Electronic Assessment: Past, Present, and Future

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Abstract

This paper traces the evolution of assessment by electronic means within the broader context of an electronic based pedagogy (e-pedagogy) by examining the incorporation of educational technology into behaviorist and constructivist learning theories. An analogy with genetic markers shows how both theories combine with specific electronic resources and functions to form e-markers which trace events in the history of e-pedagogy and, specifically, electronic assessment, from the year 1975 to the present. Abstract searches of e-markers illustrate both e-pedagogy’s development from a behaviorist to a constructivist e-learning environment and the corresponding change in the role of electronic assessment. Application of the Rogers’ Diffusion of Innovation Theory provides a means to assess the future of electronic assessment and constructivist e-learning environments with the result that a rigorous constructivist theory of teaching is necessary institutional acceptance.

The goal of this paper is to present an overview of the evolution of electronic assessment within the broader context of e-pedagogy (defined here as the merging of electronic resources with pedagogy) by investigating the changes occurring over time in the ways e-pedagogy is described. In particular, just as humans have genetic markers consisting of combinations of specific DNA which provide information about
the path of their evolution, e-pedagogy has “e-markers” consisting of combinations of specific terms which provide information about its development. It is noted that the use of the term “marker” in this paper infers no mechanism for the transference of information as is the case in genetic markers. While biological concepts such as horizontal gene transfer perhaps may be adaptable to this discussion in a broad sense, the e-markers described here simply represent landmarks or signposts used to trace events in the history of e-pedagogy. The identification of these e-markers begins with an exploration of two influential ideas: behaviorism and constructivism.

Behaviorism, the predominant learning theory in the mid–twentieth century, arose from work of Pavlov, Watson, and Skinner (Ashworth, 2004). In particular, the use instructional methods such as drill and practice, games, simulations, and tutorials as part of linear programed instruction and integrated learning systems became important components of behaviorist education. The teacher transmitted knowledge through activities aimed at behavioral modification with outcomes largely determined by summative assessments.

Constructivism, based on the work of Dewey, Vygotsky, and Piaget, entered into the educational mainstream in the last decades of the twentieth century (Ashworth, 2004). While behaviorist learning environments focused on the individual working alone, constructivist environments featured non-linear activities requiring cooperation, communication, and communities. The teacher became a guide or facilitator with the construction of knowledge monitored through formative assessments requiring both flexible teaching and instruction. Table 1 summarizes the two approaches and illustrates the differing role of the five specific elements.

<table>
<thead>
<tr>
<th>elements</th>
<th>instruction</th>
<th>teaching</th>
<th>learning</th>
<th>assessment</th>
<th>testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behaviorism</td>
<td>linear</td>
<td>directs</td>
<td>behavior</td>
<td>measures</td>
<td>summative</td>
</tr>
<tr>
<td>Constructivism</td>
<td>non-linear</td>
<td>facilitates</td>
<td>cognition</td>
<td>monitors</td>
<td>formative</td>
</tr>
</tbody>
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**Table 1. Elements and prefixes**

<table>
<thead>
<tr>
<th>prefixes</th>
<th>electronic, computer, mobile, online, web</th>
</tr>
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<tr>
<td>Function</td>
<td>assist, aide, base</td>
</tr>
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Next it is possible to examine the electronic resources used to implement the above elements. Along with generic “electronic” resources, specific examples include computers or mobile devices. In addition, computers and mobile devices also provide a means to access additional electronic resources either online or on the web. Furthermore, an electronic resource provides different functions. For example, a computer can function to assist or aid in implementing specific pedagogical elements or a computer or the web can act as a base of activities.
In practice, the electronic resource and function terms act as prefixes for any pedagogical element in Table 1. The prefixes and elements, when combined, form the e-markers which enable the description of the characteristics and evolution of e-pedagogy. Examples of the possible e-markers are online learning, computer assisted assessment, web-based testing, and e-teaching.

**Electronic assessment: 1975 to the Present**

Abstract searches of the literature provide the method for determining the occurrences of the terms which make up the e-markers. The Education Resources Information Center (ERIC) website provides a way to search all publication types (journal articles, books, and dissertations) and all education levels (elementary, secondary, and post-secondary) for the years 1975 to 2012, yielding a total of 5022 abstracts. Figure 1 shows the number of occurrences for the top 20 e-markers over the stated time interval which represents 97% of the total abstracts found.

