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Handbook of Research on Educational Communications and Technology (3rd Ed) Some reflections (2):

Learning from and thoughts on the Handbook of Research on Educational Communications and Technology (3rd edition): Part 2 — insights in complexity theory, situational theory, and several other hot topics

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Abstract: *This paper elaborates on what the author has learned from the Handbook of Research on Educational Communications and Technology (3rd edition) in four respects: complexity theory and the complex learning supported by technology, situational theory and the scenario-based teaching model and strategy, the first principles of instruction and the four-component instructional design model (4C/ID), and the debate regarding the future of educational technology as a result of the changes in the direction of technical research.*

Keywords: complexity theory, situational theory, first principles of instruction, four-component instructional design model (4C/ID), direction of technical research

The first half of this paper (i.e., **part 1 to 3**) describes how the author looks at the complexity theory and technology-supported complex learning. The second half of this paper (i.e., **part 4 to 6**) briefly describes the learning and insights that the author has gained from (a) a review of the situational theory and scenario-based teaching model and strategy, (b) the first principles of instruction and the four-component instructional design model, and (c) the debate concerning the future of educational technology as a result of the changes in direction of technical research.

The following discusses the complexity theory.

1. Concerning complexity theory

Chapter 3 in the Fundamentals Section of the Handbook of Research on Educational Communications and Technology (2008) systematically described the complexity theory. The two authors of this chapter were Xiaopeng Ni and Robert Branch and they began to encourage researchers to address complex phenomena in the educational technology field.

Complexity is a concept used to describe phenomena. As used herein, the term phenomena is defined as those processes that can constantly produce a large quantity of information, energy, levels, variations, relations, and various elements, which in turn increase the possibility of the generation of various results and decrease the certainty and predictability.

Complex phenomenon refers to a combination of many independent and mutually interrelated entities that reach a common goal through an adaptive process. It can be observed that complex phenomenon comprises several independent entities, which in turn can be divided into smaller entities. Each entity has its respective functions and characteristics and can be further divided into several sub-entities. Complex phenomena exist extensively in organisms, geological structures, and social structures.

Complexity is the essential characteristic of educational technology and complex phenomena commonly exist in the field of educational technology. However, the discipline of educational technology has been giving inadequate attention to the study of complex phenomena and complex factors since its birth in the 1960s, not to mention the careful exploration of these phenomena and factors at a theoretical level. Researchers have long been unable to simulate and predict the evolution process of these phenomena using standard linear equations, and the behavior of the entire complex entity can only be understood as an accidental consequence resulting from the holistic integration of countless behaviors inside a system. As a result, learning how to address complex phenomena and situations has become a common need of educational technology researchers.

To this end, Ni and Branch (2008) noted the need to have a conceptual, theoretical and practical understanding of complexity to provide a framework for educational technology research to effectively address the issues such as non-linearity and the complex relations of the subjects of research. Only in this way is it possible to better understand the educational behaviors that exist as complex phenomena.

This is the practical background from which this chapter on complexity theory originates, as well as the reason why the first and second edition of the Handbook did not address the complexity concept and theory. Not until the third edition in 2008 did the authors begin exploring such concepts and theories.

The complexity theory described in the third chapter of the Handbook of Research on Educational Communications and Technology (3rd ed.) addresses the following three aspects:

(1) The scientific definition of the meanings of such concepts as complexity and complex phenomenon

The exact meanings of such concepts as complexity and complex phenomenon have been described in the aforesaid introduction section, on which Ni and Branch (2008) note the viewpoints of Law and Mol (2002) in Chapter 3 that the existence of complexity is conditional upon the following three premises: (1) things inside the system are interrelated and not a simple sum, (2) the occurrence of incidents does not follow the linear rule, and (3) the space of such complex phenomenon cannot be mirrored to a 3D coordinate system.

(2) Accurate description of the definition and characteristics of a complex system.

The authors of Chapter 3 quote the studies by Levy (1992) and define the complex system as a multi-component system in which the ways several components interact are so complicated that it is impossible to predict the evolution process using standard linear equation. Later, Levy (1992) made an addition to this definition by noting that since multiple variables interact with each other in a non-linear manner, the behaviors of the entire complex entity can only be understood as accidental consequence resulting from holistic integration of countless behaviors inside the system.

