CREATIVE TEACHING IN ENGINEERING EDUCATION

TVORIVÉ VYUČOVANIE V INŽINIERSKOM VZDELÁVANÍ

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Abstract

Realisation and results of research, which verifies educational efficiency of the creative teaching model, that could be used in the teaching - learning process of mathematics and technical courses in the basic study at the technical universities, are describes in this paper. Model is used in the teaching process of Computer geometry course at Faculty of Materials Science and Technology.

V príspevku je opísaný priebeh, realizácia a výsledky výskumu zaoberajúceho sa overením modelu tvorivého vyučovania, ktorý môže byť použitý vo vyučovaní matematických a technických predmetov základného štúdia na technických univerzitách. Model bol aplikovaný vo vyučovaní predmetu Počítačová geometria v 1. ročníku štúdia na MtF STU v Trnave.

Key words

didactic, education, technical courses, mathematics, creativity

didaktika, vzdelávanie, predmety technické, matematika, tvorivosť

Introduction

The paper briefly describes realisation and results of the research, dealing with an influence of the proposed teaching model on the quality of acquired knowledge and students' attitude to the course, while using methods supporting development of creative technical thinking of students. In conclusion, this paper brings generalisation of the results, conclusion, and recommendations for the teaching experience.

Realization of the research

Aim of the research was: to verify educational efficiency of the propose teaching model and to find out influence of the model on the attitude of students to Computer geometry course. Selection of the sample of students was done in such way to assure homogeneity of the group and uniformity intervening variables. From the basic group of students of 1. year were to experimental group selected students of two study group of specialisation Information technology and in to reference group students of two study group of the same specialisation.

Average number of points was calculated that students reached in entrance examination were calculated for every study group.

In to experimental and reference groups were selected study groups so that there is not statistical significant differences between average score and between groups. Two sample t-test with identity of variance on the basic of the result two sample F-test for variance, which assumption is fulfil condition of normal distribution. It is obvious for table 1, that calculated value tested criteria is $t_{stat} = -0,729$. For given degrees of freedom $\nu = 75$ and significance level $\alpha = 0,05$ critical value $t_{krit} = 1,992$. For given values is $| t_{stat}| < t_{krit}$, it means that there is not statistical significant different between groups. It can state that groups are equivalent regarding knowledge and abilities of students, based on secondary school result.

STATISTICAL VERIFICATION OF EQUIVALENT OF THE GROUPS Table1

Type of group	Number of students	Average score	Variance	F	F krit	tstat	tkrit
experimental	42	221	1682,646	1,165	1,741	-0,729	1,992
reference	35	228	1443,84				

Experimental and reference group were approximately equivalent in indicator on the age, sex, type of second school. Average age of students was 18,81 in reference group 18,31.
Following hypotheses are given in accordance with the aim of research.
Hypothesis n. 1: Students in experimental group will reach better results in solving tasks on specific transfer compare to students on reference group.
Hypothesis n. 2: Students in experimental group will reach better results in solving tasks on non specific transfer compare to students on reference group.
Hypothesis n. 3: Performance of experimental group students in educational test will be higher compare to performance of reference group students.
Hypothesis n. 4: Experimental group students will like CG course more than reference group students.
Hypothesis n. 5: Experimental group students will consider the CG course less difficult than reference group students.
Hypothesis n. 6: Experimental group students will find the CG course more interesting than reference group students.
Hypothesis n. 7: In experimental group students will prevail positive opinion on atmosphere during exercises compare to reference group students.
Hypothesis n. 8: In experimental group students will prevail positive attitudes to method of teaching, to further use of acquired knowledge and to usefulness of the CG course compare to reference group students.

Research methods

Choice of research methods was based from objective aims and hypotheses. Following methods are appropriate:

- Natural educational experiment – main research method
- Educational test for verifying hypotheses 1, 2, 3
- Questionnaire for verifying hypotheses 4, 5, 6, 7, 8
- Statistical method processing results of research
- Two sample F-test and t-test for statistical verification hypotheses.

