More Efficient Learning on Web Courseware Systems?

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Abstract: The article describes a research conducted on students at the University in Pula, by which was attempted to establish whether there is a relationship between exam success and a type of online teaching material from which a student learns. Students were subjected to psychological testing that measured factors of intelligence: verbal, non-verbal and math-logical. Four different teaching resources were prepared for the same educational material. First of those was adjusted for students with the strongest verbal abilities, second for students with the strongest math-logical abilities, third for the students with the strongest non-verbal factor of intelligence. Fourth teaching material was prepared in such a way as to equally represent all three factors of intelligence, for a mixed group of students. Students accessed the online educational material using web courseware tool Moodle. Tests were much better solved by students who had adjusted teaching materials than by students in the mixed group, or those in the control group. This article describes the intelligence tests that were used in the study, structure of the teaching materials and results.

Introduction

In preparation of the teaching materials for online education, teachers are attempting to create contents that would be logical and understandable for students, allowing them to learn as efficiently as possible. Development of technology led to a development of informatics systems for online learning, which are enhancing more and more different aspects of educational approach, while still respecting pedagogical, didactic, psychological and methodological standards typically used in classical educational methods.

Adaptive systems for teaching offer an advanced type of surrounding, which attempts to satisfy different needs of students (Brusilovsky & Peylo 2003). Such systems approach each student based on the individual model of teaching. Accordingly, system is dynamically adjusted in such a way as to create conditions that will support the student in learning in the best possible way. For example, Rassmunsen in his study concluded that teaching system can determine students learning habits and in that way adjust itself for more efficient teaching of the student (Rasmussen, 1998).

When discussing teachers who wish to apply computers in educational process, the following can be concluded: these teachers must have different competencies from those of traditional teachers. Today's teacher needs to know how to adjust its teaching to fit the needs of each individual student, and at the same time, needs to be literate in informatics systems, and capable of finding specific teaching contents on Internet using informatics-communication technology (Muradbegovic & Zufic 2005a,b).

We recently reported our experiences acquired during online education in a system for distance learning, *WebCT* (Zufic & Kalpic 2007). In that project, we measured students' intelligence, and researched the relationship between achieved results and their relationship to intelligence. Teaching materials for all students were identical. Similar research (Zufic et. al. 2007) has shown that e-communication has a major effect on the success of the educational process conducted over the Internet or through systems for distant learning, but concluded that results would have been much better if the teaching materials were adjusted to individual student.

When discussing different teaching materials for students, an unavoidable question is whether there is a need to create different materials for individual students, and if there is – based on what criteria? Researching individual differences is a foundation for understanding why some students are more successful than others. Those who learn use different types of learning through ways of processing and organization of information, ways how they behave during learning, and their predispositions for certain type of learning.

Among other potential causes, intellectual abilities could be causes for success in students for whom there is a measurable difference in intelligence and level of ability (Neisser, et al 1995). Defining intelligence is a problem because even psychologists have not agreed what does or does not constitute intelligence. According to Zarevski, intelligence is the most visible and most relevant part of cognitive functioning, and the most important characteristic of a complete personality (Zarevski 2000). Gardner, a founder of the theory of multiple intelligence (Gardner 1983, 1993), defines intelligence as a "biopsy-chological potential that can be activated in cultural surrounding with intention to resolve a problem or create products which have value in our culture." For some cultures, intelligence is defined as an ability to come to a logical conclusion, for others it may be ability to persuade, while for third it could be the ability of constructive listening (Berry 1974, Berry & Irvine 1986, Sternberg 1990).

