EVALUATION OF AN INTEGRATED SCIENCE LEARNING ENVIRONMENT

THAT BRIDGES UNIVERSITY CLASSES AND FIELD TRIPS

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Abstract

This study focused on the development of an Integrated Science Learning Environment (ISLE) to bridge the gap between the university classroom and field trip learning environments. The program modelled a constructivist paradigm to help teachers to learn and apply science content by creating a web page. Their own unique school classroom learning environments further influenced this implementation. The aim of the study was to evaluate the ISLE in terms of promoting conceptual understanding, attitudes and a constructivist classroom learning environment. Specifically, the course design addressed two major issues that not only challenge effective field work, but are the key to effective design and integration of web-based media into the classroom learning environment: information overload and non-linear processing. The study is important in that it combines the use of: concept maps to assess adult knowledge and understanding; the Teacher's Attitude Toward Information Technology (TAT) survey to gauge experience and exposure to information technology; and a modified version of the Constructivist Learning Environment Survey (CLES) written for adults to evaluate their perceptions of the university/ field trip program. The dimensions of these instruments were found to be correlated for both teachers with science backgrounds and those with non-science backgrounds.

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This case study in science education supports development of a new Integrated Science Learning Environment (ISLE). This paper presents phase one of a two-part investigation of a long-term professional development program based on a master's level teacher training course conducted in the summer of 2000. The overall aim of the study was to evaluate the resulting integrated learning environment in terms of promoting conceptual understanding, attitudes, and a constructivist learning environment in the university classroom, extended field trip, and public/private school classroom.

Introduction/Background

Traditionally, the university classroom, field trip, school classroom and information technology learning environments have been treated as separate milieus (see Fig. 1). Although the physical environments are distinct, the issues facing students and teachers are similar in each. The ISLE pilot program modelled a constructivist paradigm to help teachers to learn and apply science content through creating a web page based on conceptual understanding represented in concept maps. Real-world applications of relevant information technologies (IT; a broad term including all types of scientific and educational tools and resources – not limited to computers and peripherals) were covertly employed to seamlessly bridge the gap between the university classroom and the field trip experience. This implementation was further influenced by the teachers' own unique school classroom learning environments.

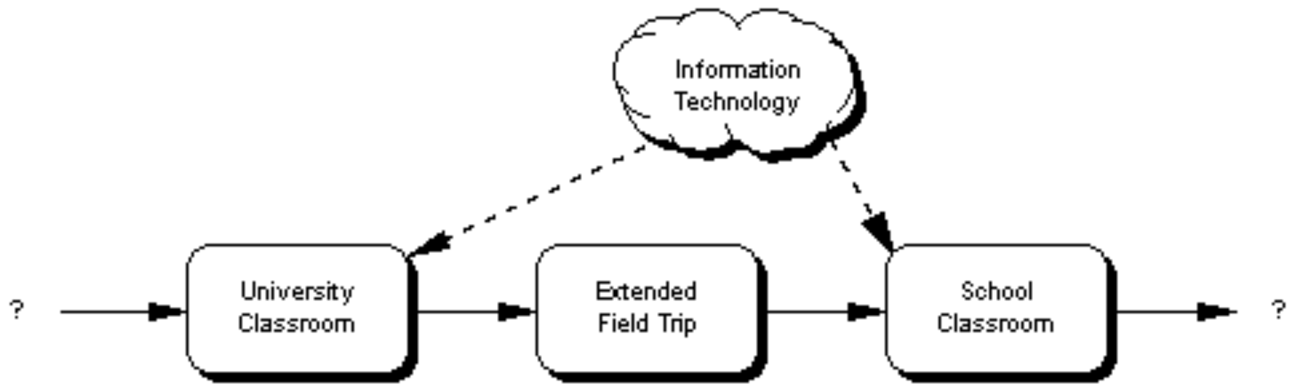


Figure 1. **Typical Learning Environments for Field-based Programs**. The traditionally separate learning environments develop a perceived two-dimensional solution (linear) that temporarily bridges the "gaps" between the "classic" learning environments. Information technology may or may not be evident in the classroom(s).

The Classroom Milieu. That today's teachers were students in a different world – technologically and otherwise – has a tremendous impact on tomorrow's education. As stated in a recent study on higher-level cognitive learning, "Teacher beliefs had a major impact on the way in which the curriculum was implemented" (Fraser & Tobin, 1991, p. 275). The ISLE program modelled the integration of information technologies into the university classroom curriculum, just as they might be implemented in the school classroom. By actually experiencing the appropriate and effective use of information technologies in educational practice, the teachers were able to appreciate the value of new tools and resources. Three key issues, critical to the effectiveness of classroom teaching, emerged from an extensive review of recent literature: 1) the challenge of rapidly and continuously changing content; 2) the diversity of students and tasks; and 3) the influence of both department- and school-level environments.

Science teachers, in particular, must find effective ways to balance issues and manage change in the classroom. Harper and Hedberg (1997) make the point that tools change knowledge. This is a critical aspect of scientific research and, therefore, an important point to consider within the context of science education (Kuhn, 1970). Changes in the textbook industry reflect the degree and impact of rapidly and continuously changing content. Advances in communications challenge teachers to be aware of current events in a multitude of student interests. Cultural diversity has long been recognised in America and is increasingly evident in the composition of classes at all levels. Language, customs, backgrounds, and overall perceptions and attitudes add to the challenge of the teacher's task in addressing a widely varied class. Not only are teachers encouraged to meet the needs of a changing world, they are still required to manage the issues of paperwork, parents and politics that confront them daily. Although it is useful to distinguish the classroom-level from the school-level environment, Fraser (1998) suggests that a confluence of the two traditionally independent fields of research would be desirable. The process of enculturation is strongly influenced by both department- and school-level environments (Milne & Taylor, 2000) and must be taken into consideration to improve the long-term effectiveness of teacher education programs.

The Field Trip Milieu. "Outdoor field trips have been researched from the standpoint of a unique learning environment" (Kaspar, 1998, p. 203). In contrast, the ISLE program encompassed the field trip, as well as the university and public/private school classroom milieus. Field trips can be used to foster positive change by creating a clearly defined and safe environment in which teachers are afforded the opportunity to risk and learn, thus bridging the gap between theory and practice in the classroom. Three key issues, critical to the effectiveness of extended field trips to natural areas, emerged from an extensive review of recent literature: 1) novelty; 2) the "three-day", "last-day", and "me too" phenomena; and 3) the "Everest" syndrome.

