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THE DEVELOPMENTAL LEVEL OF IT SKILLS AT THE END OF PRIMARY AND SECONDARY EDUCATION

THESIS OF A PHD DISSERTATION

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1. INTRODUCTION

The purposeful and creative use of IT tools is a crucial factor of social, economic and cultural life of the 21st century. The field of research aiming at the assessment and evaluation of knowledge, skills and abilities concerning information communication technology (ICT) is expanding rapidly (*OECD*, 2005, 2006; *Katz*, 2005, 2007a, 2007b; *Katz* and *Macklin*, 2007; *Lennon*, *Kirsch*, *von Davier*, *Wagner* and *Yamamoto*, 2003; *European Commission*, 2006, 2007; *Eurydice*, 2002, 2004; *Eurostat*, 2007a, 2007b), yet, no objective data from representative assessments is currently available on students' ICT knowledge. The aim of the present research is the characterization of the Hungarian primary and secondary school leavers' ICT knowledge. In the assessment process we administered self-constructed questionnaires for measuring the level of technical, application and communication skills of 14- and 18-year-old students.

2. THEORETICAL SOURCES OF THE DISSERTATION

In the first chapter as a literature review we summarize research on information literacy and review the main concepts. The concept of *information literacy* covers the recognition of the need of socially beneficial information, the determination of the quality and quantity of the needed information, the search for this information and its acquisition, evaluation, processing and legal usage *(ALA,* 2000). *Information technology literacy (IT)* comprehends the needs of information acquisition and application of technological tools. *Computer literacy (CL*) means the ability of instrumental computer use, the awareness of the different hardware and software devices and the skills of their proper usage (*Bundy,* 2004) as well as the creative, yet critical application of information communication technologies (*Eurydice,* 2002). The development of computer literacy first and foremost designates the development of the ability to create algorithms, i.e. to segment one's action up to basic operations and apprehend these operations; comprehensive application of computer softwares, coding and decoding, i. e. converting ability. *Digital literacy (DL)* incorporates cognitive and technical abilities. It demands primarily the deliberate operation of the most frequent functions of widespread, daily applied user programs, e.g. word-processors, spreadsheets, communicational or graphic softwares. Digital literacy can be certified with the *European Computer Driving Licence (ECDL)*. In the *Recommendation of the European Parliament and of the Council* (2006) digital competence is one of the defined key-competences for life-long learning. Digital competence here means the confident and critical use of *Information Society Technology (IST).* IST is based on computerized communication and active participation in community networks. IST well reflects the shift of attention from technological advancements to socially beneficial and indispensable processes.

3. RESULTS OF THE OECD PISA

In the second chapter we present the OECD projects on the usage of ICT tools. One of the background questionnaires of PISA studies surveys the potential availability of computers for students, their attitudes to computers, the frequency of the application of different computer operations and the confidence displayed in the execution of these operations (*OECD*, 2005). The knowledge maps drawn from the results of the PISA studies objectively indicate the abilities of the 15-year-old population, thus creating an opportunity to characterize their confidence displayed in the use of computer tools and to compare the Hungarian data with international sources as well as contributing to the analysis of Hungarian strengths and weaknesses.

The international comparisons principally draw our attention to the need of a perspective change resulting in more widespread use of information technology tools and the acquisition of computer functions that support learning and communication. The answers to the questions about the usage of

internet indicate that the use of the worldwide web in Hungary does not yet fulfill its goal of efficiently supporting the processes of learning and skills development.

4. THE SPLIT-LEVEL IT FINAL EXAM OF SECONDARY EDUCATION

The third chapter conjures up the implications of the Hungarian split-level IT final exam of secondary education. The goal of this examination is to assess whether the candidate possesses the ultimate basics of general knowledge, adequate factual knowledge and thinking skills, whether he is capable of structuring this knowledge, practically applying it and self-regulating the process of learning, in other words, if he is prepared for higher education (*100/1997. (VI. 13.) Korm. rendelet*, *40/2002. (V. 24.) OM rendelet, Tompa,* 2005).