Start characteristic of the methods.

Natural educational experiment

Tested was enable expressly specify relations between cause and effect. Effect of one independent variable (teaching by using methods supporting development of creative technical thinking of students) has been on dependent variable (performance of students and their attitude to the CG course). Research was conducted in the framework normal teaching process during the term.

In experimental group was used model of teaching with using methods supporting development of creative technical thinking. [2] Reference groups were taught in tradition way, characterized by transmission of ready information and knowledge, frontal teaching, stress was on development of logical convergent thinking. Intervening variables - teacher, contents of teaching, classroom and time of teaching were approximately the same in both groups.

Educational test

In research was use cognitive NR (norm referenced) test. Content of the test was teaching material from the CG course, explained during one term. It content two subtests: *Subtest1* that contains problems, exigent according to Niemerk taxonomy third standard acquire - specific transfer – ability apply theoretical knowledge, *subest2* that contains problems, exigent forth standard acquire – non-specific transfer – ability apply knowledge to new conditions. Tasks required from students to apply acquired knowledge to new situations, to use independent thinking, to use acquired knowledge creatively. Measure of success of students in the test was expressed by relative score in %. Test has 2 equivalent variant A, B modified in resulting shape on the based result of advance research. Testing time was 50 minutes.

Questionnaires

For verify hypotheses 4 - 8 was used anonymous closed questionnaire created on the based Likert scales which are used for measuring attitudes of people. Students responded to items by closing for option. Questionnaire was specified and modified in to finally shape on the based on results of advance research.

Statistical method of processing result of research

Methods of statistical description were used for description for the result of the research. Data were arrange to tables and displayed on the graph. Those methods were used to systematize obtained data (to specified medium values, calculating of variance) and also to express reliability of educational test. *Reliability* of educational test was calculated by „split-half“ method, since tasks tested ability of application of knowledge. Calculated was Person coefficient of correlation *r*. Measure of reliability of educational test is coefficient $r_c = 0{,}71$, calculated with using Spearman –Brownovej correction: $r_c = \frac{2.r}{1+r}$.

Parallel validity was calculated as Person coefficient of correlation between marks from educational test and marks of students on exam from CG. Calculating value of the coefficient of correlation is $r = 0{,}53$. This is value closed to lover border of the value of coefficient of correlation, which mean significant tightness of the relation. Results of the research are processed by using statistical function of table processor Excel 98.

Statistical verification of hypotheses

For statistical verification of hypotheses was used two sample F-test for variance and two sample t-test, both on significance level α=0,05. On condition normal distribution of group.

F-test is test of significance of difference between two variances. Value of test criterion $F = \frac{\sigma_1^2}{\sigma_2^2}$,

where σ_1^2 a σ_2^2 are variances of fundamental ensembles.
If F<F_{krit} , than difference between variances is not statistically significant for given number degree of freedom $\nu_1 = n_1 - 1, \nu_2 = n_2 - 1$ and significance level, where n_1, n_2 are size of samples. I.e. $\sigma_1^2 = \sigma_2^2$.
If F>F_{krit} , difference between variances is statistically significant , t. j. $\sigma_1^2 \neq \sigma_2^2$.
T – test is test significance of difference two magnitudes.
If $\sigma_1^2 = \sigma_2^2$, for number of degree of freedom $\nu = n_1 + n_2 - 2$, test criterion

$$t = \frac{\left|\bar{x}_1 - \bar{x}_2\right|}{\sqrt{n_1 s_1^2 + n_2 s_2^2}} \cdot \sqrt{\frac{n_1 . n_2 (n_1 + n_2 - 2)}{n_1 + n_2}} ,$$

