Virtual Teacher

Virtual Teacher: Cognitive Approach to e-Learning Material

By

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INTRODUCTION

Questions about the nature of the mind and body originate in ancient Greek philosophy. What is the role of language? What is the relation between the two? Are we free in our choices? Important ancient philosophers, such as Democritus, Plato, Aristotle and Lucretius answered these questions in different ways, while Descartes, Spinoza, Hume, Kant and many others continued where they left off. Even today in the age of technology, contemporary researchers from the fields of philosophy, cognitive science, neurobiology, and artificial intelligence ask similar, albeit technologically informed, questions. Among those, there are also the questions about a relationship between humans and machines, and implications which that carries for solving traditional problems within philosophy, i.e. the mind-body problem, mental causation problem, and the problem of consciousness. In the book the term 'machine' refers to every system which, in the contemporary world, tries to make a task easier for humans, or even tries to replace the human altogether, e.g. a humanoid robot able to perform different physical activities, for example, walking and running, as well as various mental activities, for instance, decision-making and problem-solving.

Our overall aim is to make the first step towards a connection between different disciplines involved in cognitive modelling in education, built around philosophy of mind and artificial intelligence. The gap between; neurochemistry, cognitive science, neurobiology and other rapidly developing disciplines on one side, and education as part of social sciences on the other, may seem wide and even unbridgeable except by analogy, metonymy and metaphor. Yet there exist short pathways by which to travel from one to the other and back, and the study of chaos offers one such path. Brains are composed of elementary parts called neurons, and societies are made of individuals, each with a brain. The organization of a brain's functions in terms of large numbers of neurons is governed by chaotic dynamics and is expressed in global state transitions, such as from sleep to waking, walking to running, breathing to speaking etc. One class of state transitions in brains provides for a formation of social groups, such as marriages, tribes and fraternities. We try to describe the "biology" of this class of state transitions, its role in the coalescence of relations among individuals and its importance for a human's welfare.

Our concrete intention is to bring to attention a form of learning that transcends logic and rhetorical appeal and can be best understood as a chaotic state transition in a brain's dynamics. If we want to make substantial changes in the process of education (and the introduction of artificial intelligence and intelligent learning systems certainly are substantial) the current process of education must be led to the edge of chaos and then reformulated in terms of cognitive modelling. From the experiences of recent years, it seems clear that the existing educational system, as a whole, is perceived as an ailing system that fails to meet the needs of a major portion of the society it serves. If we want to bring innovation to this process then every aspect of the educational process and system must be studied and reconsidered in the light of new and different social expectations. We will define the appropriate architecture on the basis of cognitive science and methods of artificial intelligence, and will take into account that a school system is a dynamical system which follows the dynamical systems theory. The adequate architecture includes a cognitive model that adopts both information-processing and the human mind's structure, and we will show how to build an intelligent tutoring system (i.e. a virtual teacher) and/or an intelligent teaching/learning upon it.

Artificial intelligence-based tutors and coaches could offer a new type of self-learning and self-training. Education is currently undergoing a major transition in modern societies. Europe has been losing its edge in teaching mathematics, science and arts to other countries in recent years. But currently, a change in education is under way; it comes in the form of computer-assisted learning tools and is so effective that the need for a major reconceptualization of the learning process has emerged. The goal of education must focus on reinstalling that vital desire of 'learning to learn' in today's students. To accomplish this, teachers must involve students as active, self-directed and reflective learners. Through the use of intelligent tutoring systems, students will be placed in an active role, as opposed to a passive role (one-way lecturing) that they more or less have today. The teacher can then act as a facilitator instead of merely a one-way communicator. Our 'virtual teacher' is a small step in this direction.

The book is organized into six parts, outlined below:

Part I: HISTORICAL LANDMARKS

This part of the book introduces the evolution of the education process, and mind as an information processor, by sketching out some of the key moments in the history of education and the science of mind. It highlights how the foundations for sciences of education and mind were laid in psychology, mathematical logic and linguistics, pointing out that theories of what a mind does must co-evolve with theories of how the brain works.

