Science and Mathematics Education Centre

Virtual Field Trips:
Using Information Technology to Create an Integrated Science Learning Environment

EXPANDED ABSTRACT and ABBREVIATED BIBLIOGRAPHY

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INTRODUCTION

This study evaluated a new Integrated Science Learning Environment (ISLE) that bridged the gaps between the traditionally separate classroom, field trip, and information technology milieus. As part of a deliberately designed professional development program, secondary school teachers contributed to a multi-level virtual field trip website that was based on an extended field trip to a natural area. Relevant applications of information technology were modeled in pre-trip lessons, employed during the field trip, and utilized in developing post-trip presentations.

The ISLE model involves a multi-faceted design to address the three basic forms of learning: acquisition of knowledge, change in emotions or feelings, and gain in physical or motor actions or performance. A holistic approach to teaching at the university level encompassed a step-wise, cumulative strategy that reinforced various aspects of constructivist teaching.

The general research question asked whether or not a teacher's participation in the ISLE program would lead to the teachers' implementation of constructivist learning environments in their respective students' school classrooms. The Constructivist Learning Environment Survey (CLES) was modified and used to evaluate the constructivist learning environment. Specifically, the study addressed the following questions:

Question 1: Are new versions of the CLES valid and useful in secondary schools and graduate university courses in Texas?

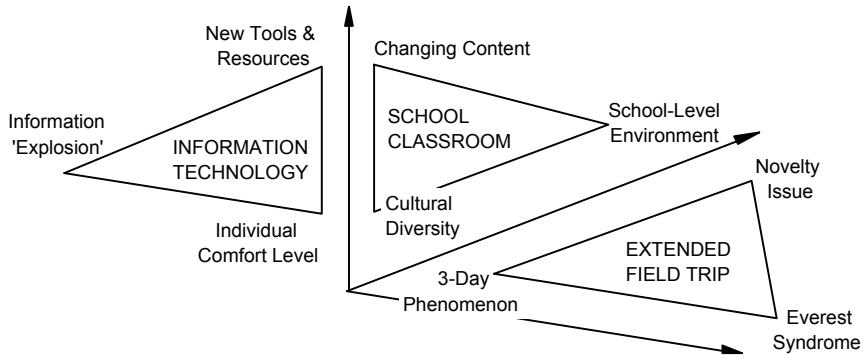
Question 2: How effective is the ISLE program in terms of the degree of implementation of constructivist teaching approaches in the teachers' school classrooms?

Question 3: How effective is the ISLE program in terms of teachers' perceptions of the university/field trip learning environment, changes in teachers' attitudes to information technology, and teachers' conceptual development?

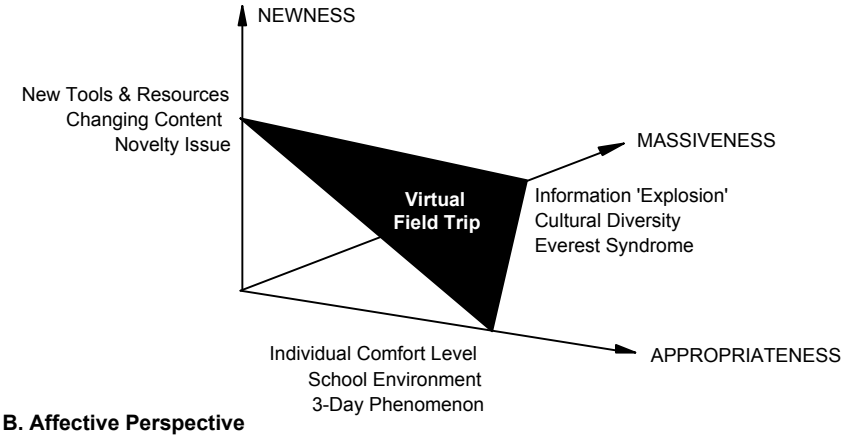
CONCEPTUAL/THEORETICAL FRAMEWORK

Interlocking conceptual and logistical frameworks were applied uniformly in the classroom and in the field. A cyclical program design reinforced key scientific, pedagogical, and technological issues to minimise the potentially detrimental effects of information overload and non-linear processing. This unique aspect of the ISLE model enabled all participants to see their role within the 'big picture'. As the common elements (knowledge) and basic components (understanding) in each realm became evident, the power of transfer for both content and concept was realised. Figure 1 illustrates how the final product of the ISLE program (virtual field trip) was constructed by linking the supporting learning environments on each fundamental level: newness, massiveness, and appropriateness.