By far, the most commonly studied aspect of field trips is the novelty factor. Opinions vary as to the positive and/or negative impact of novelty, or the newness of an environment, on learning (Orion & Hofstein, 1991; Barshinger & Ray, 1998; Mullins, 1998; Rudmann, 1994; Falk & Balling, 1979). Kaspar (1998) views novelty as a positive feature of field trips, stating that, "Although each learning environment was personal, each individual's constructions were found to be mediated by the actions of others in the social setting and characteristics of the culture in which the learning was situated" (p. 100). The "Three-Day" Phenomenon, describing the period of adjustment typically required for individuals to feel comfortable as a part of the functional field trip group, is inferred in several studies, but informally defined by Jones (1990). For this type of interpersonal novelty, participants need about three days to 'detoxify' from the influence of civilisation. A similar phenomenon noted at the end of a trip, called the "Last-Day" Phenomenon, is characterised by rising inhibitions and withdrawal for personal protection against the separation from the group and re-entry into the respective daily roles. Jones (1990) also describes the "Me Too" Phenomenon that relates to the tendency of participants to flock together (e.g., taking dozens of pictures from 'the' secret position for winning composition). The "Everest" Syndrome, named by Maddux (cited in Gallo & Horton, 1994, p.17) refers to the tendency of teachers to feel the need to use technology, specifically the Internet, in their classrooms simply because it exists. The researcher employs this term also to include the often overwhelming effect of massive amounts of information resources and technological tools made available through the World Wide Web (Brauch, Gerhold, & Patt, 1996; Belk, 1998). "Sensory overload" is a significant issue concerning adult educational field trips, as graphically expressed in a student-teacher's query: "... how can you memorize a mountain?" (Jones, 1990, p. 97).

The Information Technology Milieu. "Academics are one of the best-connected communities worldwide, and the potential of the Web to this group is enormous" (Clarke, 1998, ¶ 3). Recent technological advances have created an awareness of the 'global community' and provide graphic examples of the impact of individuals and the inter-relatedness of systems and societies (Kosakowski, 1998). The ISLE program seamlessly presented information technology as a means to an end, not the end itself! Three key issues, critical to the effectiveness of integrating information technology into education, emerged from an extensive review of recent literature: 1) a proliferation of new tools and resources; 2) "information overload" and "non-linear processing"; and 3) the present comfort level of individuals.

Technology significantly influences both the topics and tools of science education. Kessell (1997) elaborates the dichotomous nature of information technologies in education; simply having the infrastructure in place does not ensure its appropriate use. Education has and will continue to embrace advantageous tools/resources over time as technology evolves. The magnitude of today's options is overwhelming and will result in a 'virtual revolution' for teaching. In March 1998, it was reported that a new website was created every four seconds (Clarke, 1998). The "information explosion" resulted in the creation of massive amounts of 'bits' of data reinforcing the misconception that science is simply a collection of facts and figures with little relevance to the everyday lives of individuals and societies (Ledbetter, 1987). The non-linear nature of the World Wide Web poses an interesting challenge to classroom teachers, as well as teacher educators. Today's teachers are acutely aware of the lack of self-management, negotiation, collaboration and reflection skills required of today's students to gain maximum benefit from most currently marketed self-regulated information technologies (Harper & Hedberg, 1997). Their hesitation to 'reinvent education' is founded in experience and first-hand knowledge of the classroom environment. Many teachers are not yet computer literate; adequate training in the basic computer skills is a time-consuming addition to their already long list of things that must be done. "The possibilities are great, but the realities are limited" (Children's Software Review, 1998, ¶ 35), noted one teacher in a 1998 survey on "The State of Technology in Classrooms". The report personalises the key concerns that teachers have about computers in their classes: they are afraid to use them, do not have enough time to use them, do not understand how to use them, and/or see them as more trouble than they are worth.

Theoretical Framework

The ability to process information is critical in today's society and clearly reflected in state (Texas Education Agency, 1998), national (National Research Council, 1996) and international (Curriculum Council, Western Australia, 1998) standards documents for education. While machines process whatever raw data are entered into the system in a specifically sequenced context, people have an innate ability to process and synthesize sensory, perceptual and learned data in totally independent contexts derived from individual life experience. "The brain appears to be much like a camera lens: the brain's 'lens' opens to receive information when challenged, when interested, or when in an innocent, childlike mode and closes when it perceives threat that triggers a sense of helplessness" (Caine & Caine, 1994, p. 69). By creating an open, safe, and relevant environment, teachers naturally attained an appropriate level of content and comfort, and thereby maximised the opportunities provided by internalising their learning in this new integrated learning environment (ISLE).

A Process Approach to Implementing the Constructivist Paradigm. Founded in the principles of constructivism, the ISLE program is unique in that it combined a variety of processing approaches modified from experiential training and human resource development, with scientific methodology and pedagogical practice. Processing by way of experiential learning involves challenge and support (Rohnke, Tait, & Wall, 1997; Henton, 1996; Luckner & Nadler, 1997; Sakofs & Armstrong, 1996). It builds on physical activity that is deliberately structured to affect an emotional response and intellectual awareness through a cyclical pattern of experience, reflection, generalisation and application. Each stage is facilitated by a distinct processing phase to relate the group's common experience to each individual's particular situation. Foxon (1993) describes a process approach to the transfer of knowledge with respect to on-the-job application of skills and knowledge. Low motivation and lack of supervisor support are cited as the key factors that inhibit the transfer process in corporate training scenarios. Ledbetter (1999a) reports positive results from a process approach to science education using discrepant events, inquiry and open-ended activities to model teaching strategies, stimulate discussion of content information, and enable teachers to construct their own knowledge in science courses for practicing classroom teachers.

A process approach to learning requires the integration of the physical, emotional, and conceptual portions of the learning psyche. This allows the transfer of knowledge to action within the respective teaching area. Particularly relevant to the use of field trips is the idea that, according to Hammerman (1985), "... outdoor education is an approach toward achieving the goals and objectives of the curriculum, which involve (1) an extension of the classroom to an outdoor laboratory; (2) a series of direct experiences in any or all phases of the curriculum involving natural materials and living situations, which increase awareness of the environment and of life; (3) a program that involves students, teachers, and outdoor education resource people in planning and working together to develop an optimum teaching-learning climate" (p. 5). Recent literature describes several pedagogical approaches that support integrating experience into conceptual knowledge that encompasses the entire individual, not just the intellectual aspect (Nix, 1999). Teachers are typically avid lifelong learners and their distinct perspective as teacher-students allows for practically immediate transfer when provided with a clear, relevant and supportive environment.

Integration was achieved by applying a process approach to implementing the constructivist paradigm. The transfer of knowledge and understanding was simple under this multi-level design. For example, the Community Juggling activity (Nix & Ledbetter, 2000) was conducted in the first meeting to "level the playing field" by providing a common experience, unique to the assembled group (see Fig. 2).