Part II: INFORMATION-PROCESSING MODELS OF MIND

This part of the book explores the two dominant models of information-processing in contemporary science of the mind and education. The first one is associated with the 'strong symbol system hypothesis', originally developed by the computer scientists Allen Newell and Herbert A. Simon (1972), and called simply the symbol model. According to this model, all information-processing (of the mind) involves the manipulation of physical structures that function as symbols. The second one derives from patterns of artificial neurons in computational neuroscience, firstly built by Warren McCulloch and Walter Pitts (1943/1990), and called the connectionist model. According to this model, all information-processing (of the mind) is due to the interconnectedness and mutual activity of idealized neurons forming a virtual network of interactively linked and collaborative units.

Part III: OTHER APPROACHES TO HUMAN COGNITION

This part of the book makes explicit what the new cognitive models are. They are associated with two different research programs proposed by cognitive scientists, partly moving beyond the basic assumption that mind is either a symbol manipulator or a connectionist network. The first is a combination of the two traditional approaches to a mental architecture; the symbol system hypothesis and the connectionist network hypothesis, called the hybrid model. The second is associated with the dynamical systems hypothesis in mathematics, including the situated/embodied cognition movement, and is called the dynamical model.

Part IV: DYNAMICAL MODELLING AND MIND

This part of the book translates the general dynamical systems theory into the cognitive dynamical systems theory. It uses examples of brain activity and motoric control in order to prove the reduction of the mind to dynamics, and explores the theoretical possibility that the brain can be modelled dynamically using new forms of wave equations. Also explored in this section is whether or not there is a realistic chance to create an artificial brain as a result of such a mathematical modelling in the near future.

Part V: COGNITIVE SCIENCE AND EDUCATION: NEW HORIZONS

This part of the book defines the proper architecture of the teaching and learning process. It draws on methods from artificial intelligence and strategies in mathematics and is associated with the dynamical system hypothesis. On the basis of belief that a school system with its educational process is a dynamical system, it shows how to build an intelligent tutoring system (an intelligent tutor) and/or an intelligent teaching and learning material.

Part VI: IMPLICATIONS

Given (i) the possibility to create an intelligent autonomous adaptive system (be it a program, computer or humanoid machine/robot) capable of learning, adapting to new circumstances and also performing (critical) self-evaluation on the basis of the dynamical systems theory and (ii) the thesis that the human-machine reductive correlation is possible (despite the unsuccessful attempts to prove it thus far); this part of the book introduces a dynamical approach to mind-body reduction, which allows us in the end to reduce our cognitive capacities to a physical brain using mathematical algorithms, i.e. differential equations.

PART I:

HISTORICAL LANDMARKS

CHAPTER ONE

HISTORY OF EDUCATION

Ancient Greece and Rome

The history of educational sciences began in ancient times and stems from the Greek and later Latin word *didactics.* Nowadays, the term is accepted in all professional circles. When examining its roots and going back two and a half thousand years, the following can be established (Aberšek, 2012):

- *Didáskein* meant *teaching* or *learning*;
- *Didáskalos* meant a teacher;
- *Didaskaleíon* stood for school;
- *Dídaxsis* denoted a scholar or student;
- *Didaktiké téchtne* denoted a learning method or teaching skill;
- *Didactica*: a Latin version of the Greek word.

The term 'didactics' had a broader meaning in *ancient Greece* and did not only refer to teaching.

Sophists of ancient Greece, travelling national philosophers and teachers from the 5th century BC, who studied the basic questions of existence, especially questions of morality, cognition, politics, rhetoric, religion, dialectics, linguistics and economics, might be credited with being the fathers of didactics. They paid a great deal of attention to the skill of public speaking. *Protagoras* (490–420 BC) was one of the most important sophists, and in his view a man was the measure of all things. Word-formation and debating skills were two of their most important teachings. They held their lectures in town squares, gymnasiums and private homes and exerted a great influence, especially over the youth. Sophists claimed that their purpose was not to educate as a profession but to provide citizens with intelligence.

Socrates (469–399 BC) was an important figure in the history of didactics, mainly because he introduced his method of inquiry (The Socratic Method) to teaching. In his method he argued for ethical intellectualism, yet he would later be accused of corrupting the youth and sentenced to death because of his views.

