

# They Call It Learning Style But It's So Much More

Erica Melis  
German Research Institute for Artificial Intelligence  
D-66123 Saarbrücken, Germany  
melis@dfki.de

Rachada Monthienvichienchai  
London Knowledge Lab  
Institute of Education, University of London  
23-29 Emerald Street, London WC1 3QS, UK  
P.Monthien@ioe.ac.uk

**Abstract:** The questions of how important a learner's 'learning style' is for the learning outcome needs to be investigated for learning environments: (1) for a didactically flexible design and possibly for an adaptation to the individual learner and (2) for a differential evaluation of learning systems. Many dichotomies of learning styles have been investigated empirically. For several reasons, the implications for education systems are not straightforward, however: learning outcomes are influenced by many variables, some of which seems more relevant than learning styles. Learning styles in turn depend on variables such as learning situation and domain. As a conclusion we suggest an open learning environment that offers a variety of learning objects (LO) and can serve several learning strategies. This is in line with research on learning events and their balancing as well as with using 'learning styles' as a metaphor for facilitating communication between teachers and learners.

## Introduction

The psychology of human differences is fundamental to learning and it opposes a one-size-fits-all approach to education. Therefore, for a learning environment to be optimally effective, it should capitalise not only on contextual but also the learner's characteristics. The acknowledgment of the relationship between individual differences and education has a long history.

The developments of the Web and eLearning technology provide new technological means for a personalised learning experience; however, Adaptive eLearning technologies have to be based on theoretical and empirical findings about the effects of adaptation-dimensions in dependence of the various dimensions/variables of the learner to which to adapt. The empirical (psychological) investigations are known as research on Aptitude-Treatment Interaction (ATI) and go back at least to research by Cronbach and Snow (1977) which changed the thinking and research on human abilities in the 1970s. Later, Shute (1992, 1994) and Swanson (1990) investigate how initial aptitudes of the learner can be mapped onto optimal instructional environments.

While students' ability to adapt while learning should not be underestimated, the mental effort of adaptation produces cognitive load, which should be reduced in order to free it for the actual learning processes. Some teachers who subscribe to this view of minimising the cognitive load of the students say they adapt their classroom teaching to individual students by making use of the student's 'learning style' profile or whatever they mean by cognitive style.

This paper discusses the relevance of several characteristics of learners and learning context for adaptive system. It presents a report of a preliminary study into how secondary school teachers actually use learning style in their classroom and an overview of research on learning styles. The paper critically evaluates its results, and – as a conclusion – suggests implications for adaptive learning systems.

## Adaptation

The adaptation to the learner and her environment has several dimensions:

1. Customisation
2. Contextualisation
3. Personalisation

The technical equipment is part of the learning context and some functionalities of the learning system have to be **customised** to the equipment data. For instance, a handheld cannot present as many objects at the same time as a large screen. Additionally, some browsers for handheld devices, such as Microsoft Pocket Internet Explorer, are not fully compliant with W3C standards and therefore may have problems displaying mathematical formulae and some rich media content.

We want to focus, however, on the learner's characteristics. An important **contextual** dimension is the school curriculum and syllabus, which are part of the external environment that the teacher or student may not have an influencing control over. Some contextual information, such as the two already mentioned, are clearly defined while others, such as cultural and geographical context are difficult to define let alone translate into concrete requirements for an adaptive learning system. Other contextual parameters that are worth deriving concrete requirements for are home vs. in classroom use of the system.

Customisation and Contextualisation deal with the needs of a cohort of individual learners rather than a specific learner. For example, personalisation for student A, who is revising for a Grade 10 Geography exam in France, would be the same as personalisation for student B who is doing the same thing. Situational adaptation personalise the learning experience on an individual basis.

**Personalisation** includes the adaptation to more static aptitudes of the learner and to those that are more dynamic and have to be delivered Just-In-Time (JIT). For instance, adaptations may be necessary for handicapped learners (e.g., larger fonts or audio output only) but also for a learner whose motivation dropped considerably at a particular point in time.