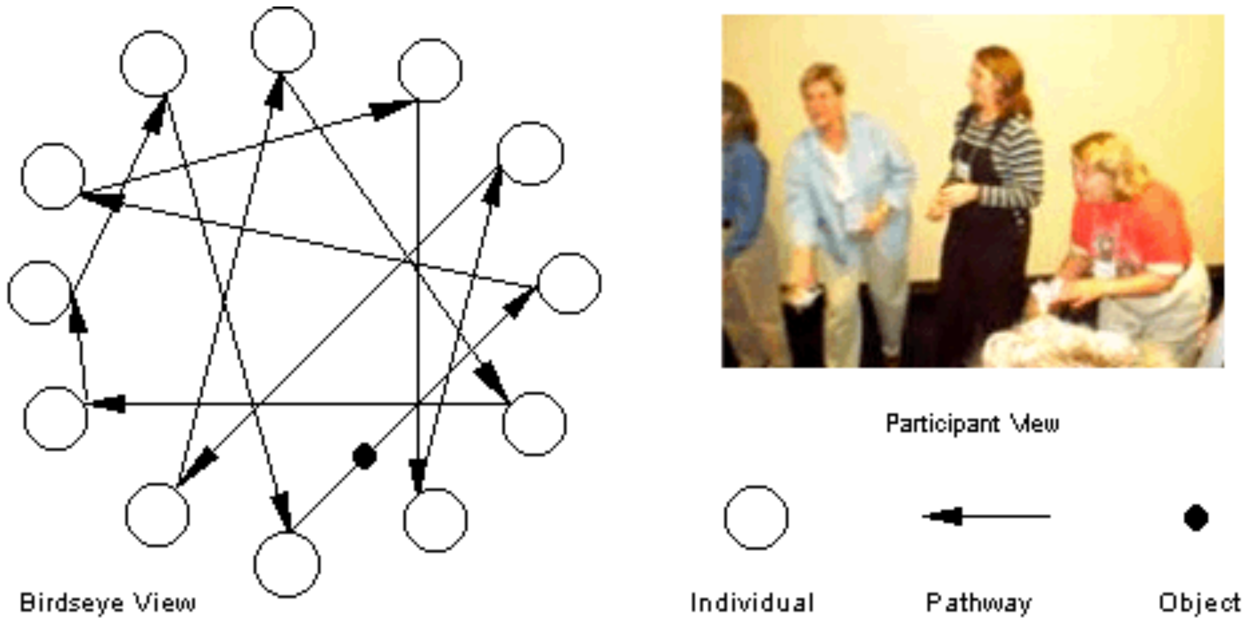


Figure 2. **Community Juggling: Birdseye and Participant Views**

This experiential training tool served as a powerful physical and conceptual metaphor for merging educational and scientific theory and practice throughout the program. The *individuals* in the circle represent the *items* on a concept map, the *pages* in a website, and the*peers* within a mentor network. The *pathway* of the object represents the *links* on a concept map, the *hyperlinks* in a website, and the*collaboration* within a mentor network. The continuous application of appropriate information technology established a personally relevant commonality among the learning environments. Information technology facilitated content *background* and preliminary*research* in the university, data *collection* and *recording* in the field, and *dissemination* to and *presentation* in the classroom. The final product of the ISLE program is a fully integrated virtual field trip (see Fig. 3). This public/private classroom resource was constructed by linking the elements common to the supporting learning environments (university classroom, field trip and information technology) at their basic levels: 1.) newness; 2.) massiveness; and 3.) appropriateness.

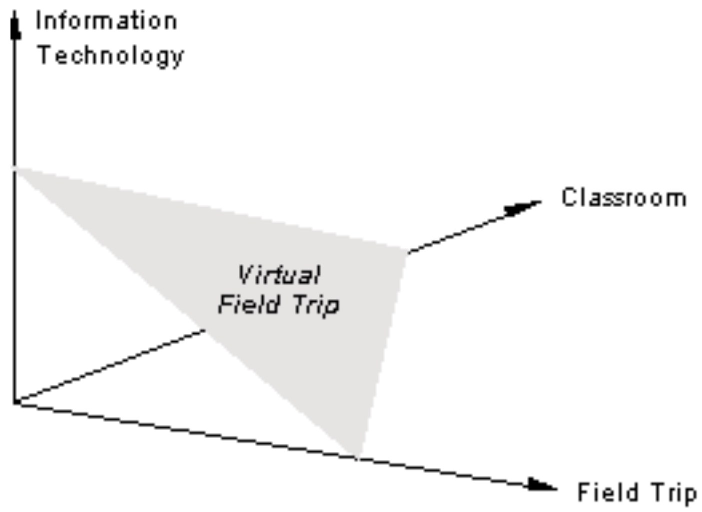


Figure 3. **Virtual Field Trip Framework**. The ISLE program addressed the key issues of each separate learning environment at their common level to create an integrated (3-dimensional) learning environment. The outcome (virtual field trip) is a tangible representation of the constructivist paradigm, enabled by a process approach to implementing information technology in science education.

Learning Environments Research. As suggested by Cannon (1996), establishing a positive learning environment is paramount to the success of any educational program. Within such a research agenda, evaluation instruments and assessment appropriately focus on content mastery, general cohesiveness of the group and individual attitude change. Many instruments employ custom items to match the language and level of the recognised variable. Studies typically triangulate multiple data sources – including tests, journals, observations, and surveys – to provide an overall impression of the experience by effectively combining quantitative and qualitative data (Fraser & Tobin, 1991). With respect to field trips, Lorsbach and Tobin (1995) suggested "research on learning environments needed to utilize the referents of the culture that underlie the sense-making processes of individuals" (cited in Kaspar, 1998, p. 101).

The ISLE study is important in that it combines the use of concept maps to assess adult knowledge and understanding; the Teacher’s Attitude Toward Information Technology (TAT) survey to gauge experience and exposure to educational technology; and a new version of the Constructivist Learning Environment Survey (CLES) written for adults to evaluate learners’ (in this case, teachers’) perceptions of a university/field trip program. This further study of psychosocial aspects of the learning environment offers potentially valuable ideas and techniques for teacher education (Fraser, 1998). Recent trends in pedagogical approaches and assessment methods, particularly the use of concept mapping (Novak, 1996; Trochim, 1986), support an open framework for student-centred learning as modelled in the ISLE program. Current direction in learning environment research, particularly validation of the Constructivist Learning Environment Survey (CLES) (Fraser, 1998; Taylor, Dawson, & Fraser, 1995; Taylor, Fraser, & Fisher, 1997), enables assessment of multidimensional aspects within the ISLE program model. Further developments in educational technology research, particularly the Survey of Teacher’s Attitudes Toward Information Technology (TAT) (Knezek, Christensen, & Miyashita, 1998), provide a valid instrument for assessing the initial affective disposition of the sample.

One critical and commonly recognised theme is that teacher change, in both attitude and practice, does take time. Therefore, a comprehensive evaluation must ‘overlap’ learning environments, thereby extending the research and its application while tracking changing needs and perceptions over time. Thus, a deliberately structured plan with an open format based on principles rather than specific content, that recognises teachers as individuals, is suggested for long-term assessment. As summarised by Fraser (1998), tremendous progress has been made in "conceptualising, assessing and investigating the determinants and effects of social and psychological aspects of the learning environments of classrooms and schools" (p. 527).