Obviously, Levy's definition emphasizes that a complex system is characterized by the non-linear interaction inside the system. For instance, a complex system is dynamic and unpredictable and does not follow a logical order or path.

Because both natural and social systems are non-linear and dynamic in nature, complexity theory maintains that a complex system is a common occurrence in organisms and in geological and social structures. The concept is well known for identifying educational systems that are non-linear and dynamic, and therefore, the educational system should be a complex system that is both natural and social.

(3) Clearly stating how and to whom the complexity theory applies

The authors of Chapter 3 acknowledge by quoting the studies by Davis, Phelps, and Wells (2004) that, in the field of social sciences, the application of complexity theory takes multiple forms, including highly technical, narrative and speculative forms, as well as other latest forms of application.

At the same time, in Chapter 3, the authors maintain that the complexity theory applies to phenomena or entities (also known as complexes) that have the following five characteristics:

1) A phenomenon comprises independent, complex entities.

2) An entity itself comprises many sub-entities.

3) Different entities inside a phenomenon interact with each other.

4) A phenomenon seeks a common goal.

5) A phenomenon is uncertain due to some unpredictable interactions both from the phenomenon itself and between the phenomenon and environment.

The human body is a typical example of being complex, as the human body has the aforesaid five characteristics contained in a complex and can be divided into smaller, independent, complex entities such as the head, trunk, and limbs. In addition, each entity comprises several sub-entities such as bones, cellular tissue, and blood.

A complex can be decomposed into several components, each being a complete complex when viewed independently. A separate entity might be able to complete a certain simple task independently under general circumstances, while complex tasks usually require collaboration between multiple entities under a complicated scenario to be completed.

A complex has multiple structures and functions, which is consistent with the system theory. Each component inside a system relies upon the information and output provided by other components to realize the interaction. The human body system relies upon muscles, bones, nerves and blood, and other entities whose interaction enables the physiological functions. The synergy between components inside the system allows their total utility to exceed the sum of the components. Uncertainty arises because of the unpredictable interaction among the components. Many social and natural systems are complexes, and the educational system is another typical example of a complex. As the basic theory and approach to dealing with and addressing such complexes or complex systems, complexity theory makes it possible to essentially understand and explore such entities or systems. Of course, it also provides a brand-new theory and approach to studying and dealing with complex systems such as educational communications and technology (in China, educational communications and technology are generally abbreviated as educational technology or e-education).

2. Analysis of the characteristics of educational technology as a complex system

To help people further understand educational technology as a complex system (or complex), the authors of Chapter 3 of the Handbook encourage readers to understand and determine the main characteristics of such complex systems from the perspective of the essential elements of such educational technology systems as the teaching event, the teaching scenario, intentional learning, and the intentional learning space.

2.1. Teaching event and teaching scenario

As described above, the educational system is a complex system that is both natural and social, while the educational technology system (or educational communications and technology system), as one of its important subsystems, is also a typical complex or complex system. The educational technology system is complicated because it results from the multiple interactions between its internal elements and between the internal elements and the outside. Educational technology is a theory and practice of facilitating learning and improving performance by designing, developing, utilizing, managing, and evaluating suitably technology-supported educational process and resources. Educational technology practitioners need to develop and use a series of products, programs, and software to facilitate the physical and mental health and development of students. Gagne, Wager, Golas, and Keller (2005) use nine types of teaching events to describe the best teaching activities based on the cognitive process model. In the context of this paper, the teaching event refers to a relatively small unit that provides learners with the external conditions matching their internal conditions. Branch (1999) defines a series of teaching events that fall within one and the same teaching category as teaching scenarios (this indicates that the teaching scenario comprises of a series of teaching events). A teaching scenario refers to an activity process during which learners are guided to learn predefined knowledge and skills and that has several variables and is complicated. Therefore, the design and use of educational technology should be adaptable to such a process.

2.2. Intentional learning and intentional learning space

To further clarify the characteristics of the complex system of educational technology, the authors of Chapter 3 bring forward a new concept of intentional learning by quoting the studies of a teaching system design using the chaos theory by You (1993) to further describe the complexity of the teaching practice.

