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THE STRUCTURE OF INFORMATICAL KNOWLEDGE IN VOCATIONAL EDUCATION IN HUNGARY – INFORMATICS INTELLIGENCE

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Abstract

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Always make new mistakes!
(DYSON, 1998)

Informatics is like love,
you cannot learn it from books.
(Graffiti on a glare screen)

1. The Definition and Characteristics of Informatics Intelligence

It is a scientific cliché that informatics and computer science are not the same. At the same time, an approach recognizing that even technical informatics cannot be interpreted as a simple subset of informatics is gaining wide acceptance in Hungary. According to this view, informatics – seen as the science of information and operations with information – must be defined and understood at a higher level in the hierarchy of universal knowledge, making it suitable for a role as a 'super-science'; that is, a structure which can include and organize various, increasingly compart mentalized and specialized branches of science. In this manner, fields which were only remotely related previously such as personal computing, computer science – or for that matter, the Internet – have become parts of the discipline of informatics (Z. KARVALICS, 1995; CSORBA, 1998).

The application of computers, multimedia, and the Internet, along with the concepts described above, provide educational institutions with the opportunity and the tools to deal with the problem of 'shrinking patterns', which is caused by the exponential growth of available information (HENCHEY, 1981). As a result, the disadvantage that educational institutions encounter versus businesses and other profit-oriented endeavors is decreasing (KUPICIEWICZ, 1984). The role and the significance of the three basic skills (reading, writing, and arithmetic) and the way we acquire these skills are transforming. Extended use of optical character recognition software and hardware is predicted to make reading easier. The teaching of writing will be complemented by the inclusion of typing skills as well as the use of grammar and spell-checker applications in the curriculum. The use of electronic calculators will be integrated into arithmetic skills. Based upon his analysis of one hundred separate studies, HAWKRIDGE demonstrated that electronic calculators improve both the learning and understanding of mathematical concepts (HAWKRIDGE, 1982); PAPERT (PAPERT, 1988) showed that the appropriate application of computers benefits form every form of learning; HEGEDŰS (HEGEDŰS, 1994) documented that the use of the computer as a tool increases the activity of students and the efficiency of their learning (i.e., understanding, permanent recollection, and problem solving). Modelling makes observation easier for students, and computers make individualized classroom teaching more feasible.

It is said that the teaching methods of the three basic skills not only will change significantly, but new basic skills will appear and be recognized as such. The appearance of these new skills will make currently existing but not yet widely available fields, activities, and skill-sets ubiquitous and routine; they will not represent distinct fields of knowledge in the future, but instead will be considered essential in every walk of life, which is the very definition of basic skills. A few examples of these new basic skills are:

- Audio-visual skills: The ‘audio-visual language’ – the visual and audio representation of thought and general structures – will complement the more traditional means of communicating information.
- Communication skills will place a more significant emphasis on the importance of interaction with others and the general societal environment.
- Information skills: The efficient way of acquiring, organizing, and processing information.

In other research (MADARÁSZ, 1997 based on Edith Cresson’s studies) we see the following five fields are essential to reaching the state of a cognitive society: mathematical thinking, problem solving attitude, informatics knowledge, communications skills, and interpersonal skills. BRUNER (BRUNER, 1974) puts an emphasis on skills, stressing the importance of manipulation, visual comprehension, and symbolic (abstract) thinking. In his opinion: ‘the curriculum must lead to the perfect acquisition of such skills that make the acquisition of other, even more powerful, skills possible.’ (BRUNER, 1974). PAPERT considers the most important skill to be technological fluency (PAPERT, 1996). According to BESSENYEI (BESSENYEI, 1997), ‘the primary importance of thinking in terms of large and comprehensive systems of thought is disappearing, while problem solving and the ability to process information are becoming fundamental skills,’ and information navigation has become a part of cognitive competency. He classifies cognitive skills (comparison, classification, deduction, etc.) as follows:

- The ability to study. He recognizes observation, coding/decoding, evaluation, understanding, justification, and proof as the main components in the process of studying a subject.
- Communications skills: The ability to give and receive information.
- The ability to think: Creating new information from currently existing information by means of organization, combination, logic, problem-solving, decision making, and creativity.
- The ability to learn: Which is defined by Bessenyei as the ability to acquire and store knowledge. He recognizes that the efficiency of learning depends on differences between learning methods, such as spontaneous, intentional, exploratory, playful or creative learning; learning by experience, learning by interpretation or explanation; or learning by discovery, objective, and social learning.

