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Preliminary Communication