Intentional learning refers to the learning conducted by using information, arranging human resources, and creating a learning environment in an intentional and planned manner to achieve a particular purpose. Intentional learning is complicated because the knowledge system is itself complex, and the connection between systems is non-linear in nature. According to You (1993), the learning process is complicated because the knowledge system itself is a dynamic system and represents the active construction of a dynamic reality, which in turn comprises the connected networks of various models.

To more clearly demonstrate the complexity inside the educational technology system, Branch (1999) brought forward a concept called the intentional learning space based on the dynamic system described in You (1993). Branch (1999) believes that the intentional learning space typically comprises of eight entities: students, contents taught, teaching medium, teachers, companions, time, objectives, and context. Branch notes that the vast majority of these entities are intrinsically complicated.

Students are intrinsically complicated because of their physiological, emotional, social, and psychological development, and their intelligence, cognitive style, learning motive, cultural background, creativity, and socioeconomic status have an influence on the behavioral pattern. The content taught is intrinsically complicated because it is a collection of information constructed by concepts, rules, propositions, procedures, and society. In addition, the types of information can be attributes, categories, classifications, components, dimensions, segmentation, objectives, levels, types, premises, procedures, rules, skills, and types of things that all make learning complex.

The teaching medium is a channel of communication that takes various forms. Teachers serve as the decision-makers who are required to set the appropriate objectives and expectations, analyze the learning needs, arrange the contents to be taught, choose the teaching medium and methods, and evaluate the teaching and learning activities.

The complexity of companions originates from the social consultation between people having the same age, status, or capabilities.

Time is a complicated entity that is omnipresent and uncontrollable and can be measured only by determining the discrete increments and intervals.

Context is a complicated entity because it refers to conditions that directly or indirectly affect the state, environment, and community and that result from substances, politics, economy, and culture (i.e., the ecological environment in which people live).

The intentional learning space refers to the space in which the education entities coexist with non-linear behaviors. The educational technology practitioners conduct research and test in an intentional learning space, and therefore, the intentional Need to add these authors in References learning practice is also complicated.

3. How to use technology to effectively support complex learning

Chapter 12 in the Strategy part of the Handbook written by Kali and Linn (2008) proposes four elementary principles and eight practical principles concerning the use of technology to support inquiry learning. Of these principles, elementary principle 2 involves the visualization of complex concepts and complex scientific phenomena. The following provides a specific statement of elementary principle 2.

Elementary principle 2 comprises of three practical principles (i.e., 3, 4 and 5). The first two practical principles are intended to help students visualize their thought processes. Practical principle 5 attempts to visualize the complicated scientific phenomena. This indicates that according to elementary principle 2, there are two measures to effectively use technology to support complex learning. First, visualize the thought process (which can be realized by using practical principles 3 and 4). Second, visualize the complex scientific phenomena (which can be realized by applying practical principle 5).

Moreover, Chapter 56 in the Methodological Viewpoints part of the Handbook written by Kim, Lee, van Merriënboer, Merrill, and Spector (2008) produces three additional measures with a view to effectively using the technology to support complex learning. Special attention should be given to the complex learning strategy and model. The following specifically describes these three measures.

3.1. Visualize the thought process using practical principles 3 and 4

Practical principle 3 addresses the need to provide students with a template to organize their thoughts. A learning tool designated as a "template" should be designed and developed for students to clearly express their thoughts on complex concepts. A typical example of effectively demonstrating how such a template can help students organize their thoughts is the Web-based Inquiry Science Environment (WISE) developed by an organization under the National Science Foundation. The WISE functions as a theory generator (Clark & Sampson, 2007), which is a tool used to help students refine the information they collected or experienced into a theory. By providing students with the basic vocabulary used to express theory, this tool can help students build the framework required to complete the refinement of a theory, allowing students to clearly express the theory using terminology instead of colloquial language. For example, in the thermodynamics course under the TESL program, the process of learning about the topic "exploring your surroundings" uses the functionality of the template in the WISE format to provide students with support, level their thoughts, and ultimately grasp the related theories (TESL program is Technology Enhanced Science Learning program established by National Science Foundation in the fall of 2003).

