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The effectiveness of the Webtable-Datatable Conversion approach*

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Abstract. Informatics education in Hungary is based on the National Base Curriculum (NAT) and the Frame Curricula. These documents contain the subjects (sciences), the number of classes for each subject and the requirements for each grade. According to the NAT2012, Informatics as a compulsory school subject is introduced in Grade 6. The filemanagement is among the first topics that students must learn according to the Frame Curricula. However, this is not their first encounter with filemanagent, since by the age of 12 most of the students are already active users of digital tools, and associated with the false assumptions of digital natives. Due to the late introduction, the filemanagement is one of the most neglected topics in informatics education. Nevertheless, this is one of the most important topics, since it is essential for further development in handling digital products. Our research group developed the Webtable-Datatable Conversion (WDC) high-mathability method to teach filemanagement. This approach not only focuses on the main file operations but handles real world problems which require firm algorithm construction and datamanagement. The aim of the present study is to measure the effectiveness of the WDC approach with Grade 9 students, where the comparison of groups studying with the traditional and the WDC methods was carried out.

Keywords: K-12 education, filemanagement, knowledge-transfer, informatics education

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1. Introduction

1.1. The role of filemanagement in studying informatics

According to researchers [5, 6, 26, 28–30] and the Hungarian National Base Curriculum [20], computational thinking is the fourth basic skill alongside the 3Rs (Reading, wRiting and aRithmetic). Consequently – similar the other three skills – computational thinking should be developed from the beginning of organized education [13, 16, 25]. Although, the development of computational thinking skills is emphasized in the National Base Curriculum, in the Frame Curricula [18, 19] – which is created on the bases of the National Base Curricula [20] – is hardly detectable. The focus of the informatics Frame Curricula [18, 19] is reather on teaching the software environments and tools, for the students to be able to navigate in programs. Furthermore, informatics as a compulsory subject is introduced in Grade 6, only one class a week. The primary reasons why the filemanagement does not receive enough attention is due to the extremely low number of classes, the late introduction of the school subject, and the attitude assigned to digital natives [16, 22]. In general, it is assumed that every student know it and use it, and consequently, there is no need to pay attention to this topic.

1.2. High-mathability teaching approaches

The IEEE & ACM report [1] defines three level of mastery, which is in complete accordance with Pólya's [21] concept-based high-mathability problem-solving method [2–4, 8, 9]. The steps are built on each other, so are the levels of mastery: analyses of the problem (1), construction of plan (2), implementation (3), and discussion (4). However, in informatics education, the focus is on the third level of problem solving, ignoring the first and the second – understanding the problem, what we know about the problem and the planning, building algorithm – thus making it impossible to reach the fourth level, the evaluation, the discussion. Overall, the Hungarian Frame Curricula [18, 19] does not pay attention to the development of the students' computer thinking skills and does not support the algorithm building and the schema construction, which play crucial role in cognitive load [27] and ultimatily activating fast and slow thinking effectively [12, 15].

2. WDC method

The Webtable-Datatable Conversion (WDC) [4, 12, 14] method is a high-mathability approach [4, 7, 10], which is based on the use of schemata and building algorithm in the subject of filemanagement. At the beginning of the educational process the teacher raises a problem: how a table available on an webpage (webtable) can be converted to a datatable for further use in spreadsheet- and/or database- management or programming. WDC is time consuming teaching-learning appoach for developing fundamental skills in informatics. Furthermore, the method heavily relies on the students' knowledge stored in the longterm memory. Considering theses bases, the teacher leads the conversation with coaching techniques [9, 17], where targeted questions are used to help students to set up the characteristics of the data, to understand the problem, and to find their own solutions. In Pólya's terminology the method is entitled guided discovery [21]. Students can also get help in Redmenta [23] where a matching test is built to find operations and the corresponding steps of the algorithms (the tasks are developed by one of our pre-service teachers of informatics). Based on the algorithm, the students complete the steps which primarily are fundamental file operations: save, save as, create, open, close, etc.

The matching tasks (Redmenta) develop students' fast thinking skills [15, 27], based on the schemata build up in long-term memory. It is important that the students do not only follow strict steps, they rather focus on the problem and the problem-solving strategies, otherwise they would not be able to solve the tasks, since they are all different – authentic content. During the conversion process, office applications are used – especially browsers, word processers, and spreadsheet programs. The selection of the program depends on the original sources, the webtables, and the goals of the classes and the projects. Here, we must note that using these programs in the conversion process allow us to lay the fundamental skills to their effective use.

