Theses of Doctoral (PhD) dissertation

E-LEARNING METHOD IN AGRICULTURAL SCIENCE

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1. Preliminaries and objectives of the doctoral thesis

With its approximately 500-600 billion HUF yearly budget and the involvement of 1.8 million student and their families, about 5000 educational institutions and 160 thousand teachers, public education is an expensive and complicated system (*Kertesi*, 2008). The magnitude of funding higher education has been around 1% of GDP for decades, whereas the number of full-time students tripled between 1990 and 2003 and the number of correspondent students increased sixfold (*Polónyi*, 2004). Therefore, increasing the efficiency of education is obviously in the interest of both national economy and educational institutions.

E-learning is a method of learning that employs the opportunities of the Internet, or, more specifically, the Web. Solutions of information and communication technology have become widespread enough to take a higher role in education and examining (*Bőgel*, 2004). Nevertheless, formal education cannot, or it can very slowly take advantage of these new technologies (*Török*, 2003; *Duval,* 2005; *White*, 2005; *Csapó,* 2009).

The gradual adaptation of the inventory of e-learning becomes increasingly unavoidable for the Hungarian agricultural higher education institutions due to the increasing student number per teacher. In our department, the need for further automatisation of the relatively fast but – due to its paper form character and the higher student number – increasingly inconvenient and expensive system was triggered by the more than 500 exams that were previously estimated in the first term of the 2004/2005 school year.

In order to solve this problem, an online accessible examination software, a network application that runs on the server side on a server-client basis was developed. Based on the successful operation of the examination system, the electronic multimedia curriculum of the topic was also worked out to help students prepare, while a continuously expanding statistical and quality assurance module was also developed on the basis of the information need of teaching.

One of the main objectives of the thesis is to describe the preparation and implementation of an own developed method of e-learning applied in land use as a specific agricultural discipline, from the preparatory theoretical overview to its introduction into education and the analysis of the data obtained during its operation.

All these have the primary intention to make processes that can be automatised contribute to the lightening of teachers' burden.

Therefore, the work described in this thesis has the following objectives:

- Theoretical establishemnt of an e-learning system in a specific agricultural discipline (preparation).
- Implementation of the e-learning system (development). (Framework, examination system, digital curriculum, introduction of the system into education.)
- Logging the data obtained during the operation of the e-learning system. Developing automatic feedback methods that make it possible to improve the quality of teaching and to further develop the education system (feedback).

2. Research methods

2.1. Locality of system development, the environment of introduction

The first components of the e-learning system were worked out in 2004 at the Department of Land Use of the Centre for Agricultural Sciences of the University of Debrecen. The practice room of the now called Institute for Land Utilisation, Regional Development and Technology seemed an ideal environment with its 16 workstations to carry out a blended learning pilot program and its related examinations.

2.2. Target group of the system

The target group of the system is constituted by the students who have been taking examinations in the subjects "Cultivation", "Land Use" and "Agricultural Land Use" since 2004.

2.3. Preliminary questionnaire survey

In order to get to know the target group better, a preliminary questionnaire survey involving the students of the first two affected grades was conducted. The questionnaire survey aimed at students' skills, competences and their needs and opinions about the system to be worked out. Since exams in the system are taken electronically, the main question was whether every student is able to handle computers to a satisfactory extent and whether anyone is hindered by the fact that exams are done electronically.

2.4. E- test

2.4.1. Exercise bank of the e-test

The e-exam system "inherited" the multiple choice tests worked out by László Huzsvai and colleagues for paper form tests. In these tests, four answers belonged to one question with only one being the proper choice.

The number of the questions in the exercise bank continuously increases, containing nearly 700 exercises at the moment. When compiling the exercises of each field of study and subject, the system poses questions in the previously determined proportion of question groups. The questions in the exercise bank were also placed in the hierarchy of 89 detailed educational units.

The records of the exercise bank were also supplemented by the dynamic information referring to the actual choice and success rate, difficulty and discrimination in connection with the exercises.

2.4.2. Course of the e-exam

When beginning the exam, examinees fill out the web form needed for identification. Once the form is successfully registered on the server, the questions appear on the screen.

Based on the observations gained during pilot tests, the time available for solving the e-test decreased to 40 minutes.

As opposed to the previous written examination – when there was a small number of tests prepared each examination day –, the online interface displays an individual list of exercises for each examinee. Owing to the random selection of the given number of questions from a database and the random order of choices, the preliminary calculation shows that it is nearly impossible for two students to get the same list of exercises, thereby we can reduce cheating.

The time available for solving the test starts after the automatic compilation of exercises.

The user interface satisfies the information need of the supervising teacher by continuously displaying the data of examinees, whereas also students are provided continuous feedback about how much time is left and how many questions are still unanswered.

The student can terminate the solution phase by sending in the form, but the exam automatically ends when the available time is up, or when forbidden user interactions (e.g. an attempt to navigate from the page) are observed.

The data of solving the exercises are stored by the system, thereby assuring the opportunity of further retrieval. After the form is sent in, examinees are immediately provided with the exam results and some statistical data.