Practical principle 4 addresses the need to provide students with the knowledge characterization tool. A good example of how the characterization tool helps students to articulate and examine their knowledge is the Model-IT developed by Michigan University; a cognitive tool that is provided to help learners explore subjects independently and can be used to build a dynamic model of scientific phenomena. It can encourage students (including students with poor mathematical knowledge) to use such characterization tools to emulate models, and analyze and verify results for the purpose of building quantitative models regarding the scientific phenomena (Jackson, Krajcik, & Soloway, 2000). For example, the students can use it to build a water quality model and then determine how the different pollutants affect water quality.

3.2 Use practical principle 5 to visualize complicated scientific phenomena

Practical principle 5 addresses the need to ensure that students are capable of 3D operation. This practical principle is intended to visualize the complicated scientific phenomena. For instance, in the course of teaching many students typically find difficult to understand the representation of the 3D structure of objects using the 2D form in the textbooks. The use of visual tools allows students to rotate the objects observed for viewing in different directions and from different angles, thus helping the students to effectively resolve this challenge. A typical example of visualizing the complicated scientific phenomena through 3D operation is the 3D graphic representation in the Geo3D software. To meet the need to cultivate the spatial imagination of the students and to resolve the difficulties encountered by high school students in understanding the geological structures, Kali and Orion (1996) asked students to observe the profile of geological structures using Geo3D to explore and discuss the relation between the visible and invisible parts of the geological structures. Such observations, explorations, and discussions can generally deepen the students' understanding of complicated geological structures resulting from the formation folds, uplift, and internal erosion. Students can remarkably improve their imagination of geological structures even if they are quite new to such 3D animation, for example, one or two hours (Kali & Orion, 1996).

3.3. Greater attention should be given to the study of the complex learning strategy and model

Authors of Chapter 56 of the Handbook (Kim et al., 2008) emphasize that over the next five years there will be two research questions drawing the most attention while forecasting the future of educational communications and technology research: first, the technical integration in rich learning scenarios and second, the complex learning strategy and model.

The authors of this chapter note that the reason the study of complex learning strategy and model should be given special attention is because society has been increasingly calling for workers who can grasp complexity quickly, react to the ever-changing working conditions, and make flexible adjustments. Moreover, individuals need to learn skills such as conventional problem solving, inference, and self-orientation because of the rapidly changing new technology and environment. At the same time new, unpredictable, and complex phenomena will inevitably occur in the process of such combinations.

The authors of this chapter also remind readers that an additional noteworthy problem related to the complex learning research is the attention to the learning evaluation and the performance of ill-structured problems and tasks. This is especially important when dealing with ill-structured problems to which there are multiple solutions and approaches, and no reliable approaches or methods to determine the progress of the related learning and performance. Because of this, it is difficult to form an effective support theory and method for such complex learning system. Therefore, giving attention to the study of the "learning evaluation and performance" of ill-structured problems and tasks is necessary as a first step.

The following is the second half of this paper, which addresses several current topics such as situational theory, the first principles of instruction, and the debate resulting from the changes in the direction of technical research.

4. Situational theory and scenario-based teaching practice and strategy

4.1. About situational theory

Chapter 9 in the Strategy part of the Handbook written by Barab and Dodge (2008) focuses on the design approach to realistic courses. Because context is an extremely important concept in the scenario-based teaching of realistic courses, and contexts are simply quoted directly in the general literature instead of being explained, they believe necessary is to clearly define the meaning of context before describing the situational theory and scenario-based realistic courses.

According to the definition given by Mario Antonio Kelly (2011) , context refers to the synergy of the numerous factors including the physical environment of the classroom (the hardware and software infrastructure), the student's family background, the cognitive characteristics, and the psychological quality and morale of a class in particular a class comprised of students and teachers. Obviously, a context involves the physiological, psychological, cognitive, linguistic, social, and cultural aspects.

