Mehmet Akif Ersoy Üniversitesi
Sosyal Bilimler Enstitüsü Dergisi
ISSN: 1309-1387
Yıl. 2 Sayı: 3 2010-Güz (s. 139-147)

From The Dynamic Infrastructure of Mind to the Multiple Intelligences Profile: A Challenge for Curriculum Design*

Zihnin Dinamik Altyapısından Çoklu Zeka Profiline: Müfredat Tasarımı İçin Bir Meydan Okuma

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Abstract

The dynamic infrastructure of mind (DIM) consists of several clusters of operations that are foundational for learning. DIM acts as a cognitive processing mechanism that is domain-general. How does a domain general mechanism allow the development of multiple intelligences? This article presents two kinds of connections between Multiple Intelligences Theory (MI) and DIM: one refers to cognitive development, and the other to applications in teaching and learning. To deal with the environmental factors, the DIM crosses a combined process of modularization and specialization along development, during which some components specialize for specific inputs. In this process, DIM engages the available strengths and weaknesses that constitute the neural constraints specific to an individual and develops a network of properties that allows the MI profile. Using multiple learning contexts and a curriculum design that stresses on the DIM operations, domain specific learning is enhanced.

Keywords: Cognition, Curriculum, Domain specificity, Dynamic infrastructure of mind, Operation

Özet

Zihnin Dinamik Altyapısı (ZDA) öğrenme için bazı operasyonlar demetini içerir. ZDA genel bilgi alanı olan bilişsel bir süreç mekanizması olarak hareket eder. Bir genel bilgi alanı mekanizması çoklu zekaların gelişimine nasıl izin verir? Bu makale Çoklu Zeka Teorisi (MI) ve ZDA arasında iki tür bağı sunar: birisi bilişsel gelişimine diğeri öğrenme öğretme ve öğrenmedeki uygulamalarına atıfta bulunur. Çevresel faktörlerle başa çıkmak için ZDA, bazı bileşenlerin özel girdiler için uzmanlaştığı gelişim

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* This study was presented as a poster proceeding at The First International Conference of Living Theorists “Howard Gardner” held by Mehmet Akif Ersoy University in Burdur, Turkey between 23-24 May 2009.

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boyunca birimlere ayrıştırma ve uzmanlaşma boyutlarını kesiştiren bir işlev görür. Bu süreçte, ZDA bir bireye özgü sinirsel kısıtlamaları oluşturan ve MI profiline izin veren özellikler ağını geliştiren mevcut güç ve zayıflıkları birbirine bağlar. Çoklu öğrenme bağlamlarını ve ZDA operasyonlarını vurgulayan bir öğretim programı tasarımını kullanma yoluyla özel bilgi alanının öğrenilmesi geliştirilmiş olur.

Anahtar Kelimeler: Bilişsel, Müfredat, Bilgi alanı özgüllüğü, Zihnin dinamik altyapısı, Operasyon

Introduction

A large gamut of research shows that infants have amazing capabilities in perceiving amounts, the rhythms of multisilabic stressed words, the spatial layout, etc. Some researchers viewed these capabilities as evidence for innate modules that are encapsulated (Fodor, 1983). Others considered that babies show cognitive biases for some basic domains such as mathematics, language, or physics (e.g. Spelke, 2003). Another line of research emphasized a progressive modularization along development (e.g. Karmiloff-Smith, 1992). Among these theories, the concept of the dynamic infrastructure of mind (DIM) focuses on the general properties of mind seen from a dynamic perspective (Singer, 2009). DIM consists of several clusters of operations identified as foundational for learning. Each of these clusters contains inborn components that are further developed in the interaction mind-environment. With its seven basic categories of operations: associating, comparing, quantitative operations, logical operations, topological operations, iterating, and generating, the DIM acts as a cognitive processing mechanism that is domain-general. The question addressed by this article comes in this context: how does the dynamic infrastructure of mind as a domain-general mechanism lead to the multiplicity of mind?

The article presents two kinds of connections between MI and DIM: one refers to interactions along cognitive development, and the other to applications in teaching and learning; one is psychological in nature and the other is didactical. Although some of the conclusions are empirically based, this article is a theoretical essay.

Methodology

Evidence for the DIM comes from a detailed analysis of many empirical studies on cognition in the first years of life, as well as from a 4-year longitudinal study of teaching and learning mathematics in primary school. The participants in this last study were 232 children in nine experimental classes. The experimental program tracked children from grade 1 to grade 4 (aged 6-7 to 10-11 years). The teachers received detailed description of the tasks that they were going to offer to students, and the teaching periods were followed by discussions, on a weekly basis. The description of the learning activities is contained in four teacher's guides (Singer & Radu, 1994-1997). On short, the technique consists in activating creative abilities by resorting to game-like tasks.

