470 seventh-graders at two middle schools, including 312 students from a suburban upper/middle-class school (School 1), and 158 students from a middle/working-class suburban/rural school (School 2). This represented approximately 90% of the seventh graders at School 1 and 75% of the seventh graders at School 2. Except for the background questionnaire, all items were administered using machine-readable "bubble" forms. The three instruments were administered by the first two authors. Students were asked to "tell us how you really feel." and to "do your best." Additionally, students were told that being "really interested" in something meant that they might choose to participate in that activity during their free time. The three instruments were completed during a single class period, requiring approximately 40 minutes. Three of the five participating teachers (two from School 1 and one from School 2, 83 students in all) were asked to select their "most typical class" to serve as a test-retest population. Students in these three classes completed a retest of the same instruments seven days later.

Three sets of analyses were carried out in this study. First, internal consistencies and test-retest reliabilities were established using the data from the Nashville sample. Second, the sensitivity of the instruments to group differences was carried out on two separate populations. Gender effects were studied using the Nashville sample, while another group contrast was explored used pretest data from one of the two Challenger Center evaluation study sites. At this site, 70 of the 200 students reported participating in at least one of the other Challenger Center's missions during the previous school year. We contrasted the scores of these "Previous-CLC" student on each of our measures with their "Non-Previous CLC" classmates who did not report attending. The third set of analyses in the present study were examinations of the theoretical constructs underlying the instruments, using confirmatory factor analysis. To create a sufficiently large sample, pretest data from all 300 students in the evaluation study were combined with the data from the 470 students in the Nashville administration. After eliminating individuals with missing data, 747 students remained.

## Results

Following is a discussion of the logic behind the three instruments we developed and the relevant research finding associated with each.

*Background.*

Table 1 presents the results from the background questionnaire for two schools in the Nashville sample. Very few students report that their parents or adult acquaintances work for NASA or as scientists. A substantial portion of students report watching one of the *Star Trek* television shows. The frequency of viewing *Star Trek* was roughly the same at both sites, and boys reported higher frequencies than girls. The total number of other space-related activities reported by students was also about the same at the two sites, and roughly the same for boys and girls. Typical responses to this question included visits to the planetarium and NASA's Space and Rocket Center. Based on these responses, the students in this population appear quite similar to the students at both sites in the evaluation study.

*Content-Specific Interest*

Following from research suggesting the potential usefulness of highly specified interest constructs, we created the *Space/Science Task Interest Survey* assessed students' interest in well-specified school science tasks. The interest survey consisted of brief descriptions of 40 school science tasks. Students were asked "How do you think you would feel" engaged in each activity, responding on a six-point scale ranging from *very bored* to *very interested.* These tasks were developed along three dimensions of *content, context, and actualization..*

The *content* dimension represents different school science domains. To identify an objective set of topics, we reviewed the middle school learning objectives from the *1990 Tennessee State Science Framework..* Eight specific topics from three areas (Physical, Life, and Earth Sciences) were selected (Table 2). The *context* dimension represented the distinction between tasks presented in a general context and a space travel context (see Table 3). The *general* context items presented tasks contextualized in a general "real world" context while the *space* context tasks were presented in the context of space travel, such as students might encounter in a space-oriented anchored instruction environment.

The third interest dimension, *actualization*, represents an attempt to operationalize the distinction between *latent* and *actualized* personal interest (e.g., Schiefele, 1991). The three levels of actualization were operationalized with tasks that involved either *Learning about* a topic area in general, *Reading about* a more specified topic in that area, or *Figuring out* a specific problem derived from that topic. Table 3 lists the five items from the *Life Science* topic *Plants*. We choose not to include *Learning about.... space* context items because this combination tended to yield nonsensical tasks such as *Learning about plants in space*. (In other words, based on our definitions, it appears that contextualizing tasks also served to increase their actualization.) The complete set of 40 items are presented in Appendix A.

As shown in Figure 1, this configuration yielded 16 space context items and 24 general context items. Our purpose in constructing such an interest instrument was to explore whether different types of tasks were more sensitive to instructional interventions and more indicative of meaningful group differences. We anticipated that the most highly actualized space context items would be most sensitive to interventions such as those we were interested in. Furthermore, this design makes it possible to study interest in specific topic areas, rather than in the more global science domains. As Bandura (1991) and other social cognition researchers involved in the global vs. specific construct debate have successfully argued, while one can derive global constructs by aggregating more specific measures, one can never derive more specific information from a global measure.

***Results.*** The interest survey results were examined by collapsing items along the different dimensions and considering the resulting scale scores. The content dimension was examined first; then the context and actualization dimension were examined simultaneously. Collapsing items along the science topics yielded eight five-item scales, each representing a specific middle school science topic. The eight content scales were highly reliable, with internal reliabilities (Chronbach's Alpha) between .83 and .90 (except for the topic *Human Body* which was .76). Test-retest reliabilities were also quite high, ranging from .73 to .85. Mean responses fell near the middle point of the scale, and responses were nearly normally distributed, with modal responses falling between 3.0 and 4.0 on all eight scales.

The evaluation study results are shown in Figure 2 While the scores are higher for the students who participated in previous Challenger Center activities, the difference only approaches significance in the Astronomy and Geology scales, $F(1,194) = 2.5$, $p = .11$, and $F(1,194) = 2.6$, $p = .11$, respectively. This finding is consistent with content typically included in the Challenger Center missions. As shown in Figure 3, boys in the Nashville sample were significantly higher on the three physical science topics (*Work & Force, Electricity & Magnetism,* and *Sound, Heat, & Light*, all $p < .0005$), while girls were significantly higher on all three life science topics (*Animals, Plants,* and *Human Body*, all $p < .005$). There were no significant effects of gender on the two Earth Science topics. This roughly corresponds with prior research on student's interest and attitudes towards school science domains (e.g., Perrodin, 1965, Zbaracki, Clark, & Wolins, 1985). Thus it appears that the different topics appear differentially sensitive to substantively meaningful group differences.

Discriminant validity along the content dimension was examined with confirmatory factor analysis, using structural equation models within the *EQS* program (Bentler, 1989). A hypothesized eight factor model could not be confirmed because correlations between topics within the three content areas were not significantly different from 1.0. The best fitting model of the content dimension included three correlated latent factors, one for each of the three science areas (Figure 4a and Table 4). Thus, while discrimination between the science areas was supported, these results suggest that the instrument did not adequately discriminate at the topic level for this particular population.

Group contrasts along the *context* and *actualization* dimensions were considered simultaneously. Collapsing items along these dimensions yielded five eight item scales with internal consistencies between .77 and .88, and test-retest reliabilities between .76 and .83. As shown in Figure 5, the difference for the two groups does in fact appear largest for Figuring

Out/Space Context items, but none of these differences were statistically significant (Figuring Out/Space: $F(1,194) = 1.7$, ns; Reading/Space: $F(1,194) = 1.1$, ns; all other $Fs < 1.$). Thus it appears that the different types of tasks were in fact differentially sensitive to meaningful group difference, and that highly actualized tasks which matched the context of the intervention were most sensitive.

Confirmatory factor analyses of the context and actualization dimension were carried out individually, by measuring the improvement over the three factor "content" model (Figure 4a) when factors representing the context and actualization dimension were added. (A model incorporating all three dimensions simultaneously appears to be unidentifiable). The content dimension was examined first by adding a single latent factor (uncorrelated with the other factors) to represent the *Space* context items (Figure 4b). As shown in Table 4, this led to a significant improvement in fit over the three factor model.