Plato (428–347 BC) was probably the most important philosopher of his time and is credited with the development of the theory of objective idealism. Among his works, '*The Republic*', representing his views on education, is the most important for the educational sciences. He greatly influenced the evolution of pedagogical ideas in ancient Greece and Rome. Some of his most important thoughts were that:

- An organized education is absolutely necessary for the development of the slave-owning society.
- The state is responsible for providing education for all children, boys and girls, who belong to the slave class as well as free citizens.
- The state should direct upbringing and education.
- The educational content should be carefully selected from theory and practice, and should aim to influence the intellectual and moral evolution of the youth.
- A teacher is a vital person, since their work is of a great social importance.
- The goal of education and upbringing is to form good citizens.

Plato is important to the history of didactics (and pedagogy) because he underlined the importance of education in the development of a society, the role of the educational content in the intellectual and moral development of individuals, as well as the importance of education for the development of society as a whole.

Aristotle (384–322 BC) was a student of Plato, and certainly outgrew his teacher to become one of the most important philosophers and scientists in ancient Greece. His philosophical and pedagogical views probably mark the height of the ancient period. Some of his most important viewpoints include:

- A precise definition of children's development levels: up to 7 years of age, from 7 to 14 years, and from 14 to 21 years of age.

- Lessons and education must be based on the nature of an individual's intellectual potential in order to ensure the reliable development of that individual and the entire society.
- The purpose of education is to contribute to the harmonious development of a personality, i.e. its physical, intellectual and moral development.
- Education must create the conditions needed to build a society of intelligent people.
- Content and other tasks during classes should be imposed carefully on the young, since an excessive burden has a negative effect on their personalities and their development.

Marcus Fabius Quintilianus (35–100 C) was the most important pedagogical thinker in ancient Rome. His most important work, '*Institutes of Oratory'*, is based on the works of Greek philosophers, practical teaching experiences and a synthesis of theoretical thoughts on teaching. His observations and views include the following:

- Intellectual and other potentials of the young always exist, but have to be activated for successful education.
- Since students vary between each other, teaching should be adapted to those differences.
- Studying mathematics is necessary to ensure logical thinking.
- Teachers should have a broad cultural and moral approach, and a love of working with the young.
- Teaching should also be fun-related to prevent boredom and increase its efficiency.
- Teaching should not be based on coercion since praising and rewarding have beneficial effects on students, especially those with learning difficulties.
- Since a memory is best developed with exercises, students should study plenty and progress gradually.
- Reading should be practised so that it becomes reliable, connected, initially slower and then gradually faster.
- Extremely talented and especially hard-working teachers should be given special recognition as they are the driving force for the development of a society.
- Teaching should include examples and role-models whose behaviour is at first emulated by students, and later equalled or even excelled.
- Exercises are facilitated through a prior theoretical explanation.

Following this, for approximately 1000 years, nothing decisively new happened in the field of education, i.e. nothing that could be compared to the achievements of the ancient period. This dark period was followed by the Renaissance, which meant enlightenment in all areas, including education.

The period of Renaissance

Renaissance promoted a return to ancient ideals, values, contents and educational methods, but primarily strived for the harmonious development of a body and soul. A human personality became very important. Renaissance thinkers from the field of pedagogy demanded that literature, natural science, mathematics, geography, history and other life sciences be taught in schools. Renaissance pedagogues asked that students develop critical thinking and other abilities required for a physical and aesthetical education. They used individual methods with a special emphasis on the discovery method. ***Thomas More*** was the most important pedagogue of this time; he proposed that teaching be combined with a productive element, and promoted the idea of a multilateral personality development for men as well as for women.