Beyond quantitative data obtained in this study, some qualitative aspects revealed by the classroom observations are more relevant for the experimental research and for this essay. Thus, in computing, the outcomes were similar in experimental and control classes – except that the results were more homogeneous in the first group and with a greater dispersion in the second. Concerning problem solving capacities, however, significant differences have been recorded. Most students in the experimental classes showed awareness of the text meaning, facility and desire to devise problems, and a preference to explain through concrete objects or other models, while students in the control group were frequently unable to discriminate redundant or missing data. Moreover, in the experimental classes students seemed to put an emphasis on a goal-oriented activity, while most students in control classes seemed to reason disconnectedly on "atoms of problems" and a certain "structural disorder" was obvious.

Findings and Further Developments

These observations led to a more systematic approach of the learning process within the categories of operations performed by the students and their different intellectual profiles.

From DIM to MI - Some Theoretical Issues

The key aspect that relates DIM to MI is functional specialization. Briefly, in order to deal with the environmental factors, the DIM inevitably crosses a process of progressive modularization along development, where some components specialize for specific inputs. In this process, DIM engages the available strengths and weaknesses that constitute the neural constraints specific to each person. DIM acts as a domain general information-processing mechanism within which multiple components concur to generate behaviors that respond adequately to environmental stimuli. In this process of adequating the response, DIM's procedures specialize for the problem domain by recruiting specific mechanisms (operation plus domain) to solve specific problems. Within the view of weak modularity (e.g. Pinker, 1997), the specialization of the cognitive system is in some way heuristic (Barrett & Kurzban, 2006) and depends on some inborn predispositions. Barrett and Kurzban (2006) argued that many systems, including central ones, might have wide access but narrow processing criteria. Thus, only information of certain types or formats is processable by a specialized system. For example, systems specialized for speech perception will process only transduced representations of sound waves; or, although eyes and ears are exposed to both light and sound, eyes process only light, and ears process only sound.

In order to respond adequately to environment, inborn components of the cognitive system specialise transducers that become domain-specific. These structure the bio-psycho-physiological potential for solving specific problems. Because the social environment induces interactions and asks for response, new transducers that process specific inputs are activated. For example, specialized transducers process attachment or hostility. In adition, these transducers depend on individual characteristics: for our example, it is easy to observe that people are more or less sensitive to attachment or hostility manifested within a group. These transducers drive the potential of creating artifacts culturally relevant in a certain community. The bio- psycho-physiological potential for solving specific problems, as well as for creating artifacts culturally relevant in a certain community is what Gardner (1983, 2006) called intelligence.

In the same time, as a general processing mechanism, DIM has the capacity to identify certain weaknesses, and to mobilize itself to find alternative ways to solve problems. For example, the difficulty in orientation in the spatial layout might be compensated by memorizing reference points on a map and on the terrain. The inborn dynamic nucleus multiplies at the level of each intelligence and develops a network of formal properties that allows interactions among specific intelligences, which lead to a MI profile.

From DIM to MI – Ways to Enhance Learning

In general terms, education is meant to expose new generations to the knowledge domains as they developed along the cultural history of mankind. From here comes another dimension of domain-specificity in learning: a domain of knowledge has structured a specific way of thinking. It follows that there is a need of domain-specific training in order to specialize cognitive mechanisms for the specific way of thinking of a domain. Moreover, to make this training optimal, it should focus various levels of expertise. The application of the DIM model led to identifying dynamic thinking structures that might be trained in order to generate expert behavior in students. This predicts a more economical way of using mental resources for learning.

Initiated as a general information processing mechanism, the DIM specializes within knowledge acquisition and acquires domain-specificity very early in life. There are at least two aspects to be considered. On the one hand, this specificity helps the processes of specialization and automatization of behavior. Experimental work with adults has shown that, in consistent mapping conditions, in which distractors are gradually interfering in a field of invariant conditions, automaticity can be achieved with practice (e.g. Palmeri, 2002). The school system has proved that basic skills such as reading and writing are relatively easy automatized in young children (and relatively more difficult in adults). Within the DIM paradigm the challenge is to automatize operatorial schemes in order to optimize cognitive processes. Experiments made in school settings seem to converge on the idea that systematic practice of the operational categories of DIM in a range of controlled variability could have an effect on the transfer of some components of these operations to the ‘‘background’’ of conscious thinking (Singer, 1995, 2007), that is, they become elements of automatic processes.

However, the real-world problems do not have pre-defined domain specificity. Therefore, a processing mechanism has to mobilize domain-specific tools to approach a problem, and to select the inputs to be processed by specific operatorial components. Therefore, domain-specific training is not enough; it has to be doubled by transfer training. Here comes the second aspect involved by domain specificity in learning. A systematic transfer training within the DIM makes the system capable of optimizing the selection of the inputs by facilitating the correlation between the inputs and the adequate processing sub-mechanisms.

The training of transfer – which is a necessary consequence of accepting the DIM model in cognitive development – is more effective when based on MI theory. Transfer does not implicitly happen (e.g. Gentner, Holyoak, & Kokinov, 2001), and this is why the training for transfer should be made explicit. To reach this target, the training methodology has to connect skills’ formation and their integration into more complex thinking structures into a dynamic network of activities.