Because the covariance between the space context items in the full set of items made it difficult to fit the actualization dimension, the *space* context items were eliminated in order to examine it. Starting with the three factor model representing the content dimension (Figure 6a and Table 5), three additional correlated factors representing the three levels of actualization ("learning," "reading," and "figuring out") were added. This revealed that the three actualization factors were very highly correlated, and that the correlation between the "learning" and the "reading" factors was not significantly different from 1.0. Thus two factors for the actualization dimension were tested, with one "learning & reading" factor and one "figuring out" factor (Figure 6b). As shown in Table 5, this led to a significant improvement in fit. However, the very high correlation ($r = .94$) between the two actualization factors shows that the actualization factor is very weakly represented.

Thus our operationalization of three dimensions of science task interest yielded mixed results in this population. The content dimension could be confirmed at the *Area* level (*Physical, Life*, and *Earth*), while the individual topic dimensions could not be distinguished. While a factor representing the *Space* context was confirmed, the actualization dimension was only marginally confirmed, and then for only two instead of the intended three factors. Our operationalization of the actualization dimension was based on what *we* conceived to be very different types of learning activities. However, think-aloud protocols collected from two students while they were completing this instrument showed that they interpreted all three tasks as variants of the same teacher-led textbook based model of schooling. For example, one student's justification for his responses to the "figuring out" items was based on his perception of the tasks as no more than locating the passage in the science textbook which provided the answer to a problem at the end of the chapter.

*Attitudes Towards Science and Space*

One objective of this study was contrasting the sensitivity of our task interest instrument with a more conventional "science attitude" measure. We choose a published seven-item scale (Ebenezer & Zoller, 1993) which assessed students' attitudes towards learning science in school using adjectives such as "like," "enjoy," and "boring." Such an instrument appears to capture global attitude towards learning about science rather than their attitude towards science *per se*. As shown in Table 6, we rewrote each item to create a second scale for assessing attitude towards learning about space and space travel.

Mean scores on both scales were around 4.0 (six-point scale) and were roughly normally distributed. Both scales were very reliable, with internal consistencies of .91 and .94, and test-retest reliabilities of .76 and .81, for the science and space scales, respectively. The evaluation results revealed that the students who participated in the Challenger Center activity showed a marginally significant more positive attitude towards science (mean of 4.1 versus 3.7, $F\,(1{,}194) = 2.9$, $p < .10$, and a significantly more positive attitude towards space (mean of 4.2 versus 3.5, $F\,(1{,}194) = 10.9$, $p < .005$). Examining the Nashville sample, revealed that boys and girls showed similar attitudes towards science (mean of 4.1 and 4.0, respectively, $F\,(1{,}194 = 1.6$, ns) but boys showed significantly more positive attitudes towards space (4.1 versus 3.8, $F(1,194) = 5.4$, $p < .02$).

Confirmatory factor analysis of the attitude instrument was carried using means from two pairs and a triplet of items from each scales as indicator. As shown in Figure 7, a model with two correlated factors, one for science and one for space led to an excellent fit which was a significant improvement over the one factor model. This model revealed that the two factors were highly correlated in this population ($r = .71$)[1]

In order to contrast the findings from these attitude scales with our task interest survey, the task interest survey items were collapsed along the context dimension, yielding a 24-item science task interest scale and a 16-item space interest scale, with internal consistencies of .85 and .87, and test-retest reliabilities of .80, and .82, respectively. Sensitivity of the two attitude scales and the two task-interest scales to the group differences were contrasted by calculating effect sizes for each difference (i.e., the difference between the means divided by the standard deviation for the population). Table 7 shows that the effect size for the evaluation results (previous participation vs. no participation) and gender. The Attitude Toward Space scale yielded the largest effect size on both contrasts, roughly twice the size of the Space Task Interest scale.

We conclude that while Task Interest scales do appear sensitive to global differences in these two particular populations, they do not yield effects as large as more conventional attitude measures. The Science Attitude measure differed from the Task Interest measure in two important respects. First, as operationalized in this instrument, "attitude" is not exactly the same construct as "interest" as defined within the contemporary interest literature. For example, attitude includes both personal value for the domain (closely related to interest) as well as more objective value for the domain, as it pertains to students in general (which is less like interest). Second, the attitude measure was a single measure of a global construct, rather than an aggregate measure like the task interest measure. A study which includes a global measure of interest and an aggregate measure of

[1]A multiple groups analysis revealed that the covariance between the two latent factors was significantly different for the boys and girls, $r = .66$ and .81, respectively.

attitude would be necessary to more precisely examine the differences which we observed between interest and attitude.

*Science and Space-Related Activities.*

A third instrument used in this study was a measure of students' participation in science and space-related activities outside of science class. Following a format used by Skinner and Barcikowski (1973), the *Space/Science Activities Survey* had students report the number of times (*0, 1, 2, 3, 4, 5+*) they engaged in 20 different science-related and space-related activities (Table 8) outside of science class in the previous two weeks. Three groups of activities included Science (5 items), Space Travel (5 items) and M.A.R.S. science topics (eight items).[2] Test-retest reliabilities were calculated for the 87 students who completed the instruments twice at a one week interval. These correlations ranged from .21 (*Buy a book or magazine about space travel?*) to .81 (*Check out a library book?*), with an average correlation across the 20 items of .46[3]. The following results will focus on just the five science items and the five space items.

Activity frequencies for each item were analyzed by collapsing responses into two responses, *0 times*, and *1 or more times*. Chi-Square tests were used to determine if the proportion of students engaging in each activity was significantly different according the two group contrasts. Figure 8 contrasts the reported pretest activities for the Previous-CLC/No-Previous CLC groups in the evaluation. The Previous-CLC students were higher on all items , with significant differences for the science activities on items 2, 3, and 4 ($p < .05$), and significant differences on the space activities on items 8, 9, 10, and 11 ($p < .005$). Figure
Figure 9 shows that boys were higher on Item 2, 9, 10, and 12, while Girls were higher on Item 7 ($p < .05$). Thus the activity measures also appear to be useful indicator of specific differences within the two populations samples we examined.

[2]These eight items were created to assess topics which were presented in each of the Challenger Learning Center's eight M.A.R.S. activity teams.

[3]Note that these correlations are based on highly skewed categorical data, and thus are not stable. Furthermore, these reliabilities are inflated by the overlap between sampling periods.

A science activity scale and a space activity scale were constructed by summing frequencies across the five items in each area. Test-retest reliabilities these scales were for these scales were .65 and .55, and the two scales correlated at .63[4]. In the evaluation sample, Previous-CLC students were higher on both the Science Activity index (5.6 versus 4.1, $F$ (1,194) = 4.5, $p < .04$) and on the Space Activity index (4.0 versus 1.9, $F$ (1,453) = 8.5, $p < .05$). Similarly, in the Nashville sample, boys were higher than girls on both the Science Activity index (4.3 versus 3.4, $F$ (1,453) = 4.4, $p < .04$) and the Space Activity index (2.6 versus 1.3, $F$ (1,453) = 12.8, $p < .001$). Thus the aggregated activity measure appears to also be useful as a global measure of group differences. As an alternative measure for studying an intervention, it appears that such a instrument, when administered properly, might be a very useful tool for further validating the impact of an intervention in terms of students' self-directed behavior.

As further comparison of the two attitude scales and the two global task interest scales, we compared correlations of these scales with the two activity indices. Table 9 displays the correlations between the activity scales and the other measures, showing that the correlation between the activity indices and the attitude scales and the interest scales are roughly of the same magnitude (between .30 and .50). Both the attitude and the interest scales exhibit the pattern whereby the space scales correlate more highly with the space activity index, while the science scales correlate more highly with the science activity index. We conclude that according to this dependent measure, that the attitude scales and the task interest scales appear equally associated with meaningful individual differences in two populations.

