Architectures of Instruction: Selecting an e-Learning Teaching Method

Higher Education Services

Clark (2000) and Clark and Mayer (2008) suggest that instructional design for e-learning generally follows one of three approaches, each reflecting a different metaphor for learning arising during the last 100 years of educational research. These approaches are receptive, directive, and guided discovery. While necessarily simplified, these approaches provide a useful framework for understanding and interpreting research in the science of instruction. Selecting an effective instructional architecture requires knowing which of these delivery methods is best for teaching which learning outcomes to which learners under which circumstances (Mayer, 2011).

Three Architectures of Instruction

Receptive Architecture

According to the information acquisition metaphor of learning, the purpose of instruction is to disseminate information to learners who then store received ideas in memory. The instructional architecture associated with this metaphor is referred to as receptive because it views learners primarily as recipients of information. Common instructional delivery methods associated with this architecture include traditional lecturing, textbook reading, and instructor modeling. In each case a learner is exposed to ideas with minimal interactivity.

Learning benefits. The benefits of receptive delivery methods are particularly notable for learners with low content knowledge. Receptive methods have been shown effective in assisting learners to link their prior knowledge with incoming information, making abstract ideas concrete through use of analogies and metaphors, and capturing learner attention through compelling narratives (deWinstanley & Bjork, 2002; Willingham, 2009). Additionally, by modeling processes or procedures, including the use of worked examples, learner cognitive resources are freed to focus on encoding relevant information, thereby producing greater learning gains than if required to solve problems immediately (Renkl, 2002; Hattie & Yates, 2014). Finally, use of instructional explanations can impart the practical significance of an idea, draw attention to important relationships or common misunderstandings, and increase knowledge transfer by providing insight into the underlying principles and concepts behind a learning objective (Schwartz & Bransford, 1998; Wittwer & Renkl, 2008).

Learning challenges. The limited capacity of our working memory systems, however, means that excessive information presentation using receptive delivery methods can also produce cognitive overload (Gobet & Clarkson, 2004; Sweller, Merrienboer, & Paas, 1998). Successful encoding of information requires that learners take frequent breaks from receptive approaches in order to engage in active learning strategies (e.g., retrieval practice, elaboration, and reflection). Research has also found that learner misconceptions and false beliefs are difficult to eliminate through receptive methods while at the same time they interfere with comprehension of received material (Aydeniz & Kotowski, 2012; Kendeou & van den Broek, 2005). Given the absence of feedback in receptive architectures many

learners are also likely to succumb to "illusions of competence," believing they understand material better than they actually do, while lacking an awareness of what content needs additional study or attention (Karpicke, Butler, & Roediger, 2009; Kruger & Dunning, 1999). And if learners already have a high degree of familiarity with the material, instructional explanations will be redundant and interfere with existing learner self-explanations, resulting in poorer learning outcomes (Leppink, Broers, Imbos, van der Vleuten, & Berger, 2011).

Directive Architecture

Directive instructional architecture is based on a response strengthening metaphor that views learning as the result of appropriately supplied rewards and punishments in response to learner performance. Directive delivery methods emphasize the importance of learners progressing through highly structured, and carefully predefined, interactions eliciting frequent learner responses in conjunction with prompt feedback. Common directive instructional approaches include computer adaptive instruction, check-your-understanding activities, and procedural training programs. Directive architectures are characterized by moderate levels of interactivity as learners are frequently expected to provide answers or select next steps.

Learning benefits. Directive instructional architectures often employ segmented presentations and afford substantial learner control over pacing, two features that help to manage learner cognitive load (Clark, 2000; R. Mayer & Moreno, 2003). Frequent learner input also lends directive instructional methods to retrieval and rehearsal activities that support successful long-term learning (Karpicke & Blunt, 2011; Rohrer & Pashler, 2010). Directive instructional methods are also crucial in supporting the extensive practice required to achieve mastery and automaticity in the foundational skills underlying higher learning outcomes (Cumming & Elkins, 1999). Many kinds of procedural knowledge and skills are immune to receptive methods and require directive instruction (Wittwer & Renkl, 2010). Finally, frequent learner responses provide crucial feedback to both students and instructors regarding learning progress and areas in need of improvement.

Learning challenges. Directive methods, because of their highly structured and predetermined nature, often produce poorer results when the desired outcome is strategic or principle-based. Extensive use of directive methods can also result in a lack of cognitive flexibility with learners simply mastering rule application while failing to understand broader conceptual or contextual implications. Consequently, focus on near-transfer skill acquisition can neglect the development of a broader conceptual understanding of a topic and become simply a mechanism for reinforcing rote procedural knowledge (Clark, 2000). Finally, directive methods can negatively impact learning through an expertise reversal effect as individuals with sufficient mastery of a topic find the highly segmented and sequential interactions demotivating and interfering with preexisting knowledge (Blayney, Kalyuga, & Sweller, 2009).

Guided Discovery Architecture

Guided discovery methods emerged from research supporting the view that learning is an inherently constructive process. The role of instruction, according to the guided discovery approach, is to provide opportunities for learners to construct knowledge by placing them in authentic situations requiring active and personal sense-making. Instructional delivery methods associated with the guided discovery approach include the use of case studies, project or problem-based work, and real-world simulations. Guided discovery methods are often characterized by high levels of learner interaction with minimal direct instruction.