2.4.3. Date logged during examination

The archived data of nearly 3000 examinations represent comprehensive statistical basic data that make it possible to run analyses in relation to the successfulness of teaching, as well as its strengths and weaknesses, the possible differences between the students of each faculty, course and major, students' success rates in solving exercises, their correction habits, as well as the usability and accessibility of the system.

The final aim of statistics is to continuously improve the objectivity and standard of teaching and examination and to find skilled students by using the feedbacks of the system.

Data logged during examination are: data given during registration (Neptun code, name, grade, field of study, demonstrator); test mode (exam, practice test); computer identification data; time of beginning the exam; identification data of the exercises in the test; identification data of the answers given; logging of interaction during the exam; method of ending the exam (sending in the form, expiration, navigation from the page); the time of ending the exam; score; control data of the values above.

2.5. Methods of statistical analysis

During examinations, a separate administration and statistical module processes the basic data stored by the system, which makes it possible for teachers to online access examination results and the data of the analysis connected to them.

2.5.1. Time concepts of the statistical analyses performed

During the statistical analyses, we used several different interpretations of the time used for solving the exercises:

- It is simplest if we interpret the *time elapsed between saving the login data and saving the answers given*.

- Instead of the value logged by the server, when observing the actual amount of time of solving the exercises (*from the appearance of exercises on the client side until the termination of the exam*), exams that take more than 40 minutes to finish disappear.
- In the third case, we interpret the time used up for solving the test as the *time elapsed between starting to solve the exercises and the last interaction before finishing them*.
- As a fourth alternative, we introduced the time concept that refers to the used up time in relation to the period between *starting to solve the exercises and the answering of the last unanswered question*.

2.5.2. Success rate, difficulty and discrimination of exercises

We used the three most frequent groups of assessment indexes as the post-examination statistical analysis of the answers given: success rate ("simplicity"), difficulty; discrimination ("power of judgement"); wrong answer analysis.

2.6. Environment used for development

During the development of the system, the major guiding principles involved that there should be no costs of the software environment used for development, whereas the interoperability between systems and the advantages of server-client applications should be provided.

Therefore, the tried and tested, freely accessible, open source and platform independent Apache web server, PHP server-side scripting language and MySQL database server constitute the background of the application.

3. New scientific results of the thesis

3.1. Student skills, competence

94.9% (88.3%) of students involved in the research in the 2005/2006 school year had a computer at home, whereas 53.8% (48.3%) of them had Internet access. (The values in brackets represent the respective data of the previous survey carried out in the 2004/2005 school year.)

The average respondent spends 5.1 hours per week on browsing. The respective extreme values are 0.5 and 21 hours per week; therefore, every interviewee is a regular Internet user to a certain extent.

Based on the answers given to the question about the expertise in using the Internet, it can be stated that there are no students who have only started to get to know what the Internet is about (it was 5.0% in the previous year). The skill level of the average user significantly increased in comparison with the previous year, it is now somewhere between the average and experienced user level.

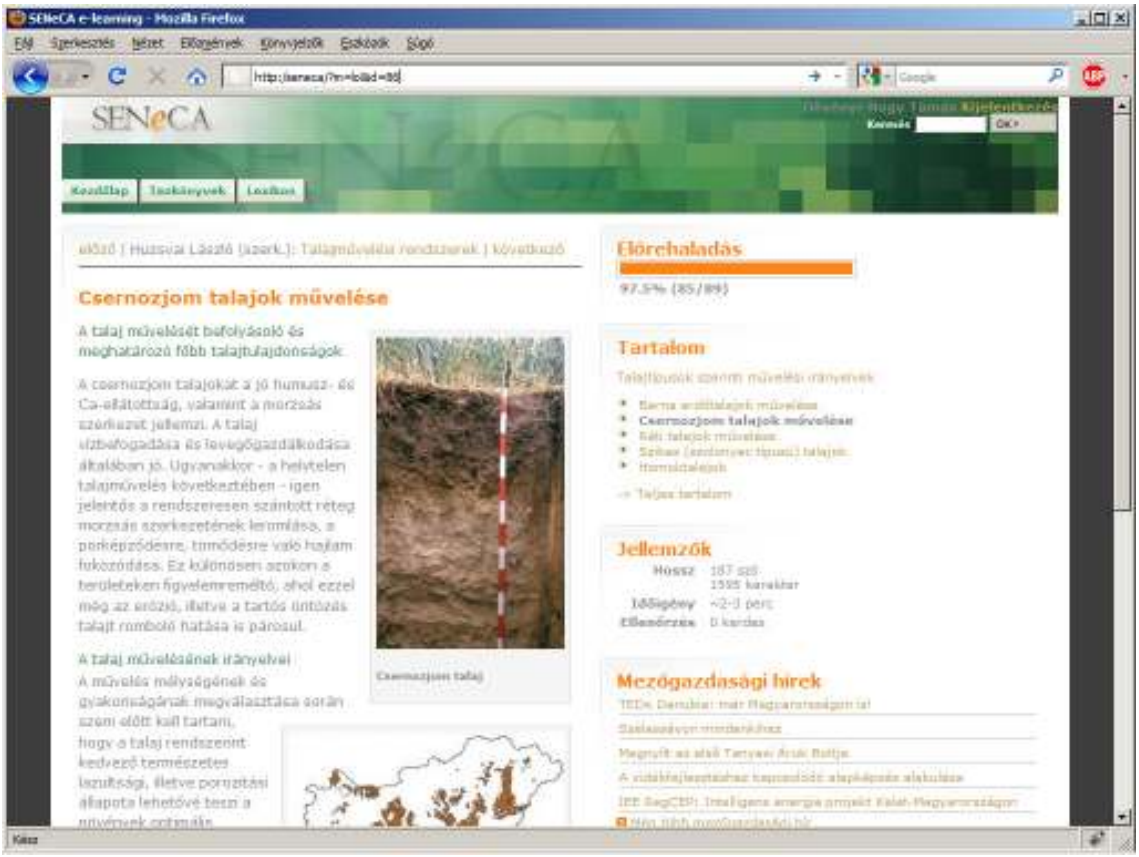
The students' answers led to the conclusion that novelties resulting from technology will not influence the success of solving e-tests.