It is obvious that a new set of skills must be developed, and that notions which enhance situational learning, problem solving, and adaptability must play a central role in this set of skills. For this relatively recently-defined yet widely discussed set of skills, Paul Zerkowksy coined the phrase ‘information literacy’, indicating the nascent independence from ‘computer literacy’, when he was describing those people who ‘in the course of their daily activities or jobs possess, use, and apply their knowledge of information technology and know-how, and those who are able to solve the problems they face by utilizing skills and techniques from the vast array of solutions provided by informatics.’ (cit. by KARVALICS, 1997).

We would like to mention that during the early stages of the development of the notion of information literacy, the term was used almost exclusively in conjunction with library science. In a 1990 report prepared for the National Forum on Information Literacy (the U.S. national organization on information literacy) the term was defined as ‘the ability to acquire, evaluate, and use information gathered from the widest array of sources.’

From the theoretical point-of-view, information literacy is ‘a set of skills which includes the recognition of the need for information, the knowledge of the means that make retrieval of the needed information possible, the methods of evaluating and synthesizing the information, and the ability to communicate these components.’

Although it has not gained absolute acceptance as an interdisciplinary point of view, informatics has become a classroom subject itself; thus it could not avoid taking on characteristics of other established classroom subjects, such as searching for its role in academia, separation from other disciplines, etc. It seems reasonable that we make information literacy the core of the curriculum of non-informatics-related professions; for example, teachers who do not teach informatics or computer science, or computer users in general. Informatics is not only an interdisciplinary science; it could easily be seen as an interdependent meta-science. If we take this into consideration, along with the assumption that the goal of teaching informatics is to teach information literacy, then we must determine the methods that are suitable to reaching this goal.

It is obvious that simply teaching the lexical material of informatics is not sufficient to today's rapidly-developing scientific environment. Also, it is impossible to teach the means of information gathering by using a 'linear' teaching method. To illustrate the difficulty of the traditional methods of teaching informatics, we would like to point out the following examples: Think about the useless array of linear information available on the Internet; AltaVista, only one of the popular indexing engines, lists more than 140 million web pages, an incredible amount of information that can hardly be called organized. Or, consider that the help files of today's popular office applications routinely have several megabytes worth of linear information. It is not only impossible, it would be futile to attempt to linearly learn the majority of this available knowledge since it, as a body, is usually organized in the nodes of a net. Think about the net-like organization of help files, reference guides, or even the body of knowledge within professions.

If we accept that it is unnecessary and unreasonable to linearly teach software applications, we have to determine the methods of teaching informatics. The common ground should not be detailed instructions on how to use specific software applications, nor teaching programming languages or operating systems; rather, the common ground should be a method or a collection of methods which enables students to independently get acquainted with the tools informatics offers; methods which help the students find, select, and use the information they need. While teaching problem-solving skills related to informatics situations, it is necessary to give students and end-users the capabilities of independent study, self improvement, and adaptability to the ever-changing informatics environment.

'The amount of available information is so huge that the traditional methods are no longer suitable for viewing, processing, or grasping it; therefore our emphasis should be placed on the selection of necessary information.' (NAISBITT, 1988). The ability to select the relevant information is already part of our basic skills set. For example, it gives one a significant advantage in today's labour market (BALOGH, 1994). It is important to note that 'the new elements of the basic skill set do not represent a divergence from the traditional professional skills, knowledge, and experiences; however, they are expected to complement the traditional elements of a profession, and change the way these elements are approached, practiced, and learned.' (FARKAS, 1993). The definition and measurement of intelligence is still subject to scientific discussion (STATT, 1994). There seems to be a consensus, however, that adaptation and problem-solving are central elements to the notion of intelligence. Intelligence is not considered in a general, abstract sense by most researchers, rather it is studied and discussed in specific situations (SZAKÁCS, 1984). These studies do not require an abstract definition. Even Binet, the 'father' of intelligence tests, did not attempt to create tests for measuring intelligence; he merely sought to separate the children who could be trained from those who could not.

A survey conducted by a U.S. scientific journal illustrates the dynamics involved in the question of defining intelligence. Researchers asked American psychologists to define intelligence, and they received nearly as many different definitions as the number of psychologists asked (HORVÁTH, 1991). The fact that we have several definitions does not disqualify any particular definition (SZAKÁCS, 1984). The reliability of any given definition of intelligence is determined by comparing it with other definitions and by testing whether it is applicable in situations where intelligence clearly plays a significant role. Thus, we should not focus on the different methods of creating intelligence tests, but rather, following Binet, we should attempt to define and measure the combination of attitude, skills, and knowledge we believe to be essential to situations we are addressing.