Learning benefits. Guided discovery architecture is typically most beneficial for high-knowledge learners who do not require strong instructional scaffolding. Once learners have gained sufficient expertise in foundational skills, research evidence supports the value of having learners work on complex real-world problems that promote the acquisition of transferable and flexible knowledge (Merrill, 2002). The use of case studies and problem-solving activities can enhance the transfer of knowledge outside the instructional environment by maximizing the similarity between the teaching and transfer situations (Mayer, 2002). Properly designed guided discovery methods can also be useful for teaching far-transfer skills (e.g., critical and creative thinking) to supplement domain specific content knowledge (Clark, 2005). Another valuable effect of the discovery approach is in cultivating learner ownership over the learning process by providing meaningful, engaging, and interesting problems to solve (Jonassen, 1999). Finally, experiments have shown that having students attempt to invent a solution prior to receiving direct instruction explaining the answer can result in significant learning gains compared to receptive instruction alone (D. L. Schwartz & Martin, 2004).

Learning challenges. Discovery instructional methods should be used with care, however, as research has found that novice learners are likely to find minimally guided discovery activities cognitively overwhelming (Kirschner, Sweller, & Clark, 2006; Mayer, 2004). High fidelity learning environments, those closely approximating real-world environments and/or discipline procedures (e.g., having students behave like scientists), introduce many extraneous and irrelevant details that can interfere with successful learning (Moreno & Mayer, 2000; Moreno & Mayer, 2002). Research has demonstrated that instructional design should minimize unnecessary information as much as possible during initial knowledge acquisition periods in order to minimize learner cognitive load (R. E. Mayer, Heiser, & Lonn, 2001). Additionally, the absence of direct instructional elements, which characterizes many discovery approaches, can prevent learner contact with essential material as well as deny instructors the ability to ensure learners are constructing desired mental models (Mayer, 2011). As Halpern and Hakel note (2003), experience alone is often a poor teacher and 'authentic' situations often lack the systematic and corrective feedback required to evaluate and improve learning outcomes (Halpern & Hakel, 2003). Comprehensive meta-analyses comparing the effectiveness of various instructional methods strongly support the conclusion that the majority of instruction should involve direct rather than discovery-based instructional approaches (John Hattie, 2009).

Which Instructional Architecture Should I Use?

It should be evident from the preceding discussion that cultivating enduring, meaningful, and transferable knowledge requires a holistic instructional design approach incorporating all of the discussed approaches (for two attempts to do this, see Merrienboer & Kester, 2005; Merrill, 2002). Furthermore, the effectiveness of any particular instructional method is highly context sensitive, a function of learner prior knowledge, desired learning outcomes, and content complexity. Designing successful e-learning experiences requires continually balancing instructional support and explanation with learner activity and knowledge construction (Wittwer & Renkl, 2010). Highlighted below are examples of effective uses of each instructional architecture discussed in this paper.

Effective Uses of Receptive Methods

- Pretraining on key concepts, connections, and ideas covered in a lesson (R. Mayer & Moreno, 2003)
- Gaining student 'buy-in' regarding the value and meaningfulness of a learning topic (e.g., beginning a lesson with a relevant story or problematizing a topic to capture learner attention) (Zull, 2004)
- Presenting advanced organizers to activate learner prior knowledge as well as frequent use of metaphors and analogies to connect ideas to students' everyday experiences (Ambrose & Lovett, 2014)
- Demonstrating desired skills and knowledge through the use of expert modeling and worked examples prior to learner practice (Renkl, 2014)
- Small bursts of instructional explanations (5–7 minutes) interleaved within lengthier guided practice opportunities (Rosenshine, 2012)

Effective Uses of Directive Methods

- Supporting the automatization and overlearning of foundational knowledge and skills (Cumming & Elkins, 1999)
- Formative assessment providing frequent feedback on learner progress and instructional effectiveness (J. Hattie & Timperley, 2007)
- Development of procedural knowledge and near-transfer skills (Clark, 2000)
- Management of cognitive load through segmented presentations and learner control over pacing (Clark & Mayer, 2008)
- Promoting active learning by incorporating interactive elements requiring retrieval practice, idea generation, and elaborative rehearsal (Roediger & Pyc, 2012)
- Transitioning from worked examples to authentic problems through partial completion tasks employing fading of instructional support (Clark & Mayer, 2008)

Effective Uses of Guided Discovery Methods

- Supporting transfer and knowledge flexibility through interactions with real-life complexity and authentic task situations (Mayer, 2002)

- Developing far-transfer knowledge such as creative, critical, and practical thinking skills (Clark, 2000)
- Encouraging learner engagement and interest through efforts to solve real-world problems (Merrill, 2002)
- Support high-knowledge learners in applying and elaborating on their existing knowledge base
- Cognitively prime learners for greater retention of material during subsequent direct instruction periods (D. L. Schwartz & Martin, 2004)
- Emphasizing the interconnectedness of ideas across disciplines as well as highlighting the human dimension of knowledge (Fink, 2013)

Where Can I Learn More?

Clark (2000) provides a comprehensive explanation of the different instructional architectures discussed here and in her other work, e.g. (Clark & Mayer, 2008, Clark, 2005). For an excellent summary of the important roles played by instructional explanations in learning, see the review article by Wittwer and Renkl (2008). A number of articles summarizing the risks of discovery and inquiry-based instructional methods are available (Kirschner, Sweller, & Clark, 2006; Mayer, 2004) and should be reviewed prior to employing these approaches.

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