Psychologists believe that the cognitive revolution comprises of two phases. The first phase emphasizes the individual thoughts and the isolated mind (Gardner, 1985). Obviously, theorists at this phase attempt to weaken scenarios partly because of the attempt to remove the shackle created by Skinner et al (1954, 1965,1968). and to focus on the individual mind separated from a specific environment. The second phase places the cognitive function in the social, cultural, and historical frameworks in which it lies, or the core of situational theory. Learners are no longer regarded as existing independently of the environment in which the learning takes place. On the contrary, individuals are connected with the environment through a series of intentionally designed, controlled practices and work together with the environment (Reed, 1991). Conventional wisdom maintains that knowledge is an object that can be acquired, while knowing is merely a cognitive behavior that occurs inside the individual mind. However, it is not the case according to the situational theory. Situational theory suggests (Barab & Duffy, 2000) that knowledge involves an activity, not an object. It is always scenario-based and contextualized, not abstract. Situational theory is built as part of the interaction between the individual and the environment instead of being created objectively or subjectively. The whole person is the one that participates in knowledge, not a mind that is isolated. Overall, situational theory maintains that cognition is not a mental behavior or information bit that is de-contextualized and to be transmitted, but a practical activity with a real situation that allows the participating individuals to be placed in a vivid, rich, and meaningful environment.

To this end, situational theory particularly stresses the need to support the meaningful participation in a rich contextual experience and to change the approach to knowledge acquisition. For instance, transitioning from an acquisitive approach to a participative one focuses on such rich environment (Sfard, 1998).

4.2. Designing scenario-based realistic courses and the related teaching practice and strategy

The give-and-receive teaching practice emphasizes memorizing factual knowledge drives the development of the superficial conceptual understanding, as manifested by the teacher-centered, classroom-based teaching practice. Such a once-dominant, teacher-centered give-and-receive pattern has been gradually abandoned by teachers since the 1990s, giving way to the experiential, scenario-based teaching practice. This new-type of teaching practice supports the natural complexity of the content taught (to avoid excessive simplification), allowing students to construct the meaning of knowledge through practice and cooperation in a complex context. Teaching can now take place in simulated or real scenarios (Barab & Duffy, 2000).

To place this new type of teaching model into practice requires the support from easy-to-experience, scenario-based, highly realistic courses. This is the type of course that allows learners to learn and inquire into knowledge independently, and highlights the teaching objectives and requirements. Creating the scenario-based realistic courses in a school setting presents a daunting challenge in terms of how to select the suitable scenarios and set the noise level to create the system of the contents of fundamental disciplines. With more situational factors included in the learning environment, the sense of reality and mystery and the fun of inquiry will grow, with the possibility that the teacher's instruction, learning efficiency, and clarity of objectives will be affected or perhaps weakened.

The design of the scenario-based realistic courses should follow the following basic principles of top-down and stepwise refinement. First, the content taught should be integrated into related scenarios to make the courses realistic to support and drive the implementation of the experiential, scenario-based teaching model. Second, whether the content taught is scenario-based and realistic depends upon whether the content to be learned can be experienced in a particular narrative scenario. The narrative scenario does not refer to any given scenario, but to an appropriate storyline provided to help students inquire and learn the content. Third, the appropriate storyline in the narrative scenario should contain a meaningful objective and the learning actions that a group of students will follow (the students' actions will inevitably result in corresponding results) to avoid the situation whereby students memorize the learning of content as isolated facts. Through such narrative scenarios that learners are enabled to generate various ideas and results as a consequence of the various learning actions so that the texts that would have otherwise been isolated from the entities now become content-rich or possibly vivid facts and experience (Barab, Cherkes-Julkowski, Swenson, Garrett, Shaw, & Young, 1999). Fourth, when creating the narrative scenarios according to the aforesaid steps and requirements, teachers should be reminded that it is necessary to carefully consider the various ideas generated by the students when experiencing the storylines in the course of the practicing scenario-based teaching model, and use such realistic courses and every means available to allow the students to examine and validate these ideas themselves (which is crucial to highlighting and deepening the teaching objectives and requirements of the courses).

To develop scenario-based, highly realistic courses, it is essential to establish real contexts (i.e., a teaching scenario with realistic elements). After many years of practice, three types of scenario-based teaching models that are relatively conducive to the implementation of realistic courses have been formed (i.e., the design-enabled simulation model, the generative simulation model, and the participatory model), each with a different implementation strategy. The scenario-based teaching strategy suitable for use with the design-enabled simulation falls within three categories: the anchored instruction, the question-based learning and the cognitive apprenticeship. The scenario-based teaching strategy suitable for use with the generative simulation model comprises of case-based inference, project-based learning and the classroom learning community. The scenario-based teaching strategy suitable for use with the participatory model comprises the participatory simulation, the academic gaming space and the community of practice. There are nine types of scenario-based teaching strategy.

