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Theory Development

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ABSTRACT

The field of educational technology is characterized by an abundance of sets of theoretical statements. These sets can be described from at least four perspectives. A first perspective pertains to the object or orientation of the (sets of) theoretical statements. Sets may address educational principles, features of interventions or tools, development procedures, or the nature of the field itself. The origin (theoretical or practical context) of these sets of statements is a second perspective from which they can be described. Theoretical statements can be clearly anchored in specific practical experiences, can be the result of a deductive effort to apply fundamental theoretical insights or theoretical perspectives, or can reflect a thoughtful interaction between a practical setting and a theoretical perspective. A third perspective relates to the level of theoretical sophistication of these (sets of) statements. Sets of theoretical statements can be collections of isolated theoretical expressions, descriptive or prescriptive models with respect to educational technological issues, or integrated, internally coherent sets of theoretical principles. The degree of justification of these (sets of) statements represents a fourth perspective. Some statements are purely explorative, whereas for others empirical evidence is readily available. Taking these differences into account, this chapter aims at discussing theory development. First, features of

descriptive and prescriptive theories are elaborated by analyzing their commonalities and differences. Second, the development of theories itself is addressed by focusing on deductive, inductive, and mixed approaches. Third, theoretical levels of sophistication and justification are dealt with. In all this, the elaboration of instructional design models is focused upon.

KEYWORDS

Instructional design model: A coherent set of mostly prescriptive theoretical statements on the appropriateness of particular instructional approaches or interventions.

Theoretical statement: Formal expression about the relationship between at least two variables or instantiations of variables.

Theory: An integrated and internally coherent set of theoretical statements that provides a sufficient basis for empirical research in which these statements can be tested.

Theory development: Systematic effort to generate (coherent sets of) theoretical statements.

INTRODUCTION

Educational technology and more specifically instructional design are characterized by an abundance of sets of theoretical statements. Repeatedly overviews of the plethora of theoretical perspectives and insights have been presented (Dijkstra et al., 1997; Dills and Romiszowski, 1997; Jonassen, 1982, 1985, 1996a, 2004a; Reigeluth, 1983a, 1999; Seel and Dijkstra, 2003; Tennyson et al., 1997). Theoretical statements typically are formal expressions about the relationships between at least two variables or instantiations of variables. Theoretical statements in educational technology generally make such claims that are regarded to be relevant for educational technology or instructional design. A theory, then, is an integrated and internally coherent set of theoretical principles that provides a sufficient basis for empirical research in which these statements can be tested. For instance, a theoretical statement may explain how a learner-related variable in combination with an instructional goal is linked to an instructional strategy or how different activities are sequenced in a development procedure. An educational technological theory consists of a series of such statements that are mutually consistent and refer to one another.

In this chapter, differences between theoretical statements are addressed by presenting four perspectives from which such statements can be described. Taking these differences into account with respect to sets of theoretical statements, the remainder of this chapter discusses theory development with a focus on instructional design. Features of descriptive and prescriptive theories are elaborated by analyzing their commonalities and differences. The development of theories is addressed by focusing on deductive, inductive, and mixed approaches. Finally, levels of theoretical sophistication and empirical justification are dealt with.

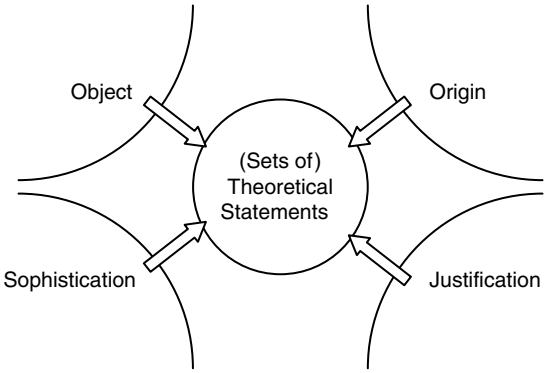

Figure 55.1 Four perspectives to describe (sets of) theoretical statements.

THEORETICAL STATEMENTS: FOUR PERSPECTIVES

Theoretical statements and sets of such statements differ in substantial ways. Their similarities and differences can be identified and described from at least four perspectives: object, origin, sophistication, and justification (see Figure 55.1). The absence of a clear and consolidated theoretical base in the field of educational technology can be shown by describing (sets of) theoretical statements from these four perspectives.

The Object Perspective

Theoretical statements differ as to what the statements are all about. There are large variations in the object of (sets of) theoretical statements. A first series of sets addresses instruction-related principles. These statements bring forward what is regarded to be important or even essential for learning to occur in an instructional setting. A clear example is Ausubel's (1968, p. vi) statement: "If I had to reduce all of educational psychology to one principle, I would say this: the most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly." A more recent example comes from Merrill, who, in an attempt to consolidate the variety of

theoretical statements in the educational technology field, postulated five *first principles of instruction*, such as "learning is promoted when learners are engaged in solving real-world problem" (Merrill, 2002, p. 45).