3.2. System structure

3.2.1. Framework

As a thematic education portal, the framework of the e-learning system connects the system modules: it makes the content management (teaching and editing) module, the administration/statistical module accessible, whereas it performs general displaying and database management tasks (*Figure 1*).

Figure 1: Web interface of the e-learning system



3.2.2. Content management system

The content management system (CMS) performs the displaying, editing and maintenance of the teaching material. Authors of the teaching material can edit the elements of the curriculum online in a simple way if they have the necessary permission.

3.2.3. Examination module – measurement of learning performance

Due to the nature of the examined agricultural higher education curriculum, the most various advantages are provided by a constructive adaptation of the electronic evaluation. The examination module of the developed system aims at eliminating the differences between traditional and electronic examination methods:

- Restricted role of navigation: every question appears on one page.
- Questions can be omitted, they can be solved in a custom order; therefore, the typical solution strategies can be tracked.

Due to the new electronic examining system, the previous nature of performance assessment is now supplemented by new – mainly surveying – aspects:

- *Diagnostic assessment* – this type of performance level assessment mainly helps teachers and it did not use to be part of teaching practice.
- *Formative assessment* – this form of self-assessment is mainly for students and it is carried out by posing control questions at the end of each unit of the online curriculum. Students practise in an optional phase of the learning process, they get to know the examination system, they gain routine in solving exercises and they assess their own knowledge.
- *Summarising assessment* – this type of performance assessment is mainly for the "public" and it used to be the primary function of examining. However, due to this new method, this form of assessment is much more objective than before, the automatic correction feature makes it simpler and the detailed statistics make it more suitable for feedbacks.

3.2.4. Administration and statistics module

The archived data of examinations represent comprehensive statistical basic data that make it possible to run analyses in relation to the successfulness of teaching, as well as its strengths and weaknesses, the possible differences between the students of each

faculty, course and major, students' success rates in solving exercises, their correction habits, as well as the usability and accessibility of the system.

The final aim of statistics is to continuously improve the objectivity and standard of teaching and examination and to find skilled students by using the feedbacks of the system.

A few services provided by the administration module of the system:

- Daily and continuous listing of examination results by various filtering and ranking options.
- Individual exam records with the data of the student and the examination.
- Daily and total quick statistics on the distribution of marks, the amount of time used up and the number of students.
- Displaying the questions and evaluation of the exam, as well as the activity observed during the exam (solutions, corrections, etc.).
- Choice, success rate and error ratio of each question.
- List of the easiest and hardest questions.
- Creation of new test questions.
- Individual and cumulated performance and ranking of fields of study, groups and examinees.
- Number of participants, marks, failing histogram.
- Successfulness of correction.
- Students' opinions.
- Descriptive statistics (number of exams, saved amount of paper and costs, environmental protection indexes, energy consumption, etc.).

3.3. Feedback, analysis

By using the high amount of information that was produced during e-learning, especially examining, we strived to develop – partly automatic – feedback mechanisms that provide direct guidance in relation to performance measurement and the efficiency of learning.

3.3.1. The number of examinees

Nearly 3000 e-exams were taken during the assessed period. The distribution of examinees over specific courses is presented in the following table (*Table 1*).

