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Instructional design, towards consolidation and validation

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Introduction

Technological evolutions (e.g. wireless Internet, mobile phones) and increased access to a continuously growing amount of data, insights, opinions, explanations, stories and clarifications stemming from a variety of cultural backgrounds are only two indicators of an apparently rapidly evolving society. It is to be wondered how individuals and groups are able to survive in such a continuously changing environment and to what extent they can cope with repeated calls for increased flexibility in the context of reduced stability and security. Moreover, there is a great challenge to identify and/or create conditions under which both individuals and groups can surpass the use of survival strategies and coping behaviour and actually make use of new opportunities and eventually contribute to their further development.

Complementary to political and socio−economical strategies, the field of instructional design deals with this challenge by focussing on one possible solution: the creation of learning environments. In learning environments individuals and groups get the opportunity to acquire strategies that help them to cope with complexity in society. By focussing on the development of problem−solving skills, information−processing skills, self−regulatory and learning strategies, learning environments may enable individuals and groups to become an active partner of society.

Instructional design aims at contributing to the development of learning environments by describing the basic components of a learning environment, their interrelations and their interactions with learner characteristics. To generate operational and mutually consistent guidelines for tuning environmental features to learner characteristics in order to increase the probability of goal−directed learning is the challenge for all those working in the field of instructional design. The complexity of the issue, the need for both analysis and synthesis and for considering contributions from a variety of disciplines, turns the challenge into a difficult one. A state−of−the−art constitutes a suitable starting point for handling the challenge.

This contribution aims at drafting such a state−of−the−art of the field of instructional design (I.D.), i.e. the field that aims at describing effective and efficient context− and learner−specific learning environments. In line with Reigeluth (1983) instructional design is limited to the elaboration of blueprints. How to instantiate these blueprints is not discussed. Answering this question is regarded to be the main task of the field of instructional development. In addition and in line with the proposals made by Clark and Estes (1998), both instructional design and instructional development are regarded to belong to the broader field of educational technology, the attempts to use scientific findings to solve practical educational problems.

In a first section, the fundamental I.D. research question is looked at. Some milestones in formulating the question and hence identifying the I.D.−problem are reviewed. The second section describes two major streams in the attempts to answer the question: the craft−stream and the technological stream. Future developments are discussed in a third section. New vantage points and problems will be identified. The conclusion while stressing the need for consolidation and validation in line with the technological nature of instructional design, also acknowledges that instructional design will remain a vulnerable technological field.

When I.D. is the answer what is the question?

The core I.D.−question can most easily be retrieved by analysing some of its outcomes namely I.D.−models. Instructional design models offer an indication of how an environment may look like in order to promote learning. The field is characterised by a plethora of models and regularly new proposals are made (for a nearly comprehensive overview: http://carbon.cudenver.edu/~mryder/itc_data/idmodels.html). I.D.−models aim at providing an answer to the question: "how does an optimal learning environment look like?".

While the question on the nature of high−quality learning environments has been fascinating to thinkers and philosophers since ever (Aristoteles, Plato, Plutarchus, Rousseau, Montaigne, Montessori,), instructional design has a more recent history (for an account of the early years of educational technology in general and instructional design in particular: De Vaney & Butler, 1996). The history of instructional design is closely connected to the history of behaviourism. One may even argue that initially behaviourism and instructional design could hardly be distinguished. In both disciplines bringing about learning results was the major issue and broad consensus existed about the nature of learning and learning results. The close connection between behaviourism and instructional design can be observed in the different contributions to a source book on Teaching Machines and Programmed Learning edited by Lumsdaine and Glaser (1960).

Leaning upon its behaviourist roots, three major milestones can be identified in the development and maturation of the question underlying instructional design: the Gagné−assumption, the ATI−hypothesis, and constructivist doubts.