A second series addresses issues with respect to (technological) features of instructional interventions, tools, or devices. Traditionally, such statements mostly pertain to links between the format and outlook of information, on the one hand, and issues of accessibility and usability, on the other (Fleming and Levie, 1993). Examples are statements with respect to typographical cues in texts (Glynn et al., 1985), headings (Hartley and Jonassen, 1985), contents lists and indexes (Wright, 1985), or various features of Web-based materials (Brooks, 1997) that may facilitate access to information in printed or digital materials. More recently, and especially under the label of multimedia design, such statements also pertain to links between the format and outlook of information and cognitive issues directly related to learning. A clear example is the multimedia principle "students learn better from words and pictures than from words alone" (Mayer, 2001, p. 63). The *Cambridge Handbook of Multimedia Learning* (Mayer, 2005) compiled a large number of such principles. To this series also belong the large number of statements about how to use technological devices such as different types of information and communication technologies (Alessi and Trollip, 2001; Jonassen, 1996b; Morrison et al., 1999) to foster learning. Currently, e-learning (Clark and Mayer, 2003; Jochems et al., 2004) is generating a large number of such theoretical statements.

In a third series, the object of the statements is the design or development process. These statements discuss what procedures or instruments are best suited for what kind of design problem (task analysis procedures; see Jonassen et al., 1999) or specify how activities in a design or development process relate to one another (Andrews and Goodson, 1980; Dick et al., 2001; Gustafson and Branch, 1997; Kemp et al., 1994; Lee and Owens, 2000; Rothwell and Kazanas, 1998).

Finally, theoretical reflections also pertain to instructional design itself: the nature of educational technology or instructional design (Clark and Estes, 1998; Heinich, 1984; Van Patten, 1989; Wilson, 1997), their development (Clark and Estes, 1999; Reigeluth, 1983b; Schott and Driscoll, 1997), and the appropriateness of particular research approaches (Reeves, 2005; Ross and Morrison, 2004) are regularly discussed. Clark and Estes (1999), for example, pointed to the technological nature of instructional design, Schott and Driscoll (1997) stressed the need to focus on efficiency, and Reeves (2005) argued for the application of more design-based research approaches.

The Origin Perspective

Theoretical statements can also be described by explicitly considering their origin. Three different origins can be easily distinguished. A first position is practice oriented and practice anchored. Theoretical statements are rooted in practice and result from a reflection on design and development practices. Examples are theoretical conclusions that are immediately linked to particular design or development projects (Elen and Clarebout, 2001; Hannafin and Land, 1997). Regularly, such theoretical statements are prescriptive. They specify how in a particular context an outcome can be realized by the application of a particular method. A second position is theory driven and theory oriented. Theoretical statements result from deliberate efforts to deduce design or development principles from more fundamental theories (e.g., learning theory, systems theory, activity theory) or specific theoretical perspectives (Gros, 2002; Jonassen and Rohrer-Murphy, 1999; Richey, 1986). A more general theory is applied to a specific problem or context to generate more specific theoretical statements. Whereas classical examples are contributions of Skinner (1968) and Gagné (1985), a more recent example is van Merriënboer's (1997) four-component instructional design (4C/ID) model. Most typical, however, is a third position in which a local instructional design theory is developed by applying a specific theoretical perspective to a specific instructional design issue. Using a specific instructional problem, intervention, or medium as an instructional design anchor point (Elen, 2004), an attempt is made to construct a consistent set of theoretical statements that directly apply to the selected problem, such as solving problems (Jonassen, 2004b). The statements may also pertain to the use of instructional interventions (Elen and Clarebout, 2006); interventions, such as problem-based learning (Schmidt, 1993) or metacognitive prompts (Bannert, 2006); or media, such as e-learning (Jochems et al., 2004) or learning objects (Wiley, 2002).

The Sophistication Perspective

Theoretical statements also differ with respect to their theoretical sophistication and empirical justification. The level of theoretical sophistication and empirical justification of these (sets of) statements clearly differs. In a number of cases the (sets of) theoretical statements are simple collections of isolated theoretical expressions; for example, in the conclusion section of an empirical study a number of implications for instructional design are mentioned. Typical for instructional design, however, seems to be the abundance of descriptive or prescriptive models with respect to educational

technology issues (Reigeluth, 1983a, 1999). Additionally, there is also a small set of attempts to really present an educational technological theory consisting of integrated, internally coherent sets of theoretical principles which provide a sufficient basis for empirical research in which these statements can be tested. The need for such integrated, internally coherent sets becomes very clear when attempts are made to automate instructional design (Spector et al., 1993). The need to formulate precise statements that are also mutually consistent and coherent helps them to become theoretically more explicit and sophisticated (Elen, 1998).

