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Studying the efficiency of hyperlearning, computer-based learning

Theses of doctor dissertation

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1. Introduction

Even in our days, one of the tasks of pedagogy consists in attempting to introduce more and more new educational methods, the "elements and factors" of which shall be continuously examined, analyzed, systematized and measured in order to enable us to use the most efficient solution in our educational system that intends to cope with the challenges of information technology. It is obvious, that the methods examined today cannot cut themselves from the challenges of information technology. Thus, the objective shall be that the research tasks in pedagogy have influence on the development of information technology and, thereby, the learning efficiency of the "internet generation [Don Tapscott (2002) is as high as possible.

1. 1. Objectives of the research

The objectives of the research are: to examine all the conditions that have influence on the "input side" of the educational methods that are continuously changing due to the new technical development; to examine the aptitude of students to perform the electronic learning successfully, with special regard to the attainment of subject matter controlled by multimedia programs; to systematize all the conditions that ensure the highest efficiency of any computer supported form of education with a drop-out rate as low as possible.

The main field of my studies includes the analysis of the efficiency of **computer-based** learning and attainment of subject matter.

It is examined, what are the factors that have influence on the computer supported learning process both on human side and in the light of the structure of training programs. It is, however, the STUDENT itself i.e. the actor playing part in the learning process that is the central element during my research activity.

1. 2. Reasons for research

- *Objective reasons*

Researchers engaged in education make attempts to formulate newer training and learning methods in proportion to the increased flow of information and the sudden development of communication means. Each one of them is motivated by the utilization of possibilities offered by the "high-tech" possibilities to a maximum extent and the development of the most efficient forms of attaining the subject matter.

- *Personal reasons*

It would be necessary to systematize all the factors to turn the opinions on the learning-on-screen — that otherwise split the society of teachers — into a positive direction. As a teacher of subject matters in information technology, I have a share in the technical development and I have the possibility of monitoring the changes in the learning manner of students. Therefore, with these factors taken into consideration, my objective is to make certain fundamental statements in order to improve the current educational system.

1. 3. Basic principles of research

The education science — similar to any other science — is of axiomatic structure and also proves its theorems; therefore, I cannot even chose but to do the same in this dissertation. As a starting point, I formulate the theorems as follows, that are hereinafter considered basic principles.

The pedagogue is an integral part of the educational process.

Interpreted as an unit of the teaching-learning process, the educational process cannot exist without the pedagogue. It is the teaching and the work of pedagogue that have the leading part in the process, while the emphasis is placed on the learning i.e. the activity of student and the quality and efficiency of the latter determine the quality and efficiency of the process as a whole.

In the environment provided with IT means, the teaching processes shall also use these means.

Formerly, it was said: "we learn for the life and not for the school." Still, if our everyday life is assisted and occasionally controlled or regulated by computers and better and better computer programs in every field, yet, they cannot even be omitted from the teaching process. But, they cannot be excluded; in fact, the students have not been using hand-written "cribs" for long time; instead, they use the means of information techology e.g. sms, e-mail, media players to "assist" them in achieving better results. The students can only prepared for their part to play in the information society if the principles of information technology, their results and the means of information technology are completely and to the full extent.

In the dissertation, the above two theorems are regarded as basic principles. It is not intended to study the part the teacher plays in the process of education and to examine whether computer is needed in the process of education.

1. 4. Research methods

With the indispensable analysis of the theoretical background, the fundamental methods of study were as follow:

First of all, experimental measures were performed, during which attempts were made to render the environmental factor i.e. a factor of influence a standard factor by ensuring the same conditions any time. For our measurements, measuring programs developed by our own were used. In the development of these programs, we made attempt to take the development rules of multimedia programs into consideration to the maximum extent.

The measurements were followed by a survey of knowledge using questionnaires. In addition to questionnaires, structured interviews were also used in the research.

For the processing of data, the means of descriptive statistics were used, while for revealing and evaluating the deeper relations, we made use of the methods of mathematical statistics. For the processing, Excel table manager and SPSS program were used.

1. 5. Means used during research

- Paper-based measuring means
- Electronic measuring means using computer.

In order to fulfill the research objectives, it was considered necessary to use several research methods.

Experiment

In respect of their site, natural experiments were used during our measurements.

In respect of their structure, experiments with selfcontroll groups were considered suitable in most cases.

In the college-scale measurements, the regular students studying at the technical manager line in the given school-year were regarded as a control group.

In the measurements, the method of random selection was used for the composition of groups. Therefore, the previous survey of knowledge and the repetition of experiments in each form with subject matters of the same type were always considered necessary.

Questionnaires

During the study, the questionnaires typically used in pedagogic measurements were used. This measuring tool measures the given psychic properties using the appropriate scale. [Benő Csapó (2002)]

Knowledge to be surveyed

Knowledge built in a short-term memory (text interpretation): reproduction of written text read from paper or screen, aimed at testing the efficiency of the means of teaching.

Knowledge of cognition type: (facts, concepts, laws). It can be attained within short time and it can be developed into permanent knowledge after a number of repetitions.