The word didactics was reintroduced around the 17th century by ***Wolfgang Ratke*** and ***Johann Comenius*** (Jank & Meyer, 2002). The latter, in particular, left an important mark on didactics. Between 1628 and 1638 he wrote *Didactica Magna* (Great Didactic), which was at the time revolutionary and is still today considered an exceptional work, in which he outlined an extensive theoretical and practical programme for schools and teaching. Comenius defined didactics as a comprehensive and meaningful theory of education. Under the influence of the Renaissance humanists, he established his theory of education from Francis Bacon's theory of cognition, which stemmed from the assumption that our senses are the source of all our knowledge. He developed obviousness (self-evidence) as one of the greatest didactic principles. He also highlighted the need for a conscious studying, systematic nature of teaching, strict assimilation of learning material and development of students' cognitive abilities. His work influenced the beginnings of the development of didactics as a scientific discipline, which brought about a revolution in education. He introduced innovations such as:

- A temporal limitation of a school year.
- Placing teaching in a classroom and within a time limit.
- Call for special schools to train future teachers.
- Call for teachers to observe obviousness, systematism, graduality, repetition, exercise and revision.
- Information (knowledge) is not the most important part of teaching: rather the intellectual and moral development of the students should be its main goal (achieved only by students' independent thinking).
- Text books should be clear and concise, but also interrelated in order to ensure a gradual learning curve.[1]

The age of enlightenment

This expression and its associated practices indicate the philosophy of 18th century Europe (*Le siècle des Lumières* in French, *die Aufklärung* in German and *the Enlightenment* in English), characterized by confidence in the reason (only by means of which, men can reach knowledge), the criticism of the traditional authorities (religious and political), the invitation to exercise thought and judgment by oneself, the optimism of understanding the movement of history like the parallel progress of knowledge, happiness and virtue. According to this common presentation, these features constitute a horizon of thought divided by principal philosophies of the time, in spite of their differences.

The term 'light' draws on a series of traditional comparisons in philosophy: knowledge is compared with the vision (one then seeks to describe the act of knowledge) or with the illumination (one then seeks to characterize the effect of knowledge). These metaphors find their roots in the rationalist theories of knowledge, where a direct contemplation is regarded as the relevant form of its justification, but the usual usage is looser, and sticks to the approximate comparison of 'seeing' and 'knowing'.

In the 18th century, the interpretation of the expression 'Enlightenment' became determined by the Christian theological distinction between the natural light and the supernatural light. Two reigns or two orders were

[1] Comenius also advocated four principles of education: (i) physical activities, (ii) sensual perception with activities for a motor skill development and experimental research, (iii) direct experience, (iv) a premature memorising having an adverse effect on students' judgment.

traditionally distinguished: the reign of the nature, and the reign of the grace. So, within the (created) nature the men have the reason (i.e. the natural light) which is, although relatively autonomous, still a limited faculty that requires the assistance of the Creator's reason (i.e. the supernatural light). From such a point of view, the reason remains subordinate to the revelation; only the latter is likely to provide a true knowledge. The trouble is that such a view makes philosophy the maidservant of theology (*ancilla theologiæ*).

With respect to education of one of the most important philosophers from the Enlightenment period is ***Jean-Jacques Rousseau***. He is particularly known for his work '*Emile'*, or *'On Education'*, published in 1762. Rousseau is the most prominent proponent of naturalism; he believed that education should be in line with the child's nature and that children are best raised on the basis of one's own experiences. To achieve the right education a child should be allowed the possibility to discover for itself, in contact with nature, the ways which lead to the reason and, consequently, to the moral conscience. A teacher must be an observer and a guide, nothing more; this holds even in the conquest of personal freedom.

Rousseau's philosophy was transferred to a direct pedagogical practice by ***Johann Heinrich Pestalozzi***. In his view children urgently need the help of a teacher to develop correctly, provided that the teacher likes working with children and is suitably trained. His ideas focused on the student; he emphasized the individual differentiation and the importance of students' self-activity. Pestalozzi did not only focus on general didactics, but he also developed special didactics for individual subjects in primary schools. He promoted rational, moral and vocational/technical education, i.e. developing the mind, heart and hands (according to Bloom, the cognitive, affective and psychomotor domains).