Table 1: Number of exams in each examination period broken down to courses

Course	2004/05 1.	2004/05 2.	2005/06 1.	2005/06 2.	2006/07 1.	2006/07 2.	2007/08 1.
Agricultural engineer	113	1	68	10	92	7	172
Agricultural economist	134	-	188	4	162	1	3
Agricultural information specialist	54	-	45	-	47	10	-
Rural development engineer	40	-	36	2	24	1	1
Environmental management engineer	57	1	79	-	59	1	44
Agricultural engineer (college)	25	2	22	-	12	-	-
Agricultural management engineer	-	145	-	49	1	3	-
Horticultural engineer (college)	-	56	-	-	10	-	-
Correspondent supplementary education	-	1	21	-	30	-	16
Agrochemistry engineer	3	-	3	1	7	1	2
Food quality assurance engineer	21	-	31	-	21	1	57
Agricultural management engineer (correspondent)	-	41	-	69	1	-	-
Supplementary agricultural engineer ed. (full-time)	-	-	9	-	35	-	-
Supplementary agricultural economist ed. (correspondent)	-	-	3	1	-	-	9
Agricultural management engineer (correspondent)	-	-	-	61	-	-	-
BSc horticultural engineer	-	-	-	-	30	-	10
BSc agricultural engineer	-	-	-	-	35	-	35
BSc crop production engineer	-	-	-	-	7	-	4
BSc animal husbandry engineer	-	-	-	-	16	-	10
Supplementary agricultural engineering ed.	-	-	-	-	-	19	-
Animal husbandry engineer BSc	-	-	-	-	-	-	12
Horticultural engineer BSc	-	-	-	-	-	-	18
Environmental management engineer BSc	-	-	-	-	-	-	35
Agricultural engineer BSc	-	-	-	-	-	-	47
Total	**447**	**247**	**505**	**197**	**589**	**44**	**480**

3.3.2. Exercise types, number of questions and answers

The main aspect is to be able to assess the knowledge of students on the basis of the test questions. This need will only be met above a certain number of questions. Nevertheless, it has to be assured that the student is not able to reach a satisfactory mark by randomly answering questions.

Multiple Choice Questions (MCQ) make it possible to quickly assess the knowledge of a large number of students. When examining the cumulated binomial distribution values in the case of 30, 40 and 50 questions, as well as 3, 4 and 5 choices, the aim was to search for a score that is very unlikely to be reached if students answer questions

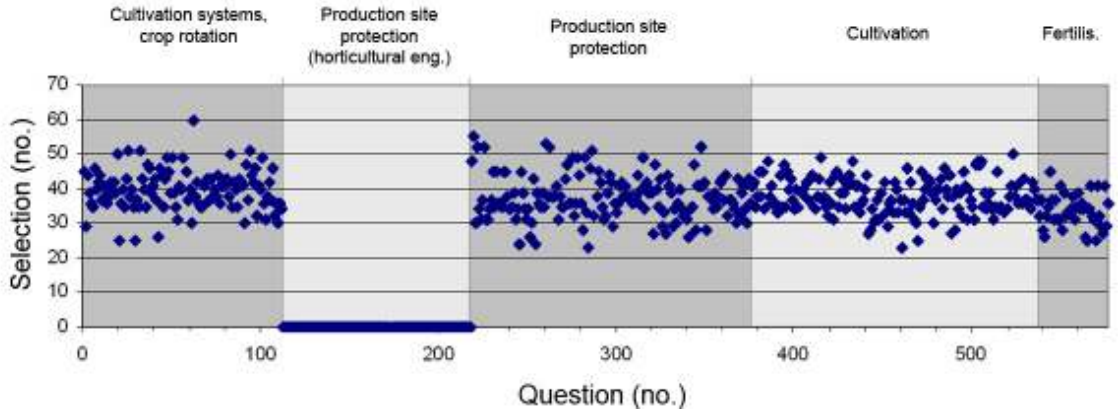
randomly. The number of random hits necessarily decreases with the increase of question number, but the time available for solving the test and the time needed to work out the answers are also important aspects in developing exercises.

3.3.3. Individual questions, selection of questions

As opposed to the previous written examination – when there was a small number of tests prepared each examination day –, the online interface displays an individual list of exercises for each examinee. Owing to the random selection of the given number of questions from a database and the random order of choices, the preliminary calculation shows that it is nearly impossible for two students to get the same list of exercises, thereby we can reduce cheating.

In accordance with the guiding principle described above, if there is a proper amount of test questions, it can be expected that there will not be identical questions in the case of two different students, i.e. every examinee receives a totally unique list of questions.

