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THE EFFICIENCY OF ACTIVITY-AIDED TEACHING USING AN E-LEARNING PROGRAM IN AGROCHEMISTRY AS A BACHELOR DEGREE SUBJECT

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Abstract

The activity-aided teaching using e-learning program was assessed in students' training in Agrochemistry subject in the first year of bachelor degree study at the Faculty of Agrobiology, Food and Natural Resources of Czech University of Life Sciences Prague. The e-learning program integrated with active methods had greater efficiency in the students' education than in classical, formal teaching. The study was achieved on two groups of students; control group (with classical teaching) and tested group (with activated teaching). Students were distributed into groups randomly and the input knowledge in chemistry followed the Gaussian distribution. Basic students' knowledge on general chemistry was very low on the average and did not correspond with the curricular programs for secondary schools established in the Czech Republic. Activated methods of Agrochemistry teaching consisted mainly from motivation, regularly repetition connected with homework and from usage of e-learning program for self-study. The teaching effectiveness was proved by students' score from three particular tests and by effective progression and by relative progression. The score from particular tests was related to the score from the entrance test. There were two coefficients of the students' progression defined properly, and are applicable for a numerical or percentage value. Students from the tested group achieved statistically significantly ($\alpha = 0.05$) higher scores (186 points) than students in the control group (136 points) in all three particular tests. Evaluation according to effective progression and relative progression proved the higher progress in the tested group compare to the control group. The evaluation of teaching efficiency can be proved by effective as well relative progression. The effective progression was 55 % in tested group and 26 % in control group. Higher significance of tested students' progression was shown on relative progression; 64 % in tested students and 19 % in control students. The e-learning teaching integrated with active methods can be recommended for higher education.

Key Words

E-learning, Activity-aided Teaching, Efficiency, Undergraduate Training, Higher Education

Introduction

Effectiveness is a major attribute in all human activities; it is a quality marker. The leading purpose of any activity is to achieve the best and most effective results, i.e. to optimize effectiveness under economic and time conditions. In addition, the teachers/student relationship should be evaluated according to progress made within process of education and knowledge obtained by individual students.

Key information can be found in pedagogical papers of authors who have made future predictions of the abilities needed in human society, for example Badescu (2006) and Afonso, Aubyn (2005).

The results of education are influenced by both inner and outer factors. Because the outputs are affected by inputs, it is necessary to prepare and select the inputs (i.e. the educational conditions) carefully. Among the inner factors of education involved are the students' awareness for education and their teachers' competence for teaching. The students' awareness means what is the present education level, i.e. the present assumption of knowledge and abilities, which are depended on intelligence and proficiency. The awareness for education is motivation (interest in a given activity) which is also very important. In fact, it represents the impetus for the education process. Thus, when the student does not want to learn, it requires finding a way to raise the interest. If we are not able to motivate students, we are not able to teach them, and the efficiency of the education process approximates to zero.

The outer factors affecting education include outer conditions such as atmosphere, where education is realized, the teacher-student relations, teaching style, methods used and facilities, organization of education, duration of teaching, frequency and duration of breaks, microclimate and facilities in a classroom, time of day and acoustic and light levels in a classroom. Most of these factors can be provided for optimal conditions (optimal inputs) for education. Teachers are mainly oriented on methods of education in an effort to use optimal (i.e. the most effective) teaching methods. In this, minimizing time and labor used to achieve the maximization of learned subject matter is a general requirement. Most teachers evade finding the best educational method (the most effective) by using homework and self-study for residual subject matter. They find that no method can fit every student, and yield the desired outcome. This problem can be solved by:

a) selection and application of a suitable method, which has motivation and activation effect,
b) teaching individual information-searching and studying,
c) production of situations for application, repetition and practice of appropriate knowledge and proficiency,
d) control and evaluation of education results and development.