Purpose and Research Questions

Phase I investigated the university classroom and extended field trip learning environments. The research combined the use of concept maps to assess adult knowledge and understanding, the Teacher’s Attitude Toward Information Technology (TAT) survey to gauge experience and exposure to information technology, and a new version of the Constructivist Learning Environment Survey (CLES) adapted for use with adults in Texas.

The data from the content-based instruments (TAT and concept maps) were compared to specific scales within the learning environment assessment instrument (CLES) to determine if there were any relationships between the instruments. The concept maps were also used to evaluate the effectiveness of the university/field trip course in terms of developing teachers' conceptual understanding of related content. The aim of the study was to evaluate the ISLE model in terms of promoting conceptual understanding through improved concept mapping skills, attitudes, and a more constructivist classroom learning environment.

The following questions were addressed specifically in Phase I:

1. Are there any relationships among scales of instruments that measure attitude, constructivism and conceptual understanding?
2. Does the program design make a difference in any of these areas?

Design of the Study

The ISLE program modelled a constructivist approach, helping teachers to learn and apply science content within the context of their current level of understanding. This extended to presenting educational technology (educational applications of information technology) as an open framework, facilitating conceptual understanding and demonstrating practical implementation of relevant options, *not* teaching information technology as a separate subject or focusing on particular aspects of a specific tool or resource.

Throughout the ISLE program, computers were used at the individual's discretion. For instance, through electronic mail students asked questions about logistics and content, turned in assignments and projects, and shared ideas with local experts, university instructors and peers. They used the World Wide Web to research the field locales and study background information on topics related to the course in various areas beyond their initial interest; they were directed to Internet resources (satellite images, virtual tours, classroom activities, etc.) used in the teaching of the course itself; and they were trained in how to conduct a successful Internet search. A secondary goal of this was to gain exposure to the non-linear nature of web-based resources and to experience focused use of a massive collection of information. Students experienced multimedia during a PowerPoint presentation, based on a concept map representing the pre-trip coursework and expected field experience. This enabled teachers to develop a "bigger picture" from information presented in small, usable "chunks"; additional electronic resources, like topographic mapping CD-ROMs, were introduced in the classroom and made available in the field. The teachers commonly used computers for personal productivity, and so they were comfortable in using the tool to create and present their projects. All participants had access to the World Wide Web in a home setting. Students also had access to the university computers and library.

There were no computers in the ISLE classroom. Overheads, handouts and electronic presentations incorporated information from the Internet; teachers were taught how to save web pages for use on a local hard-drive, just as the pre-trip website was saved for reference using laptop computers in the field. The university computer lab (30 stations) was used for the brainstorming and development of the initial (top-level) concept map and presentation of the pre-trip website showing the context for their projects. After the trip, computers in the instructors' offices were used for individual and small-group work sessions to complete the final projects. By not focusing on only computers in the classroom, information technology became transparent in its usage. Appendix A presents the ISLE implementation of IT, summarising the relative time spent in instruction versus application. It is noteworthy that less than 10% of the course was allocated to instruction specific to using the required software.

By combining a variety of approaches to learning, an integrated ('internal') learning environment develops that extends continuously across the intellectual, physical and emotional boundaries of the university, field trip and class/school learning environments that supports and encourages implementation of new technologies and teaching strategies. The primary purpose of this teaching technique is to affect personal growth through activities that place science-related content into perspective and apply the principles of collaborative problem solving in a real-world setting. In creating a singular group dynamic by requiring an integrated project rather than promoting multiple individual efforts, the inhibiting effects of site novelty, information overload, and the three-day phenomenon typically experienced on field trips was placed in context and therefore individually manageable and understandable. Directing participants to concentrate on an aspect of the field experience that has particular significance to them minimised the distractions and frustrations of 'sensory overload' in the natural setting (Ledbetter, 1999). The same techniques used to deal with these physical, intellectual and emotional issues in the field apply to integrating technology in the classroom. Effective applications of technology, and modelling inquiry-based teaching, add critical and creative thinking practices to each individual's teaching repertoire. This holistic approach bridged the gap between learning environments, providing positive life experience which allowed the internalisation of concepts and development of support networks and skills to serve as the foundation for implementation of new teaching techniques.

The sample consisted of 12 pre-service/in-service classroom teachers from the Dallas-Fort Worth metroplex area, potentially representing 1,500 students. For planning purposes, a pre-trip questionnaire was administered to determine any physical limitations of the participants and to assess their initial comfort level in a field and/or group setting.

Methods and Instruments

To address the multi-faceted aspects of the new learning environment, the research design was based on the naturalistic paradigm (Lincoln & Guba, 1985). Qualitative data sources included a daily reflective field journal outlined with specific questions to assist students in assessing their current perspective, recognizing the tools/ techniques presented as relevant to them personally, and developing options for transferring the new knowledge and experience to their unique workplace. Throughout the program, frequent peer debriefing sessions, member checks, detailed observations and videotapes of select group activities, informal interviews, and archived electronic mail messages supported statistical analysis and interpretation of pre-test and post-test results. The combination of qualitative methods and quantitative measures (Fraser & Tobin, 1991) provided insight into the field trip milieu and evaluation of the near- and far-term effects of exposure to an integrated information technology learning environment. The data from content-based instruments (focused on science and technology) were compared to specific scales within the constructivist learning environment assessment instrument (personal relevance, student negotiation, shared control, critical voice, and uncertainty) to determine inter-relationships and evaluate the comprehensive ISLE.

Concept Maps. Concept mapping (Novak & Gowin, 1984) is an effective approach for developing conceptual understanding to promote knowledge transfer (Robertson, 2001). The ISLE program utilized this technique to help teachers to think about science in a different way by encouraging them to ask and answer the '*why'* and '*how'* of the '*what'* and '*where'*. Simple in design, concept maps served as a catalyst for exploration, as well as evaluation. In the university classroom, as a group, the teachers created a 'top-level' concept map to represent the goal of their field studies and the structure of the web site. This provided a prescribed framework (context) in which to collaborate along with a purpose for creating their final reports (web pages). As the teachers recorded their own observations and interpreted the relationships to the previously defined key concepts, they developed their own 'second-level' concept maps. Each diagram was objectively analysed in terms of the number of levels (hierarchy), links (inter-relationships) and items (concepts). This mirrors the procedure set out by Fisher (2000) in that the ratio of links to items gives a measure of the interconnectivity of the map, indicating the depth to which students understand concepts. Refer to Appendix B for an example of the evaluation technique.

Teacher's Attitude Toward Information Technology (TAT). The Teacher's Attitudes Toward Information Technology (TAT) (Knezek, Christensen, & Miyashita, 1998) provides a valid instrument for assessing the initial affective disposition of the program participants. This form was used to assess how teachers' perceptions of, and attitudes toward, the integration of information technology into their teaching changed with creating their own web-based product. The 50-item semantic-differential questionnaire includes 10 items in each of the following five scales: 1) value of electronic mail; 2) value of World Wide Web; 3) value of multimedia; 4) impact of computers on their personal productivity; and 5) on their classroom in general. The TAT was administered at the first class meeting for phase one investigations.

