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DEVELOPMENT ARTICLE

A methodological framework for instructional design model development: Critical dimensions and synthesized procedures

Jihyun Lee · Seonyoung Jang

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Abstract Instructional design (ID) models have been developed to promote understandings of ID reality and guide ID performance. As the number and diversity of ID practices grows, implicit doubts regarding the reliability, validity, and usefulness of ID models suggest the need for methodological guidance that would help to generate ID models that are relevant and appropriate to the ever-changing design challenges in our world. Because the construction of an ID model involves an intricate externalization of unique sets of design experiences as well as a logical synthesis of relevant research, the purpose of this study was to formulate a methodological framework for ID model development. Through the analysis of 20 selected studies, four critical dimensions and ten synthesized procedures for constructing ID models were formulated. The resulting framework is intended to provide a useful theoretical and practical contribution to the field of ID.

Keywords Instructional design model · Model development methodology · Methodological framework · Critical dimensions · Synthesized procedures

Introduction

The history of educational technology is rich in the use of instructional design (ID) models. In a general sense, models are simplified representations of reality (Gustafson and Branch 1997), which includes factors, structures, functions, systems, tasks, events, orders, or processes (Andrews and Goodson 1980; Branch and Kopcha 2014; Davies 1996; You

J. Lee
Department of Education, Chung-Ang University, 221 Heukseok-dong, Dongjak-gu, Seoul 156-756, Korea
e-mail: leeji@cau.ac.kr

S. Jang (✉)
Center for Teaching and Learning, University of Seoul, 163 Seoulsiripdae-ro, Dondaemun-gu, Seoul 130-743, Korea
e-mail: syjang6121@gmail.com

2002). An ID model, then, can be defined as a set of core factors and tasks by which instructions can be designed (Gibbons et al. 2014; Gibbons and Rogers 2009; Seels and Richey 1994). As a systematic tool, an ID model assists designers in understanding related instructional variables and/or guides them through the process of analyzing, designing, developing, implementing, and evaluating instructional products (Branch and Kopcha 2014; Davies 1996; Gustafson and Branch 2002; Jung and Rha 1989; Rubinstein 1975; Seels and Glasgow 1998). In this sense, an ID model can provide guidance on both conceptual and procedural levels, and can serve as an essential component of ID theory (Reigeluth and Carr-Chellman 2009).

The vast number of ID models created since the 1960s (Gustafson and Branch 1997) reflect a wide variety of construction methods, contexts, and application settings. Historically, ID models evolved from first-generation linear behavioral models (e.g., Branson 1978; Gagné 1965) to second-generation instructional systems design (ISD) models (e.g., Dick and Carey 1978), to third-generation iterative technology-based models (e.g., Bergman and Moore 1990; Braden 1996), to fourth-generation constructivist learning environment design models (e.g., Willis 1995). In contrast with the proliferation of ID models in the 1980s and 1990s, fewer newly-developed models have been reported in recent research, and it is not unusual for existing models to be adopted and modified casually (Branch and Merrill 2011). The growing number and diversity of ID practices and innovative learning approaches point to the need for new design guides (Branch and Kopcha 2014; York and Ertmer 2011) providing justification for this critical investigation of newly-emerging ID factors and a serious reconsideration of current ID contexts.

In their 2002 survey of ID models, Gustafson and Branch noted that in most of the studies they reviewed the authors assumed their models were worthwhile but provided “no evidence to substantiate their positions” (p. 63). Many other researchers have expressed doubts about the varying levels of quality, as well as the reliability and validity, of many ID models (Andrews and Goodson 1980; Ertmer et al. 2008, 2009; Kirschner et al. 2002; Sheehan and Johnson 2012; Yancher et al. 2010; York and Ertmer 2011). Some ID models have been criticized as inadequately synthesizing related literature or being uniformly linear without reflecting the diverse dynamics of ID practices in a flexible manner (Bichelmeyer et al. 2006; Branch and Kopcha 2014; Willis 2009). The value of ID models has been also questioned for lacking a theoretical foundation or failing to reflect the heuristic nature of actual ID practices (Christensen and Osguthorpe 2004; Sheehan and Johnson 2012; Silber 2007; Yanchar and Gabbitas 2011; York and Ertmer 2011). Further, many researchers have noted that instructional designers often do not follow systematic step-by-step prescriptions, such as those suggested by ID models, but rather are influenced by implicit heuristics (Branch and Merrill 2011; Dick 1996; Kirschner et al. 2002; Silber 2007; Wedman and Tessmer 1993; York and Ertmer 2011) or social interactions with colleagues (Christensen and Osguthorpe 2004; Schön 1987). These criticisms, however, have not weakened the significance of ID models (Boling et al. 2011; Smith and Boling 2009) but rather emphasize the importance of constructing quality ID models using sound and verifiable methods.

Skepticism about the validity, reliability, and usefulness of ID models may be rooted in the ID field’s lack of methodological clarity about the development of ID models. Just as theorists have tended to develop models by discovering critical variables, rules, and hypotheses by which to build or improve theories (Bagdonis and Salisbury 1994), practitioners consciously or unconsciously have tended to develop models by generalizing empirical heuristics that emerge from their practical expertise and insights. Further, though

ID model building is widely seen as an advanced scholarly task, much has largely relied on personal judgment and implicit knowledge (Reigeluth and An 2009). Thus, because the construction of an ID model requires not only an externalization of unique sets of design experiences, insights, and intuitions (York and Ertmer 2011) but also a logical synthesis of relevant research (Richey and Klein 2007), a methodological framework for ID model development that is both theory- and practice-based may be helpful for ID theorists and practitioners alike.

ID models have been constructed in a variety of ways throughout the history of instructional design. A popular model by Silvern (1968), for example, was developed by connecting box-by-box functional descriptions of the ID process derived from large-scale design projects, while a model by Archer (1965) was built by classifying designer roles and activities as problems and sub-problems, and another by Briggs (1970) proposed a method based on research findings or common reasoning. Later, with the growing influence of systems theory as a broad paradigm, model developers began to create design guides in a form of ID models with boxes and arrows, feedback loops, and specific tools (Gibbons et al. 2014). Knowing how ID models have been constructed historically may give us insight into possible model development methodologies, which, however, does not enable us to understand what kinds of data were employed or which logical processes were followed for the construction of the ID model. Fresh ideas about methods for model construction may provide such information, and even result in unprecedented advances in ID model development (Boling et al. 2011; Gustafson and Branch 1997).