The didactics that we know today originated in 1806 with ***Johann Friedrich Herbart***, a German philosopher, psychologist and pedagogue (also the first university professor of pedagogy), best known for introducing formal methods of teaching; his main goal was to introduce learning units and themes gradually. He published his fundamental work *'General Pedagogics Derived from the Purpose of Education'* with the subtitle 'Purpose and Aim of Education'. Herbart's followers – *'Herbartians'* – developed the so-called theory of formal steps: a technique for structuring lessons on the basis of pupils' philosophical and psychological knowledge. Even today experts do not always agree on its advantages and disadvantages (Adl-Amini, 1979).

Various other authors from the end of the 19th and mid-20th century also had an impact in the field of education. Notable figures include: Otto Willmann, Erich Weniger, Wolfgang Klafki, Herwig Blankertz, Paul Heimann, Lothar Klingberg, Werner Jank, Hilber Meyer, John Dewey, Abraham Flexner, Jules Ferry and many more.

Large contemporary teaching currents

During the first two thirds of the 20th century, a veritable melting-pot of new ideas and innovation could be seen with regard to pedagogy. Most of these new initiatives fell into the bracket of ‘new education’, represented in particular by John Dewey, Édouard Claparède, Adolphe Ferrière, Ovide Decroly, Maria Montessori, Célestin Freinet). According to these pedagogues, education is not a preparation for life, it belongs to life, it must adapt to the specific needs of a child and their centers of interest. The pioneers of the new education movement advocated active methods to include the school in its surrounding social environment and support the training of democracy through the individuals in a group.

John Dewey was probably the most important practitioner and experimentalist in didactics amongst the new education movement. He believed that education's main objective was to encourage individuals to develop their potential as people, in the intellectual as well as the ethical and aesthetical sense. Some of the most important values that he advocated were hard work, the personal success of an individual, respect for personality, planning for the future and respecting moral norms. Some of his most important thoughts are that:

- Teaching should be based on the psychophysical potential and interests of a particular student, but subordinated to the practical needs of the entire society.
- The concept of a simple knowledge transfer should be rejected and more active forms of work by the students themselves should be introduced.
- Curricula should not be the same for all students and should not be prescribed by the state.

In spite of the richness of the ideas put forward long ago, the forward momentum of pedagogy currently seems to be losing speed. The fields of exploration have been narrowed with the profit of the educational sciences, taught at universities since 1967. Since the early 1980s, a space for teaching reflection seems largely supplanted by the (special) didactics covering various disciplines. This research, directed at the majority, gives much more importance to the effectiveness of training, rather than to the emotional life of a child. So the ideas of 'new education' did not succeed in becoming solidified within the educational establishment. Some teaching movements, (e.g. active education training centers, the French group of new education, Freinet teams) however, do continue to work with these ideas.

Future of education

When European Union (EU) heads of state and government met at a summit in Lisbon in 2000, they set the goal of making Europe "the most competitive and dynamical knowledge-based economy in the world" (Lisbon Strategy, 2000). In a knowledge-based economy, the most effective modern economies will be those that produce the most information and knowledge, and in turn make that most easily accessible to the greatest number of individuals and enterprises. This policy brief suggests that individuals and companies can easily collaborate and compete globally, and that the solution for Europe in meeting the Lisbon goals is to *invest heavily in education and skills*. Statistical evidence briefly demonstrates the high return on investment in education. It makes recommendations for ensuring that Europe's school systems become more flexible and effective in improving learning outcomes, and argues that Europe's capacity to compete in the global knowledge economy will depend on whether its higher education institutions can meet the rapidly growing demand for high-level skills. International comparisons demonstrate the challenges confronting Europe, but also illustrate the success of efforts to meet such challenges. Education and skills will be paramount in this process.

The statements examined here are over 13 years old, so let us look at this problem from a more modern perspective. What influences a student's experience is briefly shown in Figure 1.1 (Aberšek, 2013).

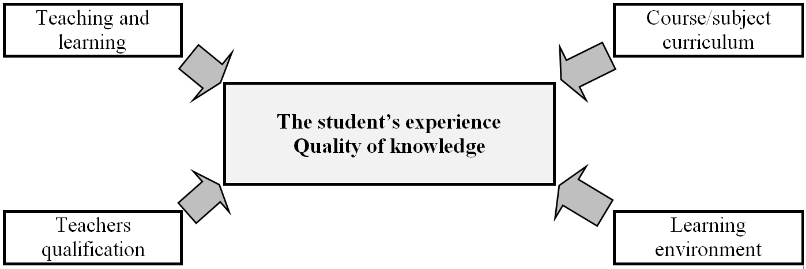

Figure 1.1: 4 Pillars of the educational system.