3. Measurement

To quantify and prove the efficiency of the WDC method, our research group tested experiment groups where this novel, high-mathability approach was introduced, and compared their results to control groups where the traditional, low-mathability, tool- and environment-focused methods are used to teach file handling (based on the Frame Curricula). Four hypotheses were formulated to see how students develop using the low-mathability and the newly introduced WDC method.

H1. In the pre-test, there is no significant difference between the results of the experimental and the control groups.

H2. The results of the students in the post-test are significantly higher than in the pre-test.

H3. In the post-test, the experimental group reached significantly higher results.

H4. The rate of development was significantly higher in the experimental group than in the control group.

3.1. Sample

The teaching and the testing process took place in the academic year of 2018/2019, in two high schools in Hungary. All students from Grade 9 formed both the experimental and the control groups. Filemanagement is taught from Grade 6 in the elementary school for every student included in the sample, based on the Frame Curricula [18, 19] and on the local curriculum of the schools. The groups were tested before (pre-test) and after (post-test) the teaching period, however some students were unable to participate in both measurement due various reasons: the teacher of two control groups refused to cooperate, students' illness, and school activities. Consequently, the comparison was based on the results of students who completed both tests. Table 1 shows the number of students who participated in our tests.

Table 1. The sample, the number of students participatin in the tests.

	Experiment group	Control group
Pre-test	30	79
Post-test	35	51
Paired	28	45

3.2. Tasks

The test consisted of six tasks with various number of questions focusing on the knowledge and conscious use of concepts of filemanagement: extensions, file types, editing/saving/opening files – in general, handling files. (Appendix)

Task F1 presents a well-known warning message of Windows operating system, which appears when one wants to change the extension of a data file [11]. The testsheet allowed students to mark more than one answer, but there is only one correct answer. With this liberty of selecting multiple answers, our aim was to measure whether students would realize that there is only one correct answer and whether they can reveal the juxtapositions in the answers. The only correct answer is "Changes what program is associated with the extension, but the file remains usable".

Task F2 was the an open question. Students had to answer the "What happens when we double-click on a document file?" question. This operation is a four-step process, where the expected algorithm is the following:

- checking the extension of the file
- checking the assigned program to the extention
- running the assigned program
- opening the file

In Task F3 students had to provide an answer on how a spreadsheet can be converted into a text file. Students were able to choose the correct answer from the listed options. Task F4 inquired about the cut file operation: "What happens when you cut a file?" In a similar way to the previous tasks, students had to choose their answers from the listed options. We allowed multiple selections even though that there was only one correct answer. In Task F5, students had to decide the types of the listed files, considering their names and extensions. Based on Tasks F1 and F2, we have found that students are not familiar with the definition of extension and their types. The results of the current task support and extend this finding. This can be explained by the widespread use of the File Explorer present in Windows operating systems, where the extensions of the files are hidden by default. We designed Task F6 to have questions about the same knowledge items using differing approaches and phrasing. In this way we could gather data about the conscious choices and reliable knowledge of students. Each question could be answered with the following options: TRUE, FALSE or I DON'T KNOW.

4. Results

4.1. Pre-test

In the pre-test the average results of the experimental (33.73%) and the control (38.02%) groups were almost the same, the statistical analyses showed no significant differences between the groups ($p = 0.0607$) (Figure 1). We examined the results of the tasks separately where also no difference can be detected (Table 2). These outcomes prove H1 hypothesis, between the results of the groups has no differences in the pre-test.

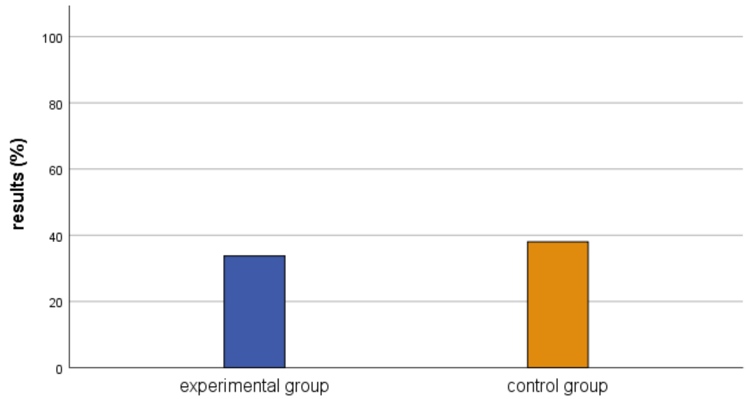

Figure 1. The total results –tasks F1–F6 – of the pre-test by groups (all sample, not only paired).