A few scholars have attempted to identify the methodologies used to develop conceptual or procedural ID models, the former focusing on theory and the latter on practice. Reigeluth (1983) outlined a methodology for developing instructional design theories or models that is close to conceptual models; the methodology involves: (1) developing formative hypotheses based on data, materials, experiences, insights, or logic, (2) discovering, describing, and classifying related variables, (3) drawing causal relationships between variables, and (4) incorporating principles or strategic elements. Richey and Klein (2007) suggested two different methods for developing procedural models—literature-based theoretical development and field data-based empirical development—and briefly described data collection and synthesis procedures for each.

These methodologies, however, only provide sketches of procedures for developing ID models, and lack sufficient comprehensiveness. Though they describe sets of generalized and abstracted steps the model developer may adopt, they are intended for all types of ID models regardless of purpose or context and fail to provide explicit descriptions of their development methods. Many are not aware of how the well-known Dick et al. ID model (2005) or ADDIE model were constructed because such information isn't published or reported. As a result, the methodologies for developing most ID models simply are not available to researchers or practitioners who may want to offer their own contributions (Reigeluth and An 2009). Yet, such knowledge could be particularly valuable for the ID field as a linking science, as conceived by Dewey (1900) (Linn et al. 2004).

The purpose of this review and analysis of ID model development studies is to: (1) identify critical dimensions of ID model development and (2) synthesize procedures from relevant studies, thus creating a methodological framework for ID model development. This framework is intended for the diverse population of model developers, including theorists, practitioners, and educators. Such a methodological guide would promote theory development based on unreported knowledge and empirical heuristics, form more valid and reliable ID knowledge, and facilitate a dialogue between field experts and academic scholars that contributes to advances in ID theory and practice.

Method

Sampling studies on ID model development

We began by identifying a set of contemporary studies that reported on the development of an ID model. We used the electronic databases *Science Direct*, *Springerlink* and *Dissertation Abstracts* for journal articles and doctoral dissertations in the area of instructional design. The procedure for identifying the studies involved several steps. First, we selected five representative journals from the US, UK, and Korea (*Educational Technology Research & Development*, *British Journal of Educational Technology*, *Instructional Science*, *Korean Journal of Educational Technology*, and *Korean Journal of Educational Information and Media*). The first three journals were selected because they are international peer-reviewed journals containing rigorous quantitative or qualitative studies on topics related to instructional design. The last two are top Korean peer-reviewed journals that continue to make a growing impact on all aspects of educational technology, including instructional design. We searched these journals for articles published from 2000 to 2013 using search terms directly related to our purposes: *instructional design, instructional development,* and *instructional desi*gn *model.* We also searched dissertations because they contain more detailed descriptions about model development methods, balancing any publication bias that journal articles might have (Cooper and Hedges 1994).

Our initial search resulted in the retrieval of 1,536 articles and 360 doctoral dissertations. Of these, 1,444 articles and 339 doctoral dissertations were excluded from the first analysis because their titles clearly indicated that they did not concern the *development* of an ID model. The elimination of these articles resulted in 92 articles and 21 doctoral dissertations. We conducted a close examination of the abstracts of these articles and dissertations for preliminary inclusion. The inclusion criteria were: (1) the study should involve the development of an *ID* model, not a generic model and (2) the study should provide relatively detailed descriptions of its development method. We defined "relatively detailed" as descriptions that enabled us to roughly identify three steps of model development: data collection, data analysis, and model ideation. Next, we excluded 80 articles and 13 doctoral dissertations from our analysis because they did not adequately describe how the models were constructed. In the end, a total of 20 studies met the criteria and were included for comprehensive review and analysis.

Sampling the relevant studies was an intricate task because, while some studies provided explicit or sufficiently detailed descriptions, other studies required considerable inferences or further email inquiries to ascertain their actual modeling methods. Due to practical constraints we chose to exclude these latter types of studies from our analysis. Figure 1 presents a more detailed representation of the selection flow.

Analyzing studies on ID model development

After selecting studies for review, we set out to identify a set of critical dimensions in the selected studies on ID model development. As we read the studies, we tried to identify the particular features, development contexts, and logic of development of the models. In some cases, we emailed authors to gain more detailed information about model construction. Informed by seminal works on the classification of ID models by Andrew and Goodson (1980) and Edmonds et al. (1994), we began to classify each model by its *function*, that is, whether it was intended to be *conceptual* or *procedural*. Following this initial classification, we iteratively analyzed features and patterns in developing the model to identify other critical dimensions. As

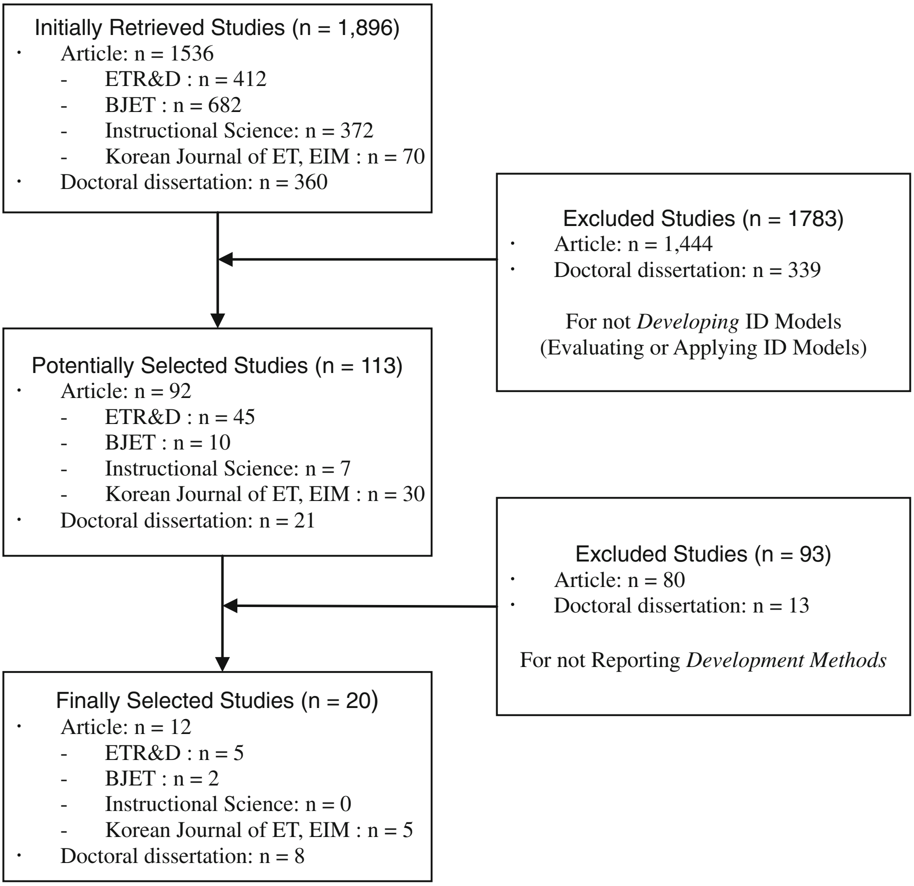

Fig. 1 Selection flow for studies sampled

a result, three other critical dimensions of the models—origin, source, and analysis scheme—gradually emerged. We then identified levels of each of these dimensions (see Table 1), and coded each study accordingly, again looking for patterns in the combination of critical dimensions characterizing each model's development. After grouping models according to the levels of critical dimensions they represented, we analyzed the development steps of each models, and synthesized the tasks in which the authors engaged at each step. In this way we determined sets of synthesized procedures for ID model development.