Constructivist Learning Environment Survey (CLES). As described in Aldridge, Fraser, Taylor, and Chen (2000), the CLES was originally developed to measure students' perceptions of the extent to which constructivist approaches are present in classrooms. Slightly modified for this study, the Constructivist Learning Environment Survey – Adult (CLES-A) form was used to assess the degree to which the principles of constructivism have been implemented in a science education course for adult learners. The 30-item Likert-type (perception) questionnaire includes six items with a five-point response (Almost Always, Often, Sometimes, Seldom and Almost Never) in the following five scales: 1) personal relevance, extent to which program leaders relate science to teachers' out-of-school experiences; 2) student negotiation, extent to which opportunities exist for teachers to explain and justify to other teachers their newly developing ideas and to listen and reflect on the viability of other teachers' ideas; 3) shared control, extent to which teachers are invited to share with the leader control of the learning environment, including the articulation of their own learning goals, design and management of their learning activities and determining and applying assessment criteria; 4) critical voice, extent to which a social climate has been established in which teachers feel that it is legitimate and beneficial to question the leader's pedagogical plans and methods and to express concerns about any impediments to their learning; and 5) uncertainty of science, extent to which opportunities are provided for teachers to experience scientific knowledge as arising from theory-dependent inquiry, involving human experience and values, evolving and non-foundational, and culturally and socially determined. The CLES-A was administered at the final class meeting.

Results and Discussion

Although small, the sample is representative of the population and thus acceptable for this particular study. The group was carefully selected to provide adequate power to detect a practical difference while minimizing the effects of extraneous variables (Kirk, 1984; Gay, 1996). As in a recent case study by Orion, Dubowski, and Dodick (2000), appropriate statistics were used to compare the data in view of the limited size of the test groups. Qualitative data suggested possible differences on the basis of previous science training. Therefore, a Pearson *r* correlation (Gay, 1996) was performed to relate CLES-A scales to TAT scales and Concept Map data for all subjects (Table 1), as well as for teachers with science (Table 2) and for those with non-science backgrounds (Table 3). The results indicate that there are significant correlations between the scales of the instruments for both teachers with science and those with non-science backgrounds.

Table 1. Means and Simple Correlations of CLES Scales with Attitude Scales and Concept Map Scores (Teachers with Science and Non-Science Backgrounds Combined)

Attitude or Concept Map Scale (Scale Mean, M)	Simple Correlation with CLES Scale				
	Personal Relevance (M = 4.64)	Uncertainty of Science (M = 3.93)	Critical Voice (M = 4.38)	Shared Control (M = 4.06)	Student Negotiation (M = 4.36)

Electronic Mail (M = 5.58)	+0.40	+0.30	+0.30	+0.22	**+0.74**
World Wide Web (M = 5.99)	+0.33	+0.51	+0.22	+0.24	**+0.74**
Multimedia (M = 5.92)	+0.19	+0.35	+0.30	+0.21	**+0.70**
Personal Productivity (M = 6.01)	+0.16	+0.32	+0.19	+0.12	+0.50
Computers in Class* (M = 5.17)	**+0.61**	+0.28	+0.10	+0.31	**+0.69**
Concept Map Analysis					
Levels (M = 4.50)	**+0.67**	+0.05	-0.18	+0.53	+0.37
Links (M = 23.17)	+0.49	-0.10	-0.03	+0.46	+0.24
Items (M = 20.00)	+0.41	-0.31	-0.13	+0.32	+0.26
Items/Links (M = 1.12)	+0.44	+0.25	+0.02	+0.42	+0.09
Links/Items (M = 0.91)	-0.50	-0.22	-0.04	-0.48	-0.04

Statistically significant correlations ($p < 0.05$) are shown in bold type.

Table 2. Means and Simple Correlations of CLES Scales with Attitude Scales and Concept Map Scores (Teachers with Science Backgrounds)

Attitude or Concept Map Scale (Scale Mean, M)	Simple Correlation with CLES Scale				
	Personal Relevance (M = 4.69)	Uncertainty of Science (M = 4.12)	Critical Voice (M = 4.36)	Shared Control (M = 4.26)	Student Negotiation (M = 4.60)

Electronic Mail (M = 5.66)	+0.54	+0.27	+0.20	-0.02	**+0.76**
World Wide Web (M = 6.13)	+0.36	+0.45	+0.33	-0.17	**+0.77**
Multimedia (M = 5.99)	+0.16	+0.22	+0.49	-0.15	**+0.78**
Personal Productivity (M = 6.03)	+0.12	+0.32	+0.44	-0.21	+0.73
Computers in Class (M = 5.43)	**+0.77**	+0.10	+0.26	+0.21	+0.73
Concept Map Analysis					
Levels (M = 4.71)	+0.68	-0.40	+0.18	+0.64	+0.41
Links (M = 23.86)	+0.48	-0.34	+0.31	+0.59	+0.45
Items (M = 21.14	+0.44	-0.51	+0.01	+0.35	+0.51
Items/Links (M = 1.09)	+0.46	+0.06	+0.72	**+0.84**	+0.21
Links/Items	-0.50	-0.02	-0.70	**-0.86**	-0.18

(M = 0.93)					

Statistically significant correlations ($p < 0.05$) are shown in bold type.

Table 3. Means and Simple Correlations of CLES Scales with Attitude Scales and Concept Map Scores (Teachers with Non-Science Backgrounds)

Attitude or Concept Map Scale (Scale Mean, M)	Simple Correlation with CLES Scale				
	Personal Relevance (M = 4.57)	Uncertainty of Science (M = 3.67)	Critical Voice (M = 4.40)	Shared Control (M = 3.77)	Student Negotiation (M = 4.03)

Electronic Mail (M = 5.46)	-0.16	+0.40	+0.52	+0.84	+0.83
World Wide Web (M = 5.79)	+0.29	+0.66	+0.07	**+0.97**	+0.74
Multimedia (M = 5.82)	+0.35	+0.67	+0.01	**+0.98**	+0.68
Personal Productivity (M = 5.98)	+0.44	+0.42	-0.20	+0.85	+0.29
Computers in Class (M = 4.80)	+0.23	+0.55	-0.12	+0.32	+0.60
Concept Map Analysis					
Levels (M = 4.20)	+0.87	+0.86	-0.74	+0.41	+0.26
Links (M = 22.20)	+0.66	+0.36	-0.66	+0.29	-0.11
Items (M = 18.40)	+0.28	-0.09	-0.37	+0.10	-0.28
Items/Links	**+0.91**	+0.82	-0.79	+0.43	+0.17

(M = 1.17)					
Links/Items (M = 0.89)	**-0.89**	-0.75	+0.82	-0.42	-0.09

Statistically significant correlations ($p < 0.05$) are shown in bold type.

