

Female Students and Science Learning Environments: Identifying and Informing Requirements for Success

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Abstract

The importance of improving science learning and teaching is evident in a renewed emphasis on science as a curriculum area in recent years. Previous research has demonstrated the relationship between science learning environments and students' learning outcomes. Through increasing equity awareness and inclusive educational approaches which address gender stereotyping, there has also been accompanying encouragement of female students to study science. However, there is very limited knowledge on what attributes of science learning environments are most significant to students, and little research on science learning environments which support female students studying science. In this study, we discuss the use of a means-end approach in systematically eliciting and analyzing female students' requirements for a science learning environment. This research provides a significant contribution as it identifies eleven critical requirements which can inform the design of science learning environments. Among all critical requirements, there are four most important requirements for female students. These include solving problems with classmates, asking the teacher questions, solving problems by investigation, and opportunities for deciding learning activities by themselves. Furthermore, a majority of critical requirements suggest two key dimensions, namely, involvement and cooperation, which illustrate female students prefer taking an active participation in group discussion and cooperation to solve questions regarding science subject. Following the means-end chain methodology to analyze the relation between female students' personal values and the perception of science learning environments, this research found that female students develop a sense of accomplishment, self-fulfilment, and fun and enjoyment of life, which motivates them to continue learning in a science learning environment when these requirements are provided. This research provides practical implications for the design and implementation of science learning environments to better meet the requirements of female students.

Key Words

Female students; Science learning; Learning environment; Motivation and learning

Paper

1. Introduction – Learning Environment Instruments and the Aim of this Research

Science education is essential for senior high school students, who intend to major in science or engineering at colleges and Universities in their future studies. During the transition from high schools to higher education, students selecting the field of science for study are likely to be influenced by their science learning experiences. In addition, the issue of gender differences in the lower participation of female students in science has received considerable attention during the past two decades. Previous studies have demonstrated that male and female students have different attitudes, interests, experiences, and perceptions of their learning environment toward science learning. This includes studies which have shown that boys have more interest than girls in science throughout elementary school. Even when female students have performed as well as or better than their male peers, female students' attitude toward science significantly decline during middle school years. These differences between males and females students influence their intention to major in science or engineering in higher education beyond high school (Greenfield, 1997; Jones et al., 2000).

The educational environments students are immersed for considerable periods of time throughout schooling, and in which science learning occurs, and are likely to influence their attitudes towards science. Studies of learning environments have identified various learning environment variables as potent

determinants of students' learning behavior (Fraser, 1998b). Learning environments have been the focus of inquiry by many educators, and in the context of science education, the effect of psychosocial aspects of the learning environment on student learning and interest is important research being undertaken in science classrooms. Previous works heavily relied on analysis of correlation between student variables, including interest, attitude, self-esteem and their perception of learning environment (Susan, 2003), and learning outcomes, . Many, earlier studies have shown that there is a significant relationships between student learning outcomes and the learning environment (Talton & Simpson 1985; Wubbels & Levy, 1993; Fraser, 1994). The implication from those findings is that, in order to improve female students' learning outcomes, classroom environments should be changed and improved in ways which take into account the preferences of female students.

Throughout previous classroom environment research, various learning environment instruments have been developed to identify students' perception of learning environment variables and identify various dimensions of learning environments. Many studies have drawn on scales and items in existing questionnaires to develop modified instruments which better suit particular research purposes and research contexts (Fraser, 1998). The development of each scale contained in these historically important instruments are informed by Moos's (1979) three basic dimensions of learning environment; namely,

- Relationship Dimensions that assesses the extent of interpersonal support and help between participants;
- Personal Development Dimensions that assesses personal growth and self-enhancement; and
- System Maintenance and System Change Dimensions that measure the rule structure and its response to change.

In reviewing various instruments, it is worth synthesising the development of several key learning environment instruments. The *Individualised Classroom Environment Questionnaire* (Rentoul & Fraser, 1979) assesses those dimensions, personalisation, participation, independence, investigation, differentiation, which distinguish individualised classrooms from conventional ones. The *My Class Inventory* (Fisher & Fraser, 1981) is useful in examining students' perception of environment at elementary school and junior high school. This questionnaire aims to measure five dimensions -student cohesiveness, friction, satisfaction, difficulty, and competitiveness in the learning environment. The *Questionnaire on Teacher Interaction* (Wubbels & Levy, 1993) relied heavily on the two dimensions of relationship and system maintenance and change to use for the assessment of students' perceptions of their teacher's interpersonal behavior. The *Constructivist Learning Environment Survey* (CLES) (Taylor, Fraser, & Fisher, 1997) investigates the extent to which constructivist pedagogy is adopted and influences the science learning environment. The CLES contain five scales, personal relevance, uncertainty, critical voice, shared control, and student negotiation. The *Science Laboratory Environment Inventory* (Fraser, Giddings, & McRobbie, 1995) is especially suited to examining access in laboratory settings in science classes at secondary school level. *What Is Happening In this Class?* (WIHIC) combines different scales of existing questionnaires to accommodate contemporary curriculum. WIHIC is a widely-applicable questionnaire that can be used in different science and mathematics class of school levels, including elementary school, junior high school, and high school. These classroom environment instruments have been carefully validated and widely applied to investigate science learning environments in terms of specific different dimensions of those learning environments.