The tasks in the five subfields of the medium-level exam (word processing; presentation and graphics; web-page design; spreadsheets and database management) and in the four subfields of the advanced-level exam (word processing, presentation, graphics, web-page design; spreadsheets; database management; development of algorithms and data modeling) reflect the expectations of the educational system. Exam assignments have a beneficial effect on the instruction of the subject as well (*Horváth and Lukács*, 2006). The results of the IT final exam reflect the knowledge of the participating students (medium-level: N_{2005}=18569; N_{2006}=22331; advanced-level: N_{2005}=679; N_{2006}=1589).

5. METHODS AND INSTRUMENTS

In the following four chapters we present the results of a survey that was carried out within the frameworks of the longitudinal study 'The role of public education in the preparation for life-long learning' of the Center of Research on Learning and Instruction of the University of Szeged. Prior to our investigations a model was developed and the key IT skills were selected and defined as those of the PISA ICT survey. Tasks assessing technical, application and communication skills were developed on the basis of the definitions and in line with the requirements of the final exam of secondary education in information technology.

According to our definition the development of *technical skills* is primarily manifested in the knowledge and understanding of file manager algorithms, the recognition of the functions of different settings, and the knowledge of the parts and data characterizing computers. The technical skills measuring tasks explored knowledge of the most widely used file manager operation, i.e., saving, the correct parameter settings of saving, the recognition of the algorithms underlying the most frequent operations of the operational system, the knowledge, recall and understanding of the proceedings in the copying of files and the recognition of the data characterizing the most widely used hardware devices.

The development of *application skills* is indicated by knowledge and understanding of procedures available in users' programs and the recognition of the functions of the different settings available during the execution of the algorithms. The most widely used software of office software packages is the word processor, although the application of other graphical programs such as spreadsheets, database managers or presentation makers are becoming important as well.

The developmental level of *communication skills* is measured as the knowledge of the procedures used for communication, the understanding of the algorithms, the recognition of the functions of the settings and the knowledge of concepts used in communication programs. The developmental level of the skills is indicated by knowledge and comprehension of the most frequently used functions of the electronic mailing systems, browser softwares, databases and search engines. In the assessment we investigated how purposeful the way of students' application of e-mail systems, browser softwares, online databases was and whether or not they were able to judge the credibility of internet contents.

The grade 8 test was solved by 3191 students from 163 classes of 94 schools. The instrument contained 14 assignments altogether in the operational levels of knowledge and comprehension. Three of the tasks aimed at measuring technical skills, six covered the application and five the communication skills. The instrument comprised of 103 items of which 70 were multiple-choice items and 33 were open-

ended questions. 17 of the closed questions aimed at exploring students' technical skills, 34 closed and 19 open-ended questions measured application skills and 19 closed and 14 open-ended ones concerned communication skills.

The grade 12 test was administered to 1747 students from 73 classes of 43 schools (40.2% from secondary grammar school, 59.8% from secondary vocational schools). The instrument contained 13 tasks in the operational levels of knowledge and comprehension. Three of the tasks aimed at measuring technical skills, five tasks covered the application and five the communication skills. The instrument constituted of 110 items of which 78 were multiple-choice and 32 were open-ended. 18 of the closed questions aimed at exploring students' technical skills, 41 closed and 18 open-ended questions concerned application skills and 19 closed and 14 open-ended measured communication skills.

6. RESULTS

6.1. THE DEVELOPMENTAL LEVEL OF IT SKILLS

According to our hypothesis our data will confirm a higher level of development of the technical and a lower level of development of the application skills, since students can begin to use application programs only after the confident acquisition of the technical skills. It is also hypothesized that students' skills development level concerning the usage of application programs is higher than that of the communication skills, since application programs comprise a central issue in the core curriculum, whereas the functions of the communication devices are mostly acquired in a social context.

The achievement of grade 8 students was the highest in the field of *application* skills (50.1%), their performance was somewhat poorer in case of *technical* skills (45.1%) and the lowest achievement was measured in the skills of *communication* (38.6%). The differences proved to be significant, which allows us to conclude that technical skills develop with the skills of application while operating user programs and students start using application and communication softwares without possessing confidently functioning technical skills. The low scores of communication skills suggest that at this age these skills do not reach the level of development required by active and conscious participation in communication-based technical activities.

In case of the eight-graders the first part of our hypothesis was not confirmed, since the developmental level of application skills are higher than that of the technical skills, therefore, the latter seems to develop during the use of office programs. However, data support the second part of the hypothesis, since the developmental level of application skills are higher at this age than that of the communication skills. This is probably due to the centrality of the application skills in the core curriculum.