→ We measured 1 to 2 hours of work. E.g. possibilities of Internet, stationary flow.

Knowledge of aptitude type: (readiness, talents, skills). This level is the result of a long development process. → We examined several years of work; e.g. reading readiness of students attending the 6^{th} class, based on the work of the previous 4 years.

The knowledge types listed above determine the method of compiling tests and test tasks.

Interviews

For sorting the items of information gained by evaluating the questionnaires during the survey, the method of structured interviews was used. During the processing, the data and results obtained from the interviews were not separated; instead, they were handled together with the questionnaires to prove or disprove the answers obtained.

Interaction analysis

The interaction of students and users learning by means of teaching programs can be e.g. keystroke, movement of mouse, reaction time of click etc. which can be recorded by using appropriately developed software and analyzed by means of statistic methods.

It is this method that was used in our research during the studies using the measuring programs. The measurement of reading rate (time spent with pages) was completed with the method of personal observation. As there were subjective observations as well during the experiments, complex results were obtained.

From the results of measurements, the average of results, their dispersion and dispersion coefficients were examined as a general rule by using the methods of mathematical statistics. Of course, there were experiments where other values were calculated.

By summarizing the results obtained from the experiments, we examined the difference and identity between the experimental- and control groups by using significance test.

2. Concept of hyperlearning

The information technology is the science dealing with the production, processing and storage of information.

In the processes observed and tested by means of measurements, we usually modeled the learning as a process of information processing. Starting from the information technology, the learning can be approached from two aspects: from "hard" side, i.e. the examination of means suitable to transfer of information, among them the screen mostly used during learning, on the one hand; and from "soft" side, i.e. the teaching methods themselves, on the other hand.

As completely new concepts were introduced in the field of teaching, our tasks also include systematizing them:

- CB—learning- computer supported learning. It consists in the self-contained learning of subject matters run on computers.
- E-learning: electronic learning – network-based learning process (through internet or intranet) using electronic subject matters run on computer. This method seems to be implemented in the best way in the current educational system.
- T-learning: television learning – interactive learning through television, preconditioned by the digital TV technology. Its essence is that the TV is rendered interactive by means of IP based interconnection for teaching.
- U-learning: ubiquitous learning – learning „being present everywhere" where anybody can learn anywhere, any time under any circumstances through computer, mobile means, TV set etc. by utilizing the possibilities offered by the most up-to-date technical-technological means.

This systematization could be continued by mixed use of the methods (blended-learning). In our system-scale view, there was a common connection point (feature) by means of which our methods can be arranged in a single set. This connection point is the monitor that represents the „output" element (data display) in each learning method. Each set, however, shall be named (labelled).

According to my proposal, these could be called hyperlearning. In this case, the „hyper" prefix does not refer to a knowledge that can be attained within very short time and easily, in spite of that would otherwise occur to us associated with the term. The

learning process cannot be accelerated to this rate; however, it is not even worth to do so if our objective is the long-term preservation of knowledge.

- First of all, consider the structure of subject matter. As opposed to the pre-defined linear structure of subject matter, the new form of information processing uses a manifold progress rich in embranchments and a ***hypertext*** text structure based on choices published in the Internet.
- The technical development also appears in the education in any case. The „hyper" prefix can also be due to the „hi-tech" means used more and more widely in the education. Only think of the high-power computers and networks capable of running interactive ***hypermedia*** and the monitors displaying the virtual reality drawn to the life.
- Last but not least, the students grown up with the electronic games are able to take decisions at an incredible speed — considered a **hyper-**speed rather than a super-speed —, that is, this prefix can refer to the speed of reactions used during learning, and to the intensity of aptitude development (not to mention the pedagogic tasks initiated by hyperactive children.)
- The „hyper" prefix can also refer to the ***hyper-development*** capable of finding its way in the sea of information, which makes the students able to get into possession of knowledge from the appropriate set by using the appropriate means in the most comfortable and quickest way. Learning the use of these means already takes only few minutes.
- The „hyper" prefix can refer to the learning environment where the teaching procedures of our days take place; these consist in virtual teaching framework in which subject matters of embranchment structure, i.e. ***hypermedial*** learning systems using the elements of multimedia were developed. It needs no saying that the orientation takes place by means of ***hyper references*** i.e. links.

For the forms of learning summarized under the name of **hyperlearning,** it is true that it is qualified to achieve „hyper" results. It means that, in respect of its technical limits, it offers the possibility of obtaining unlimited knowledge. It is suitable to transform the forms of knowledge and behaviour until now, which is already demonstrated by the current Internet generation. It is also suitable for modeling the processes of problem solution, thereby establishing the optimum **hyper structure** in the individual's brain mapped.

3. Variables, questions and hypotheses of research

3.1. Motivation (independent variable)

Hypothesis

The results of research can be strongly influenced by the motivation: In order to reduce the number of factors that have influence on the measurements, the motivation can be rendered independent variable.

The motivation represents a complex problem, caused by the teacher-student interaction that is common in the traditional educational system. It is impossible in the hyperlearning systems; therefore, it is important that this factor is considered independent variable during our measurements.