Figure2: The random character of selecting exercises



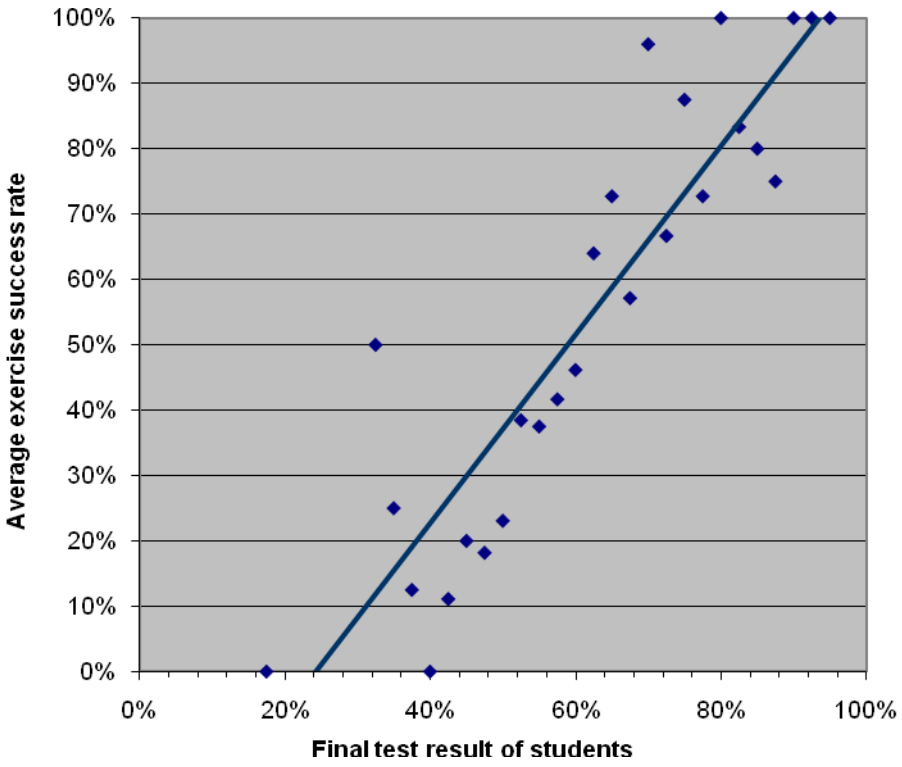
When examining the appearance of the 577 questions in the list of questions during the examination period, it can be stated that questions were selected 37.9 times on average, of which the least frequent question was selected 23 times and the most frequent one was selected 60 times (*Figure 2*). This is a satisfying result if we compare it to the 4 occasions per examination day, that is a total of 60 occasions, since even the most frequent questions are very likely to appear only once per examination day. (The missed questions in the figure are especially for horticultural students who did not attend the course in the examined term.)

3.3.4. Order of questions and answers

Therefore, the order of questions in the test is totally random. The fact that the questions in the curriculum classified into larger subject matters are ranked by difficulty helps students; therefore, we prepared the tests accordingly in the beginning: exercises were displayed in the rank of four larger subject matters and in a random way per subject matter. At the same time, there was also a need to be able to statistically analyse after how many questions the exhaustion and loss of concentration of students could be observed in the final results. In this case, the lack of homogeneity of the entire range of tests posed a problem, i.e. when examining the exhaustion of students, the answers given to the first questions of tests cannot be compared to subsequent ones, since they are in different subject matters.

3.3.5. Testing questions (success rate, difficulty, discrimination)

Figure 3: The results of students who have different total performance in the case of a well discriminating exercise



The analysis of new test questions during a pilot test is often not possible; therefore, it is important to statistically evaluate the answers given to these questions after the examination (*Figure 3*).

It is a useful method of **evaluating wrong (inappropriate) answers** if we draw a matrix on the basis of the results obtained in the case of possible answers and the terciles of examinees.

3.3.6. Clarity and readability of questions

The switch from paper form tests to electronic tests and the possibly more difficult readability of the new medium could have a negative effect on examinees' performance.

We examined readability by observing the correlation between the length of exercise texts (question + four choices) and the ratio of correct answers. It is presumable that a positive correlation could refer to the fact that readability plays a role in the performance of students in connection with the given question, which would be an unwanted effect of the e-examining method.

In order to carry out the analyses, we recorded the length of the exercise test: the extreme values of the exercises in the test lines were 56 and 682 characters (average: 260 character). The coefficient of correlation between the length of exercise tests and the ratio of correct answers (-0.006) showed that there was no correlation between longer questions and their respective success rates. This result shows that the readability of the online interface is not a discrimination factor during examination.

3.3.7. Performance, scores

In accordance with the continuous improvement of the objectivity and standard of teaching and examining, one of the major advantages of the system is that the successfulness of the answers given is available in relation to every question and subject matter (*Table 2*). After classifying questions into subject matters, this information makes it possible to supervise the major points of teaching. The successfulness of answers given to each question group can also be examined or presented in accordance with the question groups formed on the basis of the main sections of the curriculum.

The distribution of correct answers among the subject matters above does not show any significantly low values; therefore, the curriculum does not have any large area in which there is a need for a quick intervention in order to make up for the deficiencies.

Based on the statistics performed, not only subject matters, but even single questions can be evaluated. On the basis of the ratio of correct and wrong answers given to test questions, the difficulty of a given question can be determined, whereas the possibly difficult interpretability and misleading formulation of a given question can also be shown based on the special distribution of wrong answers.

Table 2: The ratio of correct answers per subject matter

	Subject matter	Question (no.)	Appeared (no.)	Correct (no.)	Ratio
1	Cultivation systems, crop rotation	112	4460	2942	66.0%
2	Production site protection (horticulture)	106	0	0	-
3	Production site protection	154	5798	3820	65.9%
4	Cultivation	165	6244	4616	73.9%
5	Fertilisation	40	1338	879	65.7%
	Total:	577	17840	12257	68.7%

As for the 12 records that were shown to be the easiest – where no wrong answers were given –, it is worth thinking about whether these questions have any sort of a surveying character, as everyone gave correct answers to them. At the same time, the aim of successful teaching is to make every student give correct answers to all questions; therefore, this issue is more of a theoretical problem than a practical one.