The results of grade 12 students were also significantly different in the three investigated fields, but the developmental order was not the same as that of the eight-graders. The highest scores were achieved in the *technical* skills (65.6%), while the poorest achievements (35.9%) were measured on the *application* subtest, on office application tasks matched to students' age level. These results suggest that students use technical skills as working tools for the application of other skills. The development of *communication* skills (45.6%) is influenced by the developmental level of social skills and the increasing importance of electronic communication in everyday situations. The low developmental level of the application skills may be due to the optionality of the IT final exam of secondary education.

In case of grade 12 only the first part of our hypothesis can be confirmed, i.e. the developmental level of technical skills are higher than that of the application skills, meaning that students belonging to the elder age group can confidently manage files during the use of applications and communication softwares. However, data do not support the second part of the hypothesis, since communication skills proved to be more advanced than application skills. The results indicate that solving application tasks similar to those of the final exam of secondary education pose a problem for most of the students of this age.

6.2. STRUCTURAL ANALYSIS

It was hypothesized that the tasks of the tests comprise a hierarchical, cohesive structure; no isolated substructures are differentiated by the dendrograms of the clusteranalysis.

Dendrograms depicting the relationships of the tasks show two distinct categories in case of both grades. This confirms that IT knowledge of students constitute more than one distinct structures in students' minds. The first category comprehends tasks requiring creative thinking and the solving of unfamiliar problems on which students scored less. Another group of tasks was comprised of those on which students performed better. Tasks outside of school context connected to the structure less closely.

The hypothesis according to which the applied tasks comprise a hierarchical, coherent structure was not confirmed, since the dendrograms of the clusteranalysis depicted more distinct substructures along with some elements isolated from these substructures.

6.3. RELATIONSHIPS BETWEEN ACHIEVEMENTS

We assumed a strong correlation between achievements on the test and its subtests. It was also hypothesized that IT related skills develop parallel, and that no significant difference exists between the developmental level of the skills.

Data confirmed the hypothesis which assumed a strong relationship between achievements on the whole test and its subtests (grade 8: $r_{test\text{-}applic}=0.92$; $r_{test\text{-}comm}=0.75$; $r_{test\text{-}techn}=0.75$; grade 12: $r_{test\text{-}applic}=0.92$; $r_{test\text{-}comm}=0.75$; $r_{test\text{-}techn}=0.69$; $p<0.01$). The strongest correlation with the test was found in case of the application subtest, meaning that achievement on the whole test is most strongly determined by the application subtest. In case of grade 12 the weakest correlation with total test achievement is shown by the technical subtest, which suggests that at this age technical skills contribute the least to total test achievement.

Considering relationships between the subtests, we find weaker correlations (grade 8: $r_{techn\text{-}applic}=0.55$; $r_{techn\text{-}comm}=0.45$; $r_{applic\text{-}comm}=0.52$; grade 12: $r_{techn\text{-}applic}=0.47$; $r_{techn\text{-}comm}=0.43$; $r_{applic\text{-}comm}=0.53$; $p<0.01$) In case of the grade 8 test the strongest correlation was found between the application and the technical subtests, while grade 12 results show the strongest correlation between the application and the communication subtests. Higher correlation coefficients refer to the interrelated development of the skills. Weaker relationships between the subtests refer to the partial connections between skills and the differences in their developmental levels.

Results also show that 25.4% of the grade 8 sample fell into 0-19% achievement category in case of the technical subtest, 14% in the communication subtest and 9.2% in the application subtest, i. e. some students use application and communication softwares without an appropriate level of technical skill development. Due to home computer use and the improvements made at school on the communication and application subtests 85.9-86.0% of students achieved between 20% and 79%, i.e. few students performed very poorly or very well.

20.5% of grade 12 students fell into the 0-19% achievement category on the application subtest and 7.2% in case of the communication and technical subtest. These results suggest that a significant ratio of students have underdeveloped application skills. On the technical subtest 37.9%, of grade 12 students performed between 80-100%, on the communication and application subtests 1.6% and 1.7%, respectively. This proves that some of the students can reach an optional technical skills developmental level by this age.