The evaluation of educational efficiency is possible from the study results (outputs). The control and evaluation of outputs can be carried out continually (regularly or randomly), or at the end of the education process. Students must be apprised of the evaluation criteria in advance. Information about education efficiency is obtained, for example, from tests, answer sheets, dialogues, essays, and oral entrances. More often, feedback helps teachers to optimize teaching methods used and the education given. The efficiency of school systems is presented in final reports of competent institutions (Soares, Gropello 2006). Also, comparative studies are very useful, e.g.: for OECD countries (Badescu 2006). Professional literature dealing with education efficiency is very often related to the modernization of education in the sense of the use of new technical support (Hejmadi 2007). Many authors advocate teacher training in information technologies (IT), or using IT for distance education (Garrison, Kanuka 2004; Veselá 2005). These authors state that the using of IT support in education can increase educational efficiency. Whenever IT is a new component in education, it increases the students´ interest in the subject matter demonstrated by IT (Slavík 2004). Whenever students have access to IT, then IT support can be sufficient medium for self-study; the subject matter can be transmitted to students very quickly, and can be used for information searching and in working with information. Professional literature discussed teaching program efficiency, and the standardization of these programs (Ullman 2003), or the theory of their development (Mayer, Moreno, 2002; Pavey, Garland 2004; Salmon 2002). The choice of the most effective method is a basic problem for education (Badge *et al.* 2005). Currently, the challenge of educational quality in connection with educational efficiency is discussed in the context of the educational environment and school climate (Petlák 2000). The relationship between teacher and student is based on going forward with a common interest (Nelešovská 2005). A broader view of the problems of education efficiency was discussed by Cooze (1991).

Agrochemistry is a very difficult subject for students at our faculty and about 60 % of them fail the credit test in the regular term. Students are apprehensive of agrochemistry; however the pursuit of the subject is not difficult. The main problem is that students have poor knowledge in chemistry from high school. The requirements of Agrochemistry are not high in intelligence. Students with average intelligence are able to learn all that is necessary in the subject. The reason why students failed the credit test is the absence of motivation.

We consider two main assumptions of this paper: to prove the reliability of activity-aided teaching using an e-learning program contrary to formal teaching and to design possible way how to express the efficiency of the teaching process. Both these points are required to be solved in connection with the modern education development at the faculty.

Material and Methods

The learning unit

Three learning units per week cover all the topics included in the educational program for Agrochemistry. The subject Agrochemistry is the basic subject in the Faculty of Agrobiology, Food and Natural Resources for all fields of studies. This subject is included in all student programs, because there is a low level of common knowledge of chemistry. In the Czech Republic educational system there does not exist uniform evaluation system for chemistry, and the differences among students after secondary school are very substantial.

The teaching was organized in a classroom for 24 students, with classical school equipment and with the possibility to use dataprojection and internet connection. The control group consisted of two study groups with 44 students altogether. The control group was educated by the classical formal teaching method. The tested group consisted of two study groups with 46 students altogether. The tested group was educated using active methods, which challenged an active response by the student.

Students' characterization and experimental design

All focused students were enrolled in the 1st year of a bachelor study programmes studying general subjects before further specialization. Students were educated in different types of high school (Table 1). The knowledge level of chemistry was assessed from the entrance test (Figure 1). From analyses of the entrance tests scores, it is evident that the students´ knowledge of chemistry was very poor in all groups, as is shown in analysis of a Gaussian distribution. The distribution of knowledge from chemistry in the tested and control groups was a non-normal distribution. Students´ knowledge from high school was very low and do not correspond with the average knowledge.

type of secondary education	agriculture	grammar school	veterinary	health-service	gardening	total
type of group	number of students					
control group	11	3	6	7	17	44
tested group	17	1	4	5	19	46