What is more disturbing is the range of questions that no students or only few of them managed to answer correctly. It is questionable whether students, teaching or even the formulation of the question itself are the main reason for this phenomenon. Of these, the third alternative is the easiest to exclude, since we know the solutions the examinees chose as wrong answers; therefore, it can be checked which answer misled most students (wrong answer analysis).

For example, when analysing the distribution of answers given to questions considered to be the most difficult ones, one of the wrong answers had a 84.1% share, i.e. it was most probably misleading; therefore, successfulness could be improved by strengthening different aspects of teaching in the next term-time or by reformulating the

answers themselves. As a matter of course, the right solution always depends on teachers, since – like in this case, too – the effect of the misleading question tends to be superficial learning (a keyword known from the subject matter of framework crop rotation), rather than improper questions.

If the question database contains relatively few records, there is a risk of an increasing number of questions and their correct answers becoming public. This can be disadvantageous if results start to improve by the students mechanically learning which the correct answer is; therefore, there is no real added knowledge behind their performance. This phenomenon could be brought to light by the time series analysis of correct answers (we did not observe any special increase), but if questions are available to the public after reaching a certain database size – along with continuously increasing the number of questions –, it could support teaching.

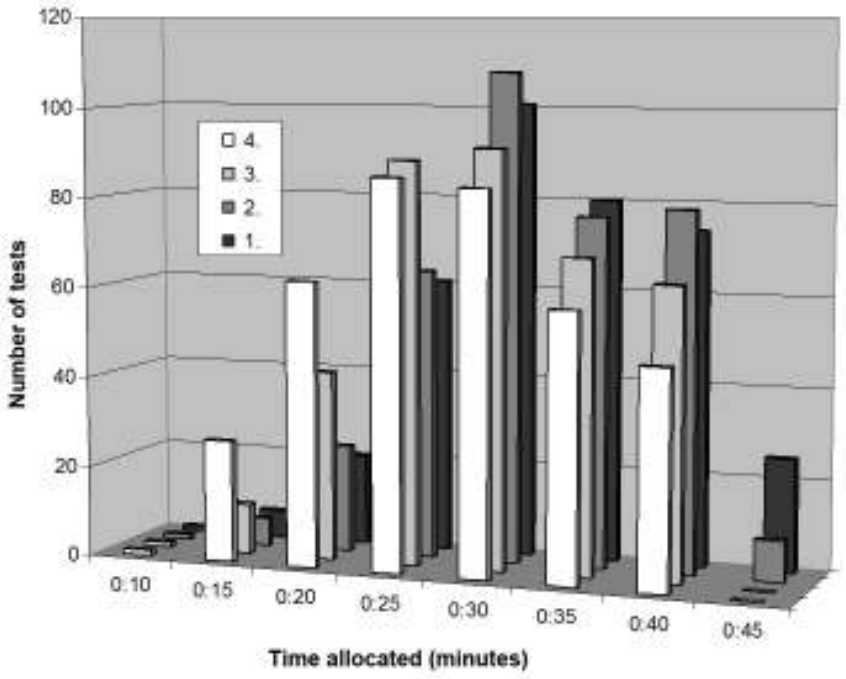
3.3.8. Amount of time used

During the calibration of exercises, one minute per question, that is a 40 minute long total time limit was set. (As for the written test, this amount of time used to be 50 minutes and the current value decreased as a result of pilot tests.) Nevertheless, it could be seen from the beginning that the amount of time spent on tests could only be accurately determined when the data of tests will be analysed. The time spent on solving exercises were determined in four ways, in accordance with the previously described method (*Table 3*).

Table 3: Average amounts of time needed for solving exercises based on different approaches (2004)

Index	Average (m:s)	Result	Time of starting and ending the test
Time 1	31:03	Recorded solution	compiling the test; making a record of it on the server
Time 2	30:22	Finished solution	starting to solve the test; ending the exam
Time 3	28:28	The solution is final	starting to solve the test; last interaction
Time 4	26:38	The solution is complete	starting to solve the test; last solution

Figure 4: Time needed to solve exercises in accordance with the four different approaches



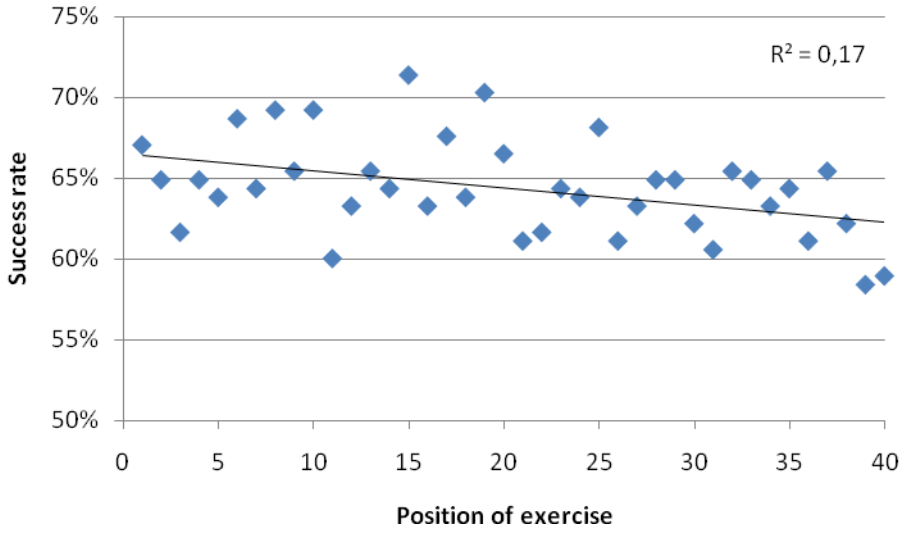
Despite the fact that several students solved the exercises in 15 minutes and the average result is between 26 and 31 minutes, the data of the histogram formed with 5 minute spacing on the basis of the four employed approaches show that the time allocated for solving the exercises cannot be reduced further, since even a 5 minute reduction would end in at least 48 students being unable to finish the test in time (*Figure 4*). The average one minute per question was shown to be realistic.