On the basis of crosstabs on achievements concerning the different skills it can be claimed that the majority of students performing poorly in one area also performed on a low or medium level on another. However, there were also some students whose achievements were low in one area but performed outstandingly in another one.

Due to the interconnected improvement of skills and the complex tasks applied during instruction the majority of those performing on a medium-level in one area performed around the same level in

another, but those whose achievements were different from the mean tended to perform on a lower rather than on a higher level.

The high achievers of one field also tended to perform on a medium or high level in other fields as well, although there were some students who had high scores on one subtest and still displayed underdeveloped skills in other fields.

In summary the hypothesis assuming the parallel development of IT skills was not confirmed by our data: there might be large discrepancies between the developmental levels of the different skills.

6.4. INVESTIGATIONS ON THE SOCIO-CULTURAL BACKGROUND

We expect large differences between schools and results being affected by other factors (gender, socio-cultural background, the mother's education) as well.

Girls outperformed boys in grade 8 ($mean_{boys}$=45.2%; $mean_{girls}$=47.8%; t=3.9; p<0.001). Boys scored higher in the field of technical skills ($mean_{boys}$=50.5%; $mean_{girls}$=42.1%; t=7.4; p<0.001), whereas girls proved better in application (t=5.3; p<0.001) and communication (t=8.8; p<0.001). Gender differences can be attributed to the more developed communication skills of female students, their endeavor for precise problem solving and generally higher pretensions (*Balázsi*, *Ostorics* and *Szalay*, 2007).

The most poorly performing school out of the 94 participating primary schools in our survey had a mean achievement of 15.7%, whereas the best school reached a mean of 75.2%. The achievement of two schools was significantly lower than the mean, while in nine cases it was significantly higher.

ANOVA showed in students' knowledge of information technology 18 times as large variance between ($F_{schools}$=18.1; p<0.001) as within schools and 14 times as large between ($F_{classes}$=14.2; p<0.001) as within classes. This difference between individual schools refers to the more determinative role of the school, its facilities, infrastructure and human resources compared to that of particular classes. Moreover, this phenomenon draws our attention to the highly determinative nature of school choice on students' future life.

Significance-test of the ANOVAs showed that the achievement of primary school pupils is further influenced by their mothers' education (F_{moth_ed}=18.7; p<0.001). In case of the technical subtest major (F_{techn}=17.0; p<0.001), while on the application and communication subtests minor (F_{appl}=10.9; F_{comm}=12.9; p<0.001) differences can be identified between students according to the parents' education. On tasks measuring technical skills differences between individual groups in the interpretation of algorithms of file manager operations are larger than in the knowledge of technical devices (F_{i01}=13.7; F_{i02}=7.1; F_{i03}=14.2; in all cases p<0.001). In conclusion, schools are not capable of compensating home-based differences between students during their developmental work, although in case of application and communication skills schools partly fulfill the principle of equal chances. With an exception of two tasks the influence of mothers' education was confirmed in all cases. The insignificancy of the effect of mothers' education on students' achievement on these two tasks (in both cases F=1.8, p=0.11) may be attributed to the widespread use of word processor softwares, to successful instructional practices and in case of judgments about the credibility of internet content to common underachievement.

In the sub-sample of the 18-year-olds boys overachieved girls, the gender differences are significant ($mean_{boys}$=45.9%; $mean_{girls}$=42.3%; t=3.9; p<0.001). by 3.6% (F=0.01; p=0.92; t=3.92; p<0.001). Among the sub-tests the only one with significant gender difference was the technical sub-test ($mean_{boys}$=77.9%; $mean_{girls}$=56.8%; F=54.5; p<0.001; t=16.1; p<0.001). It reflects the technology oriented interest of boys that they achieved better results in all the technical assignments than girls.

Out of the 43 secondary schools that participated in our assessment 68.8% was the mean of the best achieving school, whereas 23.8% of the most poorly achieving one. Two schools performed significantly below the mean while four ones above it. In grade 12 we found 20 times as large (F_{class}=20.6; p<0.001) difference between as within classes and 25 times as large (F_{school}=25.6; p<0.001) difference between as within schools. The higher F values compared to the grade 8 sample

suggests that in secondary education classes are organized from students with more homogeneous cognitive abilities which results in larger differences between classes and schools.