Even nowadays, most instructional designers accept the **Gagné−assumption** as one of the major assumptions or even axioms of the field. Gagné clarified that the question about how a learning environment should look like had to be reformulated because it is simply impossible to answer that question. Given the observation that learning results are very diverse and the empirical finding that different learning processes may lead to different learning results, Gagné (e.g. 1968) stressed the point that different learning results require different external conditions and, hence, different types of instructional environments are to be designed. Gagné introduced the need for 'if..−then..' reasonings in instructional design and made answers to the I.D.−research question specific to the situations specified in the if −term. The introduction of the Gagné−assumption has fostered analytical approaches in the field of I.D.. Analysing learning goals and identifying specific instructional conditions that foster the development of these goals became the major task of I.D. Results of these endeavours are widely published and influence the field still today (e.g. attention for task analysis methods: Jonassen, Tessmer & Hannum, 1999). While the Gagné−assumption was hardly questioned, agreement did not and still does not exist with respect to the nature of different types of learning results. Various attempts have been made to classify learning results. The most famous one is undoubtedly the taxonomy of Bloom (http://faculty.washington.edu/krumme/guides/bloom.html), but also others have proposed specific classification schemes (e.g. the approach by Merrill, 1971). Agreement is also absent on the components of the environment that are to be considered. In other words while instructional design widely accepts the need for if−then −statements, there is no agreement on what should be placed in the if or in the then term.

While in the Gagné−assumption the differentiation of learning results is addressed, learners and their characteristics get highlighted in the **ATI−hypothesis**. Cognitive psychologists in general and Snow (1986) in particular have indicated that in order to realise comparable learning results, learners with different characteristics may need different learning environments. Treatments (or, in other words learning environments) do not have a direct effect on learning, they interact with learner aptitudes and the effects result from this interaction. Consequently different types of learning environments might have different effects for different types of learners. By highlighting the need for explicitly considering learner characteristics, the ATI−hypothesis refined the if −term and made it more complex.

Although the ATI−hypothesis is a very plausible one, has been validated in a wide variety of circumstances and most instructional designers will acknowledge its validity, there is still no agreement on the if −term. It remains difficult to specify differences between learning environments and the question about the most important learner characteristics remains unanswered. With respect to learner characteristics domain−specific and domain−general prior knowledge (including cognitive and metacognitive strategies) and, more recently, motivation have received most research attention but other variables such as general intelligence, gender, perceptions, attitudes or attribution skills have been proposed as well. Similarly and as already pointed out, agreement on the most important features of the environment is equally lacking. Structure, learner control and the nature of the learning task have been argued to be important environmental characteristics (e.g. Collins, Brown, & Newman, 1989) but the media−debate (Clark & Sugrue, 1990) is illustrative for the lack of consensus.

The ATI−hypothesis focuses on the individual learner. Its introduction has resulted in an increased awareness about the lack of research attention for the group and the relationship between the individual and the other members in the learning group. Instructional design models have largely neglected the interdependence of group members.

Both the Gagné− assumption and the ATI−hypothesis rest on the conviction that learning environments may result in realising learning results. Acknowledging ample research evidence, constructivists have raised scepticism about too much naïve optimism in this respect. The **constructivist movement** has put the learner and more specifically learning activities at the core of I.D.. In line with the summary of cognitive literature by Shuell (1986), learning is described as an active, constructive, self−regulated and goal−oriented process. Learning results from activities by the learner. The constructivist movement has given rise to highlighting the prominent role of the learner, greater acknowledgement of the relevance of motivational aspects of the learning process. Initially, the recognition of the constructivist nature of learning and the limited role of the environment has resulted in serious doubts about the feasibility itself of instructional design (e.g. Winn, 1991) and discussions about its epistemological underpinnings and practical implications (e.g. Duffy & Bednar, 1991; Jonassen, 1991). It finally resulted in greater awareness about the probabilistic nature of instructional design prescriptions. The environment cannot bring about learning results, it may increase the probability that particular learning processes are engaged in by the learner (Shuell, 1988). Moreover, the need to distinguish between instructional and learning goals has become apparent. Instructional goals pertain to learning results that are aimed at by an instructional environment. Learning goals pertain to learning results aimed at by the learner. Large discrepancies between learning and instructional goals must result in poor effectiveness of instructional environments (Winne & Marx, 1982). Constructivists have induced a reformulation of the instructional design research question: "how can an environment be designed in order to enhance the probability of supporting instructionally adapted learning processes".