3.3.9. The role of exhaustion and losing concentration

One of the limiting factors of the test length besides time need is that the increase of question number continuously increases the role of students' loss of concentration in the final results.

In order to analyse the role of this factor, we used the data of 185 exams in which students were displayed randomly ranked questions from only one subject matter. It was presumable that the first questions of these thematically ordered homogeneous question series will be answered correctly to a higher extent than the subsequent ones, when the attention of the examinee is more used by the elapsed time and the increasing number of solved exercises (*Figure 5*).

Figure 5: Successfulness of answers depending on the order posing questions

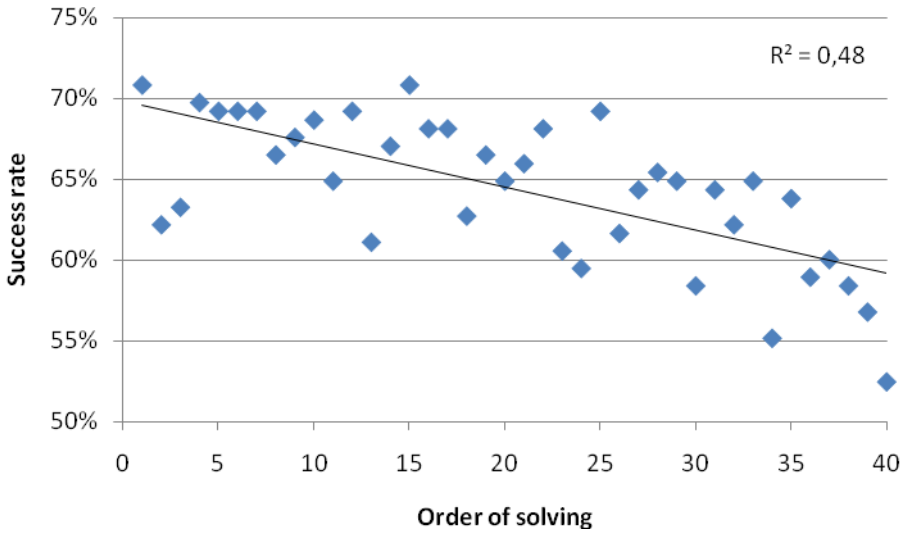


The first analysis evaluated the successfulness of answers given to these questions in accordance with the order of posing the questions. Nevertheless, due to the difference in solution strategies, it does not necessarily follow that the order of solutions is the same as that of the respective questions. There were students who started to solve the exercises with the last question and proceeded towards the first one, even though this was not the most typical strategy. It was much more frequent that students skipped more difficult questions and they only got back to them at the end of the test. Therefore, we are closer to reality if we take the order of solution as a basis instead of the order of posing the questions. The system's method of logging data provides an opportunity to do so.

As a matter of course, this second approach does not only measure the role of exhaustion in that the questions students deal with at the and are those which they are uncertain of from the beginning; therefore, even the chance of choosing the correct

answer is smaller (*Figure 6*). However, even this ranking is not identical to the final order of solutions, since there were many cases when the first solution was later corrected.

Figure 6: Successfulness of answers depending on the order of solutions



3.3.10. Efficiency of correction

As for the previous written test, we did not evaluate the corrections made due to the misunderstandable character of certain questions, as there was no option to correct the solution form in any way which we drew the examinees' attention to. The e-test not only provided the chance to correct themselves, but the logging of user interactions also makes it possible to evaluate the efficiency of correcting solutions (*Table 4*).

Table 4: Successfulness of corrections

Index	Time limit (seconds)					
	0	5	10	20	30	60
Number of corrections	1044	661	552	461	417	390
Correction from correct to wrong	277	193	165	139	129	123
Correction from wrong to wrong	370	205	162	131	116	105
Correction from correct to correct	397	263	225	191	172	162
Balance of corrections	120	70	60	52	43	39
Ratio of favourable cases	38%	40%	41%	41%	41%	42%
Ratio of unfavourable cases	27%	29%	30%	30%	31%	32%
Ratio of neutral cases	35%	31%	29%	28%	28%	27%

There were modifications after the first choices in 34.14% (126 exercise sheets) of the thoroughly logged 369 exams. Depending on the time that passed between two answers, it was needed to introduce a time limit in order to eliminate simple missed clicks. Therefore, the table provides details of the modifications done after the given time limit. In comparison with the summary of results without time limits, a five second increase shows a significant difference, i.e. the majority of modifications were not logical corrections. Accordingly, the increase of time limit reduces the successfulness of corrections, but it remains positive all the while.