Table 2. The rate of correct answers for each task in the filemanagement test including all students.

tasks	experiment group	control group
F1	3.33%	5.06%
F2	19.17%	23.10%
F3	36.67%	34.18%
F4	46.67%	54.43%
F5	36.67%	37.55%
F6	38.33%	44.94%
total	33.73%	38.02%

The students reached extremely low result in some tasks, like F1 and F2 (Table 3). The main reason for this is that incorrect answers were marked along with the correct(s). Lots of the students marked multiple answers, while only one of them was correct. Those answers were accepted as correct where students only marked the correct answer. In the experimental groups 3.33%, in the control group 5.06% of the students marked the correct answer without others. (Table 2).

Table 3. The correct solutions and the proportions of students' answers in Task F2.

	experiment group	control group
extension	0.00%	0.00%
association	0.00%	1.26%
run	0.00%	3.79%
open	75.67%	87.34%
total	19.17%	23.10%

In the other tasks, students completed between 30–50% (Table 2) in average. Despite the higher results, it is clear that the students are not aware of basic definitions and concepts. The computational thinking skills of the students are low, they are not able to explain the process of activities which they carry out frequently.

4.2. Post-test

In the post-test, the number of the students was lower than in the pre-test (Table 1). The experimental group, in almost every task reached significantly higher results than the control group, expect in task F4 (Table 4). Consequently, the total result of the experimental group is significantly higher than of the control group, which proves H2 hypotheses (p=0.0000) (Table 4).

Table 4. The average results (%) of the two groups of students in the post-test.

tasks	experiment group	control group	p
F1	28.57%	7.84%	0.0200
F2	35.00%	24.51%	0.0110
F3	62.867%	21.57%	0.0001
F4	40.00%	47.06%	0.5229
F5	53.33%	36.93%	0.0019
F6	55.95%	45.91%	0.0003
total	50.51%	37.88%	0.0000

In Task F4, similar to the previous tasks, students had to choose their answers from the listed options. We allowed multiple selections even though that there was only one correct answer. In this task, students from the experimental group reached 40%, while the control group score is 47.06%. We must note here that in the experimental group with the exception of one student, everyone marked the correct answer (97.14%). However, those answers cannot be accepted where multiple answers were marked, even though one of them is the correct answer. In contrast, in the control group 84.31% of the students could recognize the correct solution which is less than in experimental group. Table 1 contains the number of students participating in both tests. For the comparison we used and work with the results of those students who participated both tests. The experimental group improved its score except in Task F4 and they reached significantly higher results in the following tasks: F2, F5, F6 (Table 5). The development of the total results is significant compared to the pre-test (p=0.0000). Consequently, the experimental group proves H3 hypothesis.

Table 5. The comparison of the results of the pre- and post-tests.

	experiment group			control group		
tasks	pre-test	post-test	p	pre-test	post-test	p
F1	3.57%	32.14%	0.0087	4.44%	8.89%	0.4204
F2	19.64%	33.93%	0.0028	25.00%	24.44%	0.7100
F3	35.71%	60.71%	0.0698	33.33%	24.44%	0.2901
F4	50.00%	39.29%	0.3262	53.33%	44.44%	0.3770
F5	36.90%	52.38%	0.0050	40.74%	38.15%	0.5557
F6	38.69%	54.76%	0.0009	40.74%	45.18%	0.0965
total	34.14%	49.57%	0.0000	36.98%	37.87%	0.5795

The results of the control group show different pattern, they could not improve their results significantly in any of the tasks (Table 5). In task F3, F4, F5 lower results were obtained compared to the pre-test, nonetheless the differences were not significant. In terms of total results, there is lesser than 1% improvement, which clearly demonstrate the ineffectiveness of the low-mathability, traditional methods. According to the results of the test, the control group did not prove H2 hypothesis.