Figure 1. Merging of Perspectives through the ISLE Virtual Field Trip



A. Effective Perspective



B. Affective Perspective

Figure 1.A shows that, in the traditional framework, there would be three separate and perpendicular planes in which activities would occur independently from the other learning environments. In the ISLE model, the conceptual framework is shifted from an effective perspective (pertaining to physical aspects) to an affective perspective (pertaining to emotions or feelings). Specifically, the virtual field trip project changes the program focus from the physical environment (field trip, classroom, or information technology) to the basic issue challenging learning in each milieu (newness, massiveness, or appropriateness).

As shown in Figure 1.B, a single and integrated plane is constructed in which activities can occur contiguously throughout the three learning environments. The outcome is a tangible representation of the constructivist paradigm, enabled by a process approach to implementing information technology in science education. Implementation of information technology reinforced the conceptual design and therefore was evident in all stages of the program – although never the focus in the classroom or field trip milieus. Real-world applications of relevant tools and resources were covertly employed to join the university classroom and the field trip experience seamlessly. In creating a singular group dynamic by requiring an integrated project (virtual field trip) rather than promoting multiple individual efforts, the inhibiting effects of site novelty, information overload, and the three-day phenomenon typically experienced on field trips could be placed in context and therefore be more manageable and understandable.

RESEARCH APPROACH AND METHODS

To address the multi-faceted aspects of the ISLE model, the research design was grounded in the naturalistic paradigm. An array of research tools and methods was carefully selected on the basis of each instrument's validity and reliability and applicability to the overall program goals and specific research questions of this study. Of particular note, the CLES was selected for use in this study because of its ability to characterise specific dimensions of the constructivist classroom. The five scales (Personal Relevance, Uncertainty of Science, Shared Control, Critical Voice, and Student Negotiation) enable a multilevel assessment that provides the basis of the overall research design. Three modified forms of the CLES were used to assess the perceived degree of constructivist teaching in the university and the school classrooms. The goal was to quantify perceptions of the learning environment in terms of whether or not it changed with the deliberate attempt at reform through multiple viewpoints, as shown in Figure 2.

Figure 2. Multilevel Assessment of ISLE Model

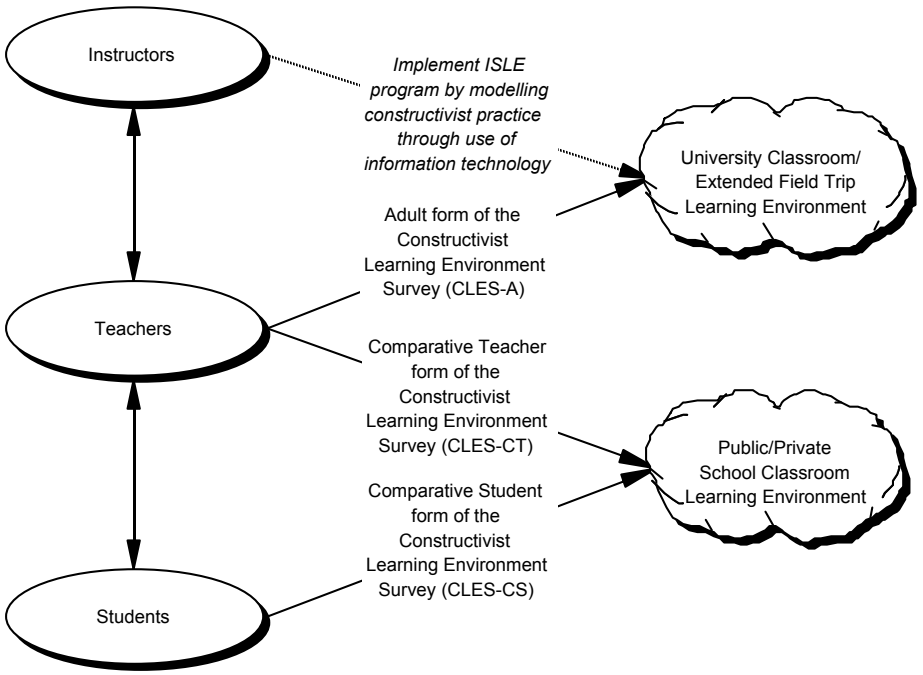


Figure 2 shows how the different participants (university instructors, school teachers, and students) were able to evaluate two different learning environments (university/field trip and school classrooms) using three versions (adult, comparative teacher, and comparative student) of a single learning environment instrument (CLES). The adult form allowed the teachers to assess the degree of constructivist practice in the learning environment which they experienced as students in the university setting. Then, the comparative teacher form allowed the same teachers to assess the degree of constructivist practice in the learning environments which they created as teachers in the school setting. This evaluation was supported by their respective students' assessment of the degree of constructivist practice in the same classroom learning environment.