The Justification Perspective

A different aspect relates to the empirical validation of the statements. Some statements are purely explorative or speculative, whereas for others empirical evidence is readily available. This empirical evidence may have been gathered through a variety of both quantitative and qualitative methods (e.g., experimental studies, usability and feasibility studies, design experiments, case studies, development research). Theoretical sophistication and empirical justification do not have to go along; for example, whereas Merrill (2002) claimed the theoretical soundness of his interrelated set of first principles of instruction, he also specified the need to test the empirical validity of these statements (Merrill, 2006).

DESCRIPTIVE AND PRESCRIPTIVE THEORIES

The educational technology field and the instructional design field are areas of practice as well as areas of scientific inquiry. Research efforts in the field of instructional design are twofold. A first series of efforts and approaches aims at describing instructional phenomena. Why a particular intervention is suitable for a group of learners or how design processes are actually practiced is described and explained. When the object relates to how instructional interventions or approaches affect learning processes of particular groups of learners (for collaborative learning, see Littleton and Häkkinen, 1999), these endeavors may result in the specification of an instructional theory (Reigeluth, 1983b). When the process is focused upon, the descriptions mainly pertain to the very different context-specific ways in which design and development procedures and processes develop (Richey et al., 2004) and to the difficulties designers experience to implement well-defined and linear design procedures (Gibbons, 2003; Rowland, 1993).

A second series of research efforts aims at identifying what instructional interventions or approaches should look like in view of reaching an educational outcome within a specific context or what steps (in what order) are most indicated to generate a suitable instruction design. These theoretical attempts are prescriptive in nature (Reigeluth, 1983b). *Instructional design* (ID) is often the label used to refer to a prescriptive discipline that aims at optimizing decision-making for instruction (Elen, 1995). The label *instructional systems design* (ISD) refers to similar efforts that also include the actual development of instruction. How exactly ID and ISD relate to each other is an object of much discussion.

Although descriptive and prescriptive theories can be distinguished, they are highly interrelated. Descriptive theories evolve into more prescriptive indications (Clark and Mayer, 2003), and prescriptive theories generate research questions (Merrill, 2006), which in turn result in the elaboration or refinement of prescriptive theories.

Descriptive Theories

Descriptive theories in the field of educational technology aim at modeling and explaining either the actual instructional processes and their learning effects or the actual way in which instruction is developed. By modeling these instructional and development processes, the theoretical statements identify which variables are relevant and how they relate to one another. Such (sets of) statements can have substantial predictive and explanatory power. They may help us to better understand what is happening in a concrete setting and to formulate expectations about probable effects and potential difficulties.

In modeling instructional processes, researchers are deeply influenced by the theoretical perspectives they adopt. The theoretical perspective greatly affects what is regarded to be important, what is considered, and what is discarded. With respect to instructional processes, for example, a clear evolution from behaviorist (Skinner, 1968), information-processing (Anderson, 1983; Andre, 1979; Kintsch and van Dijk, 1978), constructivist (von Glasersfeld, 1987; Wilson, 1996), and socioconstructivist (Lave and Wenger, 1991) can be observed. Each of these theoretical perspectives offers another set of glasses to look at instructional processes and hence results in the identification of different sets of variables and different interrelations between those variables.

After a period in which the constructivist nature of human learning was stressed, it seems that most recently a number of theoretical insights are more

realistic with regard to instructional design. First of all, more and more studies strongly stress the need to systematically consider the limits of human cognition and more specifically the limited self-regulation skills in instructional settings (Kirschner et al., 2006; Mayer, 2004). Furthermore, warnings have been uttered that learners may be less compliant than expected (Goodyear, 2000), partly because their instructional conceptions do not match those of the designers (Elen and Lowyck, 2000).

With respect to the development of instruction, it seems that the systems approach and activity theory remain important. Continuously the models are being revised to ensure that all important design aspects are systematically considered (Dick et al., 2001; Tennyson, 2000). At the same time, cognitive research has clearly shown that designers, even expert designers, do not follow a linear procedure. The development is therefore better described as an iterative process. Affected by development approaches in informatics, rapid prototyping (Dorsey et al., 1996) has attracted attention as a valuable alternative to more linear procedures. Jonassen and Rohrer-Murphy (1999) have argued and illustrated that activity theory may provide a suitable framework when the design of constructivist learning environments is the goal.

Prescriptive Theories

In contrast to descriptive theories, prescriptive theories discuss how things should be rather than how things are. Building on such prescriptive theories, various attempts have been made to automate instructional design by actually embedding the prescriptions in systems that support the automated development of instruction, such as the Advanced Instructional Design Advisor (Muraida and Spector, 1992) and ID Expert (Merrill, 1998); for a more in-depth discussion, see Spector and Ohrazda (2004).