5. First principles of instruction and the four-component instructional design model (4C/ID)

5.1. Basic meaning of the first principles of instruction

The introductory section of Chapter 14 (Merrill, Barclay, & Van Schaak, 2008) in the Strategy part of the Handbook describes and comments on the first principles of instruction. The so-called first principles of instruction refer to a set of illustrative principles brought forward by Merrill in 2002 after summarizing the numerous instructional design theories and models. His conclusion is that these instructional design theories and models need to first follow these common, illustrative principles of instruction, known as the first principles of instruction. The model comprises of the following aspects:

1) The task-centered approach — when using the task-centered approach, learners will find it easier to learn. The task-centered approach comprises the demonstration and application of component skills.

2) The activation principle — when learners activate related cognitive structures, learning will be facilitated. The activation process is guided by such activities and recall, by the description or demonstration of the related prior knowledge and experience, and the effect of activation will be improved when the learners are able to recall or acquire a structure for the organization of new knowledge.

3) The demonstration principle — learning will be promoted when the learners have observed the demonstration of acquired skills and when such demonstration is consistent with the content learned. The effect of demonstration will be improved when the learners become able to associate specific cases with the universal law after receiving guidance.

4) The application principle — learning will be enhanced when the learners participate in the application of newly acquired knowledge or skills and when such knowledge or skills are consistent with the type of content learned. The effect of application will be improved when the learners receive the guidance that will gradually be removed from the subsequent tasks.

5) The integration principle — learning will be promoted when learners integrate new knowledge into their daily life and when such integration is directed towards the reflection, discussion, or defense of new knowledge and skills. The effect of integration will be improved when learners can publicly display their new knowledge or skills.

A typical example of the universal applicability of the first principles of instruction is the remarkable similarity between it and the five-step teaching method designed by the followers of Herbart (1776-1841) (Clark, 1999). These five steps are:

1) Require students to prepare for learning new content (activation);

2) Present newly acquired content (presentation).

3) Associate new contents with previously learned viewpoints (integration).

4) Exemplify the essentials of the newly learned content (demonstration).

5) Test students to ensure they have learned the new knowledge (application).

5.2. The perfect embodiment of the first principles of instruction — four-component instructional design model

The significance and value of the first principles of instruction can be illustrated in two aspects. First, the first principles of instruction advocate the task-centered approach, and second, the first principles of instruction focus on the four principles of activation, demonstration, application, and integration.

5.2.1. The first principles of instruction advocate the task-centered approach

The most important notion in the first principles of instruction is that any effective and attractive teaching is task-centered (i.e., problem-centered). In such a task-centered (or question-centered) teaching scenario, the first step is always to present a question to the students and then teach the related components of the content before demonstrating and explaining to the students how such components resolve problems or complete the task.

Such a task-centered approach (i.e., problem-centered approach) combines problem solving with a more direct teaching of the problem components (i.e., the content component of the problem). This is different from the problem-based learning method. In the problem-based learning method, the students are on a team and given resources and problems by their teacher and asked to construct the solution to a problem of their own accord (the teacher gives minimum or no guidance). Compared with the student-centered approach advocated by the aggressive constructivism in the problem-based learning method, which lacks guidance, the task-centered (i.e., problem-centered) approach emphasizes the need to provide the necessary guidance in the course of teaching. In 2004, Klahr and Nigam conducted a comparative experimental study on the effectiveness of teaching using these two methods. In the experiment, similar students are divided into two groups, with one group receiving task-centered, guided direct instruction and the other group adopting the discovery learning that has only a minimum of guidance. The instruction is intended to help the students grasp the complex variables in scientific experiments. The team receiving the task-centered, direct instruction could observe the demonstration by the teacher and receive the teacher's guidance. On the other hand, the discovery-learning team is encouraged to undertake the experiment and to explore completely of their own accord. The results of the experiment suggest that the students receiving the task-centered, direct instruction made broader and richer scientific judgments about the scientific charts when compared with the discovery-learning team (Klahr & Nigan, 2004).

Mayer (2004) and Kirschner, Sweller, and Clark (2006) prove through various research reviews and comparisons that problem-based teaching methods containing minimum guidance do not work, and task-centered instruction containing the necessary guidance and demonstration is more practical and more popular among the teachers and students.