Table 1: Characterization of secondary education of students

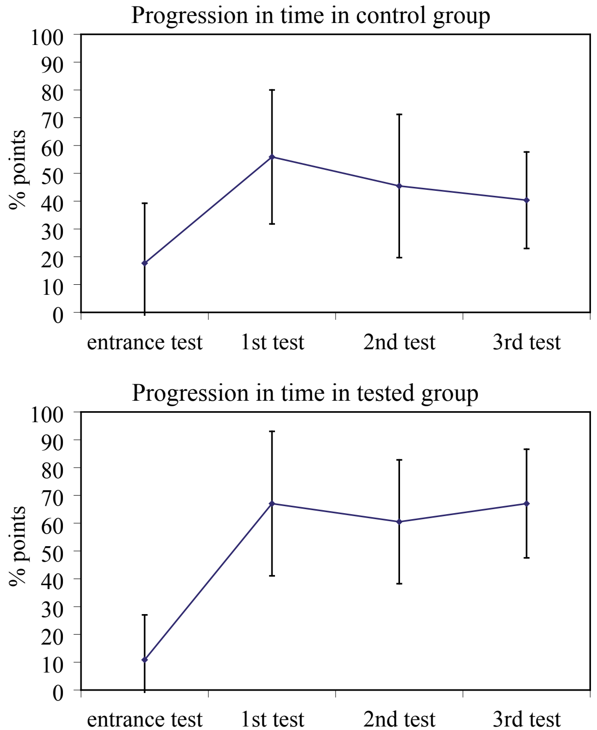

Figure 1: Development of the tests score in control and tested group

Students were distributed into study groups randomly according to alphabetical order. This distribution compensates for the accumulation of students with a specific type of high school in the same class. Students in both focused groups were educated by one teacher, in comparable day time, in the same classroom.

Active methods

The main problem of education was how to explain to students that agrochemistry is easy to learn and how to eradicate the barriers in learning. Active methods, which we used was closely connected with motivation and positive stance. In the tested group we used:

- Different subjects were separated into small clusters (e.g. inorganic nomenclature was divided into nomenclature of oxides, sulfides, acids, hydroxides etc.), which were taught individually from easily understandable to more difficult ones.
- Students had to find relations among each subject matter clusters and postulate general rules.
- The repetition of subject matter was provided before each new lesson and the active contribution of students was required.
- We tried to explain to them every chemical problem by generally speaking language with congeneric examples from normal life, e.g. a problem with counting of mass fractions was explained on the commonly used topic of cooking marmalade.
- Also we tried to be synoptical and visual in every abstract problem, e.g. when the problem of molarity was explained, the amount of one mol of substance was shown on concrete substance; students saw one mol of water, one mol of poppy seeds and one mol of bacteria in a picture.
- Moreover the e-learning program (Čipera 2001) was prepared as a teaching assistance for using in lesson and also for self-studying.
- Students received homework every lesson on the secured internet pages made for them.

The education during the lessons was provided using an e-learning program, which was controlled by a teacher. Actually, the teaching type was blended-learning. However the e-learning program was disposable on internet and students can used it to self-study.

The e-learning

On Agrochemistry web (available through the username and password) were interactive examples, theory, and homeworks. The e-learning saved time, which was imposed to practice and answer students´ questions. The main idea of the project was to arouse interest in the students of Agrochemistry, and eliminate distress from chemistry as a subject.

The e-learning included:

- hand-outs available for student,
- examples with solution:
  - theoretical question with multiple matching or open-cloze answers,
  - computations,
  - nomenclature,
  - reactions,
- a chat room,
- a glossary.

Formal teaching

Formal teaching makes an opposite to active methods. The subject matter was presented to student by a teacher without any immediate feedback. The subject matter was not divided or structuralized; the subject matter was put forward to student as fact without any space to discussion yielding to conclusion formulation by students.

The subject matter was theoretically explained to student (without any supportive method) and students tried to applied theory in lesson or at home. Neither teacher nor students had any immediate feedback.

Any examples from common life were not used and students did not obtained subject matter relation to other subject and how to use it in complex problems.

Efficiency of education

In the evaluation of education efficiency (Dytrtová, 2008) of a teaching style it is possible to evaluate:

1. ***Efficiency of a teacher*** can be ascertained by **students' questionnaire**, which appraised a teaching style of a teacher from the students' aspects. This evaluation identified :
   - The way of applied education.
   - The quality of teaching.
   - The level of communication.
   - Relation among teacher and students.
2. ***The immediate efficiency*** deals with efficiency during teaching process in short time (e.g. during one educational unit). This efficiency is detected on the base of **entrance and final test**. This type evaluation of efficiency is competent to:
   - Comparison of different teaching styles and methods.
   - Comparison of different groups of students.
   - Comparison of teaching quality.
   - Validation of new teaching methods (e.g. e-learning, blended-learning or multimedia education).
3. ***The long-term efficiency*** is suitable to the monitoring of students' progression in their knowledge or acquirement during long time period (semester). Using this efficiency can be detect the same characteristic as with the immediate efficiency reaching to longer time. The evaluation can be provided in several times during the monitoring to obtain a time development determining a progress curve. This efficiency is detected by **entrance and final/current (continuous) tests**.
4. ***The applied efficiency*** evaluates the ability of the student to apply his knowledge and acquirement in problem situation. This efficiency is very complex and includes students' creativity; however it is the best characteristic in evaluation of education process.
5. ***The total efficiency*** includes before mentioned efficiency categories, whereas it is mostly influenced by the applied efficiency.