The prescriptive orientation, as clearly outlined by Reigeluth (1983b), reveals the normative perspective and brings the goal issue immediately to the front. Prescriptive theories basically specify how instruction (in general or more specific) should look to enable specific groups of learners to reach an instructional goal or how the developmental process should look to increase the probability that adequate instruction is developed. Not surprisingly, then, changes in what are regarded to be important instructional outcomes affect the nature of prescriptive theoretical statements. Similarly, new target populations (distance education students) and, more specifically, different views on what are relevant learner characteristics result in differences between instructional design models. As an example, the interest in motivational issues is growing and may result in changes to instructional design models (Clark et al., 2006). Finally, the diversity of instructional interventions considered as serious alternatives also affects the models. Goals, target populations, and instructional alternatives are heavily influenced by the context in which the instructional design model is elaborated; for example, some specific multimedia-based instructional design models have appeared (Lee and Owens, 2000) that differ from more general models as they consider only e-learning environments as the context in which the instructional interventions can be embedded.

The issue of goals has been especially influential in the last several decades with respect to the elaboration of instructional design models. Two interrelated observations can be made. First, the scope of instructional outcomes has been broadened (Reigeluth, 1999). Far more than in the past, attention is being paid to instructional goals such as the development of attitudes and the acquisition of complex problem-solving and learning skills. This reorientation in instructional goals has resulted in the emergence of more integrated and task-based instructional design models, whereas older models can be said to be more analytical and information-based. Immediately related to the broadening of instructional outcomes, some authors have pointed to the difficulties of specifying instructional outcomes in operational terms. Not surprisingly, the models that pertain to such more vague instructional outcomes are also more general and less specific. Typical examples are the cognitive apprenticeship model (Collins et al., 1989) and the notion of powerful learning environments (De Corte, 2003). In these cases, no direct prescriptions are formulated but general criteria for instruction are presented. Interest in models on automated skills is growing (Clark, 2006), and it is well recognized that solving complex, ill-structured, or wicked problems requires the use of a rich set of highly automated cognitive skills.

DEVELOPING THEORIES

As already pointed out, theoretical statements—both descriptive and prescriptive ones—in the field of educational technology differ as to their origin. Some are generated through reflections on practical experiences, others are the outcome of deliberate deductions, and a last group results from interactions between theory-driven reflections and attempts to solve specific design issues. This section focuses on the development of instructional design models, as they constitute the bulk of more systematic sets of theoretical statements in the

field. This also implies a focus on primarily prescriptive theoretical statements.

Given the applied nature of instructional design, the classical approach is a deductive one. An instructional design model is the result of a deductive approach when a theory, primarily a learning theory, is taken as the starting point for its elaboration. In developing the model, the instructional designer analyzes a learning theory and is especially interested in what the theory specifies to be important learner variables (internal conditions) and environmental features (external conditions). The elaboration of the instructional design model implies the application of the learning theory to a specific instructional context. The model specifies the instructional implications of the learning theory. A deductive approach necessarily implies that a transition from description to prescription is made. How the learning theory describes learning is used as the starting point to prescribe what the instruction should look like. Such a transition is intrinsically problematic, as *what is* may drastically differ from *what should be*. The consecutive models proposed by Gagné (1985) are typical examples of a deductive approach. The consecutive versions of the Gagné model also clearly show that models are adapted along with changes in the underlying learning theory. To assess the validity of these deductively constructed design models evaluation studies and experiments are regarded as being adequate research approaches (Tennyson and Cocchiarella, 1986).

When instructional design models emerge from a specific practical context, they are developed in line with an inductive approach. Within a specific context and often for a specific target group a number of instructional interventions, media, or approaches are explored. What outcomes can be reached by means of these instructional interventions, media, or approaches are investigated (for such an approach with regard to video games, see Gee, 2003; for WebQuests, see Dodge, 1995). In most situations, these endeavors begin with high expectations for the potential of the instructional interventions, media, or approaches at hand. The inductive elaboration of an instructional design model entails an abstraction. The model builder aims at generalizing the specific context and at broadening the application context of the instructional interventions, media, or approaches. In the absence of critical tests for these generalizations, there is an apparent danger of overgeneralization. Case studies and usability and feasibility studies may help to test inductively generated theoretical statements.

Although inductive and deductive approaches can logically be identified as clear alternatives, most instructional design models do result from a combination of inductive and deductive approaches. Elen (1995) suggested that differences between the theoretical statements in instructional design models can be explained by considering at the same time their knowledge base and their referent system. Whereas the knowledge base refers to the theoretical basis of the model, the reference system refers to the application context of the model. Any attempt therefore to build a model by only considering the knowledge base or the referent system is doomed to fail. It is not surprising that even when not explicitly mentioned and even when a general applicability is claimed, most models are clearly linked to a particular theoretical perspective and are rooted in a particular instructional context consisting of a set of highly valued instructional outcomes, potential target groups, or the instructional media being considered. As an example, programmed instruction (Skinner, 1968) and the notion of criss-crossing the landscape (Spiro et al., 1991) can only be well understood and compared when the specific outcomes, target groups, and instructional media are considered.

Assessing the validity of models based on a mixed approach remains a concern. Design experiments deeply rooted in both theory and practice and oriented toward both theory development and solving real problems are considered adequate (Reeves, 2005).