Because there are many definitions of intelligence, there are also many theories regarding its structure. We chose Carroll's (Zarevski 2000) widely accepted and respected *The Three-Stratum Theory* of the structure of intelligence. That theory integrates two well-confirmed and very influential concepts of intelligence – Spearman's model of *g-factors* and Cattell's *Model of fluid and crystallized intelligence*. Carroll's theory is based on hierarchical structure with three levels. At the first level (the lowest, and most detailed) there are narrow factors (so far, there are approximately seventy detailed factors), which represent specialized abilities. For these factors, it is characteristic that they are enriched with several factors from the second level. Factors of the second level are grouping primary abilities into eight domains: 1) fluid intelligence (characterized by primary factors of induction, thinking, problem solving and visual perception; maximum is achieved after the age of 20 and it does not decline with ageing; variability increases with age, education, cultural differences; it has low correlation with learning); 2) crystallized intelligence (most factors that define this intelligence directly or indirectly include language; some factors that define it the best are verbal ability, language development, understanding of the read material, and general information level; maximum is reached very early, sometimes even at the age of 14, and falls after the age of 20; variability is constant among cultures and it is best to measure it using culturally unbiased tests; highly correlates with learning of the new material); 3) general memory and learning (best described as associative memory, free remembering and meaningful memorizing, and less well as a range of memory); 4) wide visual conception; 5) wide auditory perception; 6) wide ability of remembering; 7) wide cognitive speed; and 8) Speed of processing. Finally, on a third level there are factors of general intelligence derived from a mutual variance of the factors of the second level.

Choosing a theory of intelligence leads to a choice of intelligence tests that will measure certain abilities. The authors chose to test verbal, non-verbal and mathematical-logical factors of intelligence.

The goal of this study was to empirically establish whether there is a correlation between students' exam success and type of teaching materials from which the students were learning. The type of the material student would receive depended on the factor of intelligence that was predominant in that student. Tutoring and teaching materials were available exclusively through a system for distance learning.

Methods

Sample

The study was conducted on students of the first year of the teaching studies at the Department for education of teachers and pedagogs at the University Juraj Dobrila in Pula, Croatia. Starting number of students was 43 (41 women and two men). Average age of students was 19 years, with the age range between 18.5 and 22 years. Students were informed about the intended research project, and asked to volunteer for psychological testing.

Psychological Tests

As previously mentioned in the introduction, for needs of this research, the authors decided to measure three factors of intelligence: verbal, non-verbal and mathematical-logical. These factors of intelligence are directly connected with learning. For the testing purposes, two psychological tests were used. The first test was *Non-verbal*

broken series by (Hadziselimovic & Ambrosi-Radnic 2006) , while the second test was *Verbal test of intelligence KI-4* by (Hadziselimovic et. al. 2004*)*, which contains four sub-tests: *Broken series, Incomplete nouns, Fast calculation* and *Terms that do not belong*. All these tests are valid for the studied population, objective and standardized. Tests are not available in public, therefore the subjects could not see them prior to the testing.

For non-verbal component of the intelligence, used the test *Non-verbal broken series*. This type of test measures fluid intelligence and determines factor of intelligence independent of culture and education. Test consists of 30 problems, and it is performed by circling one of the five given answers. For a correct answer, subject receives one point, unanswered questions receive no points, and for each five incorrect answers, one point is deducted from the score. Maximum number of points is 30.

For verbal factor of intelligence, *Test of intellectual abilities KI-4* was used, with sub-test *Incomplete nouns*, which tests vocabulary of the subjects, and dominantly belongs to factor of crystallized intelligence. Maximum number of points is 20, and scoring system is the same as for the *Non-verbal broken series* test.

For mathematical-logical factor of intelligence, sub-tests *Fast calculation*, *Broken series* and *Terms that do not belong* were used. Sub-test *Fast calculation* requires quick use of four basic calculating operations together with concentration. It contains predominantly concentration-calculation factor, and additionally factor of crystallized intelligence. Sub-test contains 40 problems. The test is performed by writing a correct answer on an empty line. Correct result is scored with half a point, while an incorrect or unanswered question is not scored. Maximum score is 20. Sub-test *Terms that do not belong* is a test of verbal-logical thinking and by analysis it, therefore, predominantly contains factor of logical thinking, and to a lesser degree factor of crystallized intelligence. Sub-test *Broken series* is a modification of one of the Thurston's tests, and according to Horn factorial analysis, contains mostly factor of logical thinking, then factor of concentration-calculation, and to a certain degree factor of crystallized intelligence (Hadziselimovic et. al. 2004*)*. Sub-test has 20 questions, and scoring system is identical to the test of *Non-verbal broken series*. Mathematical-logical intelligence score is created by adding the scores of the three sub-tests, *Fast calculation, Broken series* and *Terms that do not belong*, each with a maximum of 20 points, for a total maximum of 60 points.

Most of the students, 90.7% (37 women and two men), volunteered for psychological testing. Psychological testing was conducted by a licensed psychologist, one of the test authors, in controlled conditions, keeping all the standard rules that need to be fulfilled in order for a measurement to be accurate and objective.

