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REVIEW ARTICLE

AN OVERVIEW OF INQUIRY APPROACH IN EDUCATION

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An Overview of Inquiry Approach in Education

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INTRODUCTION

IBL refers to a range of approaches to learning that are based around processes of self-directed inquiry. Students conduct inquiries which are designed to enable them to actively explore questions and problems within their discipline. IBL can operate as the design principle for entire modules and programmes, or can be implemented as discrete activities within a lecture-based module.

IBL is exactly the same as Inquiry Based Learning (IBL). The difference between the two is simply a matter of spelling. Sheffield has the Centre for Inquiry-based Learning in the Arts and Social Sciences (CILASS) so this report will use IBL. IBL is not identical with Problem Based Learning (PBL). Rather, PBL covers some forms of IBL. Exactly where the boundary lies around PBL to keep is as a sub-set of IBL is not stable or clear. PBL tends to be structured around a problem which is given to the students, whereas IBL can also encompass activities where students come up with the problem themselves. Definitions of PBL can specify that students work in groups to address the problem (e.g. Kahn and O'Rourke 2004:

Whereas IBL can also involve students working on their own. The PBL approach has a more defined lineage, originating in the teaching of Medicine and transferring most readily to other applied disciplines (Pawson et al. 2006). Perhaps because of this longer social science and slightly more codified status, PBL appears to be easier to write about than IBL, with a number of useful considerations of its applicability to Geography (Spronken-Smith 2005; Pawson et al. 2006).

The new Social science Program of Studies is moving beyond fact-finding and teacher-formed questions. It is based on developing critical thinking skills, processes, values and attitudes. It reflects an inquiry-based approach to learning. Inquiry is an approach to learning that steers away from the kind of "knowledge telling" illustrated in the example of the grade eight exam. Inquiry is "the dynamic process of being open to wonder and puzzlements and coming to know and understand the world".

Effective inquiry-based learning is when students are exposed to learning experiences that are not about memorizing and regurgitating facts. Facts change, and information is abundant. Also, effective inquiry is not designed to lead students to the "right answer." There often is more than one "right" answer.

Effective inquiry-based learning as defined by Alberta Learning (2004) is "a process where students are involved in their learning, formulate questions, investigate widely and then build new understandings, meanings and knowledge. That knowledge is new to the students and may be used to answer a question, to develop a solution or to support a position or point of view. The knowledge is usually presented to others and may result in some sort of action".

The new Social science Program of Studies includes specific outcomes for skills and processes designed to encourage students to apply their learning. One of the specific skills outcomes, Research for Deliberate Inquiry, is intended to develop learners who are self-motivated problem solvers and co-creators of knowledge. These students apply selected skills, evaluate appropriate resources, and use suitable technology.

In 1994 Alberta Learning published Focus on Inquiry, a resource designed to support teachers as they incorporate inquiry based learning in their classrooms. The inquiry model outlined in Focus on Inquiry includes six phases of inquiry: (a) planning (b) retrieving (c) processing (d) creating (e) sharing (f) evaluating with ongoing reflection included at each phase.

Within the document, each phase is presented through six lenses, one being teaching or "teaching tips." During the past two years, Social science teachers throughout the province have been attending in services related to inquiry and the inquiry model. As teachers completed my in services, I asked them to write down their key learnings. The table on page one includes one summarized example of a Focus on Inquiry teaching tip for each phase and one key learning as expressed by Alberta teachers as they learned about the inquiry model.

As social science teachers become accustomed to using an inquiry approach in their classrooms, they will realize how powerful this approach is in

developing proficient, investigative, and self-motivated citizens.

For over eight years, we have built a line of research investigating how we might assist teachers and learners who engage in inquiry about ill-structured social problems with the goal of developing more able democratic decision-makers (e.g., Brush & Saye, 2005; Saye & Brush, 2004). These efforts have led us to the development and refinement of the Persistent Issues in Social science Network (PIHNet), a web-based teaching and learning environment to support problem-based historical inquiry (PBHI) in social science classrooms (Brush et al., 2005). However, as we have witnessed the challenges that teachers face in attempting to PBHI, we have found that mastery of an inquiry-based practice by teachers may present a greater barrier to disciplined inquiry than the difficulties we had sought to alleviate in student learners

THE DEVELOPMENT OF INQUIRY-BASED LEARNING

Inquiry has always been a part of education. It predates Socrates and his method of leading students to self-knowledge through aggressive questioning. Dewey's reform of the educational system led to the first inquiry-based learning methods in the United States. He advocated child centered learning based on real world experiences.