THEORETICAL SOPHISTICATION AND JUSTIFICATION

Gordon (1968) formulated a number of criteria for theories of instruction. He argued that statements of an instructional theory should include a set of postulates and a definition of the terms involved in these postulates; each statement of an instructional theory or subtheory should make explicit the boundaries of its concern and the limitations under which it is proposed; any theoretical construction must have internal consistency; it must be a logical set of interrelationships. Furthermore, an instructional theory should be congruent with empirical data, be capable of generating hypotheses, contain generalizations that go beyond the data, be verifiable, and be stated in such a way that it is possible to collect data to disprove it; also, it not only must explain past events but must also be capable of predicting future events and may be expected to represent qualitative synthesis. These general criteria still apply today. A quick review of current (sets of) theoretical statements rapidly reveals that only a very limited number of such (sets of) theoretical statements actually meet these criteria. Instead of being theory based, the field is model based. The field is rather characterized by a plethora of models, which might be regarded to

be the precursors of robust theories. Some of the most prominent problems are terminological confusion, an absence of specifications of the limits of the models, and a lack of empirical evidence to back up the claims embedded in the models. Although these models replace simple collections of *implications for instruction* at the end of research articles, it can also be observed that every time new media or technologies are introduced the field is tempted to reinvent the wheel. This suggests a need for (1) a consolidation of the theoretical approaches, and (2) a kind of classification of the various models so their relationships can be more clearly exemplified and more robust theories elaborated. Some (such as Duchastel, 1998) have argued for the need of such a consolidation, but not everybody is convinced of the relevance and the possibility of such an effort (see the discussion on ITFORUM, http://itech1.coe.uga.edu/itforum/paper27/index27.html).

CONCLUSION

Educational technology, in general, and instructional design, in particular, are characterized by a diversity of efforts with respect to theory development. Despite these efforts, it is difficult to identify a generally accepted set of robust theories or even a widely accepted approach to develop such theories. From the perspective of theory development, the field is diverse and disparate. This diversity reflects both the complexity of the field in terms of the number of aspects that have to be dealt with and the diversity of theoretical perspectives that are brought to the field. More stability would require a greater consensus regarding these theoretical perspectives and the recognition of the need for a greater abstraction. Such an abstraction would, for example, require that new technological devices are not taken as the starting point for the elaboration of new models but as a challenge to apply what is known to that new device. Such attempts to apply the available models may in turn represent nice opportunities to actually validate the models and highlight their generalizability. A similar abstraction is indicated with regard to the formulation of instructional goals and target groups. Instructional goals and target groups must be described at a sufficient level of abstraction using the most relevant variables. As long as the field cannot make distinctions between relevant and superficial variables, theory development in the field of educational technology will remain a worthwhile but impossible endeavor. From this perspective, it could be argued that theory development is best helped by systematic efforts to automate instructional design. Even when the actual product of such an endeavor may never be used in actual design work, the need for clarity with regard to the variables and the need for mutual consistency in attempts to automate may very well help to generate more coherent sets of theoretical statements and to develop an actual instructional design theory.

REFERENCES

Alessi, S. M. and Trollip, S. R. (2001). *Multimedia for Learning. Methods and Development*, 3rd ed. Boston, MA: Allyn & Bacon.

Anderson, J. R. (1983). *The Architecture of Cognition*. Cambridge, MA: Harvard University Press.

Andre, T. (1979). Does answering higher-level questions while reading facilitate productive learning? *Rev. Educ. Res.*, 49, 280–318.

Andrews, D. H. and Goodson, L. A. (1980). A comparative analysis of methods of instructional design. *J. Instruct. Dev.*, 3(4), 2–16.

Ausubel, D. P. (1968). *Educational Psychology: A Cognitive View*. New York: Holt, Rinehart and Winston.*

Bannert, M. (2006). Effects of reflection prompts when learning with hypermedia. *J. Educ. Comput. Res.*, 4, 359–375.

Brooks, D. W. (1997). *Web-Teaching: A Guide to Designing Interactive Teaching for the World Wide Web*. New York: Plenum Press.

Clark, R. C. and Mayer, R. E. (2003). *e-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning*. San Francisco, CA: Pfeiffer.

Clark, R. E. (2006). Not knowing what we don't know: reframing the importance of automated knowledge for educational research. In *Avoiding Simplicity, Confronting Complexity: Advances in Studying and Designing (Computer-Based) Powerful Learning Environments*, edited by G. Clarebout and J. Elen, pp. 3–14. Rotterdam: Sense Publishers.

Clark, R. E. and Estes, F. (1998). Technology or craft: what are we doing? *Educ. Technol.*, 38(5), 5–11.

Clark, R. E. and Estes, F. (1999). The development of authentic educational technologies. *Educ. Technol.*, 39(2), 5–16.*

Clark, R. E., Howard, K., and Early, S. (2006). Motivational challenges experienced in highly complex learning environments. In *Handling Complexity in Learning Environments: Theory and Research*, Advances in Learning and Instruction Series, edited by J. Elen and R. E. Clark, pp. 27–41. Amsterdam: Elsevier.