Personalisation needs to take into account a particular student's current psychological states and understanding, and constructs the personalised learning experience to deal with the specific needs of that student. It is possible to say that it is at this level of personalisation that the learning experience is truly personalised. Having received the LOs following customisation and contextualisation adaptation, the student may still experience difficulties while interacting with these LOs. JIT adaptation requires the learning system to be able to diagnose and react to such difficulties in a pedagogically meaningful and effective way. At this stage, one of the most important personalisation variables is the level of the student's knowledge. For example, student A in the above example may need to remediate a certain topic because there is a weakness in her understanding on that topic. On the other hand, student B, having worked the whole day on the topic, may want just an overview of the syllabus to make sure that she has not missed anything at the higher general level for the exam. In this case, the motivation, learning goals and the state of the two students' knowledge of the domain (and certainly the motivation and learning goals as well) are very different. Another possible scenario for personalisation: in reaction to a student experiencing difficulties with a LO, the system finds alternative LOs that are suited to different or opposite learning styles (e.g. different type or level of description, shorter or less abstract) to the LO that the student is having difficulties with – note that this does not involve the diagnosis of the student's learning style preference. Whatever the process or level of adaptation implemented by a learning system, personalisation must be reflected not only in the content's presentation but also the actual content itself (i.e. concepts, abstractness, process: learning events, different types of exercises).

### How much personalisation?

It is possible to argue that the more characteristics of the learner and her situation are taken into account, the more individualised the learning experience, the better; however, the characteristics and situation of learners differ in too many ways and not every difference can be diagnosed and considered. Given the restricted (technical) feasibility, a very detailed personalisation may, indeed, be questionable.

How much personalisation should be carried out by a system? In order to answer this question, a good place to start is to investigate the level of personalisation and the processes actually involved during a 1-to-1 tutorial. In this

situation, the tutor is less restricted by resource limitation and other factors that may hinder the implementation of personalisation in instruction.

A preliminary study in classrooms indicates that personalisation in such a situation is often carried out just-in-time and at 'crisis point', i.e. when the student is having difficulty with a certain part of the syllabus. It is this level of adaptation in the classroom that is most closely related with 1-to-1 tutoring. However, it is worth pointing out that even at this level of adaptation in classroom learning, there are still limits to which personalisation is desirable. That is, in most cases, students learn to achieve certain goals that are often, in this context, set by a community of practice (Wenger 1998) that the students are aiming to join. In other words, over-personalisation could result in the invalidation of the students' learning experience with respect to the community of practice that they want to join. This is particularly the case in secondary education where the attainment is assessed more rigidly than at tertiary (university) level.

## Learning Style Research Overview

Several researchers have conducted research on learning style (see (Sternberg and Grigorenko, 2001) for an overview). Among them, Coffield et al. (2004) performed a theoretical analysis and evaluation of learning styles and identified 69 learning styles and their dichotomies, 13 of which were considered to be non-derivatives of other learning styles. Additionally, they also placed these 13 learning styles on a spectrum of learner vs learning method categorization; for example placing the Honey & Mumford (1992) and Kolb (1984) models at the learner-categorisation end while placing Entwistle (2001) and Vermunt (1998) models at the learning-categorisation end. The main distinction being made here is that some learning styles aim to categorise the learner preferring a certain learning style, while others aim to describe a variety of styles actually deployed by a single student.

While Coffield et al. (2004) conducted a primarily theoretical review of learning style research, some of the more important dimensions of learning styles/cognitive styles that have been empirically investigated include:

- Verbal vs. Visual (whether learner is inclined to represent and learn information verbally or in mental pictures – also known as VAK).
- Holist vs. Serialist were differentiated by Pask (1976) while other authors, such as Riding and Rayner (1998) call this dichotomy Holist vs Analytic (whether learner tends to organize and learn information in holes or parts). Typical models of that group include Field-dependence vs Field-independence (Witkin 1997), Leveler vs. Sharpener and Impulsive vs Reflective (Riding and Rayner 1998)
- Pragmatist vs. Theorist (whether learner prefers ideas that emphasize rationality or content with practical applications) are learning styles used in INSPIRE and 3DE projects (Salojarvi et al. 2001)
- Reflector vs. Activist (learning styles in INSPIRE project) (Grigoriadou et al. 2002)
- Logical vs Mnemonic strategy was distinguished by Goldman (1972)
- Marton (1988) observed the following 'phenomenon'
  - Deep processing (seeking meaning)
  - Shallow processing (reproducing)
  - Strategic (reflective organizing)
- Individual learning strategies as well as problem solving strategies are another dimension of learning style. However, as Siegler (2002) has shown, students show a high variability in strategy choice and the likelihood biases for those choices develop over time and experience.

Some authors combined learning styles with motivational influences

- Syllabus-bound vs. Syllabus-free (Entwistle and Wilson 1977)
- Converger - Diverger - Assimilator – Accomodator (Kolb 1984)
- Deep processing - methodical study - fact retention - elaborative processing (Schmeck 1988)

This problem of categorisation is made worse by the fact that, not only are there a multitude of different categories but also that there seems to be very little communication and collaboration between those involved in constructing learning style models (Coffield et al. 2004). Consequently, learning style models are diverging rather than converging to form a coherent and consistent research discipline.

