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FACTOR ANALYSIS AS TOOL OF INVESTIGATIONS OF EDUCATION PRACTICES IN TEACHING OF BIOLOGY ON SECONDARY SCHOOLS

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У статті представлені питання пов'язані з викладанням біології на середніх школах. Автор описує результати процесу викладання біології у 18 вчителів різних середніх шкіл, в основному гімназій в регіонах Прешов і Кошіце на Словаччині. Включений факторний аналіз використовуваних методів, організації роботи, типів запитань, підходів до мотивації, форм нагороди і покарання, ставлення вчителів до думок студентів. Факторний аналіз підтвердив існування семи факторів, що впливають на курс викладання біології: фактор комунікації, фактор тестування студентів, фактор мотивації та активації, фактор індивідуальної роботи студентів, фактор творчості, фактор професійної компетентності вчителя, фактор по відношенню вчителя до студентів.

Ключові слова: факторний аналіз, викладання біології, практика освіти.

Pedagogical dictionary [2] defines factor analysis as: "a file of enormous number of statistical methods that help to determine the smallest number of basic dimensions - the factors coming from a huge number of investigated variables. The aim is to reduce initial data and configure them into several hierarchically upper units. Factor analysis starts with correlation matrix (it gathers values of correlation indexes), and a small number of basic and general variables is extracted by means of mathematical methods, which enables us to explain investigated relations better".

Department of Biology at Faculty of Humanities and Nature Sciences, University of Presov carried out didactic investigation at selected secondary schools in the territory of Presov and Kosice Self-Governing Regions. The goal of the investigation was to find out what is the real situation of biology teaching at secondary schools. 18 secondary school teachers of biology and their teaching techniques were observed by means of structured method. Factors that are playing an important role in teaching were discovered after evaluation and interpretation of results.

18 secondary school teachers of biology took part in this investigation. The examined group consisted of 14 secondary grammar school teachers (women with 4, 8, 10, 13, 15, 18, 20, 23, 24, 28,

29, 30, and 32 years long experience from Medzilaborce, Michalovce, Stropkov, Vranov nad Toplou, Kosice, Roznava, Lipany, Humenne and Presov) and 4 secondary professional schools (two men with 10 and 16 years long pedagogical experiences from Silvicultural School in Presov, one man with 30 year long experience from Secondary Nursing School in Humenne and a woman from Secondary Agricultural School in Caklov).

Investigated methods in teaching process-the work of teachers (each of the teachers was observed in 5 classes/lessons) were recorded in inspection records and given observations were consequently evaluated.

We focused on basic categories (type of lesson, teaching methods, organization of students' work, types of questions, teaching aids) as well as on the atmosphere during the lessons, teacher's attitude towards students, and time and space given students for their ideas, application of educational elements, motivation, the way of addressing students, testing and evaluation of knowledge. Particular categories were considered to be variables and investigated occurrences (figured in numbers) were considered to be found occurrences of observed variables.

Statistics literature recommends multiplying the number of observations (n) at least six times by observed variables (p). Total number of observed lesson is n = 90 and a number of observed variables, that is particular issues in inspection record p = 11.

Programme STATISTICA.6.1 cz was used to evaluate data.

Principle of factor analysis lies in searching for common factors (latent variables) that characterise particular common features of observed variables. If there is a group correlation in two or more variables, we presume the common factor exists in their background. On the other hand, the same variable can be influenced by more factors. It is called 'feeding by factor', which is figured by factor load. Factor load is a vector whose closeness contains most of measured values. Computer calculated uniqueness (table 1), which is figured in percentage and in cumulated percentage of variability of observed file. We can find out what is the percentage of particular factors on the whole variability of a file.

Table 1.