During our measurements performed by using experimental teaching programs, it has always been an important factor that *the students using the experimental program are properly motivated* in order that they use the teaching program in the most efficient way; that is, they make attempt to attain the information content to the extent as complete as possible.

As we always aimed at rendering the student motivated in the same manner, therefore, we regarded the motivation as a standard factor in the performance oriented education system of our measurements.

3.2. Subject matter content (independent variable)

Hypothesis

With the motivation excluded, the results of research van be strongly influenced by the interest of the subject and the recognition of its importance. In case of CB learning, the usefulness of subject matter can have the preference that can be regarded as the independent variable of measurements.

During our measurement, we made an effort to prepare subject matters of maximum interest to the students. In addition to the motivation, this was also considered a factor of the same importance during the measurements. In the programs developed by ourselves we processed a subject matter that covered an interesting problem within the given subject matter — information technology as a general rule — ; thereby excluding that this factor has a negative influence on the results of measurements.

3.3. Form of survey using test

Hypothesis

The results of research can be influenced whether the survey of knowledge is made by using paper-based test sheets or by means of electronic test.

According to the experiment made at the Ohio University in 2000, the method of survey using test is indifferent to the students. [Ohio State Research News, (2000)]

Starting from this, we made our measurements in order to verify whether this factor have influence on the results of further measurements.

As no significant difference was found, our hypotheses cannot be supported. It can be stated, however, **that it has no influence on the survey of knowledge whether the questions are presented on paper sheets or displayed on screen**.

The method of filling the test forms was also be considered independent variable during the measurements.

3. 4. Influence of age in case of CB learning

Hypothesis

Studying the learning methods, it is assumed that the reading rate is strongly influenced by the age.

In the trade literature, our attention is expressively drawn to the appearance of „internet generation". This is the generation socialized in the digital environment of the modern times. It includes nearly 80 million people in the world. [Don Tapscott, (2002)]. It is they that have the *world* and the communication on their *„finger—tips"* (computer, network) and the *knowledge in their pockets* (communication means).

With the view of being informed on the average reading capacity of the youth of our days, I participated in a test surveying the pupils of 6th class at a primary school within the frame of the OKM (Hungarian initials for National Competence Measurement). In respect of scores, it can be stated that the majority obtained average result (77%); there were, however, pupils who could find their way scarcely (15%) or not at all (3%) between the information content of simple texts.

Following the informative measurements, we surveyed the pupils and students, respectively, of the primary schools, grammar schools and polytechnic of Dunaújváros for comparison, in order to determine whether there is any difference between the reading rate using various data carriers (paper, computer screen), broken down by age. The first group surveyed was composed of pupils of 6th class of primary school. They

had no problem with reading, in spite of the fact that there were several pupils released from the Hungarian grammar. The difficulty in interpreting the text, however, was observable even based on the time passed and the interactions experienced in the classroom. When reading from either paper or screen, they followed the lines by their fingers and "read out" the text, although in a low voice.

The pupils of 8th class failed to follow the lines with their fingers during reading either from paper or from screen. Nevertheless, they also pored over the screen.

In case of pupils of 9th class, it can be stated that, due to their age, the interest was variable. During reading, they were more inclined to look at their schoolfellows.

We experienced first time with the 11th class that they tried to swindle during both surveys and made it very apparently in most cases.

In case of students, the attitude was more serious, although they also were rather stretched during reading the texts.

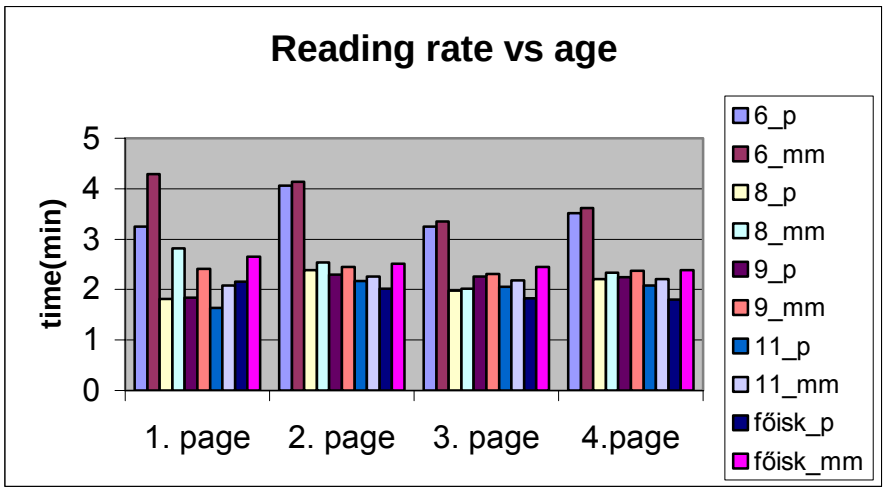

Diagram 1.
Reading rate broken down by age

The summarized average results shown in the diagram 1 it can be seen that there is scarcely a shade of difference between the two reading rates within the age-groups. Considering any text and any age group, the text was read during 2 to 3 minutes, except the pupils of 6th class.