One of the basic questions facing the educators of today is the following: *Where do we begin in seeking to improve the teaching/learning process*? Fortunately we do not have to start from scratch in searching for answers to this complicated question. The experts recommend that one place to begin is in defining the nature of thinking. Before we can make a better process, we need to know more of how people process information, how people think. New discoveries in the field of cognitive science, neuroscience and computational science hold great promise for the improvement of current teaching methods (Anderson, 2007). Yet there remains a significant gap between the scientific discoveries that could improve our education system, and the application of this knowledge.

If we want to introduce innovation in schools we must take into account the whole complexity of the education system and not only its 4 pillars. The organization, leadership, values and assessment are also a very important part of this process. The whole system is symbolically represented in Figure 1.2. Innovative learning concepts place emphasis on the holistic and systemic nature of teaching/learning environments, their intended learning outcomes, and their pedagogical, technological, and organizational characteristics that favour innovation.

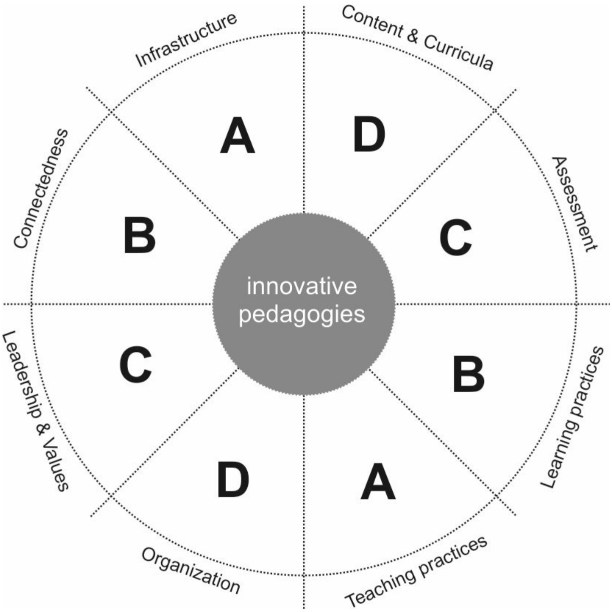

Figure 1.2: School system and innovative pedagogies.

The *multi-dimensional concept* (presented below) is intended to capture the essential elements of innovative classrooms that can be seen as live *eco-systems* (Law et. al., 2011). As complex organisms, such classrooms constantly evolve over time, mainly depending on the context and the culture to which they pertain. Hence, such a concept is composed of eight encompassing and interconnected key dimensions which capture its essential nature. As depicted in Figure 1.2, there are eight key dimensions: *Content and Curricula, Assessment, Learning Practices, Teaching Practices, Organization, Leadership and Values, Connectedness* and *Infrastructure*. It is naïve to assume that addressing one dimension in isolation will make innovation happen; evidence from research (Punie et al., 2006; OECD/CERI, 2010a, 2012; Law et al., 2011; Microsoft, 2011) clearly shows that a significant number, if not all of these key dimensions need to be tackled by the common efforts of a critical mass of actors (Bocconi et. al., 2012).

These proposed dimensions build on the following:

- Previous research on Creativity and Innovation (Cachia et al., 2010), Learning 2.0 (Redecker et al., 2009), and the Future of Learning (Redecker et al., 2011).
- Other relevant studies and existing cases of ICT-enabled innovation for learning also provide the conceptual framework for the proposed CCR dimensions, embedding core principles for designing Innovative Learning Environments (OECD, 2008; OECD/CERI, 2010a, 2012), new and creative ways of implementing the applied curriculum and informative assessment for learning in the 21st century (ACOT2, 2008), a learning leadership for a lifelong learning orientation and connectedness (Law et al., 2011), and understanding of basic conditions (such as vision, expertise, digital learning materials and ICT infrastructure) for the sustainable use of ICT in education (Kennisnet, 2011).
- Inputs were also collected through ongoing consultations with DG EAC and the Education and Training 2020 Thematic Working Group (TWG) on "ICT and Education", as well as with other key stakeholders and practitioners (e.g. European Schoolnet, European Foundation for Quality in e-Learning, European Trade Union Committee for Education, eSkills Industry Leadership Board, eTwinning teachers).