5.2.2. The first principles of the instruction focus on the four principles of activation, demonstration, application, and integration

The authors of Chapter 14 emphasize that the first principles of instruction are important not only because they are the common principles that all instructional design theories and models should follow but also because any effective teaching process is closely connected with the repeated cycle of activation, demonstration, application and integration (Merrill, Barclay, & van Schaak, 2008). Therefore, the authors of this chapter designate the repeated cycle of these four activities the "four phases of the teaching cycle" (p. 174-175). To achieve the best possible teaching results, the authors of this chapter give specific description about the priorities of each of these four phases based on the conclusions from numerous literature studies.

- At the activation phase, students should be provided with or enabled to generate a mental structure capable of organizing the learned contents and information.
- At the demonstration phase, the guidance provided should be able to help students to connect the new information with this mental structure.
- At the application phase, the training and guidance provided should help students apply this mental structure to complete tasks.
- At the integration phase, students should be encouraged to reflect upon themselves and guided to integrate such mental structures into the mental model to be applied in the future.

The most important and perfect example that can most clearly illustrate the need to advocate the task-centered approach in teaching activities and to give attention to the four principles of activation, demonstration, application, and integration in the teaching activities is the practical application of the four-component instructional design model (4C/ID). The four-component instructional design model (4C/ID) brought forward by Van Merriënboer (1997) focuses on the training of complex learning tasks. This model provides strong support based on the practical research for the notion that the first principles of instruction places the emphasis of teaching on the actual tasks in the real world followed by the teaching of the knowledge and skills of the related content components in the scenarios of such tasks (van Merriënboer, 1997, 2007).

6. The debate regarding the future of educational technology as a result of the changes in direction of technical research

There is a group of scholars devoted to studying the learning science and cognitive psychology in China. They have long been concerned with the field of educational communications and technology (commonly called "educational technology") and have been making an indelible contribution to the development of the educational technology discipline. The translation and publication of the masterpiece of the Handbook of Research on Educational Communications and Technology (3rd edition) in China in recent years is a result of the multiyear painstaking efforts of these scholars.

However, due to the limitations of academic background (learning science and cognitive psychology) and research experiences, the viewpoints of these scholars regarding many of the issues in the field of the educational technology discipline usually differ remarkably from those of scholars who have long been studying the educational technology theory and practice. For instance, given the same problem background and same objective facts, they could arrive at a completely different understanding and conclusions. This is something difficult to agree with.

Consider the Technologies part in the Handbook discussed earlier as an example. These scholars (especially Dr. Zhao Jian with the Learning Science Research Center of East China Normal University) derived two important conclusions while correctly summarizing and generalizing the differences and similarities between the technology section of the third edition and second edition and indicating that the research subject of the technology section of these two editions has the aforesaid continuity and changes (Zhao, 2010).

First of all, they quoted the viewpoint of David Jonassen (2004) described in the second edition of the Handbook by saying that technology is constantly evolving, from hardware, software to design. Then, these scholars summarized the operation of natural objects and artifacts as hard technology and that of human behavior and psychology as soft technology (Jin, 2002, p.30-36).Furthermore, they naturally derived the first conclusion that the current direction of technical research is changing from hard technology to soft one.

The second conclusion they drew pertains to the continuation and extension of the aforesaid first conclusion or the belief that the interest of present-day academia in the educational technology research is going soft (i.e., there is a shift of focus from the operation of such hardware systems as computer, multimedia and virtual reality to the adaptation, guidance, and support of human behavior and cognition). In their own words, the second conclusion can be stated as the software technology research oriented towards learning and cognition is surpassing the object-centered orientation of hard technology research, which has become an apparent trend of the development of educational communications and technology (i.e., educational technology). (Jin, 2002, p.30-36)

The aforesaid two conclusions appear rational to a certain extent, but they (especially the second one) are likely to be pseudo-propositions when viewed from the perspective of educational technology. In fact, this should be very clear when viewed from the perspective of the meaning (the inherent characteristic) of educational technology. It is well known that the inherent characteristic of educational technology (i.e., its qualitative prescription) is the use of various technologies to optimize the educational and teaching processes to achieve the goal of improving the effectiveness, efficiency, and benefits of education and teaching. The "technology" here includes both the tangible physical and chemical technology (which in turn comprise the hardware and software technology) and the intangible intelligent technology; it includes both modern and traditional technology (He, 2012).