The analysis of results **failed to justify** our hypothesis. **People belonging to various age groups read equally from both paper and screen according to their aptitude level.**

3.5. Difference between the reading processes

Hypothesis

Considering the process as a whole, there is some although not demonstrable difference between our manners when reading a single page each either from paper or screen.

The information processing begins with perception. This is the most elementary part of the process of cognition. It is here that the stimuli coming from the outside world are reflected. In respect of my study, it means that no meaning is associated with the stimulus perceived at this level. This stimulus is transferred to the first data storage of the perception i.e. to the short term memory. We would like to prove by means of measurements that no difference can be demonstrated up to this level of information processing, irrespective of the data carrier that the information is transferred from to the short-term memory.

Our tests were performed under the same conditions of measurement in the circle of students. During the research, two groups were examined. One of them read the subject matter content from paper-based teaching means while the other read the same from screen. We examined the time necessary for information processing of a single page each; i.e. whether there is any significant difference between the times spent with the pages.

In our measurements, the subject matter was composed of texts of various sizes (page number). Based on the results, we rendered it probable that **no difference can be** seen between the two different teaching means. There was no one page that excessively long or short time was spent on by the students. **It can be stated that no significant difference can be demonstrated in respect of either the time spent on the individual pages within a specified time interval or the information carrier.**

Hypothesis$_{(n)}$

As the most important result of study, it was found that the readers spent more time on the first page if it is displayed in electronic form.

During the measurements, we observed that the students spent more time on studying the first page read from screen compared to that read from paper. The results of first measurement performed with four pages are shown in the diagram below.

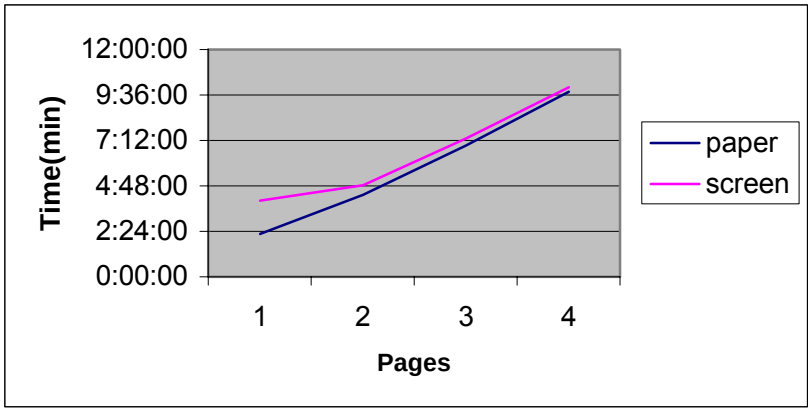

Diagram 2
Difference between times spent on studying the first page

The students' reactions observed during the reading test that were different according to age provided explication. Most of them, irrespective of their age, seemed more nervous after launching the program; they became restless and held the mouse without doing anything with it. These actions did not continue any more in case of the remaining pages.

In the light of the results of measurements, we wondered whether this phenomenon is only a special result of these tests or it has been overlooked so far. Therefore, the results of the previous section were revised. This difference can also be seen in the results of the previous measurements. As a summary, the times spent by the different age groups on the first pages can be shown in a diagram.

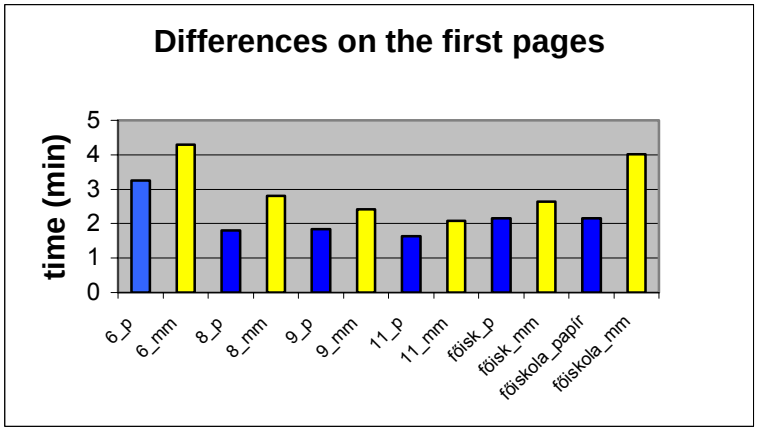

Diagram 3.
Differences on the first page in case of screen and paper

When comparing the results, it can be seen that those reading from screen spent much more time with the first page than those reading from paper. It seemed worth of examining whether the results are significant to exclude the possibility of chance. Each

of the data was analyzed by means of Wilcoxon test using the SPSS program. The p value of the result obtained was 0,02; thus, it could be stated with 98% probability that the results is not a freak of chance. As the value obtained is above the usual 95% value, it can be stated that the difference between the two sets of results is significant.
In respect of the reading rates/manners, there is some difference only between the times spent on the **first pages**.

3. 6. Measurement of performance

Hypothesis

The efficiency of CB learning is lower than that of the traditional printed paper based learning that takes place during the same time interval.