The innovation goes hand in hand with all eight dimensions, which are equally necessary and vital within CCR, and a significant effort should be made to address them all. To this end, CCR innovative learning environments need to be inspired and supported by innovative policies, ensuring the progressive implementation at system level of all CCR encompassing elements (OECD, 2010).

Figure 1.1 makes it clear that the students' experience and the quality of their knowledge is most important. From this point of view, in recent years we have talked a lot about the efficiency of the teaching and learning process. We all know that two diametrical possibilities exist in these processes, namely the 'classical' teaching in large groups (with a low efficiency) and the individual teaching, *1:1 teaching*, or one teacher for one student (for example: Socrates and Plato, Plato and Aristotle, Aristotle and Alexander the Great etc.). So the average efficiency, if normal (Gaussian) distribution is assumed, according to Figure 1.3 oscillates between 50% for the classical teaching and 98% for the individual teaching. These are our limits (Aberšek, 2013).

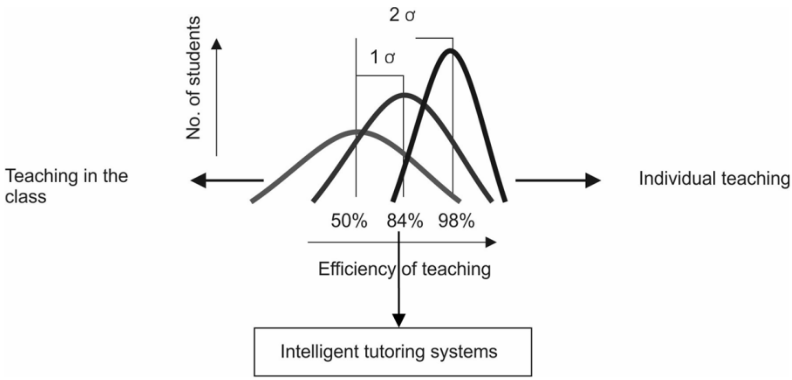

Figure 1.3: Efficiency of teaching processes.

If we want to increase the efficiency of today's teaching process from 50% we must somehow incorporate the 1:1 philosophy in the regular classroom process. But this would be possible only through the use of the technology, i.e. within the innovative 1:1 pedagogy, meaning that every student would have their own tutor, specifically their own iTutor (the intelligent computer tutor: a notebook, netbook, ultrabook or tablet). A lot of research in education is concerned with the development of intelligent applications, such as the Intelligent Computer-Aided Instruction (CAI), intelligent tutoring system (ITS) and intelligent learning environment (ILA) (Allen & Seaman, 2008; Aberšek & Kordigel Aberšek, 2010), and with the applications that can be justified on the grounds of being consistent with educational theories. Providing these forms of intelligent tutoring poses unique challenges, because it requires an intelligent system that can model domains as well as student behaviours and mental states that are often not as rigidly structured and well-defined as those involved in traditional problem solving. Advances in the AI techniques concerning; reasoning under uncertainty, a machine learning, a decision-theoretic planning, as well as the increasing availability of sensors that can help capture the relevant user states, are all promising means for the field to face these challenges (Bermudez, 2010). Success in these endeavours has the potential to have a great impact on our society, and on its ever-increasing need for high quality teaching and training. The most promising way forward today is through use of intelligent educational systems that promise increased efficiency according to Figure 1.3 of up to 84% (Conati, 2009). The most important part of such systems is the use of artificial intelligence, which makes possible the following:

- A representation of knowledge and a teaching/learning process.
- An intelligent selection (the selection of most appropriate tasks, i.e. individualization).
- Learning from previous experience (experience based learning).