The longitudinal progression was used to determine efficiency. The initial state of the students´ knowledge was determined from the entrance test. The maximal score from the entrance test was 100 points (which amounts to 100 %). When students got in the entrance test more than 60 points (60 %), they passed the credit automatically. This test was conceived with its structure and range as a simulation of final test. In the final test the same knowledge content was required. Three continuous tests during the semester were given. The maximum score for each test was 100 points. Students needed at least 180 points from three tests for passing the credit. The longitudinal progression of students´ knowledge was monitored from continuous (current) test scores. At the end of monitoring the total points were recounted (according to the rule of proportion) from points to percentage (300 points equates to 100 %). The recounting point to percentage is useful due to general applicability of results. Following this calculation we were able to count the indicators of the students´ progressiveness, and consequently to decided about the efficiency of active education. From a consideration of individual progress, it was possible to define the maximal progress (MP):

$$MP = 100 - ET \qquad (1),$$

where ET (entrance test) is the score from the entrance test in percentage. MP presents the maximal feasible progress in the students´ knowledge during their education. This maximum is given by knowledge requirements. Another very suitable measure of efficiency is the effective progression (EP):

$$EP = MP - \left(100 - \frac{\sum_{i=1}^{n} TS_i}{n}\right) \qquad (2).$$

The TS is the score from continuous tests in percentage, where i is the number of tests, and n is a total count of tests. EP is the progression which respects individual aspects of progress for each student with consideration for the score from the entrance test (entrance students´ knowledge). The value of EP can be positive or negative; when positive, means progress, when it is negative, its meaning is regression (what is also possible to notice, not just in a theoretical way).

For the comparison among students it is advisable to design a relative progression (RP):

$$RP = \frac{EP}{MP} \cdot 100 \qquad (3).$$

Relative progression tells us about a students´ knowledge progression during the focused period. This characteristic can be comparable in tested data set. RP can also take a negative or positive value (meaning).

Results

Evaluation of teaching using progression coefficients

The maximal value of progression (MP) was calculated according to the equation (1) from the difference between the maximum score of the entrance test and actual scores of the entrance tests. The value of MP (Table 2) counted for each student denotes maximal possible progression of the student in percentage. The connotation of MP results from the maximal feasible score which is possible to get in the test, as the MP has a theoretical value. Only two students from the focused students passed the entrance test; the others had very low scores from the test. The value of MP in the tested group was higher (89.14 %) than in the control group (79.65 %). This difference results from lower score in the entrance test in the tested group compare to in the control group; however, this difference in not statistically significant. The real value of students´ success is given by the effective progression (EP), counted from equation (2). The EP (Table 2) is statistical significantly higher in the tested group (55.17 %)

than in the control group (26.23 %). Moreover, the EP has not a normal distribution in the tested group compared to the control group. The relative progression (RP) counted from equation (3) is the percentage improvement of each student comparing to MP. The value of RP (Table 2) respects entrance knowledge misalignment of the students, and controls their knowledge development in dependence on using pedagogical methods individually. The RP (Table 2) is statistically significantly higher (62.40 %) without a normal distribution, compared to the tested group (19.43 %) with normal distribution. The mean values of MP, EP, RP and their standard deviation (SD) are given in Table 2.