Discussion. Students developed good conceptual understanding (concept mapping skills) and positive attitudes; they perceived a constructivist learning environment. The results of this study indicate that there are significant correlations between the scales of the instruments for teachers with science and those with non-science backgrounds. The data from the content-based instruments (TAT and Concept Map Analysis) point to specific scales within the learning environment assessment (CLES-A).

In general (Table 1), personal relevance positively correlated with using computers in the classroom (+.61). By modelling effective uses of information technology, including computers and computer-generated content, teachers may realise the value of such as a tool and resource, rather than yet another technical inconvenience intruded into the classroom. Emphasising the content, over the construction, of the website may minimise their apprehension of using new software and enable them to appreciate the benefits of appropriate applications. As teachers find computer usage more involved with their lives, they see this usefulness in more situations, and transfer its use across their teaching. Personal relevance also positively correlated with the number of levels represented on the final concept maps (+.67). Individually developed from each teacher's perspective, content that is directly related to one's unique life experience may make more sense within his/her particular frame of reference. This correlation may also indicate that participants gained information regarding science. By focusing on a single topic of interest, teachers may be able to explore it more fully and, by placing it into the broader context of the website, produce a deeper, more meaningful report. Student negotiation positively correlated with all but one scale of the TAT. Initial team-building exercises may encourage the teachers to share ideas and 'tricks' throughout the course. By design, they had to work together to successfully create a coherent web-based product. The data suggest that articulation and reflection are facilitated by the use of IT. As teachers are required to use information technology professionally, it is not surprising that personal productivity was not a statistically significant feature. The lack of significance in the areas of the uncertainty of science,critical voice and shared control may be simply attributable to the fact that the sample is wholly comprised of teachers. Teachers are often directly questioned; therefore, they accept that there is uncertainty in every answer. Teachers also tend to be "teacher-pleasers"; therefore, they may not readily question the leader's role. The deliberately open design of the program may have minimised the impact of each. This could also be a factor of maturity or the character of the teacher-student relationship in professional development programs (adult-adult versus adult-child).

Interestingly, the correlations do change when the sample is stratified by scientific background. For science majors (Table 2), personal relevance positively correlated with attitudes to computers in the classroom only (+.77). Scientists expect to use function-specific devices for their work. Presenting the computer as simply another tool demonstrated its power as a dynamic resource. Shared controlpositively correlated with links/items (+.84) and inversely correlated with items/links (-.86) on the concept maps. The program goal was to support teachers in constructing their own knowledge. As teachers assumed responsibility for their learning, they were able to make more complex representations of relevant content, indicating more meaningful learning. Student negotiation also positively correlated with attitudes to e-mail (+.76), to the World Wide Web (+.77) and to multimedia (+.78). Based on qualitative interpretation, it is not unreasonable to presume that the non-science teachers' perspectives enriched the entire experience and offered insight into teaching science to students of different learning styles. Discussion of innovative uses of information technology inspired individual creativity and opened new possibilities for science education!

The correlations also changed for non-science teachers (Table 3). Personal relevance positively correlated with links/items (+.91) and inversely correlated with items/links (-.89). Science is inherently paramount for science teachers. As science becomes more individually meaningful, these non-science teachers were able to see how the concepts fit together across many categories and in more than one situation. Like the science teachers, they too were able to limit the number of topics addressed in their final projects and more precisely place each in context by identifying more inter-relationships. That the non-science teachers gained a deeper understanding of how science relates to their everyday lives is indeed significant! Shared control positively correlated with attitudes to the World Wide Web (+.77) and to multimedia (+.98), further supporting the benefit of exposure to new and different aspects of information technology. This suggests that these tools allow for personal exploration of the topics and presentation of information in what teachers feel is an educationally sound manner.

The data appear to show that, by encouraging the construction of knowledge based on information gathered from experts and their own actual experience, the teachers accepted responsibility for their learning and gained a sense of how to implement similar strategies with their students. By requiring an integrated concept map for the final group project, facts and figures assumed a supportive function as teachers' understanding reflected a higher level of conceptual development that could be approached from any frame of reference. By developing a 'transparent' information technology learning environment, the deliberate re-focusing of perceptions may transform teachers' attitudes toward information technology from one of potential trepidation to personal enjoyment and professional satisfaction.

Conclusions

The combined results of the CLES-A, TAT and concept map analysis offer a broad context for enculturation of the constructivist paradigm. As Milne and Taylor (2000) reported, this sort of pedagogical change is difficult to realise in individual classrooms because of the influence of the school-level environment. Even the best constructivist epistemology is ineffective if not implemented. One key issue in American schools is the pressure to "teach to the test"; by creating a multidimensional (real-world) environment in which adult students personally experience learning through a constructivist approach, they are more likely to be able to provide the same sensation for their students. The ISLE program model affords teachers a tool that they understand and can use in their classrooms to promote inquiry and high-order thinking.

The transparent (integrated) IT learning environment positively affected the university classroom and field trip learning environments. Further, in the context of long-term professional development, the use of concept maps may give teachers a new perspective on methods for enhancing transfer of understanding of concepts to their students. The potential for using extended science-related field trips in a teacher education program is virtually unlimited, as is the multiplied impact of experiential understanding on classroom teaching. "Teachers with a background of outdoor education experiences are able to offer more meaningful learning experiences for the children. Through seeing, hearing, and doing in the outdoors, children are challenged to seek satisfactory solutions to perplexing problems. The student in the outdoors is guided and aided in his quest for answers because the teacher 'has been there', and can 'tell it like it is'" (Chadron State College, 1972, p. 166).

Hamm (1985), in his review of Perkes's research, states that, "The teacher's sensed adequacy to teach science emerged as a significant factor in the teacher's commitment and confidence in teaching science ..." This suggests that, "teachers develop positive perceptions of their ability to teach science by successful work in science courses" (pp. 38-39). Jelinek (1998) cites "a sense of relevance" as one of the major obstacles to effective science education. Educational field trips can give teachers an opportunity to experience effective science teaching and develop an increased awareness of relevant issues and teaching methods. Ultimately, "Such teacher variables as enthusiasm, enjoyment and motivation can influence student achievement" (Jelinek, 1998, p. 2).

Even though the sample size is numerically small, it does reflect the typical population (10-15 students) for an extended field trip program. As appropriate statistical methods were applied, the data are useful in conceptualising, planning, reporting results, and indicating areas for examination of larger groups (Fraser, 1999). Specifically, these data indicate that the language of the new CLES-A may need to be revised to better reflect adult interpretation.

The main benefit of the ISLE program design is that it allows both teachers and students to address each 'element' at multiple 'levels' so learners can cooperatively discover the same information by independent paths. A seamless learning environment links complex multi-disciplinary content through clearly defined inter-relationships to effectively and efficiently sustain a diverse range of learning, teaching and evaluation styles. Through focused activities and strategic exercises, the ISLE model encourages individual communication, collaboration and creativity to develop a sense of personal relevancy and ownership 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.