3.4. Student feedback

During the viewing of the results displayed when the test ends, students can give voice to their subjective opinions by means of an online form. According to our expectations, only a small portion of users used this opportunity; therefore, besides the few positive entries, the favourable reception of the system could be observed mainly through verbal appreciation.

The main direct advantages for students are as follows:

- only seconds pass between finishing the test and getting to know the result, compared to paper form tests, when they had to wait for days.
- their mark is being entered into their registration books after the exam, thereby eliminating the long process of inquiry and individual writing of marks into the registration book that can be rather annoying for both students and teachers.

3.5. Advantages of the implemented learning system

During the outlining of the conception of the system, we were mainly looking for alternatives of further automatising the process of examining. As regards the work phases of the previous paper form test system and the electronic one that was developed, most of them can be automatised or they do not appear at all.

On one side of the balance, system operation appears as a new work phase which was unknown in the previous method (however, it did not represent significant human intervention either in the test phase or in the production phase).

Besides the compilation of questions outside of work peaks that burdens examining teachers to an equal extent in the case of both examining forms, the only duties to be

performed are the supervision of students taking examinations and their administrative tasks, the latter of which do not necessarily occupy their teaching capacity.

Accordingly, depending on the number of available workstations, the human resource need could significantly decrease, especially in the case of marking exercise sheets, their reproduction, handing out and collection. The totally automatic compilation of exercise sheets is a further simplification of the system (*Table 5*).

Table 5: Work phases of examining

Work phase/Test type	**Paper form test**	**E-test**
Working out test questions	manual	manual
Operation, development	-	necessary
Compiling exercise sheets	partially automatic	automatic
Reproduction	manual	-
Handing out exercise sheets	manual	-
Supervision	necessary	necessary
Collection of exercise sheets	manual	-
Marking	manual	automatic
Administration	manual	partially automatic
Evaluation, feedback	not typical	automatic

Although the observations gained during similar applications led us to conclude that the switch to e-examining will not pose any problem for examinees – they will even be able to achieve better marks –, it still seemed necessary to survey and take into account the opinion of the target group before the development and implementation of the new system.

4. Usability of the results in practice

Since this system was brought into life by a real practical need, every single solution described in the thesis is connected to a specific task. Since its completion, the system has served nearly 3000 examinations.

- **Learning framework**. A free, open source software-based e-learning framework was developed which is tailored to the needs of the department due to its own developed character. This system has been serving practical teaching for six years.
- **Electronic curriculum**. The electronic version of the previous curriculum was also compiled that supplements the opportunities of performance measurement with new functions (formative evaluation) due to the control and exam questions connected with the curriculum.
- **Electronic examination system.** An electronic examination system was developed that significantly decreases teachers' burden by automatising work processes, whereas it also improves the objectivity of marking. The feedback of the results of the module that analyses the data logged by the examination system into teaching contributes to the improvement of the standard of teaching.
- **During the applied electronic examination method, the technology itself does not discriminate**. A preliminary survey showed that the target group is overrepresented in comparison with the Hungarian average concerning computer use and Internet penetration. Based on students' skills and the practice they obtained in using modern technologies, e-examining does not discriminate. 95% of students already had their own computers in 2005 and there were no students who have only started to get to know what computers or the Internet are about: every interviewee used the Internet regularly.
- **During the exam, the readability of the Web interface does not discriminate**. The analysis of the length of test exercises and the ratio of correct answers showed that there is no correlation between the two factors.
- **Recommendation at the number of test questions, score limits and the amount of time needed to solve the exercises**. The number of questions and answers that the system uses are based on probability calculation and

statistical analyses, determination of score limits, the amount of time needed to solve the exercises and the method of determining it.

- **The opportunity of correction usually contributes to the successfulness of the test, but not for every examinee.** During the early introduction of e-tests, special literature references considered the lack of opportunity to correct a choice to be a factor that reduced examinees' results in comparison with paper form tests. Our examinations show that 27-32% of the students who corrected themselves would have got a better mark if the system had not offered them such opportunity, although 38-42% of them managed to use this feature as a factor that contributes to a better mark. Therefore, correction is by no means an advantageous feature for all students.
- **Self-correction testing mechanism based on discrimination**. The dynamic evaluation of exercises on the basis of their solutions determines the discrimination value of the given question. Negative discrimination is an obvious sign that the exercise is improper: students who were successful in solving the entire exercise sheet tend to perform worse concerning the given question in comparison with students who are otherwise weaker. Based on the data referring to discrimination, the automatic mechanism of filtering out and temporarily excluding improper exercises from further exams was developed; therefore, a self-correcting examination system was worked out.

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