### **Learner Style vs. Learning Style**

Some of the investigations on styles confuse learner style and learning style. The first one means the learner's (mental) preferences and the second her actual style of behaviour. Correspondingly, one is rather static while behavioural evidence is more dynamic. Moreover, the methods for determining them differ: questionnaire vs. behavioural diagnosis.

For instance, the Verbal-Visual learning preference (as measured by behavioural tests) is distinct from Verbal-Visual cognitive style (as measured by responses to more general questions). The situational nature of instruments in authentic multimedia tasks uncovers the difference between measures of cognitive style and of learning preference.

### **Importance of Cognitive Style Relative to Other Individual Variables**

Adapting the environment to suit 'learning style' of the learner is only a fraction of the story. There are many ways that a learner is unique that results in special needs that must be met. Among those characteristics of the learner that influence learning outcomes are:

1. existing knowledge and skills
2. cognitive abilities
3. working memory capacity
4. motivation
5. personality traits
6. interests
7. exploratory behaviour
8. impulsivity
9. and learning style

The parameter that most frequently governs adaptivity and adaptive presentations and responses in existing intelligent tutoring systems and adaptive hypermedia is the learner's existing knowledge and skills. Indeed, there are many studies showing that general knowledge and skills make a significant difference in learning.

Aptitude-Treatment-Interaction can be an artefact in experiments. For instance, in (Cronbach and Snow 1977), most of the hundreds of studies of aptitude-treatment interaction were methodologically flawed (personal communication with Kurt van Lehn). They failed to separate general ability/knowledge from cognitive aptitudes. For instance, if cognitive style was checked but not the general ability of the subjects, then an interaction of cognitive style and treatment/performance could be a pure artefact. Moreover, ATI experiments may have captured a special situation as compared with real-world classroom learning and, therefore, may be ecologically invalid.

Merrill (1999) even denies a primary role of learning style for success of learning. He concentrates on scientific principles for instructional strategies and design to be consistent with the instructional goal. Therefore, he considers learning styles to be effective for fine-tuning an instructional strategy only. This is similar to adapting to learning styles at 'crisis point'.

Attempts to intervene directly in student learning by teaching stand a limited chance of success. Such interventions are themselves part of the context of learning (Ramsden 1988). A reason for this lies in the hermeneutics for interventions, which are created in a subjective context rather than neutral. One of the main weakness in the application of learning style is that learning style attempts to intervene with teaching and learning without taking into account the complex context of the teaching and learning environment, i.e. it is a decontextualised view of learning and the learner (Coffield et al. 2004).

Moreover, the acquisition of different types of knowledge and skills require different conditions for learning. That is, there are more parameters to which to adapt to than those characterising the learner, e.g. the domain, the pedagogical strategies and the learning context.

There is also evidence that consistent instructional strategies are determined primarily on the basis of the type of content to be taught or the goals of the instruction (the content-by-strategy interactions) and only secondly, learner style may determine the value of the parameters that adjust these fundamental learning strategies (learning-by-

strategy interactions). The content-by-strategy interactions take precedence over learning-style-by-strategy interactions regardless of the instructional style (Merrill 2000).

### **Theory, Empirical Research, Practice**

There is not yet a psychological theory supporting learning style treatment interaction. Discussions among psychologists address a differentiation between learning styles, individual characteristics, psychometrically-found reasoning abilities, strategies of information processing, and differential-psychological concepts. They address the dependency of learning style on learning tasks, situation, and motivation. According to Sternberg (2001), a consensus emerged that learning styles represent (motivationally influenced) choices in the face of environmental stimuli. This is an extremely broad and difficult to operationalise definition.

In fact, a preliminary study into how 12 secondary school teachers in the UK actually use learning styles in their classroom reveals that:

1. teachers aim to teach or create materials with a balance of learning style with respect to the implicit learning style model(s) that they have adopted. That is, they often do not try to match a certain style with an individual student, but to appeal to a balance of learning styles in the classroom, thus presenting choices for the students.
2. when teachers do change teaching materials to meet the needs of a specific student who is perceived to have a certain style, the teachers do far more than just change the material from one style to another. For example, a teacher who uses the VAK learning style model, when changing from a lecture about the history of the Second World War to a video, may not only be changing from auditory to visual material, but also:
  - a. change from descriptive to first-person narrative material, or vice versa, i.e. changing from a material that the student has little means of empathising with to one that allows the student to 'live' the events.
  - b. change from chronological description of event to a more generalised description of event based on the experience of different groups of people involved, e.g. jumping to and from accounts by an allied soldier to a French citizen in occupied France to a German citizen in Nazi Germany.