Measuring program and paper-based teaching material of our own development was also made for this measurement. The students were divided into groups of random selection; half of them were allowed to make notes while the remaining part was not allowed to use any aid. It was assumed that the results of measurements are influenced by the use of aids. By means of the analysis of interactions during measurements, it could be stated that this factor can be neglected in case of short-term learning; in fact, 72% of students learning from paper did not use any aid during the learning process, while 13.2% used pen and paper only from the 7- to 9th minute of measurement. In case of students learning from screen these proportions were as follows: 63.2% did not use any aid and 11.4% still started to make notes from the 3 to 6th minute onward. It is worth of mentioning that, although 9% of students took out pencil and paper, they did not write anything; instead, they held the mouse during the first half of the measurement. When filling in the test sheets, 87% of students who made notes used their notes and 13% of them filled in the test sheets without using notes.
According to the probability of results processed during the measurement, the efficiency of CB learning deviates by 15% as an average from the traditional attainment of the subject matter. The students learning from paper-based subject matter achieved results better by 15% in the test surveying the knowledge level.
The relations between the performances are shown on the Figure below.

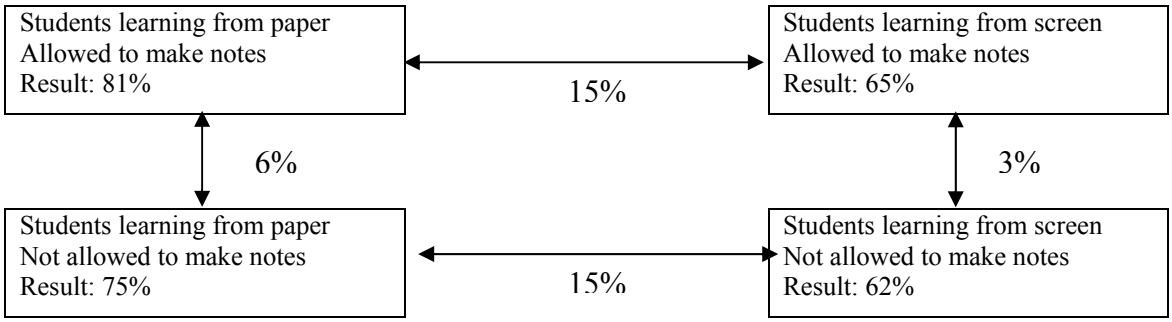

Fig. 1.
Comparison between the performances

Thus, the precondition formulated in our hypothesis can be justified. Considering the performances, the efficiency of CB learning is lower than that of learning from paper-based printed subject matters **during the same time**.

3. 7. Differences between the contents understood

Hypothesis

In case of learning from paper, we obtain more global picture on the content than in case of CB learning.

During our research tasks, we performed two different kinds of measurement relating to those laid down in our hypothesis with the view to verify our statement. Here again, we divided the students under examination into two groups during the measurement. Students using multimedia program for learning and those learning in the traditional way were examined. One of the measurements aimed at revealing in which manner the subject matter is memorized by and projected in the students. The students had the task of listing the chapters of the subject matter. The majority of students learning from printed documents could reproduce the structural parts (chapters) of the subject matter; only a few students (17%) made mistakes by using improper wording in describing the title of chapters.

The students belonging to the group of CB learning made much more mistakes; almost one quarter (21%) could not recall even the first chapter. Further 11% could not recall even the title of second chapter, while 42% of the students examined were unable to list the 3rd chapter. On the other hand, 26% of the students listed the content of the single embranchment as a title of chapter.

The results obtained lead to the conclusion that the students learning with traditional methods **recalled better the structure of subject matter** than the students using CB learning.

With the view of documenting the difference in the quality of information contained in the subject matter attained, we performed further measurements.

Within the scope of research tasks, we examined the processing of two different kinds of subject matter. At the end of attainment, the students had to compile the test serving for surveying the knowledge level by themselves, relating to the subject matter attained

The results obtained from our measurements demonstrated that the students learning from paper put more general questions that, however, covered larger part of the subject matter, while the students using CB learning put questions that were more precise and stuck to essentials and, sometimes, specific to certain details. These questions more difficult to be answered assumed a more precise attainment that also covers the details.

Thus, in respect of the types of questions, different results were obtained; different kinds of questions were put relating to the same fact. To demonstrate this, please find some questions as follows:

Those learning from paper:	**Those using multimedia program:**
When was the Internet developed?	How long has the Internet been used in Hungary?
	In which years was the wide application launched?
Is it possible to communicate via Internet?	What is the difference between Chat and IRC?
When lived Babbage?	What kind of cogging had the machine made by the firm Brunswiga?
When was the Eniac established?	What was the multiplication speed of Eniac?
Which mathematical operations could be performed by Leibniz's machine?	To which operation can the multiplication be traced back in Leibniz's machine?
Who developed the MARK 1?	How many seconds needed MARK 1 to perform a multiplication?

The questions arranged in pairs show that the **quality** of information is **completely different** in case of CB learning than in case of learning from paper-based printed matters. Thus, **our hypothesis is verified**.