Review of studies on ID model development

The definition of an ID model suggests that it functions as a *conceptual* tool that assists designers in understanding related variables or/and as an operational or *procedural* tool that guides designers through the design process (Jung and Rha 1989). *A conceptual model* can be defined as a model that represents the important variables and relationships between variables in the design of instruction, while *a procedural model* can be defined a model that depicts the design activities to be used and the ways to perform a design task by providing a visualization of the order and structure of the task along with verbal instructions. The relationships between ID variables in a conceptual model can provide designers with a macro-level perspective of an ID task, whereas the detailed procedures of design activities in a procedural model can provide a micro-level perspective of the task. Whether a model developer decides to construct a conceptual model, a procedural model, or both can be a means by which to differentiate the development method. The 20 selected studies included 7 studies on the development of conceptual models, 13 studies on the development of procedural models, and 3 studies describing the development of both a conceptual and a procedural model.

Conceptual ID models

As the origins of a model can be one of the most critical dimensions in its classification (Andrews and Goodson 1980; Edmonds et al. 1994; Gustafson and Branch 2002), the notion of *origin* provides another means by which to classify development methodologies. Four of the conceptual ID models we examined were classified as *theory-driven* and three as *practice-driven*, terms reflecting their different origins. The theory-driven conceptual ID models were based on theoretical knowledge from sources such as related literature or interview data from scholars, while the practice-driven conceptual ID models were grounded in data collected directly from actual ID practice, such as real-life design projects, simulated design tasks, or interview data from practitioners (Richey and Klein 2007).

Theory-driven conceptual ID models

A conceptual ID model can be constructed using a theory-driven approach when related theories are available and relevant fields are relatively unknown and field experts are inaccessible. In general, generic conceptual models are constructed theoretically because theories mainly address conceptual relationships. However, in the field of instructional design it is not typical for conceptual models to be designed using a purely theoretical approach. In some studies in which both a conceptual model and a procedural model were created, developers adopted a theory-driven method in constructing the conceptual model. You (2002), for example, constructed a conceptual model as part of a systemic interpretive instructional system design model (SI-ISD). He began by defining the theoretical foundation of his model and then reviewed the relevant literature on traditional ISD models, soft systems methodology, and ontology in order to compare a subjective ID model (an ID model that is affected by an instructional designer's beliefs or epistemology) with an objective ID model (an ID model that is independent of an instructional designer's beliefs or epistemology). Following a literature review, he drew up the critical variables of the model, and formulated the logical networks of the variables, which he then graphically transformed into an SI-ISD conceptual model.

Likewise, Clifford (2009) developed a local instructional design system (LIDS) model that represents a conceptualization of a general set of tasks for developing and maintaining a ninth-grade biology curriculum. Clifford chose Halversons' D-CAM model and Shewhart's Plan-Do-Study-Act (PDSA) model as a theoretical foundation. He reviewed relevant studies and derived four conceptual components: setting a problem, negotiating resources, designing solutions, and getting feedback on the effectiveness of the design. Finally, he graphically arrayed these four components of the LIDS model in the form of a cycle.

Moallem (2003) also developed an online collaborative learning design model. Using social constructivism as a theoretical framework, she reviewed the literature on interactivity and socio-cultural online learning and derived five components of online collaborative learning: group interaction, peer interaction, individual interaction, emotional support, and construction of shared outcomes or artifacts via social discourse. Finally, these five components and their relationships were depicted within a larger circle representing online collaborative learning.

Another theoretical approach to constructing a conceptual model was adopted by Adamski (1998). Whereas You (2002), Clifford (2009), and Moallem (2003) used relevant research literature to construct their models, Adamski (1998) interviewed academic scholars and synthesized their opinions into a conceptual model for designing job performance aids. He then convened a panel of scholars from relevant disciplines, and asked the scholars questions about the characteristics of an effective job aid, as well as the roles of the components and critical factors in the model he already had created. After analyzing the interview data according to categories of variables, he created a visual representation of the descriptive relationships between the variables in the form of a conceptual model.

In the studies described above, the *data sources* on which researchers relied when constructing their models carried different features of the model. When a conceptual model is based on a theoretical approach in this way, the data sources can be *literature* or *scholars*. You (2002), Clifford (2009), and Moallem (2003) used relevant literature and Adamski (1998) used data from interviews with scholars to obtain data. Thus, the data source of a model merits a place as a component of a methodological framework for model construction.

Another important component of a methodological framework is how the data were analyzed, that is, the *analysis scheme*. In the studies reviewed, the data collected, whether from the literature or from scholars, were analyzed to discover conceptual patterns. Researchers You (2002), Clifford (2009), Moallem (2003), and Adamski (1998) looked at the design *variables* that emerged from the theoretical implications of models as well as the *relationships* between the model variables. Thus, the analysis scheme component refers to how the collected data are analyzed, synthesized, and transformed into the form of an ID model.

Practice-driven conceptual ID models

A conceptual ID model also can be developed empirically using data derived from actual ID practices when relevant literature or scholastic experts have not yet been identified or are unavailable due to the novel characteristics of the model. In such cases, ID models reflect the empirical knowledge that is available in the field. Practitioners with ample experience in ID practices can provide great insights into various aspects of instructional design, and their expertise, when explicated, can be highly useful in constructing ID models. Interview data from practitioners, for example, can provide insight into model components and their relationships. Park (2010), who created a model for the design of contextual introductory learning activities, adopted this method. She defined field experts as instructors with more than 6 years of teaching and design experience and posed questions to them regarding related variables and their relationships. She then portrayed the relational structure of the variables in her conceptual model.