If $\sigma_1^2 \neq \sigma_2^2$, for $\nu = n_1 + n_2 - 2$, test criterion

$$t = \frac{\left|\bar{x}_1 - \bar{x}_2\right|}{\sqrt{\frac{s_1^2}{n_1 - 1} + \frac{s_2^2}{n_2 - 1}}}$$

Where $\bar{x}_1, \bar{x}_2$ are averages of samples and n_1, n_2 are size of samples.
If t>t_{krit} for given number of degree of freedom and significance level, null hypothesis which suppose identity of averages fundamental ensembles $\mu_1 = \mu_2$ is disallowed, difference of averages is statistically significant.
If t<t_{krit} difference of averages is not statistically significant on given significance level. Null hypotheses is relevant.

Results of the research

Following are of the **results of the research** on the based on evaluation of obtained data.
Hypotheses n. 1, assuming, that students of experimental group will reach in educational test better results in solving tasks for specific transfer than reference group students, is **not valid**. Although experimental group students achieved higher average relative score compare to reference group students (Fig.1) in tasks requiring specific transfer (tasks of subtest1), difference in relative score of the groups in subtest 1 is not statistical significant.

Calculated value of test criterion t =0,8702 is smaller compare to table value t_{krit} =1,9971, for chosen significance level α=0,05 and given number of degree of freedom. This has been surprise, since was expected opposite result on the based of study of literature and results of similar researches. This can have several possible causes. Similar researches did not distinguish ability of application of knowledge in similar and completely now situation. It mean they did not distinguish transfer on specific and non-specific. It is also possible that the result was caused by bigger using convergent thinking and imitation of solution according to known examples in tasks exigent specific transfer. In different from tasks for non specific transfer where is more used creative thinking trained in solving divergent tasks.

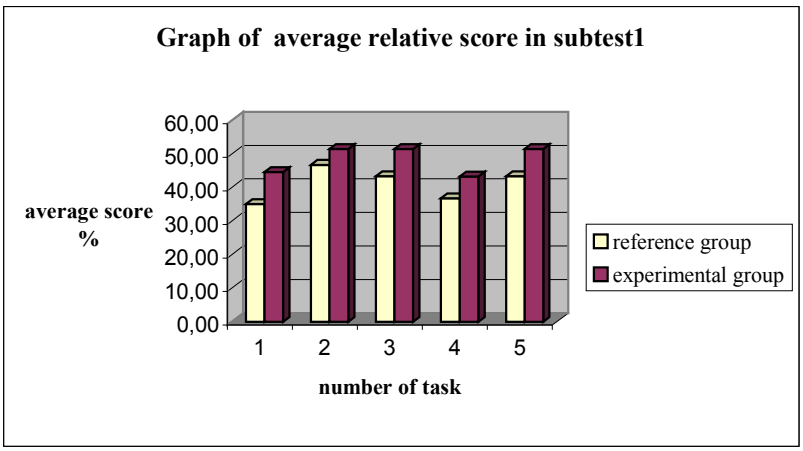

Fig. 1

Pedagogical experiment supported validity of hypothesis n. 2.

Hypotheses n. 2, assuming, that students of experimental group will reach in educational test better results in solving tasks for nonspecific transfer than reference group students, is **valid**. Figure 2 graph average relative score in tasks of subtest2. Difference pro experimental group to see visible. Difference of average relative score both groups in subtest2 was statistically significant. Calculated value of test criterion t = 2,7113 is bigger than tabular t_{krit} =1,9971, for choices significance level α=0,05 and corresponding number degree of freedom. Verification of this hypotheses present verification of intuition establishing under authority of professional literature.