Division of Students Into Groups

Based on the results of the psychological testing, students were divided into four groups. In group *Verb* were allocated students with strongest verbal factor of intelligence, in group *NoVerb* were students with the highest non-verbal factor of intelligence, in group *LogiM* were students with the largest mathematical-logical factor of intelligence. In the mixed group, *Mix*, were average students from the previous three groups, in particular those who were within the average for the group, therefore neither the best nor the worst students.

Due to the modus of group creation, it was impossible to maintain an equal number for each group, therefore, group *Verb* had 16 students, *NoVerb* eight, *LogiM* seven, and *Mix* eight students. Group *Mix* consisted of six students with highest verbal, and one each with highest mathematical-logical and non-verbal factor of intelligence.

It should be noted that we also had a control group, which did not undergo psychological testing, and who attended the same program with the same teacher during the previous academic year. Control group, *Control*, consisted of 20 students. Structure of students in this group based on gender and previous knowledge did not significantly differ from the groups that were involved in the project.

Teaching Materials

Subject *Basics of informatics* is conducted during second semester of the academic year, and consists of theoretical and practical part. For this research project, educational material consisted of the theoretical part of the subject, with a total of five educational units: *How computer works?, Basics of binary system, Computer components, Peripherals,* and *Basics of operational system.* A poll was conducted at the start of the academic year, confirming that there are no significant differences in previous knowledge for this subject.

Preparation of the Educational Material

Since there were five teaching units and four groups of students, 17 teaching materials were prepared, specifically adapted for each student group. Three teaching materials were common for two groups: two for *Verb* and *Mix*, and one for *LogiM* and *Mix*. It is important to mention that teaching materials for each of the groups contained all elements of the teaching unit. Educational materials for the *Mix* group were prepared as a compilation of all the above mentioned for individual components.

(Tab 1), composed based on published literature (*** 1994, Armstrong 1994, Gardner et. al. 1996, Gardner 1983, 1993, and Kelly 2005) and elements authors used in preparation of the educational materials, shows baseline characteristics, used in preparation of the teaching materials for each factor of intelligence, e.g. group of students.

Factors of Intelligence		***Verbal***	***Mathematical-Logical***	***Non-Verbal***
Characteristics		- efficient use of words, spoken or written - rich vocabulary - expressive speech - rich linguistic meaning - use of words in practical problem solving	- efficient use of numbers - logical thinking - ease of noticing logical structures and relationships, and cause-consequence connections - abilities of categorization, classification, conclusion	- space orientation - ability of spatial formating - feel for colors, lines and shapes - visualization ability - ability of graphical presentation of ideas
Centers of interest		- reading corner - languate laboratory (stories on audio-tapes) - writing corner (computer, paper and pencils)	- mathematical laboratory (computers, math. tools) - scientific center (experim. accessories, tapes with science programs)	- artistic space (paints, color paper) - visual media center (video-tapes, computer graphics) - space for visual thinking (maps, graphs, 2 or 3 D puzzles, picture collection)
Learning style	**Thinking through**	- words	- conclusions	- pictures
	They like…	- reading, writing, story telling, word games etc.	- experimenting, asking questions, resolving problems, calculation etc.	- drawing, doodling, shaping, imagining pictures
	Require	- books, tapes, writing materials - datebooks, dialogues, discussions, debates, stories and similar things	- accessories and materials for experimenting and thinking - visits to planetarium, scientific museums and similar	- works of art, LEGO blocks, video materials, slides, imaginative games, puzzles, picture books, illustrated books, visits to museums and galleries
Teaching strategy	**Structure of the educational material** (percentages are approximate)	- 85% text - 10% formula and examples for calculation - 5% sketches, pictures and drawings - no special care about text structure, colors, tables and graphic symbols	- 70% text - 15% formula examples for calculation -15% pictures, drawings, sketches - solid structure, more tables - low use of color and graphic symbols	- 60% text -10% formula and examples for calculation - 30% pictures, drawings, sketches - use of lots of colors, graphic symbols, accentuated text - no special care about text struct.
	Suggestion	- story telling - brain-storming - use of tape-recorder - diary - written homeworks	- calculation and quantification - classification and categorization - Socratic method of dialogue - heuristic methodology - scientific thinking	- visualization - use of different color papers and color pencils - picture metaphors - drawing of ideas - graphic symbols
	Realization	- teaching materials in a from of essays with a smaller number of pictures, sketches or additional explanations	- lesser introduction in textual form - an overview of the unit with detailed explanation of individual terms - examples of problems	- pictures or sketches at the beginning of the teaching unit that would draw attention - text in various colors and sizes with explanations - graphic symbols