## Conclusion

As an examination of three instruments developed for studying anchored science learning environments, the results of this study were very positive. The target population had no difficulty completing the instruments during a single class period and apparently had no difficulty

[4]Since these are simple correlations carried out on highly skewed categorical data, these results are presented for informational purposes only.

understanding the items. The reliabilities of the scales, both in terms of internal consistencies and test retest reliability were very high, and all three were useful for identifying meaningful differences in two populations

As an instrument for examining students content-specific personal interest in science, the task interest instrument which we developed appears quite promising. As a global measure, aggregate task interest scores served as an adequate indicator of individual differences in students' global interest in science and space, and as a predictor of students' science-related and space-related activities outside of science class. In contrast to global science measures, this task interest instrument allowed us to more precisely specify which topics and which types of tasks students interest differed on. We believe that such an instrument and the theoretical framework underlying it are useful tools for studying and evaluating contemporary classroom learning environments.

Confirmatory factor analyses of the task interest instrument revealed that the dimension of content at the topic level was only weakly discriminated by this instrument. Further study is needed to examine this issue. Given findings that students' self-concept (which appears to be related to interest) is becomes more differentiated as students get older (e.g., Marsh, 1989), we expect to more clearly discriminate between topic areas in older students. In a separate evaluation study currently under way, we are using a similarly structured set of instruments to evaluate the impact of a year-long science project in three Nashville high schools. This project integrates science curriculum around the study of a local river. Students were tested at the beginning of the 1993-1994 school year and will be test again at the end of the school year. In addition to allowing us to further explore the issues presented in the present study, this second study will allow us to contrast the findings with seventh graders in the present study to those of a high school students.

The actualization dimension of our task interest instrument was only weakly represented in this sample. From the perspective of developers of contemporary school learning environments, we viewed the difference between learning about a domain, reading about a topic, and solving a specific meaningful problem to be very distinct activities which afford very different types of learning. Our interviews with students and the results from this study suggest that the students in this population viewed these three tasks as minor variants of the same teacher-led, textbook based model of classroom learning (which we are trying to transcend in our learning environments). We view advancing our students' understanding of the possibilities for learning offered by different instructional tasks as a meaningful instructional outcome. In other words, we expect that an ideal classroom learning environment would lead students to understand "figuring out" tasks to be substantially different from "learning about" or "reading about" tasks. The "River Science" program which we are currently evaluating will provide us with an opportunity to look for such an impact, by contrasting models of the actualization dimension at the beginning and end of the school year. Other, more comprehensive interventions associated with other research projects currently underway at the Learning Technology Center may provide further opportunities to consider these issues.

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**Table 1**
***Participants (at Pretest)***

| | Site 1 | Site 2 |
|---|---|---|
| **Number** | 312 | 158 |
| **Gender** | | |
| Male | 53% | 52% |
| Female | 47% | 48% |
| **Demographics** | | |
| Attended Space Camp | 3% | 2% |
| Know adults who work for NASA | 6% | 7% |
| Parents work for NASA | 0.3% | 0.6% |
| Know adults in space industry | 7% | 0.6% |
| Parents work in space industry | 0.3% | 0.6% |
| Know a scientist | 21% | 11% |
| Parents are scientists | 1% | 0.6% |
| **Watch any *Star Trek* shows:** | | |
| "Never" | 32% | 33% |
| "Sometimes" | 40% | 38% |
| "Often" | 12% | 15% |
| "Every Chance I Get" | 16% | 8% |
| **Other Space-Related Activities** | | |
| None Listed | 45% | 41% |
| One Listed | 34% | 32% |
| Two Listed | 15% | 19% |
| Three or More Listed | 6% | 8% |

Table 2
*Middle School Science Topics*

| Science Area[a] | Topic |
|---|---|
| Physical Science[b] | Machines & Work<br>Electricity & Magnetism<br>Sound, Heat, & Light |
| Life Science[c] | Animals<br>Plants<br>The Human Body |
| Earth/Space Science[d] | Astronomy<br>Geology |

*Note.* Based on grades 6-8 objectives for the *Tennessee State Science Framework.*
[a]The area *Environmental Science* was excluded.
[b]The area *Matter and Energy* was excluded.
[c]The topics *Growth and Development* and *Microscopic Life* were excluded from this area.
[d]The topics *Meteorology* and *Oceanography* was excluded from this area.

Table 3
*Example Task Interest Items (Life Science/Plants)*

| Task | Context | Item |
|---|---|---|
| Learning | General | Learning about plants. |
| Reading About | General | Reading about how plants grow in greenhouses |
| | Space | Reading about how plants grow in the weightlessness of space. |
| Figuring Out | General | Figuring out how many trees are needed to make enough oxygen for one person. |
| | Space | Figuring out how many trees are needed to make enough oxygen for a Mars colony. |

*Note.* All items prefaced with the statement *How do you think you would feel...* Scored on a 1-6 scale of agreement: *Very Bored, Bored, Slightly Bored, Slightly Interested, Interested,* and *Very Interested.*

Table 4
*Model Comparisons for All Items*

| Model | $\chi^2$ | df | Non-normed fit index | Comparative Fit Index |
|---|---|---|---|---|
| Independence | 9830 | | | |
| One factor | 2224 | 90 | .749 | .785 |
| Three *content* factors (Fig. 4a) | 1348 | 87 | .847 | .873 |
| Three *content* factors plus space *context* factor (Fig. 4b) | 800 | 81 | .906 | .928 |
| Three *content* factors plus space *context* factor on all Earth Items (Fig. 4c) | 679 | 78 | .919 | .939 |

Table 5
*Model Comparisons for General Context Items Only*

| Model | $\chi^2$ | df | Non-normed fit index | Comparative Fit Index |
|---|---|---|---|---|
| One factor | 958 | 27 | .732 | .799 |
| Three *content* factors (Fig. 5a) | 422 | 24 | .871 | .914 |
| Three *content* factors plus two *actualization* factors (Fig. 5b) | 48 | 14 | .981 | .922 |

Table 6
*Science/Space Attitude Survey Items*

| Domain | Items |
|---|---|
| Science | I like to study science in school·<br>Science is dull.<br>I do not enjoy science.<br>I would like to study more science.<br>Science classes are boring.<br>I feel that it is important to study science.<br>Science is a valuable subject. |
| Space | I like to learn about space and space travel.<br>Space science is a dull topic.<br>I do not enjoy learning about space travel.<br>I would like to learn more about space a.<br>Learning about space is boring.<br>I feel that learning about space is very important.<br>I don't think space travel is a very valuable topic. |

*Note.* Scored on a 1-6 scale of agreement: *Strongly Disagree, Disagree, Barely Disagree, Barely Agree, Agree,* and *Strongly Agree.* After Ebenezer & Zoller (1993).

Table 7
*Effect Sizes for Interest and Attitude Scales*

| | **Populations** | |
|---|---|---|
| **Scale** | **Prev CLC/No Prev CLC (n = 67/129)** | **Boys/Girls (n = 241/216)** |
| Science Task Interest | .12 | .04 |
| Space Science Task Interest | .18 | .15 |
| Attitude towards Science | .26 | .12 |
| Attitude towards Space | .48 | .21 |

Table 8
*Science/Space Activity Survey Items*

| Category | Item |
|---|---|
| General | 1. Check out a library book (each book counts as one time)? |
| Science | 2. Check out a library book about science? |
| | 3. Buy a magazine or book about science? |
| | 4. Write anything about science outside of science class? |
| | 5. Watch a television program about science at home? |
| | 6. Talk about science outside of science class? |
| Space | 7. Talk about or read about space travel at home? |
| | 8. Check out a library book about space or space travel? |
| | 9. Buy a book or magazine about space or space travel? |
| | 10. Draw anything about space or space travel at home? |
| | 11. Write anything about space or space travel outside of science class? |
| M.A.R.S.-Specific | 12. Talk about or read about communication? |
| | 13. Talk about or read about radioactivity? |
| | 14. Talk about or read about how plants grow? |
| | 15. Talk about or read about how computers work? |
| | 16. Talk about or read about how the human body works? |
| | 17. Talk about or read about the constellations of stars? |
| | 18. Talk about or read about electricity and electrical circuits? |
| | 19. Talk about or read about robots or robotics? |
| Foil | 20. Talk about history outside of history class? |