The Educational Policies Commission (1961) reacted on the central purpose of American Education and suggested that students needed to develop "ten rational powers". These were: recalling and imagining; classifying and generalizing; comparing and evaluating; analyzing and synthesizing; and deducing and inferring. These are also some of the fundamentals of inquiry learning.

Spurred by fears that the Russians were gaining a technological and military advantage over the U.S. In the fifties, the educational establishment became particularly interested in helping students to become creative problem-solvers. Then, in the sixties, there was a movement toward the so-called alphabet soup curricula. These had such titles as Biological Sciences Curriculum Study (BSCS), the Chemical Education Materials Study (CHEM Study), the Science Curriculum Study (SCIS), the Elementary Science Study (ESS), and the Physical Science Study Committee (PSSC Physics) -- hence the name "alphabet soup".

These efforts seriously attempted to turn the traditional "cookbook" approach to science education into 'hands-on involvement' with a focus on developing reasoning activities. Unfortunately, the hands-on approach never fully turned into a truly engaging approach to learning. Critics charged that the students were spending too much time "messing around" with materials and too little time on analysis.

These problems were to a great extent, due to the nature of the school-community system, into which these programmes were introduced. Then, too, they focused mainly on only one element of the school community system i.e., the teacher.

The 'Whole Language Movement' was a very positive development in the social science of inquiry-based learning. The recognition of the roles that reading and writing play, in learning, began to change attitudes and practices in the schools. Systemic change is the latest and most significant effort that has the potential to impact inquiry learning. In 1984, a conference at the National Academy of Sciences brought together top scientists, educators, business leaders, politicians, parents, and others, in direct response to a report entitled "Nation at llisk" that detailed the failings of American schools.

This conference led I:O an attempt to reform the U.S. system of education in order to achieve a status of "first in the world by near the end of the twentieth century". Much of this effort was and still is directed toward getting students involved in the process of learning and meeting the needs of modem society b:/ changing the educational system.

There are at least two important factors in the systemic-reform effort that make it difficult to implement it in the current climate. One of these factors is that the effort is focused almost exclusively on Social Science education. It will be difficult to change a school community system that is focused on only two disciplines in the school curriculum. A second factor is that many educators have little experience in evaluating the important systemic elements and aligning them with outcomes for students. For example, when students do not perform well on statewide tests, teachers generally react with attempts to "fix students" by demanding that they 1ry harder, rather than fix the system. But lack of student motivation is often symptomatic of a larger systemic problem.

Inquiry-based learning, today, however, can be integrated into our classroom and school system gradually as teachers, principals, parents, and other community members become aware of its importance in preparing students for the postmodern world.

DIFFERENT TYPES OF INQUIRY LEARNING MODELS

We wanted to see if we could develop some inquiry models which fore grounded these different aspects of the inquiry process. We have articulated four distinct models from this literature which seem to us to encapsulate particular aspects of inquiry learning:

- Peer, collaborative inquiry learning – where the emphasis of the model is to facilitate and scaffold learners in dialogue and discussion

around the inquiry process. We see this as a mechanism in particular for supporting the learner in becoming enculturated into a Scientific way of thinking and therefore it supports the 'nature of science' characteristic outlined above.

- Hypothesis-driven inquiry learning – where the emphasis is on the inquiry process beginning with a hypothesis and designing the methods to prove it right or wrong. This fits with the 'questioning and hypothesis' characteristic.

- Multiple forms of representation – where the model helps guide the learner in seeing data in different formats, extracting information from different formats, understanding the relations between changes in representations and changes in actions or observations and helping them to understand the value of these different forms of representation. The model also helps the learner in dealing with noise in data and with erroneous data collection processes, while reflecting on the process and synthesising the scientific outcomes of each representation. This fits with the 'synthesis and metacognition' characteristic.

- Modelling – where the model enables the learner to use modelling as part of the process of investigation. This fits with the 'adopting an evidence-based approach' characteristic.

Table maps the pedagogical approaches that are needed in each of these four models. Of course these models represent extremes and the pedagogical approaches listed are seen as the minimal requirements in each case. But by separating out these different specific aspects of inquiry learning – collaboration, hypothesis, multiple representation and modelling, we will be in a better position to identify what constitutes an appropriate, technology-enhanced environment to support the inquiry process. And indeed in reality this does not preclude combinations of approaches or models from occurring – for example a peer collaborative approach to modelling or combining a hypothesis model with one demonstrating different forms of representation. The next section will describe each of these models and will discuss how we plan to use these as the basis for the development of our educational scenarios in the PI project.