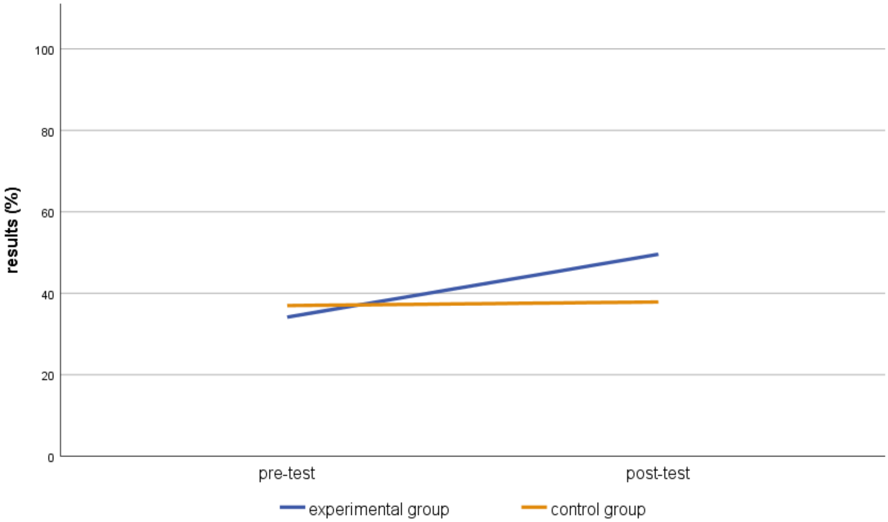

Figure 2. The results in the pre- and post-test.

We measured the difference between the rate of the development, where the experimental group obviously improved to a greater extent (Figure 2). The experimental group started from a lower level (but not significant) and reached a significantly higher level in the post-test. The control group was only able to develop 0.89% during the teaching period, while the experimental group increased its level with 15.43%. Consequently, H4 hypothesis is proved. In general, we can conclude that the high-mathability approach with focusing on schema-construction is more effective than the tool-centered, interface-dependent approaches widely accepted in schools.

5. Misconceptions

The students arrived from several schools, they learned ICT with various methods, this is a reason why they have different IT background knowledge, nonetheless, there were no significant differences between the experimental and the control groups in the pre-test. Therefore, the most common answers of the pre-test were analyzed without grouping. In Task F1 we allowed the multiple selection, however it has only one correct answer. In the pre-test 70.64% of the students marked more options. In the study, we searched for common response pairs, although there were students who marked more than two responses, but the incidence of identity in these groups is low. Based on the pre-test these are the most common response pairs:

- Option 2 with 5
- Option 3 with 6
- Option 3 with 5

Table 6. In the pre-test, the most common students' response pairs in task F1.

pairs	pre-test
2 and 5	32.11%
3 and 6	23.85%
3 and 5	22.93%

The pairs show that the students do not have sufficient knowledge of the concepts of the extension and association. The most common response pairs refer to students' own erroneous experiences and the unquestionable nature of the Windows error message (Table 6) [11]. One explanation to these low resutls that these students learned with interface-based traditional methods which are focused on navigation and the implementation without thinking and problem-solving. Another possibility is that they did not study filemanagement at school, based on the false assumption that as digital natives they already know it. Another common feature of these traditional methods are that students only work with the default extension of the office programs and they use the file explorer, where the file extension is not visible by default.

In the post-test, we analyzed the students' answers by group, where the results of all post-tests in the group were taken into account, not only the paired (Table 1). In the experimental group, the number of the students in the post-test who gave the correct answer increased (Table 4), but the number of multiple responders is still significant (60%). Based on the answers from these students, the following pairs of the answers are the most common (Table 7):

- Option 4 with 6
- Option 1 with 6

Table 7. In the post-test, the most common students' response pairs in task F1 by group.

experiment group		control group	
pairs	results	pairs	results
4 and 6	17.14%	2 and 5	15.68%
1 and 6	14.28%	5 and 6	11.76%

In the experimental group, the most common pair is the 4-6, which contains the correct answer (4), so students have already some knowledge about it, however not so clear. These students learned with WDC method, consequently, the misunderstanding points out which element of knowledge requires greater focus during the educational process. 70.58% of the students from the control group selected multiple answers. In this group the most common pair is still option 2 and 5, however, a new pair appeared (Table 7). Students in Task F2 did not provide enough answers. The number of students in the post-test who still only know one of the four steps of the process is still high in both group (experimental group 57.14%, control group 86.27%). Therefore, we have not enough data to make a conclusion.