![Figure 1. e-marker frequency over the years 1975 to 2012](image)

As illustrated in the figure, the e-, online, and web-based prefixes and the learning and instruction elements form the majority of the top e-markers. However, to uncover the development of e-pedagogy, the frequency at which the prefixes and elements occur each year needs to be examined.

The frequency or number of occurrences of each element per year for all prefixes is shown in Figure 2. (Note: Since a possible time difference existed between research and publication date, a three year moving average was used to illustrate trends in the data). Figure 3 shows the frequency of occurrences of each prefix per year for all
elements. As observed, the computer assisted/aided instruction and computer based instruction e-markers characterized the early years of e-pedagogy. These e-markers originate from the recognition that the characteristics of behaviorist pedagogy corresponded to the use of computers at that time for summative assessments in the form of drill and practice, multiple choice, or true/false testing behavioral objectives.
With the emergence of the internet in the last decade of the twentieth century, electronic, online, and web-based instruction, learning, teaching, assessment, and testing e-markers began to appear in greater and greater frequency. Constructivism and its focus in areas such as communication, cooperation, and communities offer an explanation. As the capabilities of computers increased, the creation of more varied learning environments using virtual classrooms, computer mediated communication, and cooperative learning also increased. Data (Figure 4) from a search in the ERIC database for the occurrence of abstracts containing the term combinations virtual classrooms (A), virtual classrooms and computer mediated communication (B), computer mediated communication and cooperative learning (C), and virtual classroom and cooperative learning (D) support this conclusion. As before, a three year moving average is used. For the period of 1995 to 2011, the abstracts in each area increased similarly to electronic and online prefixes (Figure 3).

The results shown in Figure 4 suggest that constructivist researchers took advantage of emerging technologies and actively pursued their implementation. Although advocating a blended behaviorist/constructivist approach, Weegar and Pracis (2012) recognized this trend when they stated that “there appears to be a theoretical shift more often than not from behaviorist learning practices to constructivist learning practices related to the increased use of educational technologies, and stemming from the fact that many available technologies support constructivist learning platforms.” One particular by-product of this implementation was the contraction of “electronic” to “e” when used as a prefix. Thus, as constructivism became the leading e-pedagogy, e-assessment, e-teaching, and e-testing emerged as separate e-markers. (Note: Although the prefixes online and electronic are often used synonymously, this paper uses the more generic electronic, or “e”.)

In summary, the identification and study of e-markers suggests that e-pedagogy emerged initially as an aide/assistant to, or base of behaviorist instruction. With the rise of the internet and continued computing advances, e-markers with constructivist characteristics became more frequent, eventually making constructivist electronic learning environments the most recognizable feature of current e-pedagogy. As a component of these environments, e-assessment thus shares a common origin describable by Rogers’ Diffusion of Innovations theory. Furthermore, while constructivist electronic learning environment e-markers currently dominate, earlier
behaviorist prefixes such as computer assisted or computer based have now become part of constructivist elements of learning, assessment, and teaching.

**E-assessment: The Future**

Rogers (2003) defines an innovation as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption." In this sense, e-pedagogy, whether constructivist-based or not, qualifies as an innovation within the framework of the diffusion of innovation theory. According to Rogers, diffusion represents "the process by which an innovation is communicated through certain channels over time among the members of a social system". In essence, the diffusion of innovation theory maintains that an innovation's adoption proceeds over time through five groups of adopters: innovators, early adopters, early majority, late majority, and late adopters (Figure 5).