While agreement has been reached on the issues brought forward by constructivists, there is no agreement on the conclusion of radical constructivists that learning environments have no impact on learning processes (Lowyck & Elen, 1991). Research highlights that given the situated nature of learning, environments do affect learning processes while at the same time it is stressed that the influence of the environment is not deterministic but probabilistic. Social−constructivist interpretations (e.g. Lave & Wenger, 1991) of the learning process help to re−conceptualise the relationship between learning and environmental input as bi−directional (mutually influencing) rather than as uni−directional (causal).

These three major milestones have resulted in a gradually more refined but also more complex I.D.−research question. The question no longer pertains to the outlook of an optimal learning environment. It must now be reformulated into what features of the environment may increase the probability that particular learners achieve instructional goals .

Past and current answers to the I.D. question

The gradual refinement of the I.D.−research question has been illustrated in the previous section. Parallel to this evolution, answers to the question have been formulated resulting in a plethora of I.D.−models. The large number of I.D.−models, each with their own terminology, structure, and particularities overwhelms instructional design novices. Moreover, the action range or application domain of these models is not always explicitly mentioned. Regularly, I.D.−models offer an answer without pre−specifying a question. To compare these models and to look for similarities and contradictions, or to investigate the extent to which they are complementary is a mission nearly impossible. Comparability is diminished by the absence of clear statements about action range and further decreased by a number of other features of these models, such as:

- different levels of formalisation (from pictorially supported heuristics (e.g. Romiszowski, 1984) to formal algorithms (e.g. Scandura, 1983));
- different application settings (different types of answers for education and training contexts (see for instance the particular developments in the area of human performance technologies : Stolovitch & Keeps, 1999));
- different theoretical perspectives (e.g. different theories on learning−related issues with related instructional prescriptions (e.g. Bruner (1966) vs Skinner (1968));
- different practical perspectives (models for instructional books (Hartley, 1978), versus models for multimedia (Alessi & Trollip, 2001));
- different conceptions about what constitutes an I.D.−model (theoretically sound and empirically valid (Elen, 1995) versus immediate practical applicability (Neill & Mashburn, 1997)), and
- different levels of generality (general models (Jonassen, 1999) versus media−bound models (Mayer, 1999)).

The number of I.D.−models could be argued to reflect the complexity of the field and its richness. However, one should not be blind to the origins of this diversity. Two related origins are the dual nature of instructional design and the focus on craftsmanship. First, instructional design has been portrayed in this contribution as a field of scientific enquiry. While the number of scholarly publications provides evidence for this statement, it must also be pointed out that instructional design is an economically important activity. Most instructional designers are not researchers who attempt to generate answers to the I.D.−research question, but professionals who attempt to apply I.D.−models to a variety of highly complex and diverse settings. Designing instruction, especially with novel technologies; training, and consulting about designing instruction is a profitable and competitive business. In the instructional design market it is a trump to have one s own model, to be a name in the field and be recognised as an authority. Professional competition and novelty inspired by marketing replace co−operation and consolidation.

The second reason for the large number of I.D.−models might even be more dramatic. Clark and Estes (1998) have stipulated that the field of instructional design is more like a craft while it claims to be a technology. Whereas a technology looks for the active ingredient and hence develops solutions that are widely applicable, a craft is experience−based. Solutions proposed by a craft provide solutions that have indeterminate causes. And, although broad applicability is claimed, these solutions can be transferred only with great difficulty to other settings. In the absence of an in−depth explanation it is impossible to determine for what problems and in what situations the solution is a suitable one. In addition to the sheer number of models , Clark and Estes question their generalizable usefulness and scientific grounding.

Clark and Estes have not been the first to make these or similar remarks. Already in the first issue of Educational Technology Research and Development, Clark (1989) pointed to the lack of systematicity in I.D.−research endeavours. In a recent article, Reeves (2000) argues in favour for design research in order to handle the poor research basis of a lot of instructional design practice.