Practitioners' insights can be more closely investigated by inquiring into their heuristics. Heuristics are general guidelines that experts use when they make decisions under vague conditions (Lewis 2006). In many cases, such heuristics take the form of a model representing interrelated factors and their implicit relationships (Kirschner et al. 2002). Using their field experiences and heuristics, Laverde et al. (2007) developed a conceptual ID model based on learning objects for creating high-quality learning content. The researchers first defined a general approach that separated informative objects and learning objects in virtual learning environments. Next, they developed a macro-level model that included three major components: learning activities, informative objects, and contextualized elements. They elaborated the model by integrating three different objects, thus creating a micro-level model. Finally, they offered three usage scenarios for instructional designers.

Similarly, Crawford (2004) used empirical knowledge derived from her field experiences for the development of a conceptual ID model for an e-learning course. She first defined her developmental needs and her philosophical framework for a constructivist-interpretivist instructional design. After developing the macro-level parts of the model that needed emphasis, she elaborated the design features, including the model assumptions. Finally, she constructed graphical representations of the model focus, design features, and model assumptions by visually depicting the feedback and interactions, and included descriptions and principles of how the model works. Thus, while Laverde et al. (2007) and Crawford (2004) reflected on their own experiences as practitioners, Park (2010) interviewed other practitioners to construct her conceptual ID model.

Procedural ID models

Although conceptual ID models enhance instructional designers' understandings of related variables and their relationships, the ultimate practical goal of instructional design knowledge is the improvement of design performance. In 13 studies in our sample, researchers developed procedural ID models, which then were divided into three types according to their sources: *theory-driven* models, *practice-driven* models, and *hybrid* models, the latter referring to models that were constructed both theoretically and practically.

Theory-driven procedural ID models

Constructing a procedural ID model using a theory-driven approach may entail logical jumps, because not every theory suggests concrete steps for instructional design. In fact, defining a specific order or sequence of theoretical implications involves processes that are highly prone to subjectivity or criticism. One possible solution to this sequence problem is arranging the theoretical implications of the literature according to the ADDIE model. In her study on the development of a trainer-training process, Forsyth (1997) reviewed 13 related studies and classified their design implications according to ADDIE. In this way, Forsyth (1997) was able to logically connect the conceptual components and design implications within the framework of the ADDIE processes, as shown in Fig. 2.

Using the same method, Alonso et al. (2005) developed an instructional design model for designing web-based learning environments. Their model incorporated diverse psycho-pedagogical learning theories. They first defined relevant theoretical perspectives (behaviorism, cognitivism, and constructivism) from which they drew the core factors (content structure, cognitive processes, and interactions among learners), and related implications. Next, using the ADDIE framework they arranged the implications, and visualized the result in graphic form. Finally, they created detailed descriptions of how the model works.

When a substantial amount of literature that deals directly with procedural knowledge is available, synthesizing the procedures into a connected process is a reasonable process. For example, Tracey (2001) constructed an ID model by incorporating multiple intelligences (MI). Tracey reviewed seven procedural ISD models and six MI-related models and then synthesized all of the sub-processes into a comprehensive process, as shown in Fig. 3.

Peterson (2007) also developed an ID model for teaching heuristic knowledge based on Landa's (1976) algo-heuristic theory and van Merrïënboer (1997)'s four component ID model. From the literature on the theoretical foundations, Peterson derived taxonomy of method, outcome, condition, and value variables for teaching heuristics. Peterson arranged these literature implications into the three steps of acquisition–application–refinement, and then connected them as a single process. Finally, Peterson represented the process as a procedural model for teaching heuristics with detailed model descriptions.

A similar method was adopted by Kang and Lee (2009) in a study of an instructional design model for designing scaffolds in a blended learning environment. They reviewed the literature on scaffolding and blended learning, synthesizing four studies on scaffolding design models into a single process, and identified a set of macro- and micro-level design principles. They then constructed a procedural model by logically combining the synthesized process and the set of principles. While Tracey (2001) connected only related procedural models, Kang and Lee (2009) integrated the procedural implications into a set of principles.

As demonstrated by Kang and Lee (2009), theoretically-formulated principles often can provide a basis for constructing a procedural ID model. A study by Lim et al. (2009) is such a case. Lim and his colleagues developed an integrated ID model to support online creative problem-solving. They first reviewed the relevant literature regarding creative problem-solving to derive general design principles and subsequently reconstructed these principles to extract the theoretical components. Using the derived theoretical components as a framework, they sequentially organized the design guidelines to build an ID procedure. Finally, they used the theoretically-constructed design principles as an interim theoretical product by which to move toward constructing a procedural ID model.

Like Lim et al. (2009), You (2002) constructed a procedural ID model by transforming his previously developed conceptual model. He described this transformation as "degrading abstractness" (p. 276). To concretize the abstractedness, You (2002) first defined the core functions and sub-functions of the model components, then sequenced concrete tasks for each of the sub-functions, and finally, provided a clear description of the detailed methods for performing the tasks. This transformation task translated abstract scholarly language into concrete practitioner language.

The process of transforming a conceptual ID model into a procedural ID model also was adapted by Adamski (1998). Like You (2002), Adamski (1998) developed both a conceptual ID model and a procedural ID model, with the procedural model grounded on the conceptual model. To do this, he first raised questions to panels of scholars regarding the expected outcomes, the characteristics of effective products, the role of the model for model users, the critical activities, and the nature of the model. The resulting interview data were analyzed to determine whether constructs, themes, patterns, key terms, and phrases could be clustered into major themes. He then classified the themes that emerged into activity components and the component elements, and visually represented them within a common procedural framework.

Practice-driven procedural ID models

As opposed to the theoretically-developed cases discussed thus far, a number of procedural ID models were developed from ID practices such as real-life design projects and simulated design tasks. One example of a practice-driven procedural ID model is a study by Jones and Richey (2000). Their rapid prototyping model was constructed qualitatively in a natural work environment. The researchers used a real-life design project and collected data directly from designers, customers, and related personnel, all of whom they interviewed; they also asked the designers to keep a task log tracking their task completion time and concurrent tasks. They then transcribed and coded the resulting data by topic to determine whether a pattern for the design process existed. Finally, they combined these documented design patterns into a procedural model.