Practical Recommendations

From a practical point of view, this study documents a new model for improving learning and understanding in the field of education, specifically science education. Ever-changing societal needs necessitate new roles for both teachers and students. A seamless learning environment links complex multidisciplinary content through clearly defined inter-relationships to effectively and efficiently meet or exceed the needs of a diverse range of learning, teaching and evaluation styles. Once people overcome the anxiety of using new tools, they are able to see the benefits and apply the options in amazingly successful and competent ways to solve their unique problems. Taking advantage of these newly discovered resources becomes an exciting and automatic 'second nature'. The same holds true for classroom teachers charged with integrating and implementing educational applications of information technology into their teaching. A process approach to applying information technology within the context of science education makes the hardware and software virtually invisible. The focus is shifted to finding ways to improve their teaching and enhance their students' learning through the most appropriate method(s).

The real world is where theory and practice come together and science becomes relevant, making sense that leads to understanding. Information technologies offer exciting applications for science education. With deliberate design and adequate support, field trips provide a unique opportunity for teachers to experience the principles of student-centred inquiry and constructivism. Successful modelling develops confidence and increases comfort with diverse applications that can be directly implemented in the respective science classrooms. The ISLE program's virtual field trip product places these tools and resources into the proper context and provides sufficient support to all learners, especially today's teachers (Nix, 2000). The possibilities are indeed endless. Tomorrow's educators must be involved in the development of a new model for science education. We will realise the potential of information technologies in science education today by approaching the challenges as our children will have to face the issues of tomorrow. We are all simply "learning by doing".

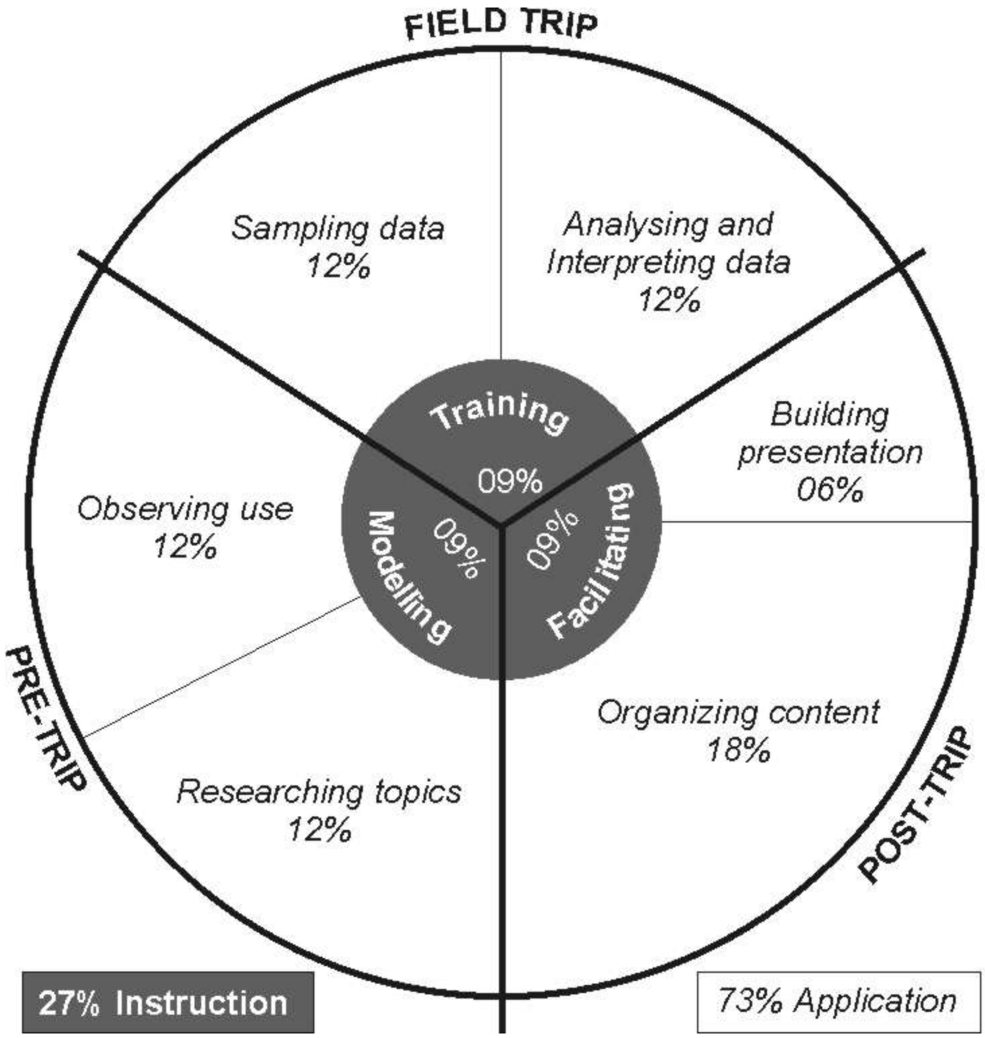
Suggestions for Further Research

Technology exposes teachers and students to an ever-expanding world. Practising communication, collaboration and creativity allows them to construct their own knowledge and develop a confidence that directly transfers into the classroom and beyond! This study addresses the first phase of a two-part investigation. Phase one looked specifically at the university classroom and field trip learning environments. In phase two, the ISLE program effectiveness will be further documented in terms of:

1. Implementation of constructivist teaching approaches in the teachers' school classrooms,
2. Changes in teachers' attitudes to the integration of information technology into their teaching, and teachers' conceptual development.

Two new versions of the CLES will be employed: the Comparative Teacher and Comparative Student forms. The specific scales within the learning environment assessment instrument (CLES) will be internally compared to determine the actual and perceived differences between classes taught by teachers who experienced the field trip based on the ISLE model (ISLE teachers) and those who participated in "traditional" field trip (non-ISLE teachers). Results will be used to evaluate the effectiveness of the ISLE program in terms of the degree of implementation of constructivist teaching approaches in the school classroom. The data will be analysed to determine the validity of the modified versions of the CLES for use in secondary schools and graduate universities in Texas. Pre- and post-test data from the TAT will be compared to evaluate the effectiveness of the ISLE program in terms of changing teachers' attitudes toward the integration of information technology into their teaching. Finally, ISLE data will be compared to non-ISLE data to determine the overall program effectiveness.

Appendix A: ISLE Implementation of Information Technology (IT)



This chart summarizes the average time spent in instruction of IT versus application of IT in the ISLE program. It is noteworthy that less than 10% [one-fourth (1/4) of one-third (1/3)] of the course was allocated to instruction specific to using the required software.