Pedagogical features	Orientate	Hypothesise	Design	Discuss	Interpret	Analyse	Model	Investigate	Represent	Reflect
Peer collaboration	√			√	√					√
Hypothesis driven	√	√	√		√	√		√		
Multiple representations	√				√			√	√	√
Modelling		√				√	√	√		

Table: Four aspects of inquiry learning

The following models take different combinations of the above and represent different flavours of inquiry learning. Each model consists of three main parts: articulation of the pedagogical approaches instantiated in the model, description of the types of tools which are needed to guide the learner through this process of inquiry – these are taken from the identified pedagogical approaches and a central schema, detailing one instantiation of the model, which can then be used as the basis for the script development. Table provides a summary of the key characteristics of these four models in terms of their 'design' and 'narrative'.

Model	Design	Narrative
Peer collaboration	Design focus is how to define/orchestrate collaboration/debate, when and how it should occur, how to summarise discussion outcomes and findings.	Narrative focus is how to represent dialogue in ways useful to the learner/teacher – i.e. different debates, themes and issues over time.
Hypothesis driven	Design focus is how to create an environment that guides the learner from hypothesis formulation to inquiry, ensuring appropriate decisions are made according to the nature of the question.	Narrative focus is to show the learner how their inquiry activity was a progression from their initial hypothesis formulation.
Multiple representations	Design focus is how to guide the learner though the selection and use of different representations and reasoning from these representations.	Narrative focus is helping the learner to understand how the different representations they have used relate to each other, and how conceptualisation evolves through their use.
Modelling	Design focus is specifying the modelling task, how modelling should be carried out and the constructs out of which the model should be built.	Narrative focus is helping the learner to understand how they developed and refined their model during the task and the theoretical implications and rationale underlying it.

Table: Design and narrative characteristics

Peer collaborative inquiry learning: The focus of the first model is to emphasise the dialogic aspects of inquiry learning. This is important as part of learners coming to understand the nature of science and its associated discourses and practice. Therefore the model begins with a question or problem being set. The students then work individually and collaboratively to tackle the question, coming together to synthesise their findings and finally they collectively reflect on the process. The key pedagogies in this model are: orientate, discuss, interpret and reflect. Hence the associated tools developed to guide learners, i.e. the script need to reflect these. Orientation tools might take the form of a question and answer space for students to clarify understanding. Discussion and collaboration tools could take a range of formats – both synchronous and asynchronous but might include scaffolding and guidance to help the students develop their arguments and understanding. Interpretative tools would guide the learners in making sense of their findings and relating these back to underlying Scientific concepts. Similarly the emphasis on the reflective tools would be to help the student take a critical stance to their findings and to enable them to develop their metacognitive skills in terms of framing this particular aspect of work in the wider context of scientific understanding.

Hypothesis driven inquiry learning: The hypothesis model foregrounds the questioning and hypothesis characteristic of inquiry learning. The tools of importance in this model are concerned with supporting the learner in the development of their hypothesis, designing and conducting the investigation, and analysing the results. The hypothesis model emphasises six main pedagogical approaches: orientate, hypothesise, design, investigate, interpret and analyse. In addition to the orientation tools described above, this model would need to included tools which specifically help the students with the development of their hypothesis, how they go about designing and investigating the problem and then support for interpretation and analysis.

Multiple forms of representation : A fundamental aspect of Scientific thinking is for students to be able to 'see', 'interpret' and 'manipulate' data and concepts in a variety of different formats and to develop an understanding of the purposes of each of these different forms of representation. The third model focuses on this, and hence the tools are those which enable learners to explore different forms of representation of data and concepts. Edelson et al., (1999) propose a technology to support inquiry learning that focuses on visualisation of quantitative geographical data for learners. The pedagogical emphasis here is very much on representation and interpretation. There are numerous tools which could be included in this model to aid different types of representations – graphical software, mind mapping, 3-D visualisation tools etc. What's more important than the tools is the ways in which they are used within the model, so the associated scaffolding in terms of guiding the students on how to use these tools and why they are using them is key. An understanding of why each tool is used relates to reflective practices that engage learners in informed scientific choices.

Modelling: The final model focuses on a specialised aspect of inquiry learning, namely the role of modelling. An interesting example of modelling software that has been used extensively to support the development of Scientific thinking is STELLA (see Doerr, 1996 for a review). It provides a multi-layer environment for modelling, which enables the learner to switch between more descriptive representations of a process to the underlying mathematical constructs.

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