Recently, awareness that the diversity in instructional design is problematic rather than a trump seems to be growing. While it must be expected that the professional field will be characterised by an abundance of targeted bundles of I.D.−guidelines, I.D. as a field of scientific enquiry seems to be more sensible for the issue of integration and consolidation (e.g. Seels, 1997). The following are illustrations of the implications of this increased awareness.

Recent efforts to summarise the field differ from older ones by their integrated nature. Publications in which overviews are given of different I.D.−models are well−known. These overviews (e.g. Reigeluth 1983, 1999; Tennyson, Schott, Seel & Dijkstra, 1997) are mostly additive. Gradually however, there is a group of instructional designers who aim at making not a summary or overview but a synthesis. Three examples may illustrate this evolution.

In his Prolegomena to a Theory of Instructional Design Duchastel (1998) argues in favour of a full theory of instructional design. Duchastel puts forward a number of characteristics of such a theory: comprehensiveness, abstractness, utility and validity. The full theory of instructional design should not simply be a tool to choose between various instructional design models but an integrated compilation of elements from a variety of models. This integration ensures that it covers all content domains, encompasses all different types of learning processes, is widely applicable and is grounded in psychology. Duchastel, in other words, argues for the development of an instructional design theory that is a fully elaborated technology. While such a theory would be encompassing, it is at the same time restricted. Duchastel prefers not to include discussions about the goal of learning and instruction in the theory. Rather, the theory would be functional to the full variety of learning and instructional goals.

The proposal by Duchastel has launched ample discussions at the ITFORUM about the feasibility and even desirability of a full I.D.−theory. One of the major problems seems to be the incompatibility of so−called objectivist and constructivist approaches in instructional design. While tentative and in line with previous proposals made by Jonassen (Jonassen & Land, 2000), Cronjé (2000) proposed a framework in which to position different types of learning environments. Interestingly while Cronjé initially proposed objectivism and constructivism to be two independent dimensions, the discussion gradually evolved towards questioning the two−dimensional approach and arguing in favour of a one−dimensional approach.

A final illustration of the growing awareness of the need and feasibility of an integration can be found in a special issue of Educational Technology edited by Cates (2001). The guest editor asked different instructional designers to design a lesson. Goals, target group and content were predetermined. Along with the contributors, one can easily observe the similarities between the different proposals. All of the designs seemed to share common properties such as starting with an authentic task, systematicity, and the inclusion of simulations (Cates & Bishop, 2001). Nevertheless, each of the contributors (Rieber, Hannum, Merrill, Cates). would argue to apply a different instructional design model. It was concluded that "An issue like this that pursues theoretical foundations as well as their implementations in design should prove extremely valuable." (p. 61). No wonder that the proposal to bring together the different ideas and integrate the various perspectives finds healthy ground.

These three illustrations reveal a tendency towards integration but do not actually bring about this integration. Evidence of actual integration is more difficult to find in current instructional design models. Probably the 4C/ID−model proposed by van Merriënboer (1997) is the best current attempt in this direction as can be seen when the various characteristics as proposed by Duchastel are looked at (coverage of all content domains, encompassing all types of learning processes, widely applicable and grounded in psychology). Van Merriënboer restricts the applicability of his 4C/ID−model to technical training but in the absence of clear indications about what does and does not belong to this type of training, the model can easily be argued to be applicable in nearly all domains and application settings. The 4C/ID−model further covers both rule automation and schema acquisition. It is therefore not restricted to declarative or procedural knowledge but covers a wide variety of learning results and their underlying learning processes. And finally, the model is fundamentally grounded in psychology. The different proposals made by van Merriënboer are not the result of experiences but are based on solid empirical research. The

4C/ID−model clearly identifies the active ingredients for different types of problems. It does not provide immediate guidelines for different instantiations but identifies the most fundamental parameters and their interrelations.