In this paper we will deduct the definition of Informatics Intelligence from Weschler's definition: Intelligence is a person's aggregate ability that makes adequate and purposeful action, rational thinking, and successful and useful interaction with the environment possible (BERNATH-RÉVÉSZ, 1994). According to this definition, we define *Informatics Intelligence (I2) as a person's aggregate ability that makes it possible for them to adequately and purposefully act in situations involving informatics and rational informatics thinking (using the notions and terms of informatics for problem solving, deduction and induction), and to successfully cope in their informatics environment.*

After the introduction of informatics intelligence, we shall summarize the most important characteristics of the term.

2. The Characteristics of Informatics Intelligence

2.1. Practice-Oriented

The importance of practical approach is inferred from the central role of problem-orientation, since information navigation and the skills of using the appropriate tools cannot, inherently, be theoretical. It is also probable that each individual will have to face his or her own difficulties, and some or most of these difficulties will be unique, based upon the pre-existing skills, personality, and other characteristics of the individual. Thus, the answers and solutions to these problems will come in a wide variety. Abstract, theoretical models are seldom suitable for solving these kinds of problems or for finding these types of solutions. The abstract models must be adapted and individualized according to a specific situation. End-users can seldom apply the general methods and formulas while attempting to solve their problems, as they have to be taught how to apply abstract models in everyday situations. For example, students of electronics are primarily interested in the operation of electronic instruments and tools; they will be familiar with the Laws of Ohm and Kirchoff only after they have acquired practical experience in the lab (JUHÁSZ-SZÁNTÓ, 1994). We could even say that the detailed knowledge of asynchronous transfer modes or overlapping cycles are not necessary for most users of informatics, although they are part of the theoretical background of important informatics applications. Students need practice, 'practice where they can experiment and try their own ideas, where they can attempt to put the material they have learned into practice without being overly controlled.' (BORÁROS, 1996).

The notion of learning by example is far from an original idea. Well-known pedagogues and researchers, such as Comenius, Dewey, Moonen, Pestalozzi, and others have been promoting the idea for quite a long time. Studies on the efficiency of differing methods of teaching informatics show the superiority of the practical approach. (BORÁROS, 1996). Informatics has to be taught through a method that maximizes the students' practical experience and, unlike many current curricula, does not over-emphasize the theoretical bases. An efficient curriculum must also focus on potential sources of error, their most frequent forms, appearances, and sources, as well as presenting potential solutions to these errors. In addition, methods of selecting the most appropriate solution should also be a matter of focus. The importance of emphasizing troubleshooting becomes immediately obvious if we consider the fact that today's software applications are far from flawless – in spite of their advanced help-files they are still not very user-friendly, and their instability frequently requires fairly advanced interventions by the user.

By creating the curriculum we described above, we may avoid a state of teachers' training which is 'conservatively ideological and theoretical' (BISZTERSZKY, 1990); for informatics is an almost pure representation of constant change. We conclude that only those materials, skills, and tools should be included in an informatics curriculum for end-users and non-informatics professionals that help navigation and orientation in our increasingly informatics-oriented world. On the other hand, students must be able to routinely, almost subconsciously, use the tools that belong to information literacy in order to avoid concentrating on the tools themselves; this allows students to focus on the goal they desire to reach by using those tools.

2.2. Dynamic

The dynamic character of informatics intelligence can be inferred from the importance of autodidactic learning and self-improvement.

We will classify the elements of informatics knowledge into static and dynamic elements. We consider skills and knowledge based on memorizing and comprehending the taught subject matter as static; creative applications and problem-solving which require the acquisition of new information, as dynamic.

In order to improve problem-solving skills, we create problem situations for the students and, especially in the early stages of the training, we must assist them in finding the solutions so that they are able to advance. We must provide students with sufficient practical and theoretical background, to make it possible for them to improve their knowledge and skills independently. SKINNER (SKINNER, 1973) notes that merely informing students of the correct solutions to problems will not have a lasting effect, and even the value of a short-term effect is questionable. Polya adds that it is unnecessary to attempt to cover every possible problem situation (not that it would even be within our ability – just think about the nefarious creativity of software developers...) because by applying the principle of similar situations in problem solving, students will soon be able to independently solve various types of problems (POLYA, 1988). At the same time, it is essential to show students how to use the available tools and resources (help files, wizards, on-line tutorials) for solving problems. By making students aware of these resources, we can also fight the effects of excess information, especially specific trouble shooting techniques and manuals which are becoming quickly outdated.