Table 1: Basic characteristics, centers of interest, learning styles, teaching strategies and how were they applied in this research project for each student group

Web Courseware Tools and Modes of Presentation of the Educational Material

Since there are many available informatics systems – tools for distance learning, it was necessary to choose a tool that would be used for teaching purposes of this research project. We chose Moodle because the Department for education of teachers and pedagogs already uses this tool, it is installed on the departmental server, there is a Croatian version of the program, it is simple to use, dependable and has a good statistical apparatus for following the attendance on this system. Moodle allows for several different types of presentation of the educational material. We chose presentation based on themes – educational units.

Four units with the identical teaching contents, but different teaching materials were prepared. Each unit had its students, and each student was able to access exclusively the unit for which he/she was assigned.

Material was available for 14 days, 24 hours a day, whether through the departmental computers or any other computer located elsewhere with an Internet connection. On the last day of the material access, students received questions that were helpful in preparation for the test. Students were asked not to use other materials except for those through the system for distance learning for their group. At the end of the learning period, Moodle system was checked and it was found that the students did not access teaching materials of any other group.

Testing Acquired Teaching Material

Test used for assessment of the adoption of the educational materials had eight questions, and was identical for all groups. Responses were written, with sufficient time for each answers, with a maximum of 30 minutes. Two questions required calculation, one question included recognition and description, while five questions required written answer. Students were allowed to use only paper, pencil and simple calculator.

An example of question requiring calculation: *Determine how many bits of information can pass through two channels of ISDN in 3.4 minutes (calculate assuming maximum speed, without interferences).* An example of description question: *What is the purpose of graphic card – mention as many characteristics of this (type of the) card*. Test page also contained a picture of the network card. Student had to recognize the type of the card, describe it and mention card's characteristics. That was an example of question from recognition and description part of the test.

Results

Results of Psychological Testing

Group characteristics are shown in (Tab 2).

		NoVerb	*Verb*	*LogiM*
Max possible		30	20	60
Max achieved		27	19	51,5
Min. achieved		8	12	28
Mean		20,2	16,8	40,9
Standard deviation		4,65	2,04	6,1
Dominant values		23	18,5	44,5
Below average	points	0-16	0-11	0-33
	N	9	0	4
Average	points	16-23	11-13	33-39
	N	14	6	11
Above average	points	23-30	13-20	39-60
	N	16	33	24
Total		39	39	39

Table 2: Results of psychological testing of students based on factors of intelligence

Results of the Knowledge Test

Testing the acquired educational material was performed one day after the end of the online access to the teaching materials. Questions were identical for all students, and answers had to be given either by description or calculation. Each answer was scored proportionally, from 0 to 1 point. Based on the achieved results, each student was categorized into of the three groups based on his/her success. In the first group were those who achieved between 0 and 49%, e.g. who did not satisfy the knowledge requirements. In the second groups were students who achieved between 50 and 74%. These students achieved sufficient and good results, and passed the test. In the third group were students who achieved between 75 and 100%, e.g. those who had very good or excellent success.

Achieved success results, by group, are shown in (Tab 3).

Success	***No Verb***	***Verb***	***LogiM***	***Mix***	**Total**	***Control***
Failed	14%	0 %	0%	33%	10%	25%
Sufficient and Good	29%	44 %	0%	50%	38%	45%
Very good and Excellent	57%	56 %	100%	17%	52%	30%
Total	100%	100%	100%	100%	100%	100%

Table 3: Results of the knowledge test by groups

Coefficient of correlation between the results of psychological testing and the achieved success for group *Verb* was 0.79. χ^2 was calculated for the entire student population who participated in the project and control group (χ^2=15.0). (Tab 4) shows success rates dependent on the results of the students' factor of intelligence.