Collins, A., Brown, S. J., and Newman, S. E. (1989). Cognitive apprenticeship: teaching the craft of reading, writing, and mathematics. In *Knowing, Learning, and Instruction: Essays in Honor of Robert Glaser*, edited by L. B. Resnick, pp. 453–494. Hillsdale, NJ: Lawrence Erlbaum Associates.

De Corte, E. (2003). Designing learning environments that foster the productive use of acquired knowledge and skills. In *Powerful Learning Environments: Unravelling Basic Components and Dimensions*, Advances in Learning and Instruction Series, edited by E. De Corte, L. Verschaffel, N. Entwistle, and J. J. G. van Merriënboer, pp. 21–33. Amsterdam: Pergamon.

Dick, W., Carey, L., and Carey, J. O. (2001). *The Systematic Design of Instruction*, 5th ed. New York: Addison-Wesley.

Dijkstra, S., Seel, N. M., Schott, F., and Tennyson, R. D., Eds. (1997) *Instructional Design: International Perspective*, Vol. 2. Mahwah, NJ: Lawrence Erlbaum Associates.

Dills, C. R. and Romiszowski, A. J., Eds. (1997). *Instructional Development Paradigms*. Englewood Cliffs, NJ: Educational Technology Publications.*

Dodge, B. (1995). WebQuests: a technique for Internet-based learning. *Dist. Educator*, 1(2), 10–13.

Dorsey, L. T., Goodrum, D. A., and Schwen, T. M. (1996). Rapid collaborative prototyping as an instructional development paradigm. In *Instructional Development Paradigms*, edited by C. R. Dills and A. J. Romiszowski, pp. 445–465. Englewood Cliffs, NJ: Educational Technology Publications.

Duchastel, P. (1998) *Prolegomena to a Theory of Instructional Design*, http://itech1.coe.uga.edu/itforum/paper27/paper27.html.

Elen, J. (1995). *Blocks on the Road to Instructional Design Prescriptions: A Methodology for ID Research Exemplified*. Leuven, Belgium: Leuven University Press.

Elen, J. (1998). Automating ID: the impact of theoretical knowledge bases and referent systems. *Instruct. Sci.*, 26, 281–297

Elen, J. (2004). Electronic learning environments as instructional design anchor points. *Educ. Technol. Res. Dev.*, 52(4), 67–73.

Elen, J. and Clarebout, G. (2001). An invasion in the classroom: influence of an ill-structured innovation on instructional and epistemological beliefs. *Learn. Environ. Res.*, 4, 87–105.

Elen, J. and Clarebout, G. (2006). The use of instructional interventions: lean learning environments as a solution for a design problem. In: *Handling Complexity in Learning Environments: Research and Theory*, Advances in Learning and Instruction Series, edited by J. Elen and R. E. Clark, pp. 185–200. Oxford: Pergamon.

Elen, J. and Lowyck, J. (2000). Instructional metacognitive knowledge: a qualitative study of conceptions of freshmen about instruction. *J. Curric. Stud.*, 32(3), 421–444.

Fleming, M. and Levie, W. H., Eds. (1993). *Instructional Message Design. Principles from the Behavioral and Cognitive Sciences*, 2nd ed. Englewood Cliffs, NJ: Educational Technology Publications

Gagné, R. M. (1985). *The Conditions of Learning*, 4th ed. New York: Holt, Rinehart and Winston.*

Gee, J. P. (2003). *What Video Games Have to Teach Us about Learning and Literacy*. New York: Palgrave Macmillan.

Gibbons, A. S. (2003). What and how designers design: a theory of design structure. *TechTrends*, 47(5), 22–27.

Glynn, S. M., Britton, B. K., and Tillman, M. H. (1985). Typographical cues in text: management of reader's attention. In *The Technology of Text: Principles for Structuring, Designing, and Displaying Text*, Vol. 2, edited by D. H. Jonassen, pp. 192–209. Englewood Cliffs, NJ: Educational Technology Publications.

Goodyear, P. (2000). Environments for lifelong learning: ergonomics, architecture and educational design. In *Integrated and Holistic Perspectives on Learning, Instruction and Technology*, edited by J. M. Spector and T. M. Anderson, pp. 1–18. Dordrecht: Kluwer.

Gordon, I. J. (1968). *Criteria for Theories of Instruction*. Washington, D.C.: Association for Supervision and Curriculum Development, National Education Association.*

Gros, B. (2002). Knowledge construction and technology. *J. Educ. Multimedia Hypermedia*, 11(4), 323–343

Gustafson, K. L. and Branch, R. (1997). *Survey of Instructional Development Models*, 3rd ed. Syracuse, NY: ERIC Clearinghouse on Information and Technology.

Hannafin, M. J. and Land, S. M. (1997). The foundations and assumptions of technology enhanced student-centered learning environments. *Instruct. Sci.*, 25, 167–202.