It is also impossible to teach error-correction on a case-by-case basis. Brown found out about 1,000 errors in the Windows 95 operating system (BROWN, 1996). Although the manufacturer has corrected about 80% of these errors since then, 200 errors have remained; quite a high number. Windows 95 is just a single program, and we know very well that the great number of new applications give birth to an unprecedented number of new programming errors. Obviously, our motto (DYSON, 1998) inspired not only the author of the present paper...

3. Knowledge Structure

Few would argue today against the desire for and necessity of ongoing learning. Inspite of this, in the practice of teaching, the requirements for engendering the ability for autonomous learning are difficult, and only partially met. Informatics and computer science are in a distinguished position, since today information is the least restricted entity (it is pure common goods), and material goods are less available.

We think that exploring the structure of the students' knowledge is of primary importance, since today's software developers rarely prioritize making their programs as user-friendly as possible. Thus, we are particularly responsible for providing appropriate methods of coping with this situation.

Within our model, we will classify the elements of informatics knowledge into static-versus-dynamic and theoretical-versus-practical elements. We consider skills and knowledge based on memorizing and comprehending the taught subject matter as static; creative applications of it and problem solving that requires acquiring new information, as dynamic. We consider problems that do not require computer or other informatical tools as theoretical, problems to be solved by using computers, as practical.

Regarding informatics knowledge, we assume that dynamic and practical elements are more useful than static elements. We also assume that we must provide the opportunity and method for gaining the theoretical knowledge, as opposed to providing the knowledge itself, since the informatics circumstances (for instance, software, hardware) are changing at a rapid pace (because they are dynamic elements) and also in a future scenario involving informatics, students need hands-on, computer experience (practical elements) rather than theoretical knowledge. We think that Informatics Intelligence correlates with practice-oriented, dynamic knowledge, but this statement is beyond the scope of the present study.

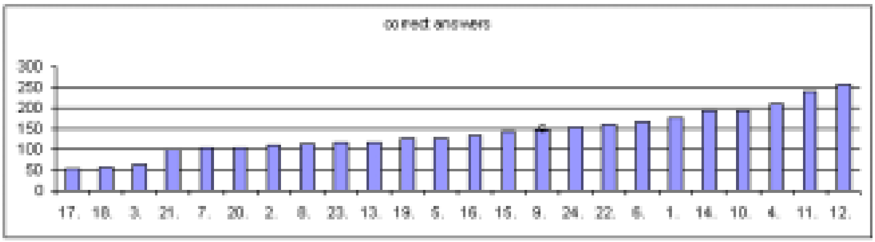
We conducted our study on students undergoing pedagogical training in technology and other students involved in vocational and professional technological education. We deem the analysis of their knowledge especially interesting, since they will eventually teach secondary school students, although not all of them will teach technological subjects. We compiled a test surveying the structure of their informatical knowledge. By analyzing their responses, we attempted to determine the composition of their knowledge with respect to the static versus dynamic and theoretical versus practical components. Although it was not our goal to measure proficiency, we were able to form a picture of the extent of the students' knowledge in informatics.

We conducted our survey in order to determine the knowledge structure necessary to reach an appropriate target level of computer-user proficiency. This appropriate target level was set somewhat arbitrarily, there is still ongoing discussion about it, but we believe that the chosen level is, at present, most widely accepted. In this analysis we did not use ideas deriving from our model, we merely presented the result of our knowledge structure analysis.

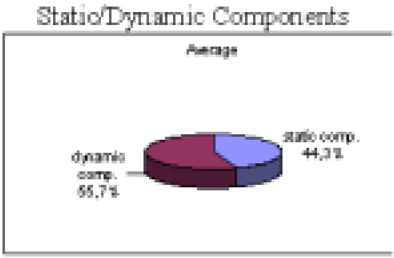
3.1. The Presentation of Test Questions and the Quantification of Results

We created our series of test questions by updating a previous test used at the Department of Vocational Education in the Technical University of Budapest. We tested our questionnaire on 23 people, and after fine-tuning it, had 285 people participate in the test. (The questions you find: http://mpt.bme.hu/nagyadam).