Type of progression	Methods of instruction			
	Test group		Control group	
	M	SD	M	SD
Maximal progression (%)	89.14	16.15	79.65	26.56
Effective progression (%)	55.17	20.85	26.23	26.04
Relative progression (%)	62.40	21.03	19.43	65.42

Table 2: Result of the teaching efficiency evaluation (in %) in control and test group

Evaluation of teaching using test score

The score in the entrance test in the tested group was 10.86 % (points), and in the control group the score from the entrance test was higher 20.35 % (points). The normality test improved in the entrance test score, not-normality in both group. The score was very low in both groups. After teaching, differences were found in student scores in the 1st test, and also in the distribution; the character of score distribution in control group was normal, however in the tested group it was not normal. The student score (Figure 1) in 1st test of the tested group was higher (67.05 %, points) than in the control group (55.91 %, points). On the other hand this difference in not statistically significant. Statistical significant differences in student scores between control and tested groups were found in 2nd and 3rd tests (Figure 1).

Statistical analyses

Statistical analyses were itemized in the program Statistica 7.1 (StatSoft, Inc.). Results from correlation analysis of each student's progress show that the formal teaching process (Table 3) gives medium correlation coefficients, while the activate process gives lower than expected progress (lower correlation coefficients; Table 4) based on the motivated cognition of most students.

test	entrance	1st	2nd	3rd
entrance	1.0000	0.4650	0.3460	0.4634
1st	0.4650	1.0000	**0.8455**	**0.6846**
2nd	0.3460	**0.8455**	1.0000	**0.7186**
3rd	0.4634	**0.6846**	**0.7186**	1.0000

Table 3: Control group correlation analysis (α=0.05)

test	entrance	1st	2nd	3rd
entrance	1.0000	0.2628	0.2454	0.2084
1st	0.2628	1.0000	**0.6298**	0.3015
2nd	0.2454	**0.6298**	1.0000	**0.5953**
3rd	0.2084	0.3015	**0.5953**	1.0000

Table 4: Test group correlation analysis (α=0.05)

Skewed values are not clearly different from 0, and the median values are near the arithmetic averages. Thus the distribution is almost normal in both groups, in all tests, except the entrance test (an asymmetrical distribution). The teaching process aims to uniformity of student records as a group.

The active teaching process (by medians comparison) significantly improves the records.

It is possible that the main contribution of active teaching is through increasing the students´ interest in the subject, eliminating students' apprehension about the subject and, last but not least, motivation. This corresponds to scores from the control group. Also the atmosphere in the control classes was very unfriendly; students copied in the test and made little effort to solve any problem. In the tested group, there was a very friendly and cooperative atmosphere and over time (during the semester) the atmosphere improved. Students in the tested group compared to the control group were polite to the teacher and asked questions and the absorption of the subject could be seen. At the end of the study, 86 % of students from the active group passed the score test compared to 35 % of students from the control group.

Discussion

The results of this short study are very encouraging for further studies, with testing of active methods and using them in the praxis. The preparation of the active lesson is more sophisticated than the classic lesson, at first sight. And sometime it is also problem with literacy of teachers in e-learning technologies (Goodfellow 2005). However, preparation of active activities for students is an investment for the future. Especially, preparation of e-learning programs is very problematic; however, its usage in lessons saves time and also is useful in students´ self-study (Pintrich 1999). Our results are better than were expected, and they are supported by progress coefficients, from test scores and from statistical analyses (Skewness test, correlation analyses and median counting).

Nevertheless, our results could be better using more sophisticated e-learning system; it means support teacher's effort by e-learning program concerning motivation, explanation and answers other possible associated questions. Clear scaffolding ("red line", context), printable handouts, search engine and bookmarking are essential. (Ardito et al., 2004)

The main treatment of the e-learning could be distance learning because of its lover cost compare to normal teaching (Wentling, Park 2002). The e-learning program is money and time demanding in its introductory part (Thomson 2000), however the long term use must get to pay back.

Conclusion

Teaching using active methods including e-learning teaching is successful. Students got better relations to Agrochemistry, decreased their apprehension of the subject, and were successful in the score test compared to the control students taught by classic formal teaching. The created e-learning program can be also used for home preparation or distance education. Active teaching, especially e-learning, will be tested next semester on a larger number of students. Thus, the question of using these modern methods does not consist in "if" or "why", but in "how" or "which way".

The mentioned description of long-term efficiency evaluation is applicable to similar problem.

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