Table 8. The order of preference for the answers to task f3, and its change in the post-test compared to the pre-test.

	experiment group				control group			
	pre-test		post-test		pre-test		post-test	
	pref.	%	pref	%	pref.	%	pref.	%
conversation	4	12.66	4	19.61	4	12.66	4	19.61
export	5	7.59	7	1.96	5	7.59	7	1.96
modifying the extension	2	16.46	2	31.37	2	16.46	2	31.37
google search	6	6.33	–	0	6	6.33	–	0
save as, selecting the new filetype	1	36.71	1	33.33	1	36.71	1	33.33
import	8	2.53	7	1.96	8	2.53	7	1.96
association	7	3.80	5	7.84	7	3.80	5	7.84
save as, changing the filetype manually	3	15.19	3	29.41	3	15.19	3	29.41
online converter	8	2.53	–	0	8	2.53	–	0
open in Notepad	7	3.80	6	3.92	7	3.80	6	3.92

In Task F3, we cannot find pairs to form groups based on the answers. Consequently, we did not look for frequently occurring pairs, but followed the preferences of the students' answers and its changes.

The number of the students from the experimental group who marked the correct answer doubled (Table 8). In contrast, the number of correct answers did not change significantly in the control group. However, the frequency of two responses – modifying the extension; save as, changing the filetype manually – were greatly increased so much so that it equals the number of students who chose the correct option. The knowledge of the control group has become even more fragmented than before. During the educational process in the control group, instead of becoming more accurate, students' knowledge became increasingly burdened with misconceptions, which is a very big problem. In Task F4 many students knew the correct answer, but they chose an extra option. In the pre-test, the most common counterparts to the correct answer is "a copy created of the file" and the "it is moved to the Recycle bin" in both group. This misconception can also be clearly detected in the post-test. The students see the cut operation in two ways:

- by itself: the operation disappears the file during the cut, so students assume that the file is deleted.
- together with another operation: when the concept of the paste operation has merged with cut.

Both methods are needed to eliminate this misconception and to pay attention to it. There is no evidence for misconceptions in Task F5 and F6, only a gap in the students' knowledge is detectable.

6. Conclusion

Filemanagement is one of the most essential topics in informatics and computer sciences. Reliable knowledge cannot be built on uncertain bases, consequently, on this topic greater emphasis should be placed and not be ignored, as has been happening so far.

We have introduced a high-mathability, schema-centered approach entitled WDC. The essence of the method is that tables originated on webpages are converted to datatables primarily through a file conversion processes. The other feature of the method is that real contexts are presented in classes, which increases the motivation of the students.

During the measurement of the effectiveness of the method WDC, we found that in the pre-test, the students, after 3 years of studying informatics in schools, do not have reliable knowledge in filemanagement. Their computational thinking skill is low, they cannot consciously use the tools of the Windows operating system, for example they do not know what happens during cutting operation, what the extension is and what it is for [24].

During the teaching period, the control groups studied with traditional, low-mathability methods, using decontextualized materials, if any, which is the widely accepted approach in educational environments. Our measurement proves that there is no difference between the students' results in the pre- and the post-test, which indicates that the teaching intervention has no effect on the development on the students' skills and knowledge. On the contrary, the experimental group studied with the WDC approach, their result increased in the post-test compared to the pre-test, and the development was found significant.

Based on the results of our measurement, we can conclude that education should not focus on the use of tools, interfaces, and the software environments, but rather on real problem-solving, where tools play a secondary role in the problem-solving process. We have found proof that with the WDC high-mathability approach students can build their knowledge level by level, and they could be solving unknown problems and situations based on their developed concepts and schemata. The analysis of students' responses has drawn attention to a number of misconceptions that provide a good basis for developing teaching-learning methods. It would be worthwhile to explore the cause of misunderstanding, which would make teaching filemanagement more effective.

Our measurement clearly shows the there is a great need for new, effective problem-solving-based approaches in teaching informatics, computer sciences. The requirement of the Frame Curricula cannot be completed with the low-mathability methods widely supported by education systems. The WDC method is an effective alternative for teaching filemanagement, and also lays the fundamentals of the topics the text- and spreadsheets-management by using authentic sources, real contents. The method based on the concept-based problem-solving approach of Pólya, using the method of guided discovery with an algorithmic focus [4, 24] is proved effective in developing the students' computational thinking skills.

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