Hartley, J. and Jonassen, D. H. (1985). The role of headings in printed and electronic text. In *The Technology of Text: Principles for Structuring, Designing, and Displaying Text*, Vol. 2, edited by D. H. Jonassen, pp. 237–263. Englewood Cliffs, NJ: Educational Technology Publications.

Heinich, R. (1984). The proper study of instructional technology. *Educ. Commun. Technol. J.*, 32(2), 67–87.*

Jochems, W., van Merriënboer, J. J. G., and Koper, R., Eds. (2004). *Integrated e-Learning: Implications for Pedagogy, Technology and Organization*. London: RoutledgeFalmer.

Jonassen, D. H., Ed. (1982). *The Technology of Text: Principles for Structuring, Designing, and Displaying Text*, Vol. 1. Englewood Cliffs, NJ: Educational Technology Publications.

Jonassen, D. H., Ed. (1985). *The Technology of Text: Principles for Structuring, Designing, and Displaying Text*, Vol. 2. Englewood Cliffs, NJ: Educational Technology Publications.

Jonassen, D. H., Ed. (1996a). *Handbook of Research for Educational Communications and Technology*. New York: Macmillan.*

Jonassen, D. H. (1996b). *Computers in the Classroom: Mindtools for Critical Thinking*. Englewood Cliffs, NJ: Merrill.

Jonassen, D. H., Ed. (2004a). *Handbook of Research for Educational Communications and Technology*, 2nd ed. Mahwah, NJ: Lawrence Erlbaum Associates.

Jonassen, D. H. (2004b). *Learning to Solve Problems: An Instructional Design Guide*. San Francisco, CA: Pfeiffer.

Jonassen, D. H. and Rohrer-Murphy, L. (1999). Activity theory as a framework for designing constructivist learning environments. *Educ. Technol. Res. Dev.*, 47(1), 61–79.

Jonassen, D. H., Tessmer, M., and Hannum, W. H. (1999). *Task Analysis Methods for Instructional Design*. Mahwah, NJ: Lawrence Erlbaum Associates.

Kemp, J. E., Morrison, G. R., and Ross, S. M. (1994). *Designing Effective Instruction*. New York: Merrill.

Kintsch, W. and van Dijk, T. (1978). Toward a model of text comprehension and production. *Psychol. Rev.*, 85, 363–394.

Kirschner, P. A., Sweller, J., and Clark, R. E. (2006). Why minimal guidance during instruction does not work: an analysis of the failure of constructivist, discovery, problem-based, experiential and inquiry-based teaching. *Educ. Psychol.*, 41(2), 75–86.

Lave, J. and Wenger, E. (1991). *Situated Learning: Legitimate Peripheral Participation*. Cambridge, U.K.: Cambridge University Press.

Lee, W. W. and Owens, D. L. (2000). *Multimedia-Based Instructional Design*. San Francisco, CA: Jossey-Bass.

Littleton, K. and Häkkinen, P. (1999). Learning together: understanding the processes of computer-based collaborative learning. In *Collaborative Learning: Cognitive and Computational Approaches*, Advances in Learning and Instruction Series, edited by P. Dillenbourg, pp. 20–30. Amsterdam: Pergamon.

Mayer, R. E. (2001). *Multimedia Learning*. Cambridge, U.K.: Cambridge University Press.*

Mayer, R. E. (2004). Should there be a three-strikes rule against pure discovery learning: the case for guided methods of instruction. *Am. Psychol.*, 59(1), 14–19.

Mayer, R. E., Ed. (2005). *The Cambridge Handbook of Multimedia Learning*. Cambridge, U.K.: Cambridge University Press.

Merrill, M. D. (1998). ID Expert: a second generation instructional development system. *Instruct. Sci.*, 26(3–4), 243–262.

Merrill, M. D. (2002). First principles of instruction. *Educ. Technol. Res. Dev.*, 50(3), 43–59.*

Merrill, M. D. (2006). Hypothesized performance on complex tasks as a function of scaled instructional strategies. In *Handling Complexity in Learning Environments: Research and Theory*, Advances in Learning and Instruction Series, edited by J. Elen and R. E. Clark, pp. 265–281. Amsterdam: Pergamon.

Morrison, G. R., Lowther, D. L., and DeMeulle, L. (1999). *Integrating Computer Technology into the Classroom*. Upper Saddle River, NJ: Merrill.

Muraida, D. J. and Spector, J. M. (1992). The advanced instructional design advisor. *Instruct. Sci.*, 21(4), 239–253.

Reeves, T. C. (2005). Design-based research in educational technology: progress made, challenges remain. *Educ. Technol.*, 45(1), 18–52.