A combination of qualitative methods and quantitative measures provided insight into the milieus and the near- and far-term effects of exposure to constructivist pedagogy in order to answer the main question of whether changing teachers' learning environments leads to changes in their respective students' learning environments. Throughout the program, frequent peer

debriefing sessions and member checks were conducted to ensure observer credibility and identify participant bias. Teacher and student perceptions of dimensions of the learning environment were used as dependent variables (i.e. criteria of effectiveness) in the evaluation.

DATA SOURCES AND METHODS OF ANALYSIS

Evidence derived from multiple sources was triangulated to ensure that the data were non-contradictory, and therefore more likely to accurately describe the investigated item. Quantitative assessment through learning environment dimensions, in addition to attitude scales and concept map analyses, was supported by qualitative data derived from reflective field journals, interviews, and observations to evaluate the impact of the emergent model. The study was conducted in two distinct phases. Phase I focused on the university classroom and extended field trip learning environment, involving the primary sample of ISLE program participants. Data from the Teachers' Attitude Toward Information Technology (TAT) pretest, adult form of the CLES, teacher-generated concept maps, and Reflective Field Journal questions were collected during Phase I. Phase II focused on the public/private school classroom learning environment, involving a subset of Phase I teachers comprised of inservice teachers with science backgrounds only and their respective classroom students, along with a student control group derived from teachers who had completed traditional field trips led by the same instructors within two years prior to the ISLE program implementation. Data from the TAT posttest and two comparative forms of the CLES were collected in Phase II.

SPSS for Windows was used to provide information about the validity of the CLES by analysing the student data in terms of the factor structure, internal consistency reliability and discriminant validity, and the ability to distinguish between different classes and groups (ANOVA). A non-parametric model was employed to investigate the smaller samples of teacher data. Similar to a pretest/posttest design, descriptive statistics (means and standard deviations) and a Wilcoxon matched pair signed rank *T* test were used to compare perceptions of the learning environment. Pearson correlations were performed to relate CLES scales to TAT scales and concept map scores. Detailed observational case studies, along with informal interviews and archived messages, supported statistical analysis and interpretation throughout the entire study.

FINDINGS AND RESULTS

In summary, the new versions of the CLES were shown to be valid and useful in secondary schools and graduate university courses in Texas (Research Question 1). Data from 1079 students in 59 classes were subjected to principal components factor analysis with varimax rotation and Kaiser normalization, confirming the *a priori* structure of the CLES-CS. The factor structure, internal consistency reliability, discriminant validity, and the ability to distinguish between different classes and groups were supported for the comparative cases (THIS and OTHER) of the CLES-CS. Data from 12 adults enrolled in a graduate course in north Texas supported the usefulness of the CLES-A form. Based on the conceptual strength and psychometric structure of the questionnaire, the validation of the CLES-CS with a large sample, and the acceptable use of the CLES-A, the results support the usefulness of the CLES-CT form with north Texas teachers. These results are similar to previous studies using the CLES.

The data also suggest that the ISLE program was effective in terms of changes in the degree of implementation of constructivist teaching approaches in the teachers' public/private school classrooms (Research Question 2). Data from the CLES-CT (N=7) suggested that the ISLE program was effective in terms of the degree of implementation of constructivist teaching approaches in the teachers' public/private school classrooms as perceived by the ISLE science teachers. Data from the CLES-CS (N_{ISLE} = 445 students in 25 classes taught by 5 ISLE science teachers; $N_{Non\text{-}ISLE}$ = 328 students in 19 classes taught by 5 other science teachers) suggested that the ISLE program was effective in terms of the degree of implementation of constructivist teaching approaches in the teachers' public/private school classrooms for the ISLE science teachers, as perceived by their respective students. When an ANOVA was used to compare students' perceptions of THIS and OTHER classes, statistically significant differences were found for some CLES scales. In particular, students whose teachers had attended the ISLE program (THIS) perceived higher levels of Personal Relevance and Uncertainty of Science in their classrooms relative to the classrooms of other teachers in the same schools (OTHER).