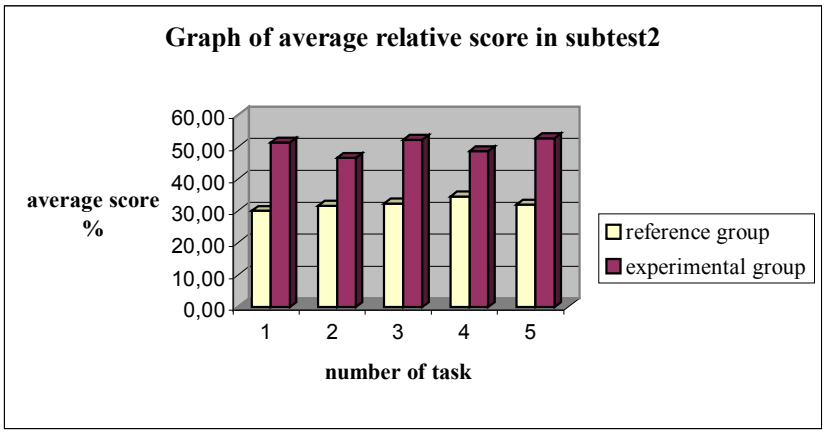

Fig. 2

Hypotheses n. 3, assuming, that global achievement of experimental group students in educational test will be higher in compare with achievement of reference group students, **is valid** on significance level α=0,05 (t = 2,0789, t_{krit} =1,9971). Accordingly difference in achievements (14,63%) was not caused by events, with probability 95%, but using different methodology of teaching of experimental and reference group.

High statistically significant differences in achievements of experimental and reference group students in educational test indicate, that applied specific exercises, techniques and practices influenced global achievement of students in educational test positively.

To have possibility to check hypothesis n.4 - 8 statistically, scattered answers on items of questionnaire had allotted values 1 - 4. Two-sample F-test for variance and two-sample t-test was applied for statistical verification hypothesis, both on significance level α=0,05. Is

possible to state, following results of statistical verification hypothesis ($|t_{stat}| \geq t_{krit}(\alpha)$), that difference in answers of experimental and reference group students to items 1,2,3 and 4 are statistically significant. Of it follow, that

Hypotheses n. 4 (assuming, that experimental group students will favor the subject more as the reference group students) is **valid**.

Hypotheses n. 5 (experimental group students will judge subject less difficult as reference group students) is **valid**.

Hypotheses n. 6 (subject will be more interesting for experimental group students as for reference group students) is **valid**.

Hypotheses n. 7 (experimental group students will have more positive opinion about the atmosphere on exercise in comparison with reference group students) is **valid**.

Hypotheses n. 8 (experimental group students will have more positive attitudes to teaching style, to future utilization of acquired knowledge and ability as compared with reference group students) is **not valid**.

Finding and recommendations

Acquired results is possible to summarize as follows:

- Proposed teaching model has not marked influence at achievements of students in solving of tasks exigent specific transfer. Although experimental group students reached higher relative score than reference group students, difference was not statistically significant.
- Teaching model has marked influence for achievements of students in subtest oriented for nonspecific transfer. Difference of relative score between experimental and reference group was statistically significant.
- Inscribed results expressly refer about positive influence of designed teaching model with utilization of methods supporting development of creative technical thinking not only in stage of achievement but in stage of attitudes towards course.

On the base of above stated findings, some **recommendations for teaching experience** can be made**:**

- Tasks oriented onto overcoming the barriers of creativity to include into beginning of the lessons.
- Creative atmosphere maintain throughout the lessons. To assess not only knowledge but also original thinking and creativity.
- To use more of divergent tasks with multiple solutions in the lessons.
- To maintain real conditions for using the methods supporting the development of creative technical thinking. (Not to overload the curriculum)

Conclusions

Realized educational experiment verified educational efficiency of proposed creative teaching model. Results of the experiment moreover pointed onto the fact, that application of specific methods, supporting development of creative technical thinking in the conditions of standard teaching, influenced in positive way the overall score of the students in educational test and also the quality of gained knowledge and skills. Experiment also proved the positive influence of proposed teaching model onto students attitude towards the course.

Listed results indicate justness of using the methods supporting development of creative thinking into teaching process at technical university. [1], [3]

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