3.8. Quantity of information content displayed on the screen at the same time

Hypothesis

I assume the existence of an index number that allows the quantity of optimum subject matter content that can be simultaneously displayed on the screen to be clearly modeled.

As the index numbers used to measure the reading rate were mixed during our measurements, we made attempt to find the index numbers best adapted to the various theories. The formulas used in the information theory seemed to be the best suitable for this purpose. Thus, the **bit** was selected as the unit of measurement of the information content and any relevant results of measurement were adapted accordingly.

During the measurement of information content, it was an important aspect that the processed subject matter is suitable to be used for teaching. While ensuring the identical information content, we took care that the pages form independent units instead of structure built on each other and, still, to form an unified part of the subject matter.

The students participate in a knowledge survey test after each measurement with the view of verifying the efficiency of processing the subject matter. The results of measurements are summarized in the table as follows:

Information content [bit]	Average performance [%]	Dispersion
≈ 2497	31,27273	2,413885
≈ 3158	40,3	5,408486
≈ 4518	61,45455	5,874673
≈ 5324	69,5	7,193302
≈ 9616	40,35556	7,508043

Table 1
Relation between the information contained on the pages and the performance

As seen from the table, the students produced the **highest** performance when **a screen** contained approximately **5000 to 6000 bits** of information, **i.e. 1000 to 5000 characters.**

This result supports the results of examination obtained by the specialists of information theory stating that the rate of information processing of an average man when reading amounts to 20 to 100 bits/s. With this rate of attainment, the efficiency is up to 75% (Neumann, Farkas). During our measurements, this theorem also seemed to be verified. In fact, in an optimum case, the information content contained in a page was 5324 bits as an average. The average of times spent on the study of one page was found to be 311, 52 s during our measurements. It can be stated that the students produced nearly 70% performance with 17,094 bits/s information processing rate during our measurements.

3.9. Time factor

Hypothesis

I assume that a proportion between the processes of learning from paper and CB learning can be set which allows the two learning methods to be clearly planned.

For comparative analysis of times spent on learning, two kinds of measurement were performed, in which the processing of a single topic each of two subject matters were examined. The students participating in the measurement learnt within the scope of traditional lectures and exercises from paper according to a remote education system or learnt individually within the scope of mixed education and from computer, respectively. No stress was laid on surveying the previously obtained knowledge during the measurements; in fact, each of the students participating in the survey learnt the same fundamental subject (physics, information technology I-II).

The three forms of teaching resulted in the performances represented on the diagram below:

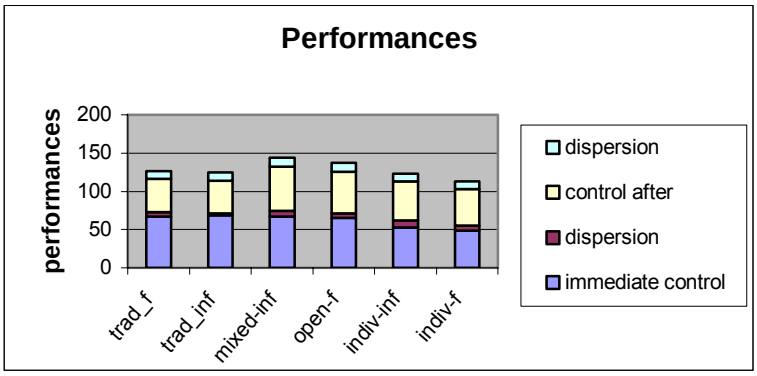

Diagram 4
Examining the efficiency of three forms of learning

The results show that the traditional form of education is the most efficient, provided that the knowledge is controlled immediately. Compared with the e-learning — which is

of the lowest efficiency in this particular case —, it can be stated that the efficiency of electronic learning is lower than that of the traditional teaching. This was verified in processing of both subject matters.

Considering the value, it is important to note that the dispersion of performances offered by the students learning within the frame of traditional education is very low (2,693 and 5,718) as opposed to that of the students using CB learning which shows a high value (7,376 and 10,703). The students using "mixed" learning method produced performance between the two previous methods.

During the measurements, an additional research was also performed in which the development of performance offered by the students using CB learning was examined with the state marks from the measuring programs removed: i.e. the tree following the path from the multimedia subject matter of non-linear structure while the state marks demonstrating the time and the quantity of the subject matter processed from the teaching subject matter of linear structure. The results obtained from our measurement completely verified our assumptions i.e. **teaching programs must not be developed without using these means;** in fact, these resulted in the further reduction of performances by nearly 10%. In addition to the performances, the dispersion shows excessive values that are unacceptably high and certify a state of disorientation. It shall be noted here that, if the student did not observe the time passed and the part already processed, he/she could process 54,16% of the whole subject matter during a specified time (exercise).

During the measurements, the performance of students offered a week after the learning process in various cases of learning using different methods. Based on the results obtained, it can be stated that it is the students using mixed learning method produced the best performance. The students using mixed learning method produces average results. It shall be noted that these result deviate from the average results of the polytechnic in positive direction.