*Note.* All items are prefaced with the stem: *In the last two weeks, did you...* Response categories are *1 time, 2 times, 3 times, 4 times, 5+ times.*

Table 9
*Correlations between activity indicies and interest and attitude scales*

| Scale | Science-Related Activities | Space-Related Activities |
|---|---|---|
| Science Task Interest | .43 | .32 |
| Space Science Task Interest | .45 | .42 |
| Attitude towards Science | .50 | .33 |
| Attitude towards Space | .43 | .49 |

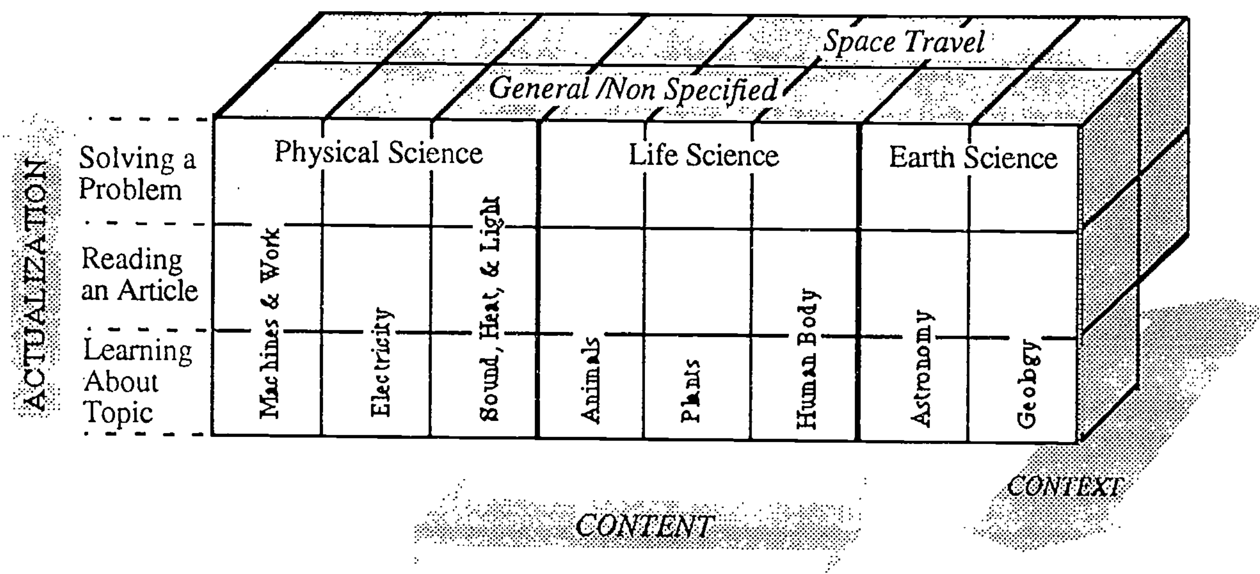



**Figure 1**

**Three dimensions of content-specific interest measured.**

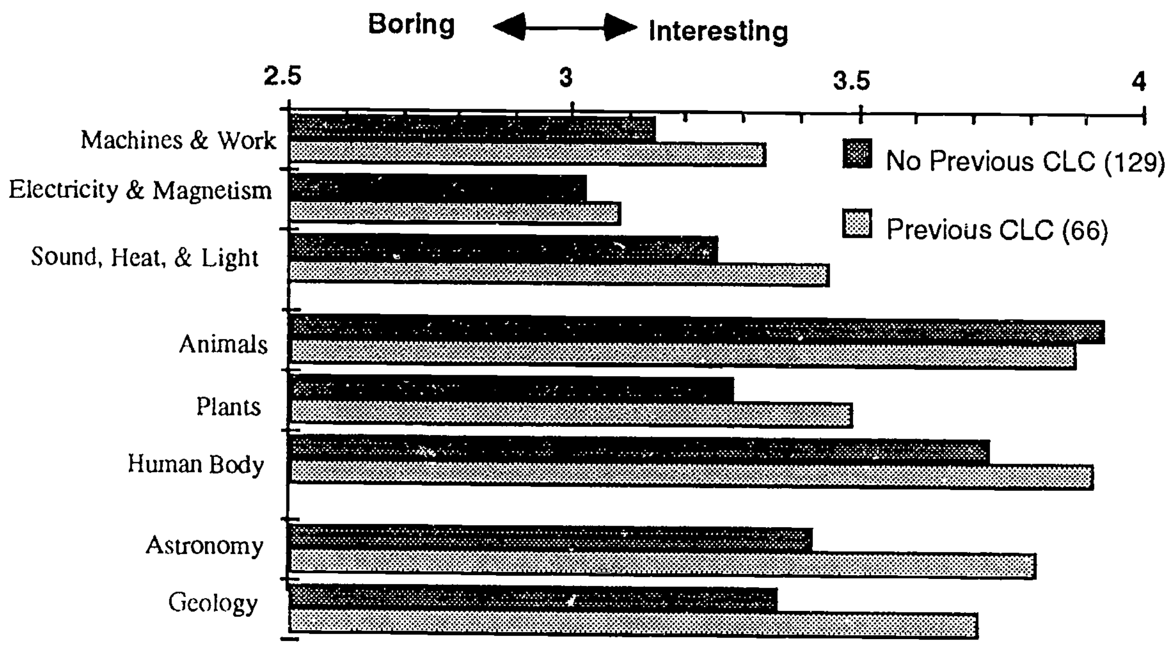



Figure 2
Pretest topic-specific interest for students who did and did not participate in CLC during previous school year at Site 1.