![Figure 5. Diffusion of Innovation Groups](image)

One particular detail of the adoption process, as described by Moore (2006), is a chasm arising from the different viewpoints held by innovators/early adopters and the early majority. Specifically, the innovators/early adopters represent the visionaries and experimenters whose focus is on the technology, what it is able to do, how it might be used, and who might use it. In short, their focus is the technology potential. Regarding e-pedagogy, this side of the chasm corresponds, in part, to the authors of the search results shown in Figures 2, 3, and 4. The early majority, on the other hand, are pragmatists who value how the innovation fits into the organization, what disruptions are possible, what resources are required to implement and support it, and what existing record, if any, it has. Their focus is therefore on technology institutional implementation, and many teachers and administrators comprise this early majority on the chasm’s other side. The future and ultimate viability of constructivist electronic learning environments utilizing e-assessment depends upon their ability to move from the experimental stage of innovators/early adopters to the implementation stage of the institutional early majority. According to Rogers, the rate at which this movement occurs depends upon the level of perception of five attributes. An examination of these attributes therefore provides the information necessary to forecast whether constructivist electronic learning environments and e-assessment together can bridge the chasm.
Relative advantage is the degree to which the innovation is perceived as better than the idea it supersedes. For e-pedagogy, the flexibility to provide increased access to education in a more efficient manner is tacitly perceived as a major advantage. For example, online courses for United States institutions have increased from approximately 10% of total enrollment in the Fall of 2002 to 32% in the Fall of 2011 (Allen & Seaman, 2013). The most specific advantage, however, is the perception that constructivist electronic learning environments provide the best environment for the developing higher order thinking particularly as described by Bloom’s taxonomy.

Specifically, Bloom’s revised taxonomy provides a basis for assessing knowledge levels. Efforts such as Hench and Whitelock’s (2012) model to assess metacognitive skills online by linking confidence and performance to cognitive skill levels serves as an example, as does the call by Elliott (2012) to incorporate existing taxonomies such as Bloom’s into an e-pedagogy that reflects the modern capabilities of online learning environments. Even though Booker (2007) charged that its use by constructivist educators resulted in a de-emphasis of lower order thinking skills, Lee’s (2008) statement that “Whatever its origins, Bloom’s taxonomy offers a promising approach for designing classroom experiences for students, experiences that promote critical thinking and constructivist approaches to learning” shares wide consensus. Thus, increased accessibility and the perceived ability of constructivist electronic learning environments to foster higher order thinking skills together represent a major relative advantage.

Compatibility is the degree to which the innovation is perceived to be consistent with the existing values, past experiences, and needs of the potential adopters. Since the innovators and early adopters developed and subsequently adopted constructivist electronic learning environments, the values, practices, and needs examined represent those of the many teachers and institutions which make up the early majority. However, the compatibility of constructivist pedagogy itself precedes any subsequent inclusion in an electronic learning environment. While Barr and Tagg (1995) state that a paradigm shift from behavioral instruction to constructivist learning is needed, Schuyler (1997) recognized that to make the shift “the entire structure would require reform including the measurement of units of learning based on knowledge instead of time spent in class” and “the redefining of the very concept of efficiency and production itself in higher education from cost per hour of instruction to cost per unit of learning.”

Clearly, such an effort presents great institutional challenges. Furthermore, Richardson (2003), in citing two cases where both teacher-centered and student-centered pedagogy succeeded equally well, cautions about assuming that constructivist pedagogy is “the best practice for everyone”. While Duffy and Cunningham (1996) see educational technologies as “an integral part of the cognitive activity”, Gance (2002) takes issue as to whether computer-based educational technology is, as claimed by some, inherently constructivist and whether its application in some cases is potentially detrimental. In addition, Scholtz (2007) writes that in the areas of validity and reliability of summative high-stakes situations
“concerns regarding assessment are shared by many who otherwise embrace social constructivist learning environments”. Schwartz, Lindgren, and Lewis (2009), while cautioning that “We have been using non-constructivist assessments in an era of constructivist beliefs”, nevertheless posit that constructivism can provide guidance in developing effective assessment techniques and propose a shift in emphasis from instruction to assessment when applying constructivist ideas. In view of these comments, the viability of constructivism specifically as it relates to e-assessment and constructivist electronic learning environments requires further research before a wholesale effort to achieve compatibility commences by restructuring schools, classrooms, and teacher education courses.