DIM proposes a general framework for the computational endowment that constitutes the core of emergence of each intelligence. Most of the applications of the theory of multiple intelligences in school tried to rely on the more developed intelligences of each student and proceeded to organize the training using a communication tool that is dominant for that intelligence. A slightly different type of MI application in the teaching practice supposes two stages for curriculum development: first, identifying some structural developmental elements in a knowledge domain in relation to the strengths of a related intelligence, and second, transforming them in procedural tasks that emphasize the operational clusters of the DIM. To better respond to individual needs, the procedural tasks are assorted with cultural artifacts/ actions based on individual strengths in areas that are, eventually, at a far distance from the core intelligence relevant for that domain of knowledge. For example, in learning addition in the first grade a child with a dominant logical-mathematical intelligence might focus on procedural tasks that operate on the number line, while a bodily kinesthetic kid uses concrete objects and icons for dynamic representations of the union of two sets. The target is to build a domain-specific intellect using the operational and conceptual tools available for each individual and optimizing the process by attuning individual strengths to the typical procedure of the most domain-related intelligence.

The Curriculum Design in Practice : Cycles of Learning

If we accept the hypothesis of a progression from DIM to MI, then the curriculum should move along schooling from general to specific, from integrating to specializing. This actually happens, in general terms: roughly, in primary education things and activities are more integrated, while in secondary there is a progression towards more specialized disciplines. However, statistical data show that the “integration” of primary does not take into account the transfer training and the “specialization” of secondary does not operate satisfactorily with the specific way of thinking of a discipline.

As presented above, domain specific learning is enhanced when using multiple learning contexts and a curriculum design that stresses on the DIM operations that are included in domain specific procedures. This kind of training supposes identifying and developing optimal individual pathways in a multidimensional network. The practice of procedural tasks on the one hand and of transfer on the other hand might be organized within a constructivist didactical process in three major phases of the teaching and learning cycle. These were called: Immersion, Structuring, and Applying (Singer & Moscovici, 2008), albeit these labels do not cover the complexity of actions to be taken under this framework.

Immersion aims at using the general mental resources to create bridges to the new domain-specific knowledge. During this phase, students get immersed into the problem - address and use previous knowledge, seek more information, plan and perform experiments, and, based on all these resources and processes, identify tentative pattern(s). The students learn to select pertinent knowledge from what they know realizing that personal knowledge might prove insufficient and deciding to look for resources (including library and Internet), and to judge resources in terms of reliability of information. Students also learn to correlate between variables and experimental results (hypothetical-deductive/ hypothetical-predictive, if-then type), understand limitation of experiments, and become familiar with the use of higher-order thinking skills such as synthesis, analysis, or the creation and expression of a complex solution to a problem. Moreover, students constantly shift between concrete (e.g., personal experiences relevant to the problem under scrutiny) and abstract (e.g., understanding patterns underlying peer's concrete examples or described in texts) while making first trials to solve the problem.

During the Structuring phase, students move to another level of understanding when they interpret their concrete experiential results from the Immersion phase and adjust the pattern. They explain the claim developed during the previous phase in terms of examples and counter-examples, and create new situations in order to challenge their own claim and to add to the generalizability of the knowledge they produced. Students move during this phase from the concrete aspects of experimentation into the complex and multifaceted conditions of real life problems. They also move from concrete into abstract during the generalization process, when they shift from a specific solution for a specific problem to finding solution(s) for classes of problems.

During the Applying phase, students learn to use the abstract pattern that they developed into related and unrelated situations, and they modify/adjust their pattern to be more generalizable and applicable in a wider range of situations. They apply learned concepts and patterns to new situations by trying to solve existing problems, and by creating/describing new hypothetical or realistic situations that need solving. These processes lead to a more generalized pattern that identifies constraining elements.

Immersion, Structuring and Applying, as stages of constructing knowledge in classroom settings, advance from integrated learning to domain specific understanding within a teaching and learning cyclical process. The target is to transform internalized structures into dynamic ones (i.e. ability to solve various problems in various contexts by identifying the invariants). These recurring cycles of understanding provide the space in which the individual attunes his/her strengths to the ones of the domain and the related typical intelligence.

Conclusion

From a cultural-anthropological view, each domain of knowledge developed a way of thinking, which is intrinsic to that domain. Specialized thinking modalities might be the focus of an effective training in a domain-specific approach. There are multiple pathways to achieve knowledge, but in order to optimize learning and understanding the training may systematically incorporate the basic mental operations, together with systematic passages in between them. Moreover, from an epistemological view, the dynamical infrastructure is developed within each core domain and thus, it comes to be predictable that, by using it in teaching, the specific code and procedures of the domain to be learned are better internalized.

As stressed above, the DIM hypothesis suggests that, instead of focusing educational training on information acquisition, it would be more efficient to focus it on the basic mental operations. Instead of a multitude of drill and practice exercises that parse the knowledge in small chunks making the whole difficult to perceive, an operations-based curriculum can stimulate the dynamics of connections. This moves the didactical approach from a "horizontal" way of perceiving teaching: islands of information to be transmitted, to a permanent process of "vertically" restructuring students' knowledge by incorporating the new elements into a dynamic structure. Particularly, this implies the systematic practice of the basic operations by creating patterns of variability. Strategies for optimizing dynamic stability of learning acquisitions are still to be developed and observed through empirical studies.

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