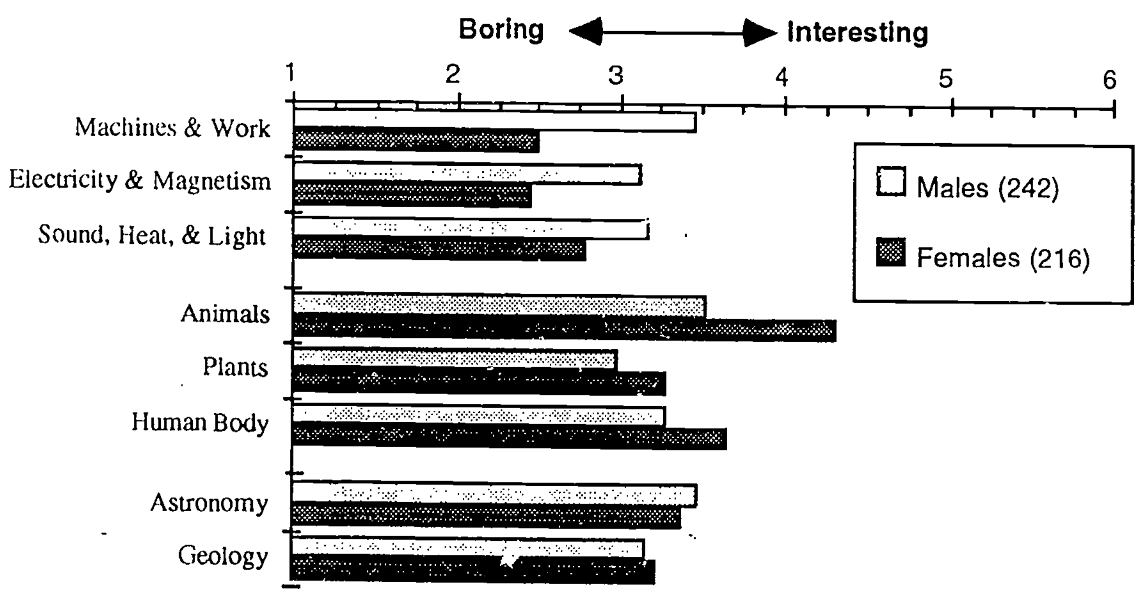



Figure 3
Topic-Specific Interest by Gender

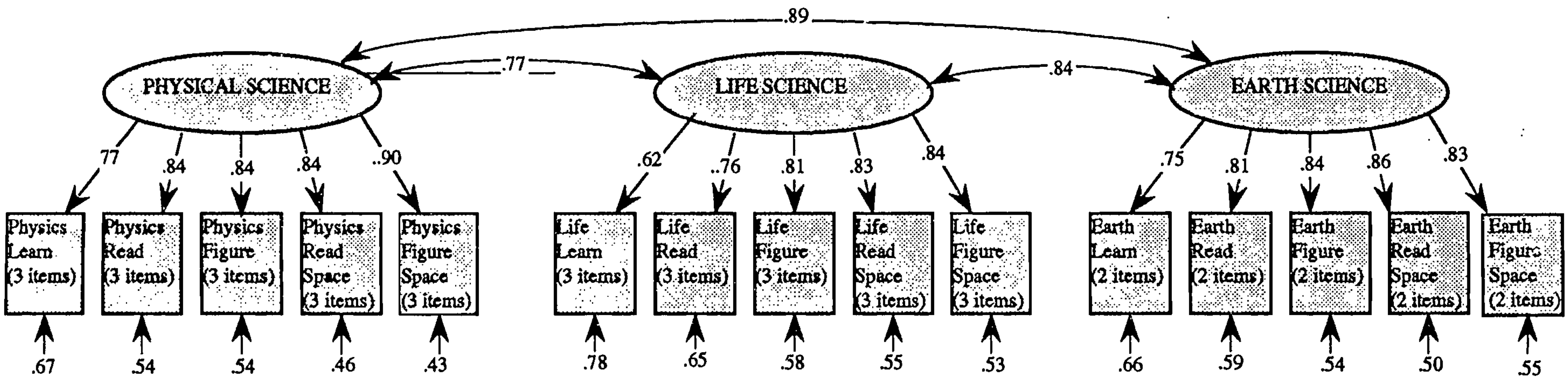

.89
.77
.84
PHYSICAL SCIENCE
LIFE SCIENCE
EARTH SCIENCE
77
.84
.84
.84
..90
.62
..76
.81
.83
.84
.75
.81
.84
.86
.83
Physics Learn (3 items)
Physics Read (3 items)
Physics Figure (3 items)
Physics Read Space (3 items)
Physics Figure Space (3 items)
Life Learn (3 items)
Life Read (3 items)
Life Figure (3 items)
Life Read Space (3 items)
Life Figure Space (3 items)
Earth Learn (2 items)
Earth Read (2 items)
Earth Figure (2 items)
Earth Read Space (2 items)
Earth Figure Space (2 items)
.67
.54
.54
.46
.43
.78
.65
.58
.55
.53
.66
.59
.54
.50
.55

**Figure 4a**

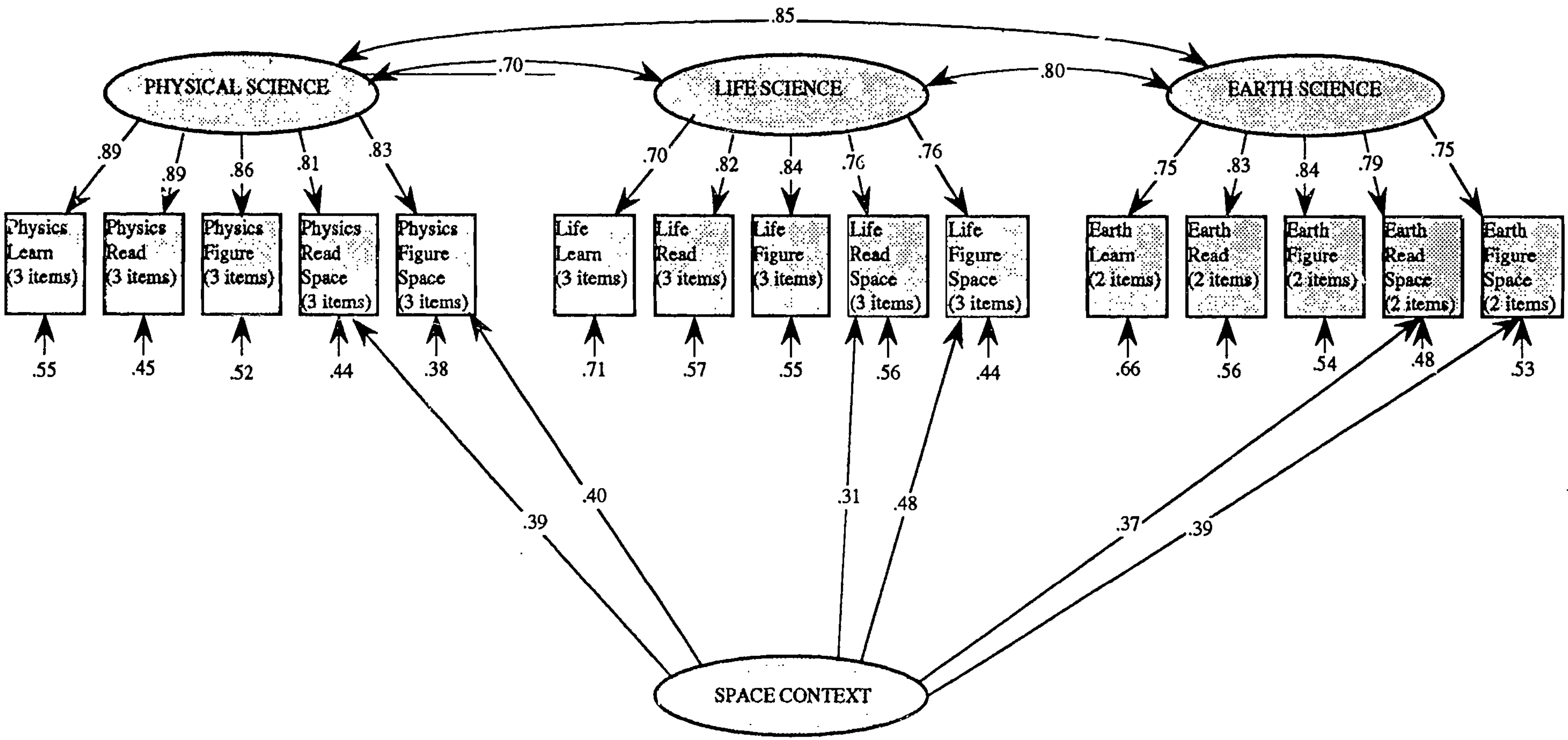

.85
.70
.80
PHYSICAL SCIENCE
LIFE SCIENCE
EARTH SCIENCE
.89
.89
.86
.81
.83
.70
.82
.84
.76
.76
.75
.83
.84
.79
.75
Physics Learn (3 items)
Physics Read (3 items)
Physics Figure (3 items)
Physics Read Space (3 items)
Physics Figure Space (3 items)
Life Learn (3 items)
Life Read (3 items)
Life Figure (3 items)
Life Read Space (3 items)
Life Figure Space (3 items)
Earth Learn (2 items)
Earth Read (2 items)
Earth Figure (2 items)
Earth Read Space (2 items)
Earth Figure Space (2 items)
.55
.45
.52
.44
.38
.71
.57
.55
.56
.44
.66
.56
.54
.48
.53
.39
.40
.31
.48
.37
.39
SPACE CONTEXT