Similarly, Rha and Chung (2001) developed a web-based instruction (WBI) design model using a real-life WBI design project. The researchers observed three design teams

Teacher Education Literature	Analysis	Design	Development	Implementation	Evaluation
Howay & Zimpher (1994)	- examine how teachers learn to teach - assess the need for alternative programs	- revisit duration & structure of teacher education programs	- provide alternative programming through a diverse teaching force	- collaboration between schools and universities	- advocates rigorous evaluation
Curtin, et al (1994)		- context specific - development of a learning community (teachers, pupils parents)	- use of computers, multi-media & interactive television	- conducted in a classroom setting	- pupil & parent Interviews - survey with teachers
Vella(1994)	- analysis - use of the seven steps of planning	- design - consider relevance & Immediacy - consider sequence	- develop learning tasks - consider time	- inclusion - provide lavish affirmation	- evaluation - provide reinforcement
Canella & Reiff (1994)	- analysis in school settings	- each person creates and constructs his /her reality	- Knowledge construction through experimentation & exploration	- learning occurs through invention	- teachers as observers and critical evaluators
Tillema, et al (1990) and Tillema (1994)	- conduct diagnosis	- develop instruction 1) concept based i.e. Trainer led or, 2) experience based i.e. Sharing of ideas form practice	- conduct demonstrations	- application and discussion of previous learning - utilize a training setting	- conduct field experiment - provide coaching & feedback
Winn(1990)		- incorporate learning theories & instructional design		- emphasis on cognitive learning theories	
Cruikshank, et al (1981) and Cruikshank (1985)		- small group interaction - peer teaching - discussing & reflection	- low technology	- field studies	- written feedback - reflective observation
Zeichner & Liston(1987) and Core & Zeichner(1991)		- based on specific criteria ie, Academic, social efficiency, development, social reconstructionist		- commitment to social justice and an ethic of care	

Fig. 2 Arranging literature findings in the order of ADDIE (Forsyth 1997, pp. 37–39)

with total of 11 designers working on the project. They collected data via individual in-depth interviews and focus group interviews using questions pertaining to the design procedure. They then constructed a procedural model based on the observational and interview data to discover design patterns. The difference between these two studies is that whereas Jones and Richey (2000) constructed their model strictly based on documentation from field observations and interviews, Rha and Chung's (2001) model was solely based on interview data from practitioners. Chang's (2011) employed a method closer to that of Rha and Chung (2001) in that her data source was interviews with instructors, but she also relied more on observational data. In order to develop her action learning design model, Chang (2011) observed five exemplary real-life cases in which five instructors designed and managed action learning in their classrooms. She also interviewed the instructors regarding the tasks they performed. After transcribing and coding the resulting data, and analyzing it into sub-tasks, she constructed a procedural model to connect the design patterns of the sub-tasks and represent the interactions among the tasks.

Less authentic, simulated design tasks also can be used to build a procedural model. Unlike that which occurs in natural work settings, simulated design tasks are similar to experimental tasks that occur in a laboratory setting, except they specifically emulate an actual design situation. Spector et al. (1992) developed a cognitively-based model for designing computer-based instruction partly through the use of this method. They asked 16

Summary of Models

MAJOR ACTIVITE CORE ELEMENS	ANALYSIS				DESIGN								DEVELOPMENT			EVALUATION			
	Learner Needs				Determine Goals and Objectives			Construct Assessment Procedures		Design/ Select Delivery Approaches			Try out Instruction System			Install and Maintain System			
	Assessment of Needs	Problems Identification	Occupational Analysis	Competence or Training Requirements	Formulation of Goals and Detailed Sub Goals	Analysis of Goals and Sub Goals for Types of Skills/Learning Required	Sequencing of Goals and Sub Goals to Facilitate Learning	Develop pre-Test and Post-Test Matching Goals and Sub Goals	Formulation of Instructional Strategy	Selection of Media	Development of Courseware	Consideration of Alternative Solutions to Instruction	Try Out Courseware with Learner Population	Diagnosis of Learning and Courseware Failures	Revision of Courseware Based on Diagnosis	Formulation of System and Environmental Descriptions and Identification of Constraints	Materials and Procedures for Installing, Maintaining, and Repairing the Instructional Program	Costing Instructional Program	TOTAL
ISD MODELS																			
IDI	●	●	●		●	●	●	●	●	●	●		●	●	●	●	●	●	16
IPISD	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	17
Seels and Glasgow	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	17
Smith and Ragan		●	●	●	●	●	●	●	●	●	●		●		●	●	●		14
Morrison, Ross, and Kemp		●	●	●		●	●		●	●	●		●	●	●	●	●	●	14
Dick and Carey		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	18
MODELS WITH ISD																			
ARCS	●	●			●	●	●		●				●	●	●				9
MI MODELS																			
Problem-Based Learning	●	●	●		●		●		●		●	●		●		●			10
Year-Long Curriculum	●				●	●	●		●										5
Thematic Learning	●	●			●	●	●		●		●		●	●		●			10
Developing Mindful Learning	●	●	●	●	●	●			●										7
Model of Learning Preferences									●							●	●	●	4
Performance Learning	●	●	●	●	●	●	●		●	●	●	●	●	●			●		14

Fig. 3 Synthesizing the procedures into a connected process (Tracey 2001, p. 64)

designers to design a lesson module and to think aloud. The researchers maintained 30-h observation logs regarding the tasks the designers performed, and they recorded the designers' reactions and questions. Additionally, they collected survey and interview data from the participants. The data were analyzed qualitatively and then organized into an input-process-output framework.

Another technique for constructing a procedural model is the heuristic task analysis (HTA) method. In Lee and Reigleuth (2009) formative study of e-learning course development by instructional designers, they proposed and utilized the HTA methods in order to analyze designers' procedural knowledge in designing e-learning courses. The authors interviewed three instructional designers with 6–7 years of experience and asked HTA questions starting from the simplest version and moving progressively to more elaborate versions (Lee and Reigeluth 2009). They conducted the interviews in an iterative manner until the findings were saturated, after which they recorded, transcribed, coded and qualitatively analyzed the data, using triangulation techniques such as member checking. In this way, the researchers identified salient patterns in the experts' procedural knowledge.

Hybrid procedural ID models

We also identified hybrid studies, that is, studies describing the development of procedural models using a combination of methods with theory- and practice-driven approaches. In the hybrid studies, these approaches complemented one another, since theory-driven model development is a top-down approach with high levels of theoretical validity and low levels of practical usability, while practice-driven development is a bottom-up approach with high levels of practical usability and low levels of theoretical validity (Lee 2012). Coupling these approaches can create a more thorough and nuanced model.

Hegstad (2002) reported the development of a procedural model for designing formal mentoring programs. He modeled the procedure first using a theoretical method, and after, a practical method. The theoretical implications from the relevant literature constituted an initial mentoring process model that followed the ADDIE steps. Hegstad supplemented the theoretically-constructed procedural model with heuristic design patterns, that is, regular and repeated courses of action that designer follows when making design decisions based on intuitive judgments. The heuristic design patterns were discovered by observing real-life projects and interviewing mentoring coordinators and operating staff. Finally, after integrating all the data, both theoretically- and practically-based, he visualized a comprehensive procedural model.