Significant differences were found between achievements of subsamples based on mothers' education (F_{moth_ed}=4.2; p<0.001). The influence of mothers' education on achievements can be confirmed in all cases with the exception of five tasks. Due to solid instruction and everyday use of word processing softwares ((F=0.8; p=0.58), i.e. because of achievements independent of social background, in case of the application subtest (F=1.0; p=0.39), on three application tasks (Presentation: F=1.4; p=0.22; Database-management: F=1.1; p=0.37; Database management – requests: F=2.0; p=0.08) and on one communication task (Electronic library: F=1.7; p=0.13) the influence of mothers' education on achievements was not significant.

In conclusion, the hypothesis that assumed large differences between schools and classes and achievements being influenced by gender, socio-cultural background and mothers' education was confirmed by our data.

6.5. ANALYSIS OF THE HIGHEST ACHIEVEMENTS

According to our hypothesis with the analysis of the achievements of best performing students it can be proved that the development of technical skills successfully supports improvement, and that communication skills develop at a slower pace even in case of the best performing students.

In the grade 8 sample the achievement of the sub-sample of the best achieving students on the sub-tests are partially ranked differently compared to those of the whole sample. The best performing students achieved 41.8% better on the technical sub-test, 28.5% better on the application sub-test and 22.9% better on the communication sub-test than the total sample. The modification in the order of the different skills levels and the exchange of the technical and the application skills suggests that in certain fields of IT skills one can reach outstanding achievements only when possessing confident technical skills, yet in this age-group even the best performing students are unable to apply communication skills at a high level.

On grade 12 the largest difference between the best-achieving students and the total sample was found in case of the technical skills (35.4%). The same ratio on the technical skills and the communication tests are 26.7% and 21.8%, respectively. Large differences measured in application skills reflects that this is the field where students develop the most during secondary school, since this is the skill that curricula support the most. Minor discrepancies in communication skills indicate that this sub-sample is also unable to use communication skills at a high level. The high level of technical skills confirms that they are to be interpreted as a precondition for outstanding achievement in IT.

As it was assumed, the development of technical skills supports the development of others, but the communication skills of even the best-performing students develop slower.

6.6. THE DEVELOPMENT OF IT SKILLS

Differences between the achievements of secondary and primary school students are, presumably, significant in all skills and on all tasks, but the width of discrepancies might be different in the various fields.

Significant differences were found between the achievements of the two age groups in all skills. Grade 12 students proved more confident in tasks measuring technical skills, which might be due to the regular and complex practice of operations. The difference between the two sub-samples is also significant in most tasks on communication skills, where the change might be attributed to the joint effect of informal and formal instruction, although the latter has a more moderate effect. Both age groups performed poorly on the task requiring the analysis of web pages. The slightest change was measured in case of the application sub-test, which suggests that students ignore the concepts that would be needed for the professional use of softwares.

In summary, age differences in achievements are significant in all of the skills, yet not in case of all tasks. The most prominent improvement was found in the comprehension of perceptual-level operations.

6.7. CONCLUSIONS

In our research we characterized future secondary- and higher education students' IT skills. On the basis of achievements concerning skills, tasks and items we described on three levels in which skills, algorithms and sub-tasks students are confident, what kind of knowledge supports the effective use of operations and what deficiencies hamper the operation of given skills.

During secondary years technical skills show a major, communicational and application skills a moderate development. Skills development is supported by the regular everyday use of operations. Results confirm the hierarchy of IT skills, the optimal development of the technical skill can be viewed as a precondition of the communication and the application skills, its deficiencies may undermine the development of skills building upon it. In those fields, where students do not recognize its importance neither in their activities at home nor during their school studies, the responsibility of development is passed on to higher education and the labour market.

Furthermore, the present study proves that students' knowledge is heavily context-dependent. In numerous cases they are able to solve a certain task if they have already encountered with similar content and formal requirements within class context (*Csapó* and *Korom*, 2002). Instead of formal improvement, content-based improvement techniques might be more efficient in IT education. During the training, cognitive skills should be improved in a context that provides opportunities for a complex development of skills. Successful solving of IT tasks requiring the joint activation of technical, application and communication skills demand a complex application of skills, but preparation for these tasks must be based on the optimal development of individual skills. During the skills improvement emphasis should be put on the confident application of algorithms.

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