From the measurement data, the reduction of successfulness is experienced in any case. The proportion of performance reduction in the various cases, however, is apparent. The largest performance reduction is experienced in case of traditional learning and the largest dispersion of performances offered by the students can be observed. In case of mixed learning, the performance is reduced by around 10% (10,06% and 8,94%) which can be considered good as compared to the performance reduction of nearly 25% (25,56% and 24,04%) mentioned above. In case of CB learning, however, the

performance reduction is very low (1,46% and 0,86%). It is very important to emphasize that it is in this method that the dispersion increased to the least extent (2,26 and 0,62). All these can be explained by the fact that, during the attainment of subject matter, the information made and experienced by ourselves remains much better in the long-term memory. By analyzing the results of written examinations, it can be seen that the students stored certain details very deeply in their mind. This measurement also made our hypothesis discussed in chapter 3.7 probable; in fact, during CB learning, the students pass through a different attainment procedure and attain completely different quality of information and these items of information are built into their memory more deeply.

During our measurements performed so far, we examined quite a number of influencing factor; however, the same time interval was specified for the two different learning processes *Therefore, it is assumed that there is a relationship between the volume of subject matter and the performances in case of the different methods*.

The research was extended to examine this factor. The examination took place in three groups where the processing time of subject matter using mixed method and individual CB learning was related to the work controlled by the teacher. In the first series of measurement, the students had to develop a web page each where the times necessary for the preparation of the individual web pages and the total times necessary for the task as a whole were measured. The times spent on preparing the individual web pages are summarized in the diagram below:

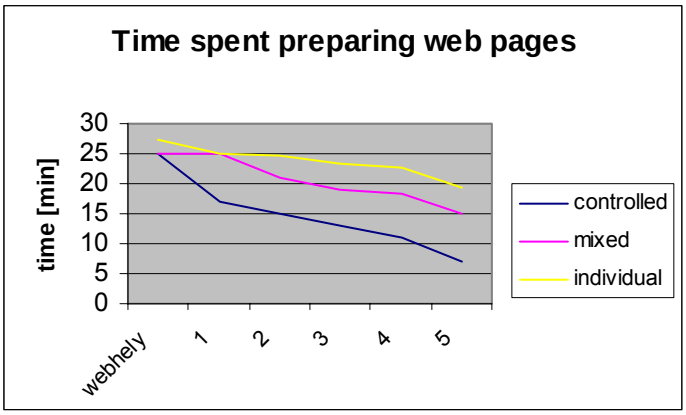

Diagram 5
Time spent on preparing web pages – Examined in case of three learning methods

The diagram shows some relationship between the times necessary for preparing the pages. Considering the times spent on preparing the web pages, it appeared that a linear relationship exists between the times passed. Then, the measurement was followed by the survey of knowledge that was performed in the same manner as in the measurements of previous chapter in order to facilitate the comparison. The performances offered by the students are summarized in the table below.

	Short-term performance. [%]	Dispersion	Long-term performance [%]	Dispersion
Controlled	70,15	4,786	63,45	7,115
Mixed	69,12	5,092	66,39	8,694
Individual	64,23	6,451	63,32	7,427

Table 2
Performances offered by the students- in case of different learning times

It can be seen that the students' performances are closer than in the previous cases to each other. The most apparent change occurs in the performances controlled at the end of learning process; in fact, only nearly 7% difference instead of the nearly 15% one experienced so far can be shown between the traditional learning and CB learning. With this in view, we examined the results between the two forms of learning by using regression analysis. The data processed are analyzed by means of excel. From the results obtained it could be demonstrated that, according to our assumptions, there is a linear relationship between the times necessary for processing the traditional learning process and the electronic subject matter.

By using regression analysis, we obtained the relationship between the time results of the two learning methods. From the analysis of data, it could be demonstrated that — considering that the significance level of regression coefficient is 96,72% — the regression describes the relationship between the two variables in a significant manner. Thus, the slope is 0.57 and the constant value is 15.70 in the regression equation obtained.

In the knowledge of this, we performed a control measurement in which the students (97 persons in total) processed the next chapter of the subject matter. From among the groups described above, only the results of students using the traditional and the CB learning were considered. The results are shown in the diagram as follows:

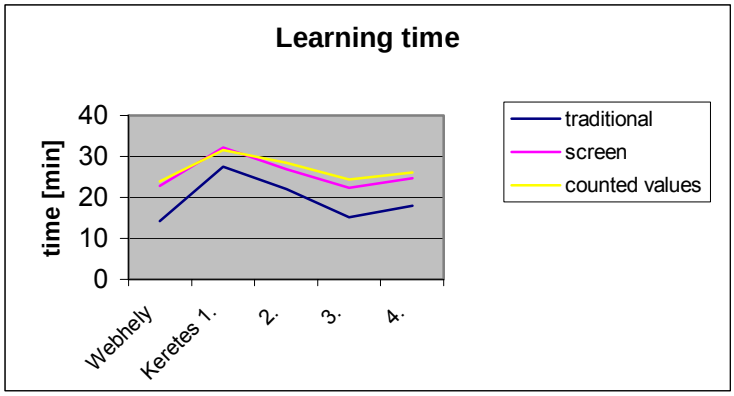

Diagram 6
Learning times

The curves well represent the verification of our hypothesis; i.e. the results expected and those measured coincide nearly perfectly.