Results of calculation of uniqueness

Factor	Communality	Uniqueness	Percentage of variability	Cumulative percentage
1	1,0	2,15986	19,625	14,50254
2	1,0	2,053061	17,667	27,75147
3	1,0	1,94338	12,299	38,95115
4	1,0	1,60297	9,542	48,49338
5	1,0	1,411408	8,206	56,7019
6	1,0	1,35292	7,2293	63,93093
7	1,0	1,06009	6,523	70,45446
8	1,0	0,81165	5,226	76,2662
9	1,0	0,684226	5,184	81,17941
10	1,0	0,457006	4,913	85,54763
11	1,0	0,39436	3,585	100,000

The intent was to obtain whole numbers of factors (hidden variables) that are important from the point of view of 11 observed variables. In this case there are seven factors that have uniqueness > 1. All together they can feed 81.09% of the file variability. The first of them partakes in 19.63%, the second one partakes 17.67, the third one share in 12.30%, the fourth one 9.54%, the fifth one partakes in 8.21%, the sixth factor partakes 7.23%, and the seventh take a share in 6.52%. Spare 18.91 % partakes in between less important

components.

Indexes of factor equation of factor load before the end of rotation are figured in a bar shape (table 2). Each factor is calculated as a linear combination of variables. Of all these loads it is not always clear which variables the factors are related to. Vectors turn (rotate) so they could feed variables by particular factors. Computer evaluated supply of individual factor loads on the basis of dispersion of values of each observed variable. This matrix was rotated by Varimax method.

Table 2.

Factor matrix for considered 7 factors

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
1	0,557701	0,612709	-0,337827	0,020837	-0,367792	0,467190	-0,002710
2	0,1156566	0,314493	0,274254	-0,155453	0,146103	0,093962	0,492961
3	0,763154	0,568408	0,658494	0,348607	0,205998	-0,384219	0,063873
4	0,384819	-0,551341	-0,265028	0,396580	0,450621	0,424227	0,413562
5	-0,131091	0,337914	0,492961	0,120358	0,001878	0,078567	0,164446
6	0,254722	-0,213255	0,262282	-0,120691	-0,050113	0,489024	0,085299
7	0,339402	0,698723	0,607610	0,207304	0,211904	0,133731	0,174191
8	0,132104	0,472206	0,515202	-0,115319	0,135602	-0,025489	0,047097
9	-0,718066	-0,308424	0,245494	0,258684	0,039334	0,199696	0,442652
10	0,389996	0,254583	0,359025	-0,298056	0,100996	-0,216732	-0,011794
11	0,265472	0,345042	0,198621	0,090643	0,338957	0,056802	0,142074

Indexes of equation and a part of variability after rotation are given in table 3. The aim of the rotation was to obtain new factors so each vector achieved high correlation with several original variables. The rotation simplified explanation of factors. Due to better limpidity, important indexes were emphasised. Informatively, we can determine the importance of loads in several ways. Level above 0.45 was chosen in our investigation. If the results of calculations of particular important factors reflect reality, these variables correlate for the same factor and are of great importance.

Factor analysis proved the presence of seven factors that are important for educational process of biology:

The first factor is so called communication factor. It feeds variables 4, 5, 9 (table 3) constituted by: teaching methods (mostly diag-

nostic), organization of students' work (frontal and group) and time and space for students' ideas. Reality is also reflected in our investigation. If teacher communicates with students, and there is enough time and space for students' ideas, he or she gets the feedback and overall survey about students' learning and systematization of knowledge. Overall variability is fed by this factor by 19.63%.

The second factor was named as a factor of examining of students. It feeds variables 2, 6, 10, 11 (table 3): traditional organization of lesson, types of questions, forms of evaluation and testing students' results. It proves the results of our investigation. Teachers accentuated oral examining in an opening part of a lesson. Such structure of a lesson is typical for traditional educational process which also resulted from our investigation. It influences variability by 17.67%.

Table 3.

Rotated factor matrix

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
1	0,080151	-0,080151	0,293008	-0,067413	-0,557838	0,675128	-0,001271
2	0,025643	0,745590	-0,159829	0,251562	0,146103	-0,216732	0,450389
3	0,104874	0,256043	0,123666	0,065871	0,205998	-0,516302	0,113250
4	0,511004	0,104874	0,290210	0,523651	0,681254	-0,422740	0,620897
5	-0,496156	-0,361282	0,451239	0,493568	-0,127796	0,238277	0,174109
6	-0,361282	0,667977	0,070819	-0,036952	0,050113	0,460325	0,085299
7	0,247298	0,024123	0,742506	0,125892	0,211604	0,175298	-0,047097
8	-0,067059	0,129457	0,667472	0,265942	0,496581	0,026589	0,329064
9	0,691355	-0,096401	0,018123	-0,158901	0,039334	0,133703	0,767351
10	0,026291	0,751046	-0,311139	-0,712654	0,007010	0,078567	-0,142074
11	0,033942	0,824681	0,064852	0,018121	0,100996	0,118165	0,232627

The third factor is factor of motivation and activation. It feeds variables 5, 7, 8 (table 3): the organization of students' work, atmosphere at the lessons and bringing in motivation. Students' relation to the subject depends on atmosphere at lessons and external motivation from a teacher that accrues from teacher's personality. This factor feeds file variability by 12.30%.