The test contained 24 questions. We analyzed the static-versus-dynamic component in questions (S:2, 3, 5, 7, 9, 10, 12, 13, 16, 17, 18, 23, 24; D:1, 4, 6, 8, 11, 14, 15, 19, 20, 21, 22), the theoretical-versus-practical component in questions (E: 1, 2, 3, 4, 7, 9, 13, 16, 18, 20, 21, 24; G: 5, 6, 8, 10, 11, 12, 14, 15, 17, 19, 22, 23). The test contains only open-ended questions. The most problematic aspect of our survey is the quantification of results. We attempted to overcome this difficulty in the following manner: By giving 1 point for each correct answer, 0 point for each incorrect or insufficient answer. Hence, we must determine the correctness of each answer. We used a 3 member group in our evaluation in order to minimize the subjective element.



The combined ratio of correct answers to all questions is 48.7%. Questions with the lowest correct answers are (in descending order of correct answers): 17, 18, 3 (SG, SE, SE). These results indicate that the students’ static-type knowledge is the least proficient. Questions with the most correct answers are (in descending order of correct answers) 12, 11, 4, 10, 14 (SG, DG, DE, DG, DG). These results indicate that the practical problems are easiest for the subjects.



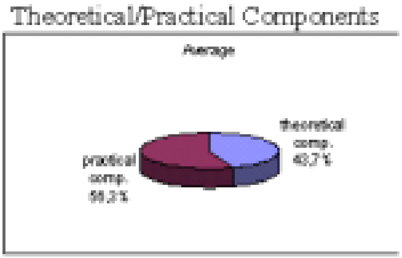
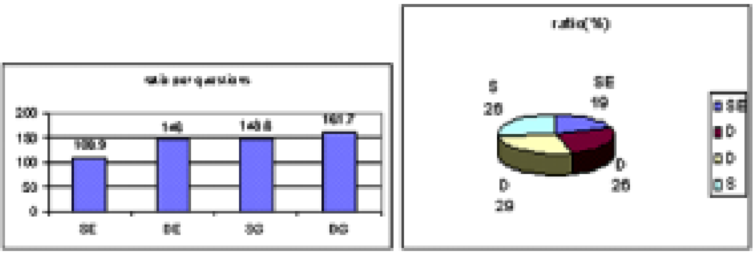


Table 1. Two-dimensional analysis

Component	Question No.	Total	Average by Question Ratio	(%)
SE	2,3,7,9,13,16,18,24	871/8	108.9	19.3%
SG	5,10,12,17,23	743/5	148.6	26.3%
DE	1,4,20,21	584/4	146	25.8%
DG	6,8,11,14,15,19,22	1132/7	161.7	28.6%



Average by Question Ratio

The ratio of correct answers to questions concerning dynamic and practical components (as a result of one- and two-dimensional analysis) indicate that students are interested in and engaged in computer science, but the ratio also warns us that much is left to be desired. There is no significant difference between the ratio of correct answers to theoretical and practical components. Similarly, the ratios of correct answers concerning dynamic and static components are very close to each other. However, the ratio of correct answers is altogether very low, which informs us that the knowledge-level of our students is too low compared to the taught material. This knowledge is virtually negligible compared to the knowledge present in today's informatics. It is a cause for some worry that our subject has already completed one semester in informatics. Within our students' knowledge, their informatic knowledge is still worse. Most of them do not know what or who a hacker is, they do not know the features of C++ or DOS, and the most they could say about the difference between analog and digital telephone networks is that 'digital is better'. There are predictions that informatic knowledge will even be essential in routine household chores and, of course, other areas of everyday life. It is doubtful that this kind of knowledge will ever be taught in schools.

Summarily, we are of the impression that students are far better at questions which require giving explanations, but they give fewer correct answers than average to questions which require factual knowledge. It is interesting that students are more successful in answering questions which require them to recall definitions of informatics and computer science, but they have considerable trouble illustrating the difference between the two by their own examples.

3.2. Conclusions of the Questionnaire

> How much time does it take for the command to get from
> the computer to the robot, if the robot is a kilometer away
> from the computer and they are connected by a wire?
> A fraction of a second. It would take longer on foot.

Due to the small sample of our study, we have only outlines. However, our study allows us to conclude that the students' practical and theoretical knowledge is at about the same level regarding dynamic-versus-static, but their amount of knowledge regarding informatics is very far from sufficient.