Factor of intelligence - group	**Success**
Noverb	
86% above average	58% very good and excellent 14% sufficient and good
14% average	14% failed 14% sufficient and good
Total	100%
LogiM	
100% above average	100% very good and excellent
Verb	
91% above average	55% very good and excellent 36% sufficient and good
9% below average	9% very good and excellent
Total	100%

Table 4: Results of acquired knowledge based on factor of intelligence

Result Analysis

Generally, results of the psychological testing have shown that most of the students (33 out of 39, 85%) had above average verbal factor of intelligence, 61% (24 of 39) had above average mathematical-logical factor of intelligence, and 41% (16 of 39) had above average non-verbal factor of intelligence. It was somewhat disconcerting that as many as 23% (9 of 39) of students had below average non-verbal factor of intelligence. Of these nine, four students (10% of the students) had below average mathematical-logical factor of intelligence, but two of those nine had above average mathematical-logical factor of intelligence, and another two average verbal factor of intelligence.

Results of dominantly expressed verbal factor of intelligence were expected because the tested persons were not normally distributed, but rather represent a selected group, students who are well-read, and the type of the studies and future job is such to attract student population with more developed verbal factor of intelligence.

Mean value of non-verbal factor of intelligence is within the range of average values, verbal factor in the range of above average values, and mathematical-logical is borderline between above average and average. Similar results were achieved using dominant values, and standard deviations were relatively small in all three groups.

Knowledge test results show very high passing grade among students who learned using online materials (90%), better than in control group.

All three groups, verbal, non-verbal and mathematical-logical, had much higher percentage of students who achieved very good and excellent results (up to several times higher), and far lower percentage of students who did not satisfy on the knowledge test than the *Mix* group.

Coefficients of correlation, r, between results of psychological testing and achieved success for group *Verb* was very high, r=0.79. For other groups, coefficients of correlation were not shown due to a small number of students in those groups, which makes this type of calculation less dependable.

Also, total results of learning through online teaching materials were better than those through classic teaching methods. This fact is confirmed by χ^2 values. χ^2 value for all students who participated in this project and control group was 15. With two degrees of freedom and significance level p=0.05, limited value of chi-square was 5.991. This result suggests that achieved success between experimental and control group are significantly statistically different.

When results of psychological testing and test success for students who are part of a certain group are analyzed, it is visible that students in those groups represent persons with above average abilities for that type of factor of intelligence. Such students were predominantly achieving very good and excellent results, with several less successful exceptions in groups *Verb* and *NoVerb*. This suggests that although some students have above average factor of intelligence for the group in which they were placed, to achieve very good and excellent results requires high motivation and investment of effort in order to learn specified educational material. A small percentage of students in the *Verb* group is a positive exception from this rule. In that case, students were motivated, although they had below average abilities, and achieved very good and excellent results in the knowledge test.

Conclusions and Suggestions for Continuation of Research

In this research, we evaluated a connection between success in learning through online learning of various teaching materials and the predominant factor of intelligence in students. Education was conducted using system for distance learning, Moodle. Students were first tested using psychological tests to establish their predominant factor of intelligence, and then assigned to three groups, verbal, mathematical-logical and non-verbal. Fourth group was consisted of participants with mixed factors of intelligence. There was also a control group. For each group, a special and separate teaching material was created and used for online learning by students.

Results of our research have shown that students who had their teaching materials adapted to their predominant factor of intelligence achieve much better results than those in the mixed group, and better results than the control group.

Adaptation of teaching material to an individual allows for more efficient teaching and achievement of better test results, but teacher must be prepared to invest much more time for preparation of such teaching material.

Authors are aware that the research has been conducted on a small student sample, and therefore the results of this research should be interpreted cautiously. Authors will continue the research project by increasing teaching materials for few more teaching units, increasing number of students participating in the research, equalizing the number of students with a specific factor of intelligence, by creation (or adaptation of an existing) web courseware system on which the entire process will be automated.

Such a system should offer possibilities of establishing the predominant factor of intelligence for a student, and accordingly offer the appropriate teaching material. It should also offer possibility of self-testing of knowledge after each teaching unit and at the end of the educational process. If the results of self-testing would be successful, then the teaching material prepared for the same group should continue to be offered. If the results would not be successful, it should offer a student teaching material for the same teaching unit that is adapted for different factor of intelligence.

Authors are certain that such programmed adaptive teaching of each individual student would enable more efficient adoption of the educational material.

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