

## Chapter 6

### Summary

This chapter includes a summary of the results of the two research articles, a discussion of the implications of these results, as well as the limitations of the research, and identifies potential extensions of these two studies. The chapter concludes with a brief statement of my personal learning experience through the work of completing the research and writing of my dissertation.

### Results

#### *Validation Study*

This study has provided new and up-to-date evidence concerning the validity of SLEI measures. Coupled with the existing research revealing positive correlations between student perceptions of their learning environments and academic achievement (Fraser, McRobbie, & Giddings, 1993), the outcomes reported here provide a foundation for future assessment of the relationship between classroom environment and student achievement. In addition, the differences presented in this research based on biology experience and academic grouping have implications for the evaluation of pedagogical approaches in the biology classroom.

Examination of the multiple fit indices across three substantive models indicated that the Fraser five-dimensional model exhibited the best model-to-data fit ( $\chi^2$ ,  $\chi^2/Df$ , and RMSEA), relative fit (CFI and NFI), replicability (ECVI), and model parsimony (PNFI). This was after the removal of the negatively worded items. Prior research has suggested that negatively worded items often do not function as intended, so this is not a surprising outcome (Marsh, 1996; Schriesheim & Hill, 1981; Yamaguchi, 1997). In addition, the moderate to low latent variable correlations suggest that the five-way distinction seems reasonable and that measures of these

dimensions do not provide unnecessarily redundant information about student perceptions—an outcome that is consistent with the validation work completed on these measures in the early 1990's (Fraser, McRobbie, & Giddings, 1993). This is likely to be important from the perspective of researchers and program evaluators who would like to depict science laboratory learning in a diagnostic manner because the relatively low correlations between the latent variables will allow for the development of profiles that indicate relative strengths and weaknesses of individual classrooms or programs.

The relative fit of the partial credit and rating scale versions of the MRCMLM configuration of Fraser's five-dimensional model, as measured by the BIC values, indicated a statistically significant improvement in fit of the partial credit model over the rating scale model. A comparison of the threshold estimates from the partial credit scaling across items indicated that application of the rating scale model to these data is reasonable.

The results of the examination of the rating scale based on Linacre's criteria, suggest that the five-point rating scale structure used on the SLEI is not optimal and that, perhaps, a four-point scale may work better. There have been no prior analyses of the SLEI rating scale's function. Future studies will be necessary to determine whether a four-point rating scale for the SLEI does, indeed, remedy the minor problems that were identified concerning the proximity of the lower rating scale thresholds on all five of the SLEI subscales.

With regard to item quality, the results indicate that the SLEI items work well as indicators of student perceptions of the science laboratory environment. None of the items were flagged for serious concern, an outcome that is consistent with previous studies (Fraser, Giddings, & McRobbie, 1995; Fraser, McRobbie, & Giddings, 1993). However, thirteen negatively worded items were removed from analysis because they did not behave as expected.

This is not something that had been done prior to this research. Based on the analysis and findings, a modified form of the SLEI should be used with the negatively worded items removed and replaced with new items to supplement the dimensions where the negatively items were removed from.

The multidimensional reliabilities are reasonably high and are consistent with Fraser's previous work (1992). However, these reliabilities were lower than those found in the earlier validation work even though a multidimensional scaling model was utilized. This may be the result of the sample being more homogeneous than samples in previous work, coupled with the fact that 13 reverse worded items were eliminated leaving several dimensions with low numbers of items. Based on the results of the entire validity study, using the instrument with a four-point scale and removing the negatively worded items would be optimal.

#### *Group Differences Study*

Students in high achieving courses had a more favorable perception of all aspects of their learning environments when compared to students in the regular courses. This is consistent with earlier research that found gifted students more positive about their learning environments (Lang, Wong, & Fraser, 2005). The differences between regular and high achieving students were statistically significant, although the effect sizes were small. The small effect sizes indicate that while there are significant differences, there are likely a number of other factors influencing student perceptions.

Student perceptions of their lab may be influenced by the extent of students' experience learning biology. Grade level was used as a proxy for experience with ninth graders having the least experience and twelfth graders having the most. Grade level differences in student perceptions were statistically significant across all five factors of the lab environment. Our

analysis showed that ninth graders tended to be more negative than students in other grades. The tenth graders reported the most positive perspective of all the students. Eleventh graders were more positive than twelfth graders.

First year biology students were compared to those beyond their initial biology class experience. Biology classroom experience influenced student perceptions between first student and those beyond the first year. Negative perceptions of the classroom environment were reported for first year students. In contrast, students beyond the first year were typically found to have positive lab environment perspectives. The most meaningful differences between the students in first year and all other classes were instead found in the dimensions of Student Cohesiveness; Integration; and Material Environment.

To determine whether differences observed by grade level could be attributable to biology learning experience versus experience in school, additional analysis was completed. The analysis revealed that differences in perception were consistent across academic achievement groups as well as experience level by first year and beyond (course level) rather than by grade level. Perceptions were consistent amongst regular and high achieving students regardless of grade level. In addition, first year and beyond student perceptions were consistent regardless of grade level.

