The acquisition of scientific inquiry skills through computer-based scientific inquiry learning environment is a challenge for computer-based learning researcher. Due to the nature of scientific inquiry learning environment that employs exploratory learning approach, learners are granted the freedom to explore and evaluate their ideas through interaction with the interfaces. However, research showed that there exist learners who do not benefit from such learning approach. Such learners lack of implicit factors that drive the conceptual change of knowledge, or skills. To tackle the challenge, this research proposes decision-theoretic approach, an Artificial Intelligence technique, to optimize learning sequences in a scientific inquiry learning environment. The research aims to contribute to (i) the development of decision-theoretic algorithm that takes n-step look-ahead when performing inference, (ii) integrate affective components and conceptual change model into INQPRO, an existing scientific inquiry learning environment.

There are four main objectives for this study. Firstly, this study aims to determine the computational variables from model of conceptual change as well as conceptual change with affective attributes; secondly, to construct a Bayesian networks based on the variables identified in the first objective; thirdly, to develop an n-step look-ahead decision-theoretic algorithm based on the Bayesian networks constructed in the second objective; and lastly, to integrate and empirically evaluate the algorithm proposed in objective three.

Since little work has been reported on three fronts; the motivations of this study includes: for one, the usage of decision-theoretic inference mechanism for computer-based scientific inquiry learning environment is fairly novel; for another, the construction of Bayesian networks for conceptual change and affective states for scientific inquiry learning environment still leaves room for more research; and lastly, not much has been said about the method for assessing and optimizing scientific inquiry. The subsequent paragraphs discuss briefly the literature review of this project.

Conceptual change is a process that changes or replaces an existing conception with a new conception (Kuhn, 1970). The process of knowledge restructuring is what distinguishes conceptual change learning from other types of learning. In conceptual change learning, an existing conception might be fundamentally changed, replaced or assimilate by the new knowledge. The importance of conceptual change in education and scientific enquiry learning is that it forms a conceptual framework that is useful to solve future problems and explain the knowledge (Posner et al., 1982). The Conceptual Change Model (CCM) is the best known conceptual change model in science (Posner, et al. 1982). The model shows that dissatisfaction or cognitive conflicts of the students occur when their belief and conception in the existing conception framework fail to meet the new conception. When a new available conception is intelligible, plausible, and fruitful to replace the existing conception, accommodation will occur. An intelligible conception is sensible if the meaning is understood by the student, and is non-contradictory; plausible means the conception is believable and the student knows meaning of the new conception; and, the conception is fruitful if it helps to solve other problems or provides opportunities of further research (Posner, et al. 1982). This
research work attempts to firstly identify all the variables in CCM and subsequently, defining the causal dependencies between the variables.

In addition to defining the variables for CCM, the research work looks into affective modeling. Affective characteristic includes a learner’s emotion and attitude, such as confusion, frustration, excitement, boredom, motivation, self confidence and fatigue (Woolf, 2009). These factors affect students’ self-efficacy, goals, intentions, purposes and expectations in learning (Pintrich et al., 1993). Research has shown that failing to address appropriate learner properties can lead to ineffectiveness of the learning environment to achieve its learning objectives (Njoo & De Jong, 1993; Reiser et al., 1994; Shute & Glaser, 1990; Ting et al., 2006; van Jollingen & de Jong, 1991). Personal, motivational, social, historical factors and situational beliefs influence the content of students’ theories, beliefs and models. In short, lack of attention from science education researchers in the affective domain of conceptual change modeling is mainly due to the difficulty in modeling and the ineffectiveness of current assessment method to accurately represent result. Based on extensive refinement of conceptual change theories that included motivational beliefs and classroom contextual factors in the process of conceptual change (Pintrich et al., 1993), it is identified that some of the important variables of affect in conceptual change were defined in the epistemic belief of learners, situational and personal interest, self efficacy and learner’s goal, all which were deemed important in fostering motivated learning in classroom context. To extrapolate the benefit of these characteristics from classroom learning to intelligent tutoring system learning, some key variables were extracted and included in the construction of conceptual change model with affective components. These key variables included epistemic belief, attention, self efficacy and mastery goals.

This research work involves four main milestones, which included: (1) the construction of Bayesian networks; (2) the integration of conceptual change and affective Bayesian network into the existing INQPRO learner model; (3) the development of decision-theoretic algorithm; and (4) empirical evaluations on the proposed algorithm.

References