The results obtained were subjected to further analysis and the times necessary for processing the subject matter as a whole for the whole educational unit (adapted to the time content of approximately two practical lessons in this particular case). Considering the total time, the linear relationship could be verified here. Taking a significance level of 95.87% into consideration during the analysis, the equation can be established. For the purpose of testing the coefficients of the equation obtained, we made two student groups to measure our teaching material of physical subject. As compared to the 90 minutes interval — i.e. time spent for learning previously (time of two lessons of 45 minutes each) — the students used 144.58 minutes as an average for processing the chapter. Based on the result calculated by us, they should have learnt the subject matter during 152.907 minutes; i.e. there was 8% difference between the measured result and the expected one. The performance of students showed 12% increase after the use of learning time considered by them necessary. (Its value was: 60.13% with dispersion value of 7.23.)

The results obtained verified our assumption; i.e. a **relationship** between the **times** necessary for CB learning and traditional learning can be found so that the students' performances approach to each other at the end of the learning process.

4. Results and conclusions

4. 1. Results of the research

Based on the analysis of the research results, the answers and theorems as follows can be formulated relating to the questions raised.

Question 1

Can the electronic teaching programs be utilized for everybody in the education?

Theorem 1

88% of the students still fail to show inclination to use only CB learning; they insist upon the written instruments used so far during their studies and shown as an example in the school environment.

Question 2

Can the learning supported by electronic teaching programs be used with the same efficiency in each age of life and can its use be attained?

Theorem 2.0

In our days, learning from paper is still more successful than the CB learning, which is the result of our habits established in the traditional teaching systems. The people of any age, however, are able to read from the screen at a rate corresponding to their age-dependent average.

Theorem 2

Considering any age, no significant difference can be demonstrated in respect of the time spent on the individual pages during the use of paper-based and multimedia learning means.

When planning the teaching processes, however, it shall be taken into account that the readers spent more time on the FIRST PAGE if it is presented in electronic form.

Question 3

Is the quality of information attained during CB learning the same as that attained during traditional learning from paper?

Theorem 3.

During the CB learning, the students using CB learning acquire information of different kind as compared to those learning from paper. The content of information is of different quality and more relevant in the case of CB learning.

Question 4

During the planning of multimedia teaching programs, can an index number be determined to render the subject matter content displayed on a single screen optimum?

Theorem 4

The CB learning can be considered the most successful if the volume of information displayed on a single screen-page is specified appropriately. This volume amounts to 5000 to 6000 bits of information in case of subject matters developed for individual learning.

Question 5

Is there any relationship between the performances to be attained during the traditional teaching and the CB learning?

Theorem 5.0

A subject matter intended for individual learning cannot be developed without using the optimum access path or the part of subject matter processed or any other learning aid in our programs.

Theorem 5

A linear relationship exists between the times necessary for attainment of subject matter using traditional paper-based teaching means and for the CB learning. That is, in the knowledge of the information content of traditional teaching materials and the time necessary for their processing, the time of CB learning can be determined so that the students' performances approach to each other at the end of learning process.

4. 2. Further research tasks

As already mentioned several times, the up-to-date means of information technology became an indispensable part of our everyday life. In response to the new challenges, the applied scientific results of information technology also gain an increasing ground in the process of education. It shall not even be excluded that the results obtained in the science of artificial intelligence cannot be omitted from the progress of pedagogic sciences. It would be important that the science of pedagogy had influence for example on the development of knowledge based systems and not just the opposite.

- The questions raised during the research and the results obtained form an appropriate basis for further studies and analyses aimed at addressing further details of multimedia programs. Possibly, they have positive influence on the development of an education system based on an artificial self-learning expert system which can be successfully used in the home learning. It is important to emphasize that even these learning forms can be used for purpose oriented transfer of knowledge Thus, for the progress, further questions and fields of research can be formulated by using the starting data studied by us.
- By means of the results obtained during the survey, the means of research can be developed and, using programs written in other programming languages. Measuring programs appearing in internet environment and by developing PDA-based applications enabling Java applications to be used in the education, further information can be obtained.
- Further trends of research may be: the development of determining the optimum subject matter content and the optimum running path of multimedia programs [Fauszt T. (2007)] as well as the development of a system suitable to be used for revising software applications used country-wide in the education.

5. Summary

Within the scope of studying the computer supported learning process and during our measurements, the possibility of studying the learning habits of the students of Dunaújváros Polytechnic and, to a reduced extent, those of the pupils of the primary schools and grammar schools in the region as well as analyzing the structure and content of the multimedia education materials used for teaching was offered. The results obtained reflect the experiences and performances of the students learning in any form of education in both the current and the future higher education. The information and knowledge gained during the measurements can be used to lay the ground of the new education systems that allow any hyperlearning method to be used successfully within the traditional institutional framework.

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