Finally, the data suggest that the ISLE program was effective in terms of improving teachers' perceptions of classroom environment, attitudes to technology, and conceptual development (Research Question 3). Data from the CLES-A (N=12) documented the teachers' perceptions of the university/field trip learning environment suggesting that the instructors' teaching in Phase I successfully modelled constructivist pedagogy for the ISLE participants, particularly for science teachers. Data from the TAT and various qualitative methods were used to assess the effectiveness of the university/field trip course in terms of changes in teachers' attitudes toward information technology. Qualitative data from the participants' journal entries (N=12) suggested that the instructors' teaching in Phase I successfully modelled the seamless integration of information technology in an educational context. Pretest/postest data from the TAT (N=7) suggest that the ISLE program facilitated a positive overall change in the science teachers' attitudes toward information technology. Additional data from the participants' journal entries (N=12) suggested that this positive change in the teachers' attitudes toward information technology had a positive impact on their public/private school classrooms.

Qualitative data from reflective field journal entries, observations, and interviews was combined with quantitative data from concept maps, along with an individual case study, to describe the teachers' conceptual development in order to assess the effectiveness of the university/field trip course in terms of teachers' conceptual development. Specifically, data from participant-generated concept maps (N=12) suggested that the methodology used to implement a constructivist paradigm within the ISLE program was appropriate and successful in increasing participants' conceptual understandings. Further, the qualitative data suggest that the science teachers' conceptual development changed from studying science as a series of discrete 'parts' to seeing the value of scientific information positioned in the wider context of a delicately balanced, open-ended system. In parallel, the non-science teachers' conceptions of science as a separate and distinct subject developed toward the idea that science was an integral part of their environment and could be dealt with as such irrespective of the discipline or topic of discussion. Such multi-faceted insights allow teachers to integrate information into a coherent whole for all types of learners, thereby affecting the learning environment of their classrooms by meeting the needs and interests of a diverse student body.

CONCLUSIONS AND IMPLICATIONS

As a result of this study, the new versions of the CLES were shown to be valid and useful in secondary schools and graduate university courses in Texas. Administration of these versions of the same instrument was used to characterise the learning environment of the ISLE university/field trip program, as well as the public/private school classrooms. Further analysis and interpretation of these data suggest that the ISLE program was effective in terms of the degree of implementation of constructivist teaching approaches in the teachers' school classrooms and in terms of promoting positive teachers' perceptions of the university/field trip milieu, changes in attitudes to information technology, and conceptual development.

In order to understand the inter-relatedness of the main aspects of ISLE model (instructors' modelling of constructivist practice and teachers' attitudes toward information technology and conceptual development), the nature of relationships between the scales of the instruments used in Phase I was explored. The data from the content-based instruments (TAT pretest and teacher-generated concept maps) correlated with specific scales within the learning environment assessment (CLES-A), indicating that there are different associations between the scales of the instruments for participants with different content backgrounds.

SIGNIFICANCE OF THE STUDY

The ISLE model provides a catalyst for educational change. Because the ISLE instructors changed the teachers' learning environment in the university/field trip course, the ISLE teachers' were able to improve each of their students' classroom learning environments in their private/public schools. Explicitly founded on the five scales of the CLES, the ISLE program directly supports the goals of educational reform effort in science. As noted in the literature, holistic transformation can be exponentially promoted in the school classroom through established teacher education programs. Influenced by the school-level environment, this sort of pedagogical change is difficult to realise in individual classrooms.

In terms of program development, this study examined a novel combination of influences from the fields of science education (constructivism and concept mapping), psychosocial cognition (experiential training and knowledge transfer), and information technology (data management and web-based presentation). Deliberate in design, the model encourages individual communication, collaboration, and creativity to develop a sense of ownership in and a personal relevance of a complex group product. Such skills are critical to the success of both teachers and students in today's rapidly advancing information-driven society. Despite the limitations, the strategic incorporation of information technology into teaching and learning enabled an open design that can be tested in other locales with other topics. This study contributes to the research by evaluating a comprehensive professional development program that used information technology to initiate teacher change from the central perspective of the learning environment.

This study is also distinctive in that it employed a learning environment framework in evaluating an integrated program. As learning environment dimensions have not been used previously in such an evaluation, this thesis makes a unique contribution to the field of learning environments research by evaluating an integrated milieu that envelops three classically-distinct learning environments. From a practical view, this study documents a new model for improving learning and understanding in the field of education, specifically science education.

The real world is where theory and practice come together and science becomes relevant, making sense that leads to understanding. The conceptual and logistical frameworks of the ISLE model seamlessly merged theory and practice with science and education through effective applications of information technology to create a rich learning environment. Virtual field trips, based on the ISLE model, can enable the principles of student-centred inquiry and constructivism to be practised for the benefit of all styles and ages of lifelong learners.

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