The fourth factor is so called factor of student's individual work and it feeds variables 4, 5, 10 (table 3): educational methods (mostly monologues, work with literature and copied texts), individual students' work and individual examining as form of verification of obtained knowledge. Teachers leave the space and time for individual students' individual work which leads them to self education and individual obtaining of knowledge in various kinds of literature. Overall variability is fed by 9.54%.

The fifth factor is signified as factor of creativity. It feeds variables 1, 4, 8 (table 3): independent teacher, teaching methods such as didactic game, brainstorming, problem cases, and application of

motivation to student's creativity. Mastery of a teacher's personality rests in application of motivation to students' creativity. The selection of creative teaching methods and setting the problem cases contributes to activation of student's occupancy and raises students' inner motivation during lessons. Variability is influenced by 8.21 %.

The sixth factor is factor of teacher's specialised skills because it feeds variables 1, 3, 6 (table 3). They are constituted by mastery of his personality, type of a lesson and types of questions. It reflects teacher's abilities on the selection of a type of lesson as well as the selection of suitable questions which are also related to the effectiveness of educational process. It feeds variability of the file with 7.23%.

The seventh factor is called teacher-student factor and feeds variables 2, 4, 9 (table 3): lesson organization, teaching methods (mostly dialogues), students' opining. It reflects teacher's mastery and his attitude towards students. If there is a partnership between a teacher and students, he or she leaves students time and space for opining and consequently he or she accepts, modifies and makes students' work

more effective. Overall file variability is influenced by 6.52%.

Conclusion. Complex occurrences without any quantitative but qualitative characteristics can often be observed in the theory of biology teaching. Investigations and their correlations help us to register only external manifestations of occurrences while subject-matter often stays undisclosed.

On the basis of observed and measured occurrences we may assume the existence of latent variable in the background. Hypothesis of latent variable, also called factor, can be proved on the basis of the

results from analysis of main components and factor analysis. Factor analysis is mathematical conception of analyse which discloses hidden variable in the system of more variables. A factor analysis was used to process the results of investigation statistically. It supports the existence of seven factors influencing the course of biology teaching at secondary schools: communication factor, feedback factor (examining), factor of motivation and activation, factor of students' individual work, factor of creativity, factor of teacher's specialized skills, and teacher-student factor.

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В статье представлены вопросы связанные с преподаванием биологии на средних школах. Автор описывает результаты процесса преподавания биологии у 18 учителей на различных средних школах, в основном гимназиях, в регионах Прешова и Кошиц в Словакии. Включен факторный анализ используемых методов, организации работы, типов вопросов, подходов к мотивации, форм вознаграждения и наказания, отношения учителей к мнениям учащихся. Факторный анализ подтвердил существование семи факторов влияющих на курс преподавания биологии: фактор коммуникации, фактор тестирования студентов, фактор мотивации и активации, фактор индивидуальной работы студентов, фактор творчества, фактор компетентности учителя, фактор отношения учителя к студентам.

Ключевые слова: факторный анализ, преподавание биологии, практика образования.

The article presents matters associated with teaching of biology on secondary schools. The author describes findings during teaching of biology by 18 teachers on different secondary schools, mostly gymnasiums, in Presov and Kosice regions in Slovakia. There is included factor analysis there concerning of used methods, organizations of works with students, type of questions by students, motivation approaches, types of bonuses and penalties and teachers' relations to comments by students. Factor analysis confirmed the existence of seven factors affecting the course of biology education: communication factor, feedback factor (examining), factor of motivation and activation, factor of students' individual work, factor of creativity, factor of teacher's specialized skills, and teacher to student relationship factor.

Key words: factor analysis, teaching of biology, education practices.

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