Reigeluth, C. M., Ed. (1983a). *Instructional Design Theories and Models: An Overview of Their Current Status*. Hillsdale, NJ: Lawrence Erlbaum Associates.*

Reigeluth, C. M. (1983b). Instructional design: what is it and why is it? In *Instructional Design Theories and Models: An Overview of Their Current Status*, edited by C. M. Reigeluth, pp. 3–36. Hillsdale, NJ: Lawrence Erlbaum Associates.*

Reigeluth, C. M., Ed. (1999). *Instructional-Design Theories and Models. A New Paradigm of Instructional Theory*, Vol. II. Mahwah, NJ: Lawrence Erlbaum Associates.*

Richey, R. C. (1986). *The Theoretical and Conceptual Bases of Instructional Design*. London: Kogan Page.*

Richey, R. C., Klein, J. D., and Nelson, W. A. (2004). Development research: studies of instructional design and development. In *Handbook of Research for Educational Communications and Technology*, 2nd ed., edited by D. H. Jonassen, pp. 1099–1130. Mahwah, NJ: Lawrence Erlbaum Associates.*

Ross, S. M. and Morrison, G. R. (2004). Experimental research methods. In *Handbook of Research for Educational Communications and Technology*, 2nd ed., edited by D. H. Jonassen, pp. 1021–1043. Mahwah, NJ: Lawrence Erlbaum Associates.

Rothwell, W. J. and Kazanas, H. C. (1998). *Mastering the Instructional Design Process: A Systematic Approach*, 2nd ed. San Francisco, CA: Jossey-Bass.

Rowland, G. (1993). Designing and instructional design. *Educ. Technol. Res. Dev.*, 41(1), 79–91.

Schmidt, H. G. (1993). Foundations of problem-based learning: some explanatory notes. *Med. Educ.*, 27, 422–432.

Schott, F. and Driscoll, M. P. (1997). On the architectonics of instructional theory. In *Instructional Design: International Perspective*, Vol. 1, edited by R. D. Tennyson, F., Schott, N. Seel, and S. Dijkstra, pp. 135–173. Mahwah, NJ: Lawrence Erlbaum Associates.

Seel, N. M. and Dijkstra, S., Eds. (2003). *Curriculum, Plans and Processes of Instructional Design: International Perspectives*. Mahwah, NJ: Lawrence Erlbaum Associates.

Skinner, B. F. (1968). *The Technology of Teaching*. New York: Appleton-Century-Crofts.

Spector, J. M. and Ohrazda, C. (2004). Automating instructional design: approaches and limitations. In *Handbook of Research for Educational Communications and Technology*, 2nd ed., edited by D. H. Jonassen, pp. 685–699. Mahwah, NJ: Lawrence Erlbaum Associates.*

Spector, J. M., Polson, M. C., and Muraida, D. J., Eds. (1993). *Automating Instructional Design: Concepts and Issues*. Englewood Cliffs, NJ: Educational Technology Publications.*

Spiro, R. A., Feltovich, P. J., Jacobson, M. J., and Coulson, R. L. (1991). Cognitive flexibility, constructivism, and hypertext: random access instruction for advanced knowledge acquisition in ill-structured domains. *Educ. Technol.*, 31(5), 24–33.

Tennyson, R. D. (2000). Fourth generation instructional systems development: A problem solving approach. *J. Struct. Learn. Intell. Syst.*, 14, 114–128.

Tennyson, R. D. and Cocchiarella, M. J. (1986). An empirically based instructional design theory for teaching concepts. *Rev. Educ. Res.*, 56(1), 40–71.

Tennyson, R. D., Schott, F., Seel, N. M., and Dijkstra, S., Eds. (1997). *Instructional Design: International Perspective*, Vol. 1. Mahwah, NJ: Lawrence Erlbaum Associates.

van Merriënboer, J. J. G. (1997). *Training Complex Cognitive Skills: A Four-Component Instructional Design Model for Technical Training*. Englewood Cliffs, NJ: Educational Technology Publications.*

Van Patten, J. (1989). What is instructional design? In *Instructional Design: New Alternatives for Effective Education and Training*, edited by K. A. Johnson and L. K. Foa, pp. 16–31. New York: Macmillan.*

von Glasersfeld, E. (1987). *The Construction of Knowledge*. Seaside: Intersystems Publications.

Wiley, D. A., Ed. (2002). *The Instructional Use of Learning Objects*. Bloomington, IN: Agency for Instructional Technology, Association for Educational Communications and Technology.

Wilson, B. G. (1996). Reflections on constructivism and instructional design. In *Instructional Development Paradigms*, edited by C. R. Dills and A. J. Romiszowski, pp. 63–80. Englewood Cliffs, NJ: Educational Technology Publications.

Wilson, B. G. (1997). Thoughts on theory in educational technology. *Educ. Technol.*, 37(1), 2–26.*

Wright, K. C. (1985). Designing contents lists and indexes for access. In *The Technology of Text: Principles for Structuring, Designing, and Displaying Text*, Vol. 2, edited by D. H. Jonassen, pp. 264–286. Englewood Cliffs, NJ: Educational Technology Publications.

* Indicates a core reference.