Likewise, Olsafsky (2006) adopted a hybrid method in constructing a procedural ID model for designing learner-centered software. Olsafsky combined the theory-driven method of synthesizing relevant procedural models and the practice-driven method of documenting the design patterns in a real-life design project. He first collected literature implications from the studies on constructivist learning and learner-centered design, and arranged them using the ADDIE steps. Next, he accumulated practical design pattern data from his own real-life development of classroom software, and analyzed the data for patterns. His final ID model, then, incorporated and represented the data from both theoretical and practical sources.

Based on his aforementioned conceptual ID model, Clifford (2009) constructed a procedural ID model for a local instructional design system (LIDS). The purpose of the model was the development and maintenance of a school- or classroom-level curriculum that would reflect the local contexts of specific schools or classrooms. Clifford used his conceptual ID model as a theoretical data source, and he arranged the theoretical constructs using the ADDIE process. He also obtained field data by intensely documenting the design patterns of the real-life school curriculum design project. The final LIDS model represented and described the flow of local instructional design tasks, which included the tasks set problem, negotiate control, design, and get feedback.

Results

Critical dimensions of ID model development

Based on our review of the selected studies on ID model development, we defined four dimensions of model development that critically affect the selection of a model development methodology: function, origin, source, and analysis scheme.

Function

As discussed in the study reviews, the function of a model refers to its goal or purpose. A conceptual model and a procedural model each has a different function and contains different kinds of information, which can distinguish its development method.

Origin

The functions of a model can be driven by theory or practice. The origin dimension refers to the extent to which the foundations of the ID model are closer to theory or practice, or represent some combination of the two. Thus, the development methodology can be selected based on the availability of relevant theories or practices.

Source

The source dimension is related to where and how the data can be collected, as well as to the specific research context. In other words, model development methods partly depend on available data sources. The potential sources of useful data or information for constructing ID models include *related literature, interim theoretical products, real-life design projects, simulated design tasks, scholars*, and *practitioners* (Richey and Klein 2007). *Related literature* is a dominant data source for the construction of ID models, in part because "a thorough critical evaluation of existing research often leads to new insights by synthesizing previously unconnected ideas" (Hart 2001, p. 2). Related literature also can provide suggestions about critical variables, relationships, steps, and activities. *Interim theoretical products* are frequently a source of data when a conceptual model is developed prior to a procedural model. Design principles may be used as an interim product that reveals related theoretical components. In field contexts, *real-life design projects* or *simulated design tasks* represent valuable sources of practical information that seldom are found in the research literature. Real-life design projects occur in natural ID contexts, while simulated design tasks occur in experimental settings (Richey and Klein 2007). Such practical data sources contain daily ID logs that document not only time, activities, reactions, tools, and resources but also the think-aloud protocols of designers, all of which can reveal design patterns in ID practices. Finally, *scholars* or *practitioners* can be another source of data for constructing ID models. The implicit knowledge of practitioners may be an excellent source of data by which to uncover design patterns and heuristics (Reigeluth and An 2009), just as scholarly data from interviews or surveys may be used to identify the theoretical foundations, directions, components, and conceptual structures of variables of interest.

Analysis scheme

The analysis scheme dimension refers to the methods by which model developers analyze, synthesize, and transform collected data to create ID models. Collected data can be arranged in a variety of ways, such as according to a scheme of variables and activities; ADDIE or a generic procedural framework (e.g., beginning-mid-end, input-process-output, and acquisition–application–refinement); heuristic design patterns and functions; theoretical components; or design guidelines. When organizing data according to particular formats, previously invisible design patterns may emerge, so the analysis scheme is a dimension that may afford assistance to model developers by facilitating a close examination of the data and providing information for later stages of model development.

For example, when data are organized into *variables*, as in conceptual models, the variable analysis scheme may help developers to identify influencing factors and their structural relationships. Likewise, an analysis scheme containing *activities*, such as that used in procedural models, may help model developers identify design patterns and their sequences. When arranged according to *ADDIE* or a *generic procedural framework*, diverse data can be transformed into procedural prescriptions. Multiple processes, such as A → B, B → C, or C → D, can be connected as the process A → B → C → D. Data can be analyzed and then organized using a *heuristic design pattern*. The heuristic design patterns can reflect the cognitive threads, or lines of thinking, of practitioners. Beginning with the simplest version of practitioner activities and moving through progressively more elaborate versions can reveal a set of processes that actualize in model form the intuitions, judgments, and procedural knowledge of practitioners (Pearl 1984; Reigeluth 1999). ID model developers also can synthesize data by identifying functions/sub-functions, theoretical components, or design guidelines from design principles or a conceptual model and then transforming them into sequences or relationships.

Table 1 summarizes the critical dimensions and levels within each dimension that we identified as parts of a methodological framework. Model developers may obtain guidance by considering: (1) *function*, or whether the target model is a conceptual model (F1) or a procedural model (F2); (2) *origin*, or whether the model is driven by theory (O1), practice (O2), or is a hybrid of both origins (O3); (3) *source*, or whether the model will be constructed with data from literature (S1), interim theoretical products (S2), real-life projects (S3), simulated design tasks (S4), practitioners (S5) and/or scholars (S6); and (4) *analysis scheme*, or whether the collected data will be analyzed according to variables or activities (A1), ADDIE or a connected process (A2), heuristic design patterns (A3), or functions, theoretical components, or design guidelines (A4).

Synthesized procedures for ID model development

After combining into groups the studies containing the same types of combinations, we sought to identify broad steps of model development. We carefully considered the tasks in which authors engaged to develop their ID models, and synthesized these tasks to arrive at five broad steps of ID model development that applied to all cases: Data Source Definition, Data Collection, Data Analysis, Model Ideation, and Model Representation. Through further analysis we derived ten different synthesized procedures for ID model development from the critical dimensions and steps of development we identified; the details of these ten synthesized procedures are presented in Table 2.