Answering the I.D.−question: the future

Current answers, especially in the technological/scientific stream of instructional design tend towards integration and consolidation. Duchastel identified the formal characteristics of a full theory of instructional design; Cronjé discussed a possibility to reconcile theoretically opposed positions; the special issue of Educational Technology illustrates design commonalties for different theoretical positions, and van Merriënboer has already elaborated an interesting example of a possible integration. One may expect that the orientation towards integration and consolidation will further grow and have an increasing impact in the near future. However, one may wonder why exactly at this moment with a society becoming the more and the more complex, integration and consolidation seem both desirable and feasible. In our view this relates to a growing consensus about the knowledge base of instructional design and the methodological features of instructional design research. A common and balanced understanding of learning processes is a first major element of this knowledge base. It facilitates communication by providing a set of common assumptions and a more stable terminology. Socio−constructivist interpretations of learning enable the integration of cognitive connectivist insights about the functioning of the brain and the information−processing system on the one hand and the constructivist notion of situated cognition on the other (Elen, 2000). Simplistic deterministic ideas are avoided. The (socio−cultural) environment and the interaction with others in that environments get clear roles with respect to learning processes. The notion of situated cognition (Brown, Collins & Duguid, 1989) has highlighted the role of the environment and revealed the power of the group. Because meaning is negotiated the acquisition of knowledge implies that one s own understanding is confronted with the view of others. Collaboration, the exchange of ideas and the confrontation with alternative perspectives are valuable means in the knowledge acquisition process. Learning is an interactive process in which continuously actions and reactions are exchanged between an individual and his/her (socio−cultural) environment. It is a balanced view that does not solve all types of problems but provides a useful framework in which to integrate insights. The socio−constructivist interpretation builds on the outcomes of cognitive research. Prior knowledge and motivation are conceptualised as the main determinants of learning in instructional settings. However, both prior knowledge and motivation remain extremely complex concepts due to their encompassing nature. Prior knowledge for instance refers to domain−specific and general declarative and procedural knowledge as well as to metacognitive knowledge and strategies. Similarly motivation refers to a complex set of processes that regulate goal−directness, attribution and volition (Masui, 2001).

The three previously discussed milestones have also contributed to enlarged consensus. The Gagné−assumption has initially launched more analytical approaches and a variety of goals to be addressed. By the single −objective approach of Gagné instructional designers have been induced to be highly goal−specific. The observation that most goals entail multiple objectives was largely neglected or only considered as a secondary problem. The explicit distinction between single−objective and multiple objectives that is made nowadays, the notion of disposition as well as the evolution towards competency−based instruction, illustrate consensus about the need to acknowledge complexity and interrelationships. Future I.D.−models will probably be layered by specifying guidelines for the attainment of single objectives as well as for complex interrelated competencies. Such models will aim at addressing complexity while at the same time they will recognise the feasibility and usefulness to decompose complex skills, dispositions or competencies. The ATI−hypothesis has resulted in a recognition of the importance of individual differences and the constructivist movement has contributed to better define the role of the environment.

Taking into account the contributions by the Gagné−assumption, the ATI−hypothesis, and the constructivist doubt, future I.D.−models can also build on consensus with respect to the probabilistic nature of supportive interventions in learning environments. Different (combinations of) instructional methods or interventions may suit different instructional goals to be attained by different types of learners. However, there is no one−to−one relationship between goals, and methods. One method may serve different purposes for different learners and one particular goal may be reached with higher probability by using different methods. Similarly, different methods may be supportive for different types of learners, although there is not a one to one relationship between type of learner and method. Given the complexity of instructional goals and learners, diversity with respect to goals and instructional approaches is welcomed. While a variety of methods is acclaimed, consensus seems nevertheless to exist about the overall structure of learning environments especially when directed towards the attainment of complex learning goals. Overall, inductive methods with realistic tasks seem to be preferred. By using these inductive methods the constructive nature of learning and transfer is considered and fostered. Interestingly, in the technology−branch of instructional design, new technologies are not actually considered. There seems to be consensus about the potential of new technologies. However, these new technologies or media do not require the elaboration of new I.D.−models. They do require investments in finding out how active ingredients can be instantiated.