According to the data, students are more likely to memorize the text book (although they are doing this very poorly, with less than 50% efficiency), than to undergo independent adventures in the realm of informatics. As long as some of our students think that C++ is an improved version of the C64 computer, and they only know the difference between analog and digital telephone systems as 'digital is better, other I have no idea', we cannot be satisfied with our current training methods.

If we accept the necessity of an appropriate user-level knowledge, then we have to push the balance towards dynamic, practice-oriented knowledge. In this spirit, we must move the teaching of informatics toward the direction of practice-oriented, platform-independent training as soon as possible. The traditional rules are invalid for informatics and the field is developing at a rapid pace. By continuing traditional teacher and material-centric education, it is doubtful that we can achieve any meaningful change in attitudes or lasting results. In addition, informatics accelerates and dominates static knowledge and static thinking. Thus, self-education is the solution.

In our model we simply assumed, but did not prove, the reason for introducing dynamic and practical knowledge and its correlation, with informatics intelligence. Differences in knowledge structures, the need for and methods of the change in current knowledge structures are intended to be the subject of a future paper. Perhaps a pedagogical experiment based upon curricula aiming at these questions, methods, and changes, with an emphasis on end-user-oriented problem-solving skills. For example: usual office work, installations, migrating to new operating systems, algorithmic thinking, research, or troubleshooting.

4. Motivation

According to the pedagogical literature, proper motivation is required for efficient autodidactic learning. Combined with skills for using the necessary tools and the ability to select the right information, this is sufficient. Several experiments show that the positive attitude students display upon entering a school significantly decreases later on. Our own study, which was conducted among students undergoing pedagogical training in technology, found an initial non-negative attitude with 95% certainty and a 7% margin of error (NAGY, 1998). In the case of motivation, the emphasis should be put on its preservation – a positive attitude and interest must not be depressed. The tools of maintaining motivation can come in a large variety, such as challenging tasks, bonus exercises, even games. The only limit is the teacher's imagination.

If we can establish and maintain our students' motivation – their skills in using the appropriate tools, and their aptitude for information navigation – then we have already laid down the basis for their independent study; they will be able to build their own knowledge based on their own needs. It is not necessary to focus on how much specific knowledge we communicate to our students. Instead, we must make sure that they are able to differentiate between the various sources of information. Our students must learn how to critically evaluate and select information.

Thus, our students will be able to acquire the specific knowledge by themselves. Let us rest assured: They will be able to do it faster than we can.

That is why we can assume:

$$\text{autodidactic learning} = \text{necessary skills} + \text{motivation}$$

5. The Next Steps

If we describe informatics intelligence as the ability to adapt to and solve problems in informatics situations, we may propose a working hypothesis, similar to the procedure Biszterszky used (BISZTERSZKY, 1980) when he was evaluating the concept of programmed learning: Informatics intelligence is at least as efficient in problem-solving as the knowledge-content communicated by traditional teaching methods.

Although there are several methods for comparing didactic efficiency, we shall use the one described by Varga (VARGA, 1988). He finds that teaching methods are more efficient didactically when they require less time to achieve the same level of knowledge, if the time is kept constant, as the proven method which results in higher level of proficiency in the given subject. We must note that Varga's method compares time and not effort invested in learning.

We may also interpret informatics intelligence as one way of acquiring knowledge and skills necessary for information literacy. This means we have to concentrate on the acquisition of skills that make independent learning possible; the knowledge of currently valid facts is of less importance. If we accept the priority of problem-solving skills, along with the primary importance of skills utilizing the appropriate informatical tools, we may propose this working hypothesis: Regarding informatics knowledge, we assume that dynamic and practical elements of the knowledge structure are more useful than static elements, since the circumstances of informatics (for example, software, hardware) are changing at a rapid pace. Also, in a future scenario involving informatics, students need hands-on, computer experience (practical elements) rather than theoretical knowledge. Thus, by making our students' knowledge structure dynamic and practice-oriented, we will achieve a 'platform-independent' teaching of informatics. Since informatics is changing so rapidly, the traditional teacher- and material-centric education will not demand the required changes in attitude and long-lasting results. If our experiments succeed, our students, trained by the methods described above, will always be competitive and efficient in informatics teaching professions and in the labour market in general. The costs of the on-going informatics education of students who completed our curriculum will also be lower than they were traditionally. In order to prove the above hypothesis, a pedagogical experiment is being conducted at the Technical University of Budapest.