PRE-TRIP	
Modelling	Experiencing IT integrated into classroom/field teaching
Observing use	*Day-trips to local facilities using IT for everyday operations*
Researching topics	*Searching the Internet for reference sites and other IT resources*
FIELD TRIP	

Training	Demonstrating functionality of IT tools and resources
Sampling data	*Actual collection of field data using IT devices*
Analysing/Interpreting data	*Recording and manipulating data with various IT resources*
POST-TRIP	
Facilitating	Supporting the presentation of content with applications of IT
Organizing content	*Outlining reports and verifying content using IT resources*
Building presentation	*Using software to create final project to be integrated into website*

Appendix B: Concept Map Evaluation

The number of items compared to the number of links gives an indication of the degree to which students understand the overall subject matter (main idea or given topic). Fewer links than items (L<I) indicates rote knowledge of content without context (see Fig. B-1, Map A). An equal number of links and items (L=I) indicates understanding of process within the limited context of the specific instance (see Fig. B-1, Map B). More links than items (L>I) indicates meaningful understanding of the relationships of content and process, demonstrated by the ability to transfer such understanding to other subject areas (see Fig. B-1, Map C).

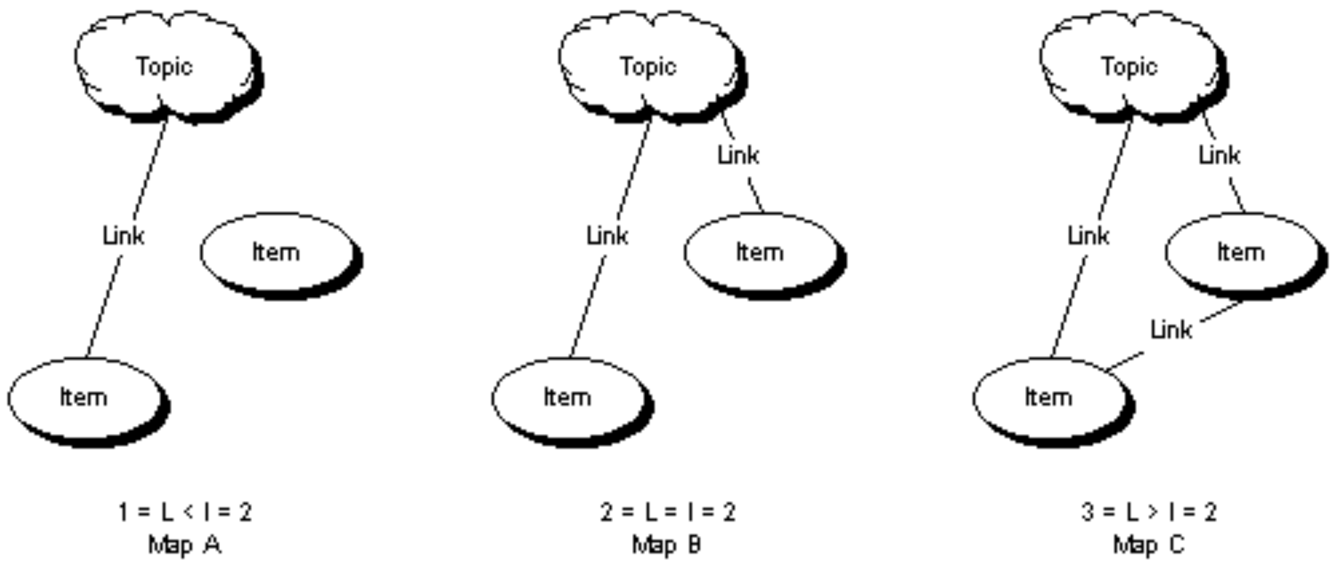


Figure B-1. Sample concept maps showing possible relationships among number of links and items

The number of levels gives an indication of the degree to which students are able to assemble (information overload) and organise (non-linear processing) concepts related to the subject matter (see Fig. B-2). Based on the number of levels, individual students may be "ranked" within groups to indicate similar degrees of comfort in manipulating the represented information. This analysis may be useful in determining the homogeneity of the class' understanding. It may also determine groupings for customised remediation.

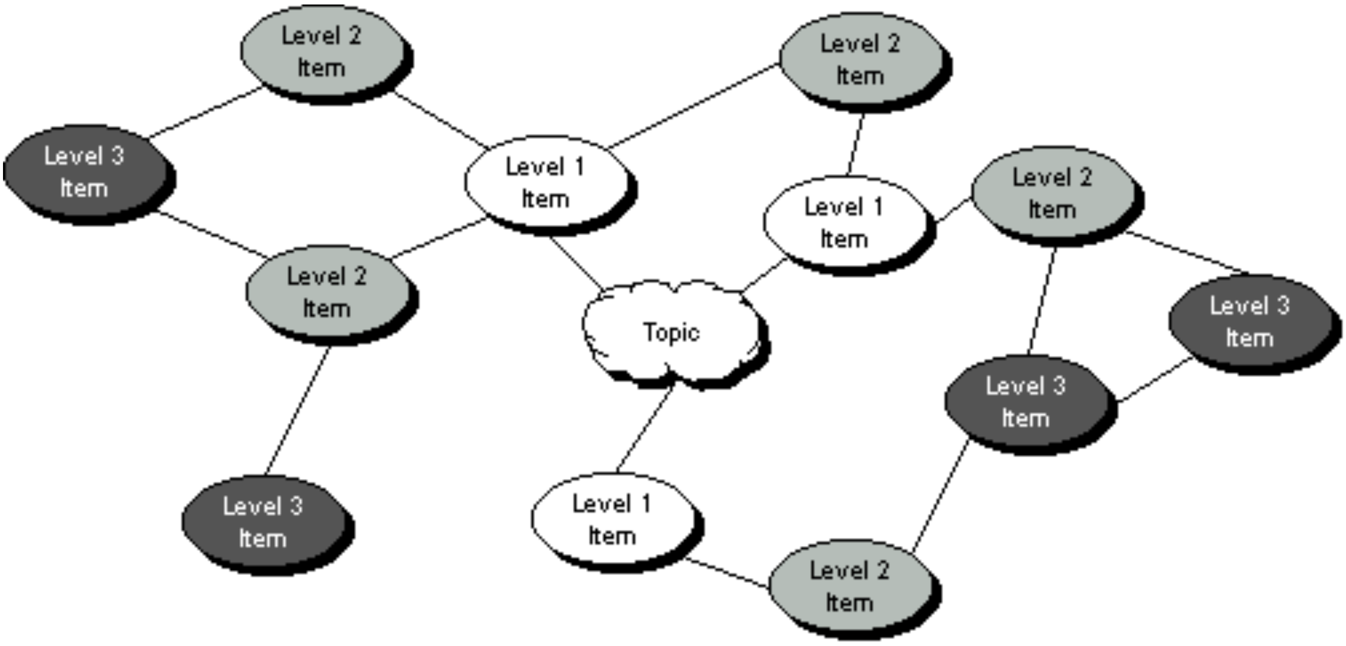


Figure B-2. Sample concept map showing the increase in number of levels

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