**Figure 4b**

32

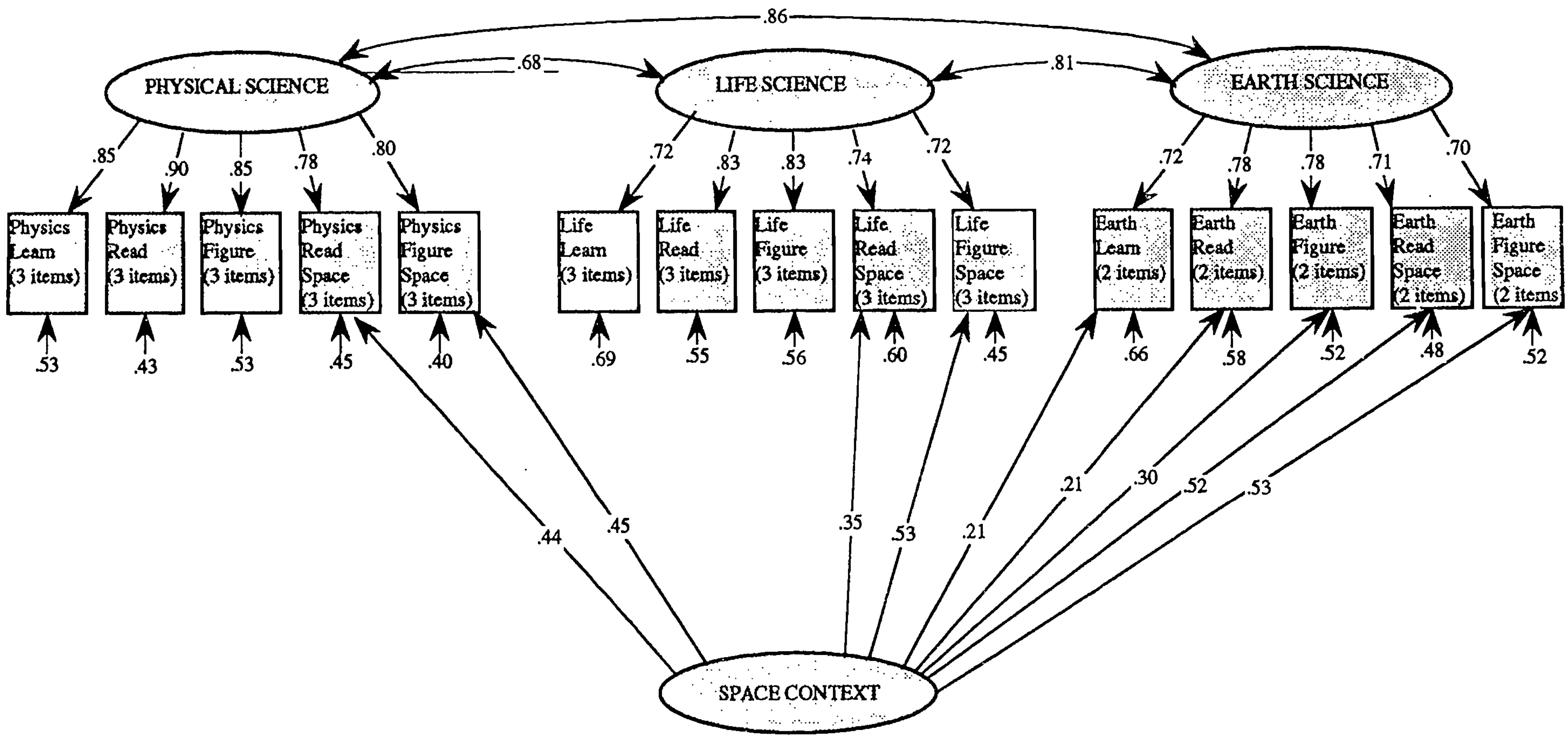

.86
.68
.81
PHYSICAL SCIENCE
LIFE SCIENCE
EARTH SCIENCE
.85
.90
.85
.78
.80
.72
.83
.83
.74
.72
.72
.78
.78
.71
.70
Physics Learn (3 items)
Physics Read (3 items)
Physics Figure (3 items)
Physics Read Space (3 items)
Physics Figure Space (3 items)
Life Learn (3 items)
Life Read (3 items)
Life Figure (3 items)
Life Read Space (3 items)
Life Figure Space (3 items)
Earth Learn (2 items)
Earth Read (2 items)
Earth Figure (2 items)
Earth Read Space (2 items)
Earth Figure Space (2 items
.53
.43
.53
.45
.40
.69
.55
.56
.60
.45
.66
.58
.52
.48
.52
.44
.45
.35
.53
.21
.21
.30
.52
.53
SPACE CONTEXT