The findings of this study indicate that, while the pedagogic implications of learning style theory are unclear and conflicting (in that it does not comprehensively prescribe the best course of action for specific learning style profile), it seems that the teachers refusal or failure to adhere to strategies for changing the material as prescribed by learning style theories is what is making 'learning style' effective in the classroom. This irony is further underlined by the attitude of the teachers, who even when confronted with the fact that learning style is not the 'magic wand' in the classroom, were unwilling to give up the practice of using what they call 'learning style'. The main reason that was given was that, in a teaching environment (such as that of the UK) where the curriculum and syllabus are rigidly prescribed to the teachers (sometimes even down to 5-minutes segments), learning style offers a legitimised means of varying and creating richer teaching material. The fuzziness of the meaning of 'learning style' does not limit what the teachers can do, but instead presents a space in which teachers can apply their creative teaching skills.

The findings of the study underlines the fact that the learner is unique in many respects and an appropriate reaction to the learner's and situational peculiarities can be very complex (for human teachers and for systems as well). Still, the teachers' views and practice may be different from what is needed or useful in non-classroom situations, such as in a museum or at home in the case of a self-directed learner, when perhaps the community of practice does not play such an prominent role. Intelligent tutoring systems have mostly been tackling self-directed learning and comparing that with 1-to-1 tutoring. Consequently, it may be the case that in such a situation, adaptation to the individual learner may be more important and not only temporary, as is the case in classroom practice.

There is also evidence that consistent instructional strategies are determined primarily on the basis of the type of content to be taught or the goals of the instruction (the content-by-strategy interactions) and secondly, learner style determines the value of the parameters that adjust these fundamental learning strategies (learning-by-strategy interactions). The content-by-strategy interactions take precedence over learning-style-by-strategy interactions regardless of the instructional style (Merrill 2000).

## Implications for Adaptive Learning Environments

Given that a theoretical basis for the interaction of learning style with pedagogical treatment/instructional design is missing and some empirical results may not be fully reliable, we hesitate to adapt a learning system's instruction and choice of pedagogical strategy to learning style without further empirical evidence or validation.

Implications for the pedagogical design of learning environments include the provision of variability in the sense that "creating a course that is varied in its approaches can help to motivate all students and keep them involved" (Palloff and Pratt 2001, p.112). A real-world realisation of this could involve offering the student choices of different learning objects (LO), of different presentations of the LO (e.g., visual, textual, symbolic), and ways to learn, e.g., holistic and serial may lead to best results in terms of synergy of individual preferences and characteristics with the learning environment. Additionally, scaffolding may suggest prioritised LOs. Consequently, we advocate a learning environment that is open in the sense that it offers these choices.

Independent of the adaptation of learning objects, in terms of their sequencing and presentation, learning styles can be a useful tool in raising student awareness of their own styles or preference while learning. By providing a language with which students can communicate with their teachers about their learning and discuss how it can be improved, learning style may have more benefits in terms of creating students who are more responsible for their own learning, than as a strategy for matching learning materials to certain learners. Again, it seems that it is the ambiguous nature of learning style theory implications for pedagogy that is allowing such meta-cognitive learning activities to take place – it is easy for a student to talk about their learning style without having to study learning style description in great details. It may be possible to argue then that the adoption of learning style in teaching practice does not in itself improve learning, but facilitates or supports other activities that do.

Possible adjustments of instructional strategies according to learning styles include:

1. content sequence: cognitive-restricted learners and serialists learn better from content arranged in logical sequence and prefer each topic in order. Cognitive-flexible learners or holists learn better when they can select on their own and getting the whole picture before studying each topic in detail. Holists prefer an inductive sequence with examples and demonstrations prior to figuring out a definition or seeing steps listed. Serialists prefer deductive sequence with definition or list of steps first prior to examples and demonstrations.
2. Visual learners learn best when information is presented in graphic form. Verbal learners learn best with textual presentations. Thus, several presentations have to be available.
3. Holists tend to have a problem with under-generalisation; they need to see more divergent examples. Serialists tend to over-generalise; they need to see more matched example non-example pairs to facilitate discrimination between examples and non-examples; however, those tendencies are heavily influenced by the learning domain.