### Implications

This study was undertaken to generate up-to-date norms for the measures of the SLEI and to complete an examination of the validity of these measures within the frameworks of modern validity and measurement theory. There are several implications to the field of educational research as a result of this study. The first implication concerns the findings regarding negatively worded items. This study provides further evidence that reverse worded items simply do not

behave as expected. They may be useful in preventing response sets, but they do not hold in context with the other items for the measures. The behavior of negatively worded items in instruments should be explored further. Second, the research that was completed has ensured that inferences regarding the current context of science learning based on student perceptions are valid, with a few modifications to the measures of the instrument (removal of negatively worded items, modification to rating scale) as previously discussed.

Third, this updated and validated form of the SLEI can be used in classrooms and in curriculum development. Enhanced understanding of student perceptions will enable educators to identify and address potential gaps in pedagogical approaches as well as modify learning environments based on specific student needs. Directly addressing students' negative perceptions and assessing ways of positively changing the lab environment for students may be a powerful way to keep them interested and engaged.

Fourth, the outcomes of this study, combined with the existing research revealing positive correlations between student perceptions of their learning environments and their academic achievement (Fraser, McRobbie, & Giddings, 1993), provides a foundation for future assessment of the relationship between classroom environment and student achievement.

### Strengths and Limitations

#### *Strengths*

This research study provides up-to-date norms for the measures of the SLEI for populations of U.S. secondary students and presents updated and more complete evidence of the validity of SLEI measures for depicting U.S. student perceptions of the science-learning environment. The evidence concerning the reliability and validity of the SLEI measures was dated and represented a range of performance scores from multiple countries without presenting

a cohesive body of evidence for any one of those countries. In addition, the evidence to date was scant when held to current standards for validity and reliability (Wolfe & Smith, 2007a, 2007b). In particular, research concerning the instrument measures has not focused on at least two critically important validity aspects. First, no attention has been directed toward the quality of the items, Messick's (1995) content aspect of validity. Second, no attention has been directed toward the quality of the rating scale that is used to elicit responses from students, Messick's structural aspect of validity. In addition, prior studies of the SLEI have only addressed the external aspect of validity tangentially.

### *Limitations*

A response set of 355 was sufficient to complete this comprehensive validation study. However, the size of the sample limited analyses of certain subgroups by ethnicity and/ or grade level. To further understanding of differences in student perceptions by a wider variety of ethnic groups, a larger relative sample should be analyzed. There were insufficient responses in the 9<sup>th</sup> and 12<sup>th</sup> grades in several subcategories to fully explore research questions regarding experience in biology. A larger, more heterogeneous sample may remedy these limitations. In addition, because minor modifications have been suggested for the rating scale structure employed on the SLEI along with removal of the negatively polarized items, a new validation study that evaluates a revised version of the SLEI should be completed to further the application of the validation evidence presented here.

An additional minor concern is that two dimensions are measured by only three or four items. The fact that the data was scaled with a multidimensional model allowed us to achieve higher levels of reliability than would be the case for true score or separate calibrations for the subscales. Future researchers may consider adopting multidimensional scaling model or may

want to consider developing additional items for these dimensions in order to increase the levels of reliability. Of course, the fact that this sample may be more homogeneous than a more general population means that reliability estimates for a more heterogeneous population will likely be higher than what was observed in this study.

#### Potential Extensions of this Research

Future research should include an expanded administration of the SLEI to encompass a larger sample and should also include an examination of the actual and preferred environment differences available through the multiple forms of the instrument. New items should be developed to replace the reverse worded items that were removed. Future studies will also be necessary to determine whether a four-point rating scale for the SLEI does improve the rating scale weaknesses identified in the study.

A full study and exploration of the behavior of the negatively worded items is certainly warranted. There is prevailing literature that discusses the many possible reasons for this item behavior. These should be further examined to contribute to the methodological knowledge of the effect of polarized items.

Expanding the research findings of the SLEI through qualitative research may provide further evidence toward the formulation of curriculum as well as informing teacher understanding of the specific needs of the students in their classrooms. Teachers can use the student perceptions of their learning environment to emphasize critical pedagogical approaches and modify other areas that will enable the enhancement of the science laboratory-learning environment.

#### Personal Learning Experience

The completion of this research has enabled me to apply my theoretical expertise across a range of methodological applications in the field of measurement and science education, as well as some practical learning experiences. I began the study with the perspective that we would have close to 900 participants for data analysis. This became a challenge as commitments from different schools suffered because of district permission, lack of parental consent, the prioritization of standardized testing and individual personal crises. Certainly doubling the prospective sample by surveying more students may not have been practical, but it would be ideal in a future research project.

The richness of the data analyses available through Rasch measurement methodology allowed for further research into the nuances of the measures of this instrument, as well as the application of this methodology toward the provision of robust validation/ revalidation information for other published measures. It was exciting for me to enhance my understanding through practical application of theory and research tools.

Working with multiple methodologies across the analyses process enabled me to examine results from various perspectives to further my overall confidence in the findings. The discovery that the negatively worded items were not functioning as intended by the instrument authors was certainly an interesting and provoking aspect of the research. Reading about the misbehavior of polarized items is certainly not as interesting as discovering and documenting their existence in your own work. Further exploration of the behavior of negatively worded items is another research study unto itself.

I look forward to the opportunity to continue and expand my research in the field of measurement and learning environment research. The experience I have developed over the

course of my doctoral work is only the beginning of a lifetime of understanding and applying knowledge in the furtherance of excellence in education.