In addition to consensus about substantial elements of the knowledge base, recent articles (Reigeluth & Frick, 1999; Reeves, 2000) also seem to agree on the nature of the research that must help to expand the knowledge base and contribute to its further validation. Design experiments are described as a good way to further develop the instructional design discipline. Design experiments are not simple formative evaluations but theory−driven attempt to analyse the boundaries of the effects of active ingredients .

While future answer to the I.D.−research question may build upon consensus about a number of important issues, one must not expect integration and consolidation to be an easy task. The issue is far too complex to look for easy and fast solutions. Major problems relate to the translation of the general conceptions about learning and the relationship between learning and environments into more operational and testable theoretical statements. Such a translation effort (even prior to any empirical work) is hampered by terminological confusions and, hence, the sheer impossibility to talk about instructional and learning goals at different levels of complexity, to describe in any systematic way differences between learning environments and/or groups of learners. Complexity and the need for layered answers further aggravate things. While research is available on active ingredients , more research is needed on combinations of active ingredients in relation to combinations of learning goals and combinations of learner characteristics. Analytical approaches are to be complemented with more integrative approaches. These integrative approaches will have to take into account that the relationship between environmental variables and learner characteristics is often not linear but mostly curvilinear.

Given the dual nature of instructional design, growing consensus with respect to components of the knowledge base and appropriate research and the problems that will have to be solved, one may wonder how I.D.−models will look like in the (near) future. We see three possible categories of I.D.−models. A first craft−like set is directly linked to experiences in the field. Starting from observations about what does and does not work in the field, prototypical learning environments will be constructed from which more abstract statements will be derived and based upon which guidelines will be formulated. The models will be primarily experience−driven. Theoretical considerations and empirical evidence are added a posteriori in order to indicate validity and increase credibility. A second set of I.D.−models will be the result of a theory−driven attempt to systematically derive theoretically sound and empirically valid guidelines. Given the complexity of the endeavour and the number of variables to consider, automation will be an necessary ingredient of (the construction of) such models. These models will not look like extensive descriptions of I.D.−guidelines but look like automated tools with ample documentation. Finally, the future of I.D. will most probably be also characterised by numerous attempts to create learning objects , reusable object−oriented programmes that embody a particular instructional method or approach and can be linked to other objects in order to create more complex instructional environments (Wiley, 2001). While it is to be expected that initially attention will be primarily focussed on technical issues (object−oriented programming) and practical aspects such as granularity and metadata, later on discussions will focus on the theoretical underpinnings of these objects and their empirical validity. Ultimately the discussions may result in proposals on the creation of learning environments by combining learning objects at different layers of complexity. To a certain extent previous discussions about learning environments will be simply repeated. Nevertheless one may hope these discussions to be more functional and operational. The availability of learning objects will compensate for the current lack of terminological agreement and help to transparently define and, hence, compare (components of) learning environments.

Conclusion

In this contribution a state−of−the−art of the instructional design field was drafted. Three milestones in the development of the I.D.−research question have been identified. As a consequence of the evolutions, the I.D.−research question has become more complex. Instead of answering one I.D.−question (How does an optimal learning environment look like?), I.D.−models have now to provide an answer to at least the following questions in order to propose a probabilistic solution:

1. what types of goals are identified and what is the relationship between these goals;
2. what learner characteristics are considered to be relevant and what is the relationship between these characteristics;
3. what components of the environments are considered to be relevant, and
4. who decides about linking goals, learner characteristics and environmental components and based upon what principles.

It is argued in this contribution that while current answers mostly illustrate the craftsmanship of instructional designers, the future of instructional design is necessarily a technological one. The consensus about substantial elements of the knowledge base and about the nature of I.D.−research facilitates this technological development of the field. Of course, numerous problems will have to be resolved and still require ample research. One may conclude however that the growing awareness of the complexity of the learning and instructional processes, has induced the need for the consolidation of I.D.−models. The problem is too complex to loose any more time in vane and purely theoretical debates. Time has come for more systematic, i.e. technological, approaches to consolidate and validate I.D.−models. Such models are basic to the design of learning environments that help individuals and groups to surpass the development survival strategies and coping behaviour.

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