**Complexity** is the degree to which an innovation is perceived as difficult to use. While issues of implementing constructivist activities are addressed as part of the trialability attribute, the language used in constructivist literature represents potential problems in developing these activities. Slezak (2010) maintains that the jargon of constructivism itself often is mistaken for deep theory which inhibits meaningful applications. For example, “unbroken contingent flow of communicative interaction between human beings” translates as “talking” and “communities characterized by distinct discursive practices” equates to “different groups”. His view is also advanced by Davis and Sumara (2002) who state “that constructivist vocabularies have had little hope of prompting new ways of thinking, much less of informing practice” and at times foster an “anything goes” approach to implementing constructivist theory. In addition, Gordon (2009) specifically lists the lack of clarity and coherency in the literature regarding the varying versions of constructivism as major reasons for the absence of concrete teaching proposals and suggests that the role of teachers as appliers and not co-developers of constructivist theory further deepens misunderstanding of the constructivist view. If constructivism cannot be easily understood, then e-assessment activities cannot be properly designed and constructivist electronic learning environments better implemented. Thus, a less complex constructivist theory is needed.

**Trialability** represents the opportunity to experiment with the innovation on a limited basis. Here, the data presented in Figures 1 to 4 suggest the magnitude of the work done already in investigating the different components of constructivist learning environments. An important factor in determining the trialability is whether constructivist learning theory provides examples of actual teaching activities. Models, such as those proposed by Jonassen (1999) aimed at solving authentic, real world problems, offer important perspectives in designing constructivist learning environments with aspects of objectivism (behaviorism) included within them. Nevertheless, Geer and Rudge (2002) found that one major detriment to the implementation of constructivist strategies is “simply figuring out how to translate even practical techniques offered by other authors to their own teaching contexts.” This issue also relates to the previously mentioned complexity of constructivist language. In an article questioning the efficacy of pure discovery-based learning, Mayer (2004) advocates for a more clearly stated expression of constructivist theory in order to make testable predictions verifiable by evidence-based arguments. Tobias
and Duffy (2009) add that “constructivism remains more a philosophical framework than a theory” and state the need for research to identify common design principles. Hence, a more adaptable constructivist theory is needed to ensure the trialability of constructivist electronic learning environments and specifically e-assessment designs incorporated within them.

**Observability** is the degree to which the innovation results are visible or available to others. As with the trialability attribute, the previously presented data represent the availability of results of “trials” or investigations. However, Geer and Rudge (2002) conclude that “a major detriment to successful implementation of constructivist-based strategies "is a lack of familiarity with relevant science education literature" and “difficulties science faculty may have in interpreting the results of education research”, a conclusion consistent with the previously discussed constructivist language concerns. In short, the literature is available but possibly not always observed (that is, read) or understood, with lack of preparation time and technical support constituting major barriers (Ward, 2001; Geer & Rudge, 2002; Sicilia, 2007). Until constructivist theory reaches the main steam of education, the observability of e-assessment and constructivist electronic learning environments results remains limited.

**Conclusions**

In summary, constructivist electronic learning environments evolved as the predominant component of e-pedagogy and presently straddle the adoption chasm. While some have managed a crossing to institutional implementation, compatibility, complexity, trialability, and observability concerns have deterred others. Until constructivist theory becomes less complex and difficult to apply, constructivist teaching will remain, as Sjøberg (2007) states, as a research program with “a set of ideas that provide a platform of common assumptions and ideas about certain phenomena.” If constructivist electronic learning environments and e-assessment are to achieve a high degree of institutional implementation, a research-supported constructivist theory of teaching and assessment is required. Such a theory with less complexity and greater compatibility, trialability, and observability provides e-assessment and constructivist electronic learning environments with a firmer footing to bridge the chasm.

Whether or not solely constructivist electronic learning environments cross the chasm to institutionalisation remains to be seen. As Shield (2000) notes “different learning objectives may require different teaching and learning strategies to achieve them” and that many teachers already employ a blend of behaviorist and constructivist strategies to assess the range of thinking skills. Furthermore, Ebert’s (2012) comment that, regarding behaviorism and constructivism, “We can absolutely conclude that both theories have been relevant and will most likely remain relevant” when dealing with educational technology implementation suggests that a blended approach may be the future of e-assessment and e-pedagogy. In addition, possible leveling off of certain elements and prefixes and the current rapid rise of mobile e-
markers (Figures 1, 2, and 3) suggest a potentially new developmental direction. However, regardless the direction e-pedagogy takes, research-based e-assessment must continue to play a crucial role.

References


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