Table 1 Critical Dimensions for ID Model Development

Function	Origin	Source	Analysis scheme
F1. Conceptual F2. Procedural	O1. Theory-driven O2. Practice-driven O1 + O2 Hybrid	S1. Literature S2. Interim theoretical products S3. Real-life projects S4. Simulated design tasks S5. Practitioners S6. Scholars	A1. Variables or activities A2. ADDIE or a connected process A3. Heuristic design patterns A4. Functions, theoretical components or design guidelines

Table 2 Synthesized procedures for ID model development

Type	Steps	Details of synthesized procedure
1. F1-O1-S1-A1 Constructing a *Conceptual* ID Model with a *Theory-Driven* approach using *Literature* review connecting *Variables/Activities* e.g., Clifford (2009), Moallem (2003), You (2002)	Data source definition	1. Determine the theoretical foundation of the conceptual model
	Data collection	2. Review the relevant literature within the theoretical foundation
	Data analysis	3. Identify and re-conceptualize variables/activities from the literature to derive model components (if necessary)
	Model ideation	4. Make logical networks based on the relationships between variables or activities
	Model representation	5. Graphically represent the relationships in a conceptual model
2. F1-O1-S6-A1 Constructing a *Conceptual* ID Model with a *Theory-Driven* approach integrating *Scholars*' opinions connecting *Variables*/activities e.g., Adamski (1998)	Data source definition	1. Convene a panel of scholars from the relevant disciplines for the conceptual model
	Data collection	2. Interview the panel of *scholars* constructs, themes, and patterns for the model components
	Data analysis	3. Identify variables/activities from the interview data 4. Re-conceptualize variables/activities to derive model components (if necessary)
	Model ideation	5. Make logical networks based on the relationships between variables or activities
	Model representation	6. Graphically represent the relationships in a conceptual model
3. F1-O2-S5-A1 Constructing a *Conceptual* ID Model with a *Practice-Driven* approach integrating *Practitioners*' opinions connecting *Variables*/activities e.g., Park (2010)	Data source definition	1. Convene a panel of practitioners from the relevant fields
	Data collection	2. Interview the panel of practitioners on constructs, themes, and patterns that could constitute a conceptual model
	Data analysis	3. Identify variables/activities from the interview data 4. Re-conceptualize variables/activities to derive model components (if necessary)
	Model ideation	5. Make logical networks based on the relationships between variables or activities
	Model representation	6. Graphically represent these relationships in a conceptual mode

Table 2 continued

Type	Steps	Details of synthesized procedure
4. F1-O2-S5-A3 Constructing a *Conceptual* ID Model with a *Practice-Driven* approach integrating *Practitioners*' opinions *Heuristic Design Patterns* e.g., Crawford (2004) Laverde et al. (2007)	Data source definition	1. Convene a panel of practitioners from relevant fields
	Data collection	2. Interview a panel of practitioners on their design processes
	Data analysis	3. Analyze practitioners' design processes and identify heuristic design patterns at macro- and micro-levels of the model
	Model ideation	4. Make logical networks based on practitioners' heuristic design patterns
	Model representation	5. Graphically represent these patterns in a conceptual model 6. Refine the representation with feedback, interactions, principles or usage scenarios (if necessary)
5. F2-O1-S1-A2 Constructing a *Procedural* ID Model with a *Theory-Driven* approach using *Literature* review *ADDIE or Connected Process* e.g., Alonso et al. (2005), Forsyth (1997), Peterson (2007), Tracey (2001)	Data source definition	1. Define theoretical foundations of the model
	Data collection	2. Review the relevant literature within the theoretical foundation
	Data analysis	3. Arrange literature implications according to the ADDIE or a connected process
	Model ideation	4. Connect the related procedural models within a single process
	Model representation	5. Graphically represent the connected processes into a procedural model 6. Construct detailed descriptions of how the model works (if necessary)
6. F2-O1-S2-A4 Constructing a *Procedural* ID Model with a *Theory-Driven* approach using *Interim Theoretical Products* design principles/conceptual constructs e.g., Kang and Lee (2009) Lim et al. (2009), You (2002), Adamski (1998)	Data source definition	1. Define the theoretical foundations
	Data collection	2. Review the relevant literature within the theoretical foundation
	Data analysis	3. Develop the design principles or a conceptual model based on the literature findings 4. Identify functions/sub-functions, theoretical components, or design guidelines from the design principles or a conceptual model
	Model ideation	5. Transform the functions, components or guidelines into sequences or relationships
	Model representation	6. Graphically represent the sequences or relationship in a procedural model 7. Construct detailed descriptions of how the model works (if necessary)

Table 2 continued

Type	Steps	Details of synthesized procedure
7. F2-O2-S3-A3 Constructing a *Procedural* ID Model with a *Practice-Driven* approach during real-life projects reflecting *Heuristic Design Patterns* e.g., Rha and Chung (2001), Chang (2011), Jones and Richey (2000).	Data source definition	1. Define a relevant real-life project, considering its accessibility
	Data collection	2. Observe designers/design teams implementing the project 3. Collect data from design task logs (e.g., tasks, subtasks, concurrent tasks, completion times) and additional documents (e.g., reports, learners' journals) 4. Interview designers and related personnel (e.g., customers, focus groups, students, and employers)
	Data analysis	5. Analyze data into design patterns of tasks/sub-tasks and their interactions
	Model ideation	6. Connect the patterns within a procedural model
	Model representation	7. Graphically represent the design patterns in a procedural model
8. F2-O2-S4-A3 Constructing a *Procedural* ID Model with a *Practice-Driven* approach during *Simulated Design Tasks* reflecting *Heuristic Design Patterns* e.g., Spector et al. (1992)	Data source definition	1. Define relevant participants and a simulated design task
	Data collection	2. Observe designers performing the task and record their performances, reactions, questions, and think-aloud protocols 3. Interview designers with questions about expected outcomes, the characteristics of ideal products, the role or nature of the model, its critical activities, and its components
	Data analysis	4. Analyze data into design patterns of tasks/sub-tasks and their interactions
	Model ideation	5. Connect the patterns within a procedural model
	Model representation	6. Graphically Represent the design patterns in a procedural model 7. Construct detailed descriptions of how the model works (if necessary