Figure 4c

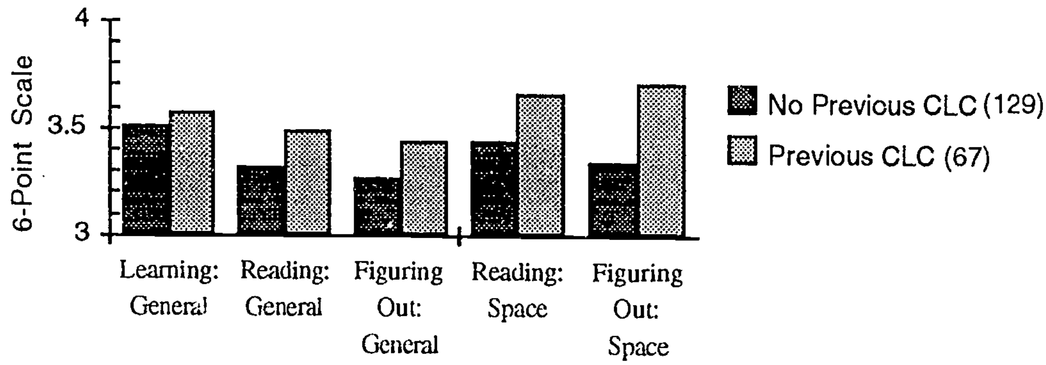



Figure 5
Task Interest by Activity Level and Context

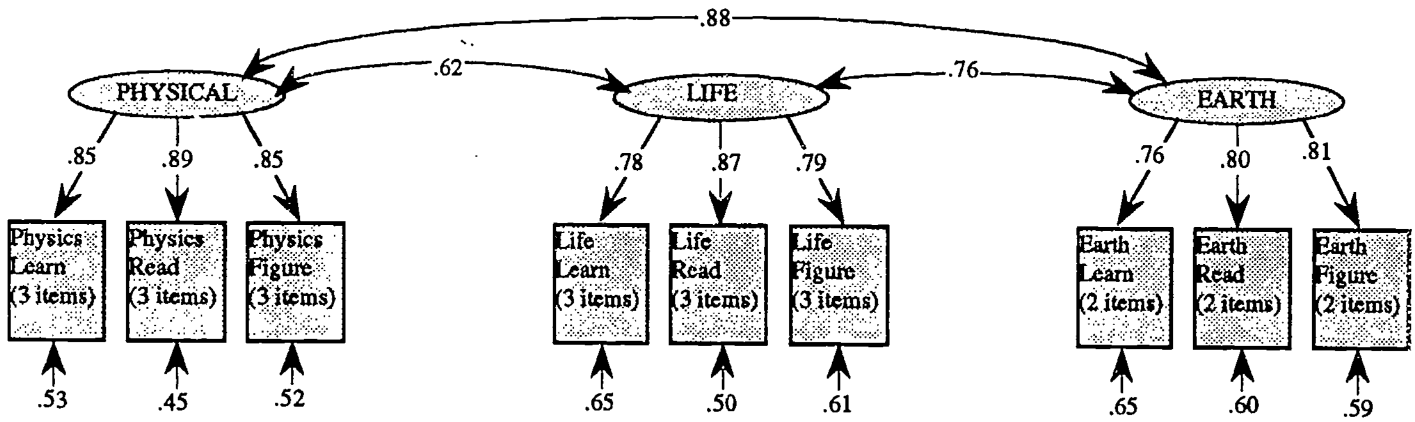



**Figure 6a**

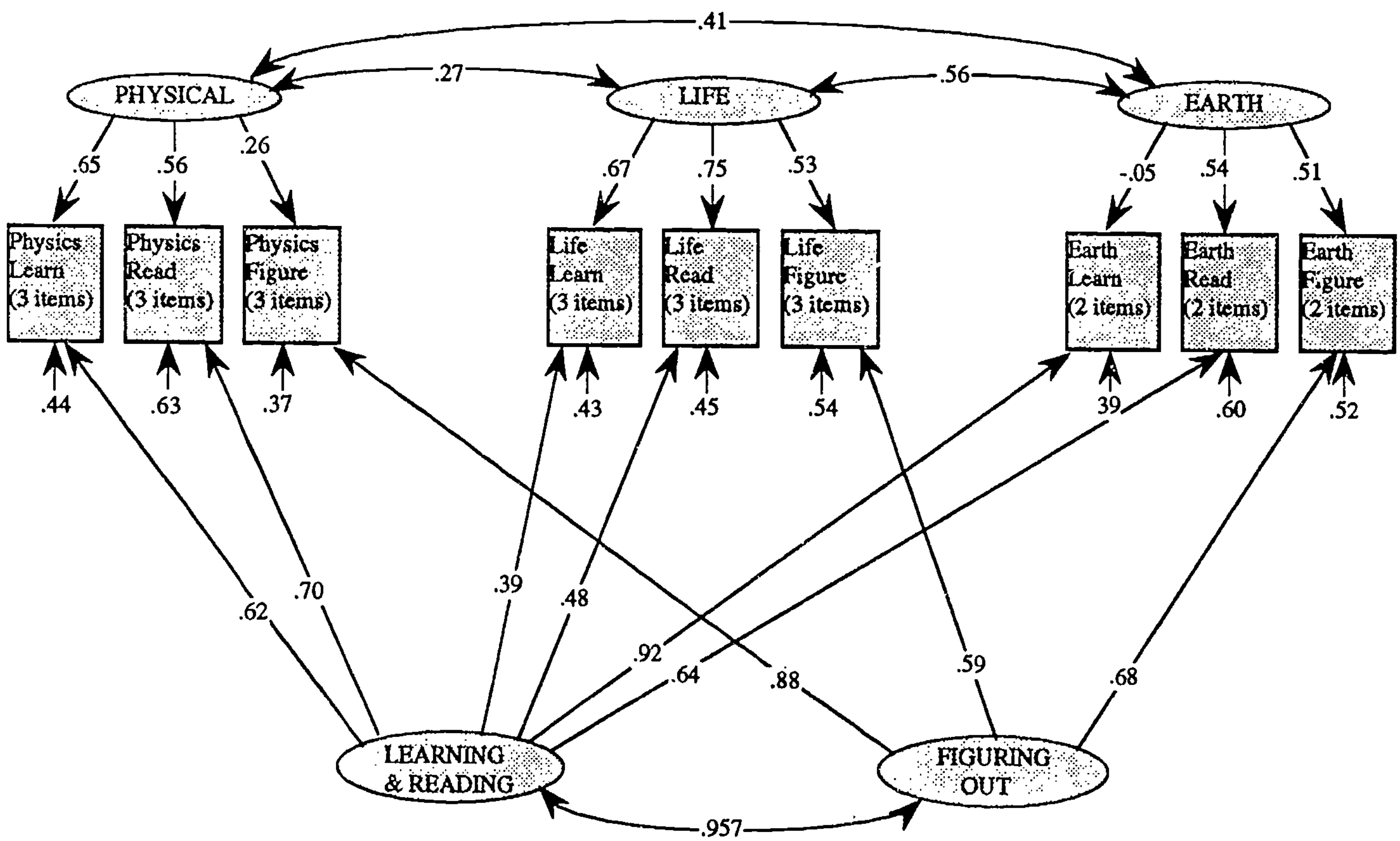
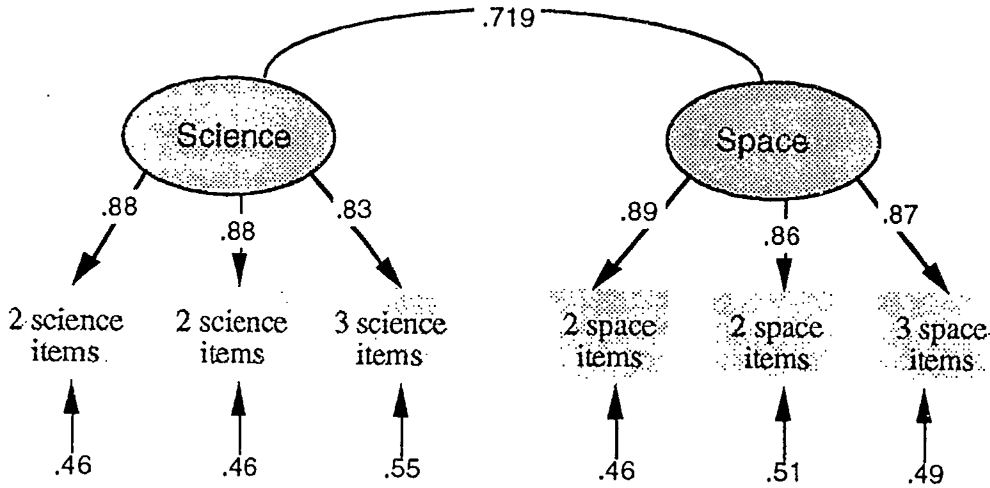



**Figure 6a**




| Model | $\chi^2$ | df | NNFI | CFI |
|---|---|---|---|---|
| Null | 2383 | 15 | | |
| One-Factor | 658 | 9 | .669 | .810 |
| Two-factor, | 27 | 8 | .989 | 994 |

