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A review of features of technology-supported learning environments based on participants' perceptions

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ABSTRACT

In this study we reviewed 22 studies on developing instruments that measure teachers', students' and adult students' perceptions of learning environments enhanced by a certain type of technology. We conducted a review of all the instruments to propose a new framework conceptualizing technology-supported learning environments (TSLEs) for future instructional designs, and research on learning environments. This framework was also confirmed with the literature on learning theories. The framework consists of six dimensions: technical, content, cognitive, metacognitive, social, and affective. We found that the studies took more into consideration the technical, cognitive and social dimensions, and less the content, metacognitive, and affective dimensions. Moreover, usability in the technical dimension, relevance in the content dimension, inquiry learning in the cognitive dimension, student autonomy in the metacognitive dimension, and teacher support in the social dimension are the salient features most often investigated in TSLEs. The results provide insights into an overview of the instruments used for TSLEs, implications for the instructional design of TSLEs, and trends in the current and future research on perceptions of TSLEs.
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1. Introduction

Technology-supported learning and instruction have attracted increasing interest from researchers in the past two decades. Owing to the rapid growth of advanced educational technologies, the features of learning environments have undergone significant changes. For example, Internet technology may create an environment wherein collaborative, distant, interactive and inquiry-based activities are provided to foster knowledge construction and meaningful learning (Lee & Tsai, 2010). Recent review studies have indicated that learning environments can be enhanced by advanced computer technology such as simulations, probeware, augmented reality, and virtual reality applications, to facilitate learning and to shape instructional practices (Chen et al., 2012; Wang et al., 2014). Technology-supported learning environments (TSLEs) can help learners develop knowledge and skills that can be attained in conventional learning environments but in a more efficient way (Mayer, 2005). Moreover, incorporating technology into a learning environment introduces new affordances that can possibly facilitate new knowledge, skills or even attitudes that cannot be otherwise advanced in traditional learning environments (Noroozi, Weinberger, Biemans, Mulder, & Chizari, 2012; Wu,

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Lee, Chang, & Liang, 2013). Although the design community of TSLEs is enthusiastic about incorporating advanced technology to facilitate learning, a considerable amount of research including review studies is needed to provide solid evidence of how and when TSLEs benefit teaching and learning practices. A necessary early step to address this issue is to precisely conceptualize the essential features of TSLEs.

Understanding the features of a specific learning environment can offer vast potential for shaping educational practice (Fraser, 1998a). Important features of learning environments can originate from learning theories that stress certain important aspects of learning, such as the social constructivist theory (Kragh, 1998; Vygotsky, 1978), which points out the need to consider the roles of teachers, students and experienced others, and those in relation to each other, in a learning environment. A previously published review study examined 15 theoretical studies on classification schemes of learning environments, and proposed a new classification scheme to characterize learning environments including learning goals, the division of teacher and learner roles, and the roles of the learners in relation to each other (de Kock, Sleegers, & Voeten, 2004).

We employed another approach to identifying important features of learning environments by reviewing instruments (e.g., surveys or questionnaires) that measure participants' perceptions of learning environments. This approach was suggested by Fraser (1998a). Studies that focus on the development of instruments measuring participants' perceptions of learning environments use the participant data to conduct factor analysis, and to identify salient factors (or scales) of a learning environment based on the participants' perspectives. These factors represent the characteristics of a learning environment that appear to be important to the participants. A synthesis study of these instruments and their factors can help identify key elements of learning environments. Such a synthesis would be useful to researchers for developing new instruments to assess participants' perceptions of learning environments, and for designing learning environments to address theoretical and empirical concerns regarding technology-supported learning. Specifically, this study provides an overview of some current instruments that measure participants' perceptions of TSLEs, and conceptualizes the key learning environment features which are emerging as a result of incorporating technology into educational settings. We also examine how well these recent instruments target the key features of TSLEs to different degrees for future research directions.

2. Frameworks of TSLEs

A learning environment by definition includes the physical context, the roles of teachers and learners, learning goals, instructional methods and materials, as well as learners' tasks (de Kock et al., 2004). A learning environment incorporating technology may lead to changes in teaching and learning practices by changing the physical context, instructional methods, role of teachers and so forth. Teachers need to adapt different instructional methods to best take advantage of the affordances of the technology for productive and efficient teaching and learning. Therefore it is necessary to distinguish technology-supported learning environments (TSLEs) from others. TSLEs are instructional systems incorporating technology through which students conduct learning activities with the help of teachers, peers, supporting tools and technological resources (Wang & Hannafin, 2005). It is also helpful for researchers to further distinguish among learning environments using different types of technology such as online or multimedia learning environments to characterize a distinct type of technology and how it may shape the environment.

Several frameworks have been proposed to evaluate the design of a specific type of technology learning environment. For example, Hadjerrouit (2010) proposed a conceptual framework for evaluating web-based learning resources. The framework includes features of pedagogy, technology and content, usability criteria, and context of use/evaluation. Another framework, LORI (The Learning Object Review Instrument), was developed to support the evaluation of multimedia learning environments (Leacock & Nesbit, 2007), including nine dimensions: content quality, learning goal alignment, feedback and adaptation, motivation, presentation design, interaction usability, accessibility, reusability, and standards compliance. HELAM (a hexagonal e-learning assessment model) was proposed for the evaluation of learning management systems with a focus on their social and technical issues (Ozkan & Koseler, 2009). The Community of Inquiry framework was used for online learning in consideration of social, cognitive and teaching aspects (Arbaugh et al., 2008). In general, these frameworks were proposed from the designer's or instructor's point of view, and provide valuable insights with regard to what should be considered in the development of an effective learning environment from the designer's perspectives. It is less known what are considered the important features of a learning environment from the viewpoints of the participants in the environment. To address this issue, Fraser (1998a) suggested reviewing studies on developing instruments that measure participants' perceptions of learning environments, since these studies identified significant factors of learning environments using participants' responses.

Fraser (1998a) reviewed nine instruments that probed learners' perceptions of traditional classroom learning environments. Since Fraser's (1998a) review, published nearly two decades ago, it appears that no subsequent article has conducted a review of instruments assessing participants' perceptions of TSLEs. Rather than a top-down (from the literature) approach, we employed a middle-out approach to proposing a framework for TSLEs. That is, we examined current instruments on participants' perceptions of TSLEs in terms of significant factors or scales identified by the participants in the empirical studies, and then categorized the factors into different dimensions. Meanwhile, we applied learning theories and perspectives to form the dimensions. Factors that could not be categorized into the dimensions would suggest a need for us to reconsider the dimensions. However, we were able to categorize all the factors into the existing dimensions, although our discussions mainly focus on which factors belong to which dimensions. Such an approach allowed us to form a framework of TSLEs considering both the perspectives from the literature and of the participants, thus providing insights that may have been overlooked by designers. We discuss how the framework formed in this study differs from previous frameworks in the Discussion section.

3. Methods

Our decision to review studies on participants' perceptions was based on Fraser's (1998a) viewpoint that it is important to define a learning environment through the perspectives of "the milieu inhabitants" (p. 528, Fraser, 1998a) of that environment. The resulting framework in this study reflects significant factors from participants' perceptions, and is confirmed by contemporary learning theories. We use the term "factor" or "scale," consistent with the perception studies, to indicate characteristics of learning environments identified from statistical analysis that represent a coherent thread of participants' perception responses. We use "dimension" as a larger unit that contains strands of factors.

3.1. Identification of studies

We used the Web of Science, one of the highly recognized databases indexing essential journals in the social sciences, to search

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