Table 2 continued

Type	Steps	Details of synthesized procedure
9. F2-O2-S5-A3 Constructing a *Procedural* ID Model with a *Practice-Driven* approach integrating *Practitioners*' opinions reflecting *Heuristic Design Patterns* e.g., Lee and Reigeluth (2009)	Data source definition	1. Define a relevant panel of practitioners from related fields
	Data collection	2. Interview the practitioners with HTA questions (moving from simple versions to progressively more elaborate versions of their tasks)
	Data analysis	3. Analyze data into design patterns of tasks/sub-tasks and their interactions and triangulate the data (if necessary) (e.g., member checking)
	Model ideation	4. Connect the patterns within a procedural model
	Model representation	5. Graphically represent the design patterns in a procedural model 6. Construct detailed descriptions of how the model works (if necessary)
10. **F2** ⟨ **O1 — S1— A2** / **O2— S3/S4 —A3** ⟩ Constructing a *Procedural* ID Model with both a *Theory-* and a *Practice-Driven* approach e.g., Hegstad (2002), Olsafsky (2006), Clifford (2009)	Data source definition	1. Define the sequence of the approaches (theory-driven—practice-driven or vice versa) based on the development contexts.
	Data collection	2. Collect data from proper sources for each of the approaches
	Data analysis	3. Analyze the data using proper schemes for each of approaches
	Model ideation	4. Connect the resulting components into a procedural model and refine the model by complementing one approach with the other
	Model representation	5. Graphically Represent the model 6. Construct detailed descriptions of how the model works (if necessary)

F1 Conceptual, *F2* Practical, *O1* Theory-driven, *O2* Practical-driven, *O3* Hybrid, *S1* Literature, *S2* Interim theoretical products, *S3* Real-life project, *S4* Simulated design task, *S5* Practitioners, *S6* Scholars, *A1* Variables or activities, *A2* ADDIE or a connected process, *A3* Heuristic design patterns, *A4* Functions, theoretical components or design guidelines

Discussion and conclusion

Our review and analysis of a selected group of ID model development studies revealed four critical dimensions and ten synthesized procedures that together form a methodological framework for ID model development. After reflecting on our findings, several topics of discussion emerged.

The dimensions and uses of the methodological framework

The critical dimensions of this methodological framework may be used by ID model builders as a starting point for model development. The first dimension—function—is closely related to the pertinent features of the model per se. The last three dimensions—origin, source and analysis scheme—concern the data collection and analysis involved in developing the model. The dimensions and subtypes also are related to target users, the focus of the model, the developmental approach, and other contextual problems in research situations. Once the set of information is sufficiently defined, a proper method for modeling can be selected and applied. The finer details of the specific techniques that model builders can use within each of the identified steps may vary. Model builders may be flexible in the specific methods they employ within each step. In order to identify heuristic design patterns, for example, a model builder may use techniques such as interviewing designers, observing their tasks, or having them to think aloud, depending on his or her competence, preferences, or accessibility to a certain data.

Interaction between theory and practice in ID model development

Many ID models are constructed to reflect both theory and practice. Theory-driven development is a top-down deductive approach, whereas practice-driven development is a bottom-up inductive approach (Strauss and Corbin 1998). Interactions between theories and practices are extremely desirable because purely theoretical models can lack usability in practice while purely practical models, especially those based on relatively few cases, can lack content validity. In fact, studies that begin with a top–down approach tend to balance out their theoretical naivety with bottom-up practical verification (Silber 2007; Willis 2009; York and Ertmer 2011). Personnel from both academia and field practice settings can offer complementary contributions with their scholarly expertise and proficiency in fieldwork. This tendency towards interaction between theory and practice is reflected in design-based theory development (Reigeluth and An 2009). Such an approach improves theories by integrating data from real-life settings with findings from relevant literature and encourages close interactions between practitioners and researchers. Further, this approach provides researchers with flexibility when considering multiple contextual variables and iteratively refining designs and theories (Wang and Hannafin 2005).

Relationship between the features of an ID model and its development method

A close interaction exists between model characteristics and model use. Gustafson and Branch (2002) classified instructional models into three categories: classroom, product, and system models. These categories are related to the conditions under which a model can be used. The taxonomy and selected features of each category imply that the model's use can influence model characteristics and vice versa. Similarly, methods can influence the features of a model, and the type of model desired can suggest a certain method. The four critical dimensions portrayed in Table 1 can produce 144 possible combinations ($2 \times 3 \times 6 \times 4 = 144$) of features. However, in the sample of studies examined here, we identified only a limited number of combinations (ten), suggesting the existence of a limited number of patterns of model development. Certain methods of development are suitable for particular types of models, and the model development methodology can influence the model characteristics and also be affected by the model characteristics.

Model and theory building as ID knowledge extension

Model development involves a critical investigation of the factors and theories related to instructional design. This task enables researchers and practitioners to accumulate and extend knowledge within the ID field. However, there have been longstanding doubts about the reliability and validity of the proliferation of new ID models (Andrews and Goodson 1980; Ertmer et al. 2008, 2009; Kirschner et al. 2002; Sheehan and Johnson 2012; Silber 2007; Yancher et al. 2010; York and Ertmer 2011). Such skeptical views of model development may well be caused by a lack of methodological guidance for both theory-driven and practice-driven models. The critical dimensions and synthesized procedures described in this study are intended to create a methodological framework that will help to develop productive and practical ID models. It is our hope that such a framework also will contribute to greater collective knowledge creation by academia and practitioners. As Reigeluth and An (2009) have noted:

> They [Practitioners] can gain powerful insights into what works well and when they work well. They intuitively develop a theory of instruction based on their practice to guide their practice. However, this is often tacit knowledge and is seldom shared with other practitioners or researchers. This is a terrible waste of an opportunity to advance our collective knowledge about how to create powerful instruction. (p. 374)

Several limitations to this study must be acknowledged. First, the studies we reviewed and analyzed did not represent a comprehensive sample of every possible methodology for developing an ID model. The studies we selected were limited to those published after 2000 and were chosen because they described their development processes in a relatively explicit manner; those excluded had only implicit references to the development process and would have required undue inferences or investigation. Second, our choice not to address the validation portion of model development is not meant to suggest that we consider the initial construction process to be more important than the validation process. Rather, we view validation as a broad area of study beyond the scope of this study, albeit one that deserves more investigation in the future.

This study provided a much-needed examination of ID model development studies, and led to the identification of critical dimensions and synthesized procedures to form a methodological framework for ID model development. It is our hope that this framework will be elaborated, broadened, and improved with more extensive study, in this way advancing knowledge within the field of instructional design and providing valuable tools for theory construction.

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Jihyun Lee is a Research Professor with the Department of Education at Chung-Ang University in South Korea. She earned a master's degree from the Technology in Education Program at Harvard Graduate School of Education, and a doctoral degree in Educational Technology at Seoul National University. Her research interests include model development methodologies, media theories, brain-based instructional design, and technology integration for higher-order thinking.

Seonyoung Jang is a Research Professor with the Center for Teaching and Learning at the University of Seoul in South Korea. She earned a master's and doctoral degree in Educational Technology from Seoul National University. Her research focuses on instructional design models, problem-based learning, scaffolding strategies for collaborative learning, and e-learning support for higher education.