**Figure 7**

**Science/Space Attitude Model**

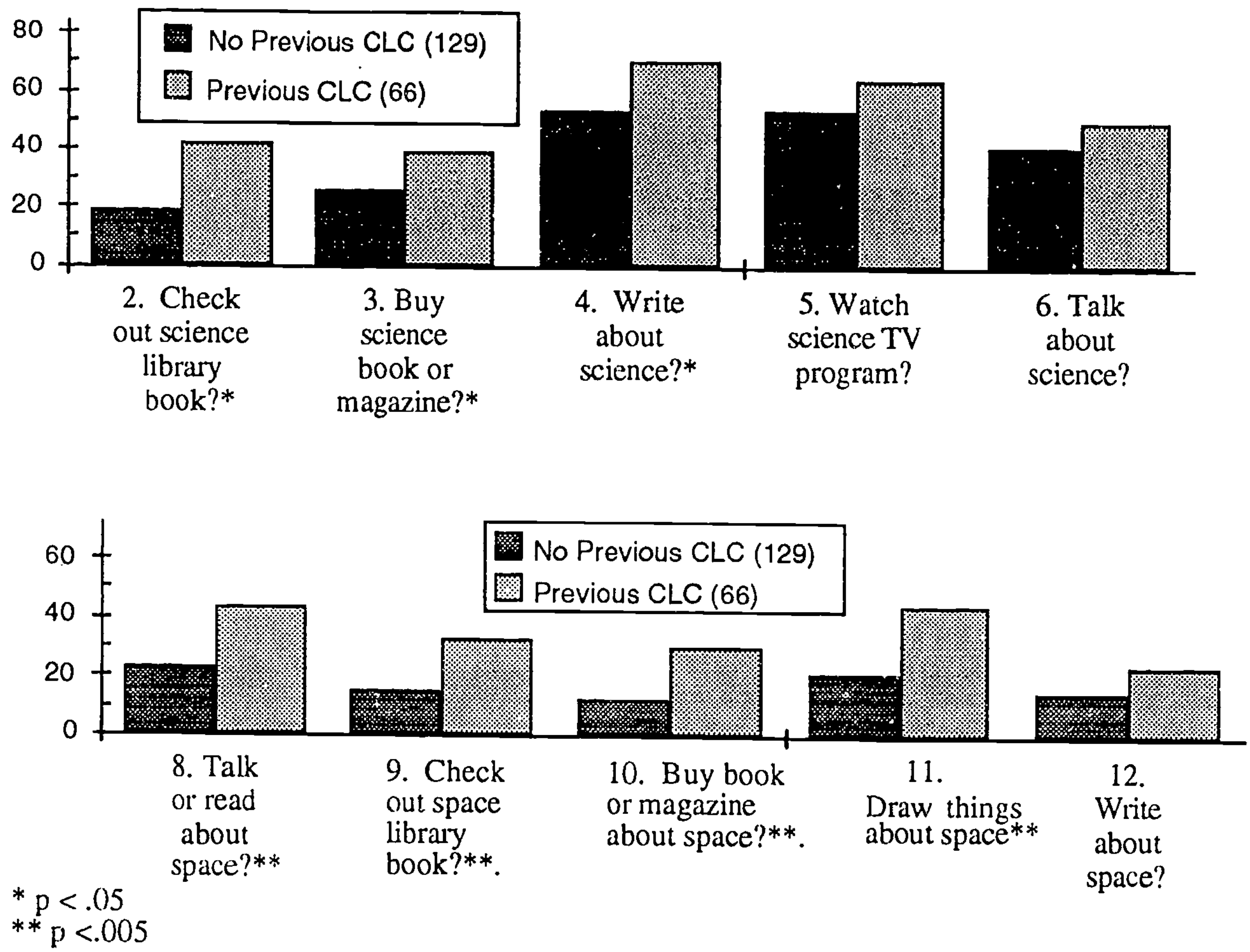
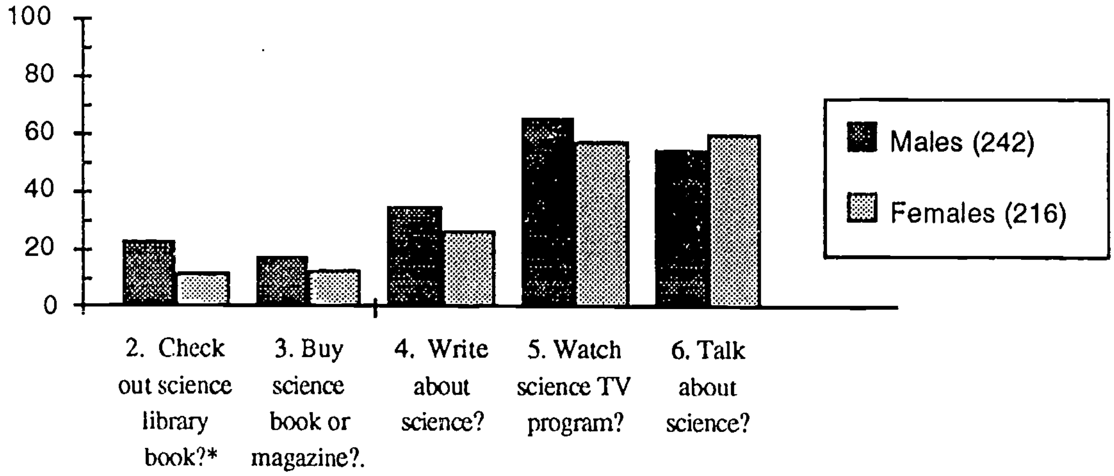
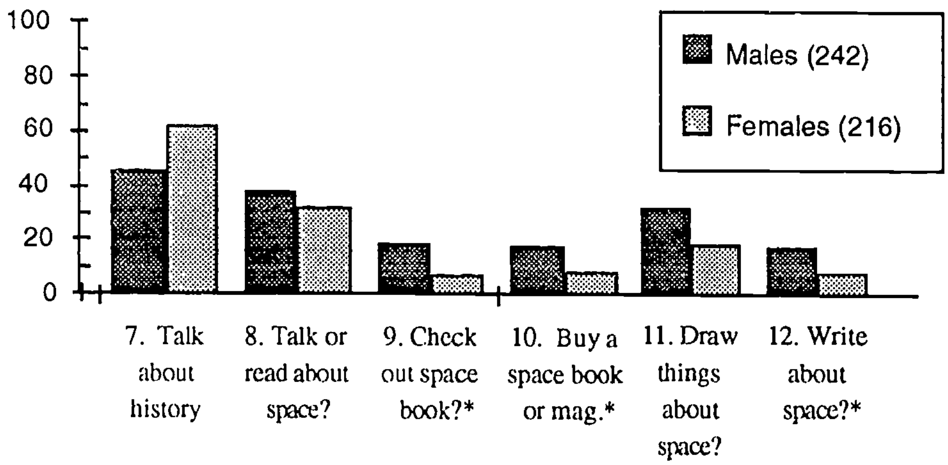



**Figure 8**
**Proportion of evaluation students engaging in science and space-related activities.**




* p < .05

**Figure 9**
**Science and Space-Related Activities by Gender**

## Appendix A

## SPACE/SCIENCE TAKS INTEREST SURVEY ITEMS

**(PHYSICAL/Machines & Work)**
Learning about machines and how they are used to do work?
Reading about how an motorized vehicle works?
Reading about how a Mars robot vehicle works?
Figuring out the forces that affect how a motorized wheelchair works?
Figuring out the forces that affect how a Mars rover vehicle works?
**(PHYSICAL/Electricity and Magnetism)**
Learning about electricity?
Reading about how electricity is produced and used?
Reading about how electricity is produced and used a spacecraft?
Figuring which is the most effecient way to make electricity?
Figuring out the best way to make electricity in a spacecraft?
**(PHYSICAL/Sound, Heat, & Light)**
Learning about sound, heat, and light?
Reading about how light and sound travel?
Reading about how light and sound travel in space?
Figuring out how long it takes light to travel one mile?
Figuring out how long it takes light to travel from the Sun to Mars
**(LIFE/Animals)**
Learning about animals?
Reading about how certain animals develop and reproduce?
Reading about how certain animals develop and reproduce in weightlessness?
Figuring out the best animals to use in a self-contained terrarium?
Figuring out the best animals to use in self-contained colony on Mars?
**(LIFE/Plants)**
Learning about plants?
Reading about how certain plants grow in greenhouses?
Reading about how certain plants grow in the weightlessness of space?
Figuring out how many trees are needed to make enough oxygen for one person?
Figuring out how many trees are needed to make enough oxygen for a Mars colony
**(LIFE/Human Body)**
Learning about the human body?
Reading about how age affects how the human body works?
Reading about how weightlessness in space how the human body were?
Figuring out which food provides the best nutrition for a camping trip?
Figuring out which food provides the best nutrition for a two-year space mission?
**(EARTH & SPACE/Astronomy)**
Learning about the solar system and the universe?
Reading about the different things orbiting the Earth?
Reading about the different things orbiting the Sun?
Figuring out how long it should take to travel to the Moon?
Figuring out how long it should take to travel to Mars?
**(EARTH & SPACE/Geology)**
Learning about Geology
Reading about the geological forces which created the Rocky Mountains?
Reading about the how the Valles Marineras (Mariner Valley) on Mars was formed?
Figuring out how the Great Smokey Mountains could have been formed?
Figuring out how Olympus Mons (a mountain on Mars) could have been formed?