Given our goals and opportunities, we should make an effort to create a general informatics curriculum to be used in teachers' training, regardless of their subjects. The beneficiary of the new Information Society will be today's cyber-generation, most members of which are still at school; thus it is imperative that the teachers of future generations possess information literacy, since only teachers with appropriate informatics skills can help students practice informatics-related activities. We all know: Only literates can teach literacy.

5.1. A Few Words on the Future

What kind of changes and adaptivity are required on the part of our education system – most importantly, on the part of teachers – in order to realize the future we have dreamt about? How should we change our attitudes, our ways of thinking?

What should we know? The society of the future is called by many the society of knowledge. Knowledge will play an even more significant role than it plays today – even market demands will be governed by ever newer knowledge technologies. Many of today's buzz-words indicate this trend: knowledge discovery, database mining, knowledge detection, knowledge extraction, knowledge-packaging, knowledge design, knowledge broker, knowledge engineer, even chief knowledge officer. The Hungarian educational system is ready to be transformed into a 'knowledge-laboratory', that can serve as an example of a system which has the structure and content that is required by a knowledge-based economy (Karvalics, 1997).

Informatics perfectly illustrates the problems of preparatory vs. fact-teaching functions in didactics. We no longer have the fixed points of reference that we had in our former, more stable world. It is almost impossible to make even short-term predictions, not to mention long-term ones. Observing the most frequently-referenced literature (Schaff, 1984; Roszak, 1990), we see that many long-term predictions have already been reached, while many short-term predictions have not only not been achieved, but we can hardly say that we have made the first steps towards them. It is as if a bookmaker of the Eocene Age tried to call the winner of next year's Epsom Derby, based on his knowledge of ancient horses (metaphor taken from Komenczy). It is impossible to prepare for specific contents of knowledge; the only goal can be adaptivity. From this point of view, today's 'Neumann-being' has a much easier job than the 'Gutenberg-man', since the first shock-waves of unprecedentedly rapid change have already reached us and we only have to cope with the secondary, expected waves. Adaptivity is not like lexical knowledge, it can be practiced.

If knowing specific facts is only of secondary importance, then readiness for acquiring facts will become a basic skill. We will no longer talk about a society of knowledge, we will most likely talk about a society of skills and proficiency. We can use this as our new paradigm. At the same time we must exercise caution, and should never forget about 'Lewin's firefighters'. Nevertheless, the question of what to teach – programming, theory of algorithms, software applications, touch-typing – will be seen from an entirely new perspective.

We may ask whether information literacy will replace traditional literacy. We hope that the above thoughts show that the Neumann-universe will not destroy, but integrate the Gutenberg-galaxy.

If we accept that information and communication are basic needs of human existence, they should be declared as universal rights.

We do not claim that the ideas of this paper are revolutionary or have never been heard of before. We have merely attempted to synthesize and to contribute to a more sophisticated informatics curriculum, and to demonstrate more efficient teaching methods in the subject.

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Appendix 1: The Questions

1. Define computer science with your own words.
2. What is C++. Give an example for its application.
3. Describe the UNIX operation system, list a few features of it.
4. Define informatics with your own words.
5. Make pairs (only the most significant:)

Multitasking,	DOS
CPU,	Central Processing Unit
One task at a time,	Norton Commander
File-handling,	printer
Sub-directory,	4th generation
Output device,	tree structure
ENIAC,	150 Kw
IC,	Windows

6. Draw a flow-chart of an exam.
7. List the three main features of the DOS operating system
8. Give your own example for the difference between computer science and informatics.
9. What are Neuman’s principles?
10. What is arj?
11. Name three computer games.
12. What does a computer do when the rd command is given?
13. How many bits are in 1 Gbyte (you don’t have calculate!)
14. Describe directory structure for an eight-year-old child.
15. Which operating system appeals the most to a six-year-old?
16. What is the basic difference between memory and hard disk? Why?
17. How much time does it take for the command to get from the computer to the robot, if the robot is a kilometer far from the computer and they are connected by a wire?
18. What is HTML?
19. How do you make a table with WinWord?
20. What is the difference between the analog and digital telephone systems?
21. What does the word ‘hacker’ mean?
22. Give an example of using computers in the teaching of chemistry.
23. Describe the roles of the three wires in a grounded cable that is not used for telecommunications?
24. What does the expression ‘operating system’ mean?