More recently, a new instrument called the Outcomes-Based learning Environment Questionnaire (OBLEQ) (Fraser, 2006; Aldridge, Fraser, & Laugksch, 2011) was developed to investigate students' perception of outcome-based learning environments. The design of OBLEQ in terms of students' learning outcomes and extended scales of existing questionnaires are appropriate for investigating science learning environments involving outcome-based education. As displayed in Table 1, the OBLEQ consist of seven important scales, which were selected from previous questionnaires and relevant to outcome-based education, including involvement, investigation, cooperation, equity in WIHIC, differentiation in ICEQ, personal relevance in CLES, and adding a new dimension – responsibility for own learning – which was newly developed in the OBLEQ. In a bid to increase equity awareness and ensure inclusive educational goals, the dimensions of OBLEQ provide us with improved ability to investigate today's classroom settings.

Table 1: The dimensions of environment which OBLEQ investigates (Fraser, 2006)

Involvement	The extent to which teachers relate science to students' out-of school experiences.
Investigation	The extent to which students have attentive interest, participate in discussions, do additional work and enjoy the class.

Cooperation	The extent to which students cooperate rather than compete with one another on learning tasks.
Equity	The extent to which students are treated equally and fairly by the teacher.
Differentiation	The extent to which teachers cater for students differently on the basis of ability, rates of learning, and interests.
Personal Relevance	The extent to which teachers relate science to students' out-of school experiences.
Responsibility for Own Learning	the extent to which students perceive themselves as being in charge of their learning process, motivated by constant feedback and affirmation.

To summarise, this research summarised in this paper is situated within this context of learning environment research. The aim of this research is to apply means-end chain methodology in better understanding what attributes of science learning environments are significant to female students, and systematically eliciting and analyzing their requirements for science learning environments.. Following an explanation of the means-end chain model in the following section, and a discussion of key findings, this research provides practical implications for the design and implementation of science learning environments to better meet the requirements of female students

2. Means-end chain model

The means–end chain model constructs a hierarchical value map (HVM) to systematically obtain an underlying rationale about individuals' perceptual orientation toward an object under consideration. This is achieved by analyzing the association between the attributes of the object, and the consequences, and the values with respect to individuals (Gutman, 1982; Kahel & Kennedy, 1989; Rosenberg, 1956). An example of the HVM is shown in Fig. 1. The means–end chain model categorizes the perception and requirements of individuals toward the object under consideration to provide a concrete basis for relevant decision making. Applying this approach in eliciting people's requirements can better understand how people perceive benefits to themselves.

The attributes of an object in Fig. 1 refer to its physical observable characteristics, such as colour or smell, as well as abstract feelings, such as quality or elegance, derived from the object. In the context of science classes, attributes are those aspects of science learning environments, e.g., interaction between students and teachers, or support and help other classmates. The consequences (functional and psychosocial) in Fig. 1 are defined as any result produced by individuals experiencing the object (Gutman, 1982; Olson & Reynolds, 2001). Functional consequences are the benefits accruing to people from experiencing the object. For instance, cooperating with other students to solve problems makes process more correct and efficient. Psychosocial consequences for individuals reveal psychosocial characteristic of mind in nature. For example, by solving difficult and complex problems in science can enhance students' interest toward science learning. Values, including instrumental values and terminal values, refer to the psychological needs of individuals accomplishing important goals through the object (Rokeach, 1973). The instrumental values are related to a means of achieving goals, such as taking risks or being honest, whereas the terminal value is concerned with the preferred end-states (goals), for example, happiness, security, and accomplishment.

The means–end chain approach consists of in-depth interviewing and analysis methodology, termed “laddering”. The laddering technique (Reynolds & Gutman, 1988) has been frequently used for uncovering the means-end hierarchies defined by linkages or connections between attributes, consequences, and values. We can gather means-end data through in-depth one-on-one interviewing technique for building meaningful “ladders”; i.e., interrelation of the attributes and the personal values, representing dominant perceptual orientations of interviewees. During the interview process with the goal for developing cognitive hierarchical value maps, we used a series of directed probes through questions, such as “Why is that important to you?”, to establish sets of linkages between key perceptual elements across attributes, consequences, and values. Laddering has been successfully applied in accessing individual evaluation of a product or brand, and developing advertising strategy (Hofstede & Audenaert, 1998; Reynolds & Gutman, 1988; Søndergaard, 2005; Walker & Olson, 1991). More recently, application of means–end chain model has been extended toward more useful understanding of users' requirements of information system and e-learning system (Chiu, 2005; Sun et al., 2009)

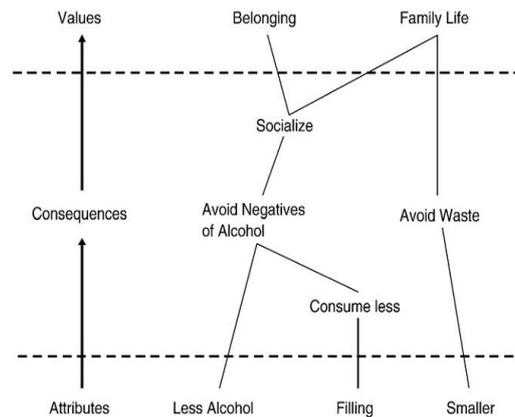


Figure 1: Hierarchical value map (HVM) of wine cooler category (Reynolds & Gutman, 1988)

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