The reason the effectiveness, efficiency, and benefits are emphasized in the qualitative prescription of the educational technology is because: (a) effectiveness is manifested by the improved quality of teaching in each discipline and the improved overall quality of the students., (b) benefits are reflected by a greater output with less capital input (for education, greater output indicates the emergence of more talented people), and (c) efficiency is improved when the anticipated results are achieved in less time. Therefore, given this inherent characteristic, the educational technology can also be defined as the technology of how to effectively teach (in short, "the technology of how to teach"). This was exactly how the definition of the application fields of educational technology in China and the Chinese Standard for Educational Technology Capability of Primary and Middle School Teachers promulgated in December 2004 had been developed. As discussed earlier, the "technology" involved here includes both the tangible physical and chemical technology (which in turn comprise the hardware and software technology) and the intangible intelligent technology; it includes both modern and traditional technology. The reason multiple types of technology are included is because they are necessary to achieve the goal of improving the effectiveness, the benefits, and the efficiency. Whether it is the current direction of the technical research changing from hard technology to soft, this is still a controversial question about which people have different opinions. Indeed, as David Jonassen (2004) phrases it:

In the past four decades, the computer has evolved from a bulky, expensive and giant machine into a cheap, handheld device characterized by continuous standby, flexibility and ease of use. Computer application has also evolved from original coaching to a tool for individual inquiry, from typewriting and display to high-definition visual display and immersive 3D computer-supported virtual environment (p.1-400).

However, the research and exploration of the hard technology has not stopped or changed its course, but continues evolving in a way similar to the research into soft technology. At present and worldwide, a giant tide of research, development, and application is forming having to do with the hardware technology of cloud computing (including in the field of educational technology), which is the best example that the direction of technical research has not and will not completely change from the hard technology to the soft.

Even under particular circumstances, there is a need for the direction of technical research to change from hard technology to soft technology. In the eyes of educational technology scholars, such as us, the research on soft technology-oriented towards learning and cognition is not likely to replace the object-centered research on hard technology, not to mention become a remarkable trend in the development of the educational technology in the future. This is because the inherent characteristic of educational technology, as described earlier, is the need to optimize the educational and teaching processes using various technologies to achieve the goal of improving the effectiveness, benefits, and efficiency. The "technology" includes both the hard technology and the soft, and under certain circumstances the soft technology might be given more attention. Such soft technology is by no means limited to learning and cognition, given the meaning and attributes of the educational technology discipline. It is well known that the most essential course of the educational technology discipline is instructional design (also called "instructional system design") and the most important capability of the students majoring in educational technology is "instructional design capability." For instance, the capability to use the system science and methodology to apply "instructional theory" and "learning theory" (the education community generally refers to the theories related to "learning science and cognitive psychology" collectively as "learning theory") in the planning and design of the entire instructional activity process to resolve the various practical problems encountered in the teaching process is a part of this. Instructional design, as the most essential course and the most important capability in the discipline of educational technology, involves at least three theories: the system theory and methodology, teaching theory, and learning theory. Not only one theory oriented towards learning and cognition (i.e., oriented towards "learning theory") that should be given close attention, but all simultaneously.

At present, the fundamental reason a group of scholars engaged in research on the learning science and cognitive psychology in China and around the world have lost the focus on the aforesaid issue (by emphasizing learning instead of teaching and by focusing on the learning theory related to learning science and cognitive psychology while ignoring all of the other theories) is that they did not carefully examine the logical starting point of the "educational technology discipline" or the "learning science and cognitive psychology. They failed to conduct an in-depth, comparative study of the difference between the logical starting points of these two disciplines (the logical starting point of the learning science is apparently "learning), while that of the educational technology discipline is "technology-enabled education" (He, 2005). The various logical starting points mean that the nature, meaning, research content, and theories of these two disciplines naturally differ remarkably from each other. As a result, these scholars, without any knowledge regarding the nature and meaning of the educational technology discipline, take for granted confusing these two closely connected (but by no means equal, let alone interchangeable) disciplines. This effect is disappointing and makes me deeply concerned regarding the development of the educational technology discipline.

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