The following adaptations have been investigated with results that are not counter-intuitive:

1. learners evidencing greater exploratory behaviour learn better, if they are assigned to the inductive environment, and less exploratory learners benefit from the more structured application environment (Shute and Towle 2003)(Shute 1993)
2. learners with low inductive reasoning skills perform better, when the concept is presented at the outset of the instructional sequence.
3. low working memory capacity learner should receive smaller units of instruction (Shute 1991)
4. if learner's preference is on contextualized learning experience, i.e., very concrete and experiential, then instead of starting with an introduction unit, start with an assessment/problem.

## Conclusions

We have expressed our scepticism concerning the viability and validity of using learning style of the learner to adapt or personalise a learning environment to suit the needs of the learner. In particular, we are concerned about the validity of the pedagogic implications following a learning style profiling of a learner. Learning style theories do not provide a clear methodology for reliably deriving the appropriate pedagogic strategies even if learner's profile could be obtained with reliability and certainty.

However, it is possible that we are asking too much from learning styles. Empirical studies have demonstrated that the intuitive semantics of learning style can be a useful tool for supporting communication between student and teacher, encouraging the student to reflect on his/her own learning experience and actively seek different ways in which it can be improved. This is surely a vast improvement on a student who merely 'sponges' whatever he/she considers as knowledge from the teacher.

Additionally, while there may not be a valid and comprehensive method for deriving pedagogic strategies solely based on the learning style profile of the learner, it may still be useful in adaptive learning environment. A common feature of learning style models is a description of the learner or learning with respect to dichotomies. A possible application of this in adaptive learning environment is to use learning style when a learning object is perceived to be inadequate. If that learning object can be described as appealing to a certain learning style, then a strategy that aims to provide alternative LOs from an opposite end of a learning style dichotomy may produce LOs that have a better chance of being more effective than the original failed LO.

To conclude, we have the following issues and questions, which we suggest and will be investigating:

1. So far learning styles are not based on variables specific for communication or collaboration.
2. There is a huge number of potentially relevant learning styles for adaptive learning systems. Are these models appropriate for operationalisation in adaptive learning environment? Additionally, for models that are operationalised and validated for higher education, can they be operationalised for application in the K-12 education setting?
3. We have already mentioned learning style as a useful communication tool between student and teacher. However, would learning style also be useful for teachers as metaphor for a complex process/condition for adaptation? That is, while the theory of learning style needs further development, does the addressing of learning style allow the teacher to begin to deal with the complex nature of personalisation rather than be overwhelmed by its demands?
4. Finally, how exactly does learning style help with meta-cognitive learning and how can the associated processes of learning through this mean be effectively supported by an adaptive learning environment?

### Acknowledgment

We thank the following researchers for information and discussions: Kurt van Lehn, Valery Shute, Dominique Verpoorten (University of Liege), Faezeh Seyedarabi (IOE) and Don Peterson (IOE) This publication is partly a result of work in the context of the iClass project, funded under the 6th Framework Programm of the European Community (IST 507922). The authors are solely responsible for its content. The European Community is not responsible for any use that might be made of information appearing therein.

### References

- 3DE Project – <http://www.3deproject.com/>
- J. Biggs (2001). Enhancing learning: A matter of style or approach? In R.J. Sternberg and L.F. Zhang, editors, *Perspectives on Thinking, Learning and Cognitive Styles*. Lawrence Erlbaum, Mahwah, NJ, London, 73-102
- F. Coffield, K. Ecclestone, E. Hall and D. Moseley (2004). Learning Styles and Pedagogy in Post 16 Education (full printed version to be published at the end of April 2004). Learning and Skills Development Agency, UK <http://www.ncl.ac.uk/ecls/research/education/cll/research/LearnStylesPedPost16.htm>
- L.J. Cronbach and R.E. Snow (1977). *Aptitudes and Instructional Methods*. Irvington, New York.
- Coffield (2004)
- N.J. Entwistle and J.D. Wilson (1977). *Degrees of Excellence: The Academic Achievement Game*. -, London, 1977.
- N.J. Entwistle, V. McCune and P. Walker (2001). Conceptions, Styles, and Approaches Within Higher Education: Analytical Abstractions and Everyday Experience. In R.J. Sternberg and L.F. Zhang, editors, *Perspectives on Thinking, Learning and Cognitive Styles*. Lawrence Erlbaum, Mahwah, NJ, London, 103-136
- R.D. Goldman (1972). Effects of logical versus a mnemonic learning strategy on performance in two undergraduate psychology classes. *Journal of Educational Psychology*, 63:347–352
- M. Grigoriadou, K. Papanikolaou, H. Kornilakis and G. Magoulas (2002) INSPIRE: an Intelligent System for Personalized Instruction in a Remote Environment. *Hypermedia: Openness, Structural Awareness, and Adaptivity*, International Workshops OHS-7, SC-3, and AH-3, S. Reich, M.M. Tzagarakis and P. De Bra. Heidelberg, Springer, 215-225.

- D.A. Kolb (1984) *Learning Style Inventory*. McBerr.
- F. Marton (1988) Describing and improving learning. In R.R. Schmeck, editor, *Learning Strategies and Learning Styles*. Plenum, New York, 54-82
- M. D. Merrill (2000). Instructional strategies and learning styles: Which takes precedence? In R. Reiser and J. Dempsey, editors, *Trends and Issues in Instructional Technology*. Prentice Hall.
- M.D. Merrill (1999). International forum of educational technology and society. formal discussion initiation. *Learning strategies then and now: Same or different?* <http://ifets.ieee.org/discussions/discuss7.html>
- Honey, P. and Mumford, A. (1992). *The Manual of Learning Styles*. Available from Peter Honey, Ardingly House, 10 Linden Avenue, Maidenhead, Berks., SL6 6HB, UK
- R.M. Palloff and K. Pratt (2001). *Lessons from the Cyberspace Classroom: The Realities of Online Teaching*. Jossey-Bass, San Francisco CA.
- [10] G. Pask (1976). Styles and strategies of learning. *The British Journal of Educational Psychology*, 46:128-148.
- P. Ramsden (1988). Context and strategy: Situational influences on learning. In R.R. Schmeck, editor, *Learning Strategies and Learning Styles*. Plenum, New York, 159-184.
- R.J. Riding and S.G. Rayner (1998). *Cognitive Styles and Learning Strategies*. London Publishers Ltd.
- S. Salojarvi, L. Saarikoski and D. Del Corso (2001). 3DE: an Environment for the Development of Learner-Oriented Custom Educational Packages. *International Conference on Information Technology Based Higher Education and Training (ITHET2001)*, July 4-6, 2001, Kumamoto, Japan.
- R.R. Schmeck (1988), editor. *Learning Strategies and Learning Styles*. Plenum, New York.
- V. Shute and B. Towle (2003). Adaptive e-learning. *Educational Psychologist*, 38(2):105-114.
- V.J. Shute (1991). Who is likely to acquire programming skills. *Journal of Educational Computing Research*, 7(1):1-24.
- V.J. Shute (1992). Aptitude-treatment interactions and cognitive skill diagnosis. In J.W. Regian and V.J. Shute, editors, *Cognitive Approaches to Automated Instruction*. Erlbaum, Hillsdale, NJ, 15-47.
- V.J. Shute (1993). A macroadaptive approach to tutoring. *Journal of Artificial Intelligence and Education*, 4(1):61-93.
- V.J. Shute (1994). What does the computer contribute to learning? *Computers and Education: An International Journal*.
- R.S. Siegler (2002). Microgenetic studies of self-explanation. In N. Granott and J. Parziale, editors, *Microdevelopment: Transition Processes in Development and Learning*. Cambridge University, Cambridge, NY, 31-58.
- R.J. Sternberg (2001). Epilogue: Another mysterious affair of styles. In R.J. Sternberg and L.F. Zhang, editors, *Perspectives on Thinking, Learning and Cognitive Styles*. Lawrence Erlbaum, Mahwah, NJ, London, 249-252.
- R.J. Sternberg and E.L. Grigorenko (2001). A capsule history of theory and research on styles. In R.J. Sternberg and L.F. Zhang, editors, *Perspectives on Thinking, Learning and Cognitive Styles*. Lawrence Erlbaum, Mahwah, NJ, London, 1-21.
- J.H. Swanson (1990). The effectiveness of tutorial strategies: An empirical evaluation. *Annual Conference of the American Educational Research Association*, Boston, MA.
- Vermunt, J. D. (1998). The regulation of constructive learning processes. *British Journal of Educational Psychology*, 68, 149-171.
- E. Wenger (1998). *Communities of Practice: Learning, Meaning, and Identity*. Cambridge University Press, Cambridge, UK
- H.A. Witkin (1977). Field-dependent and field-independent cognitive styles and their educational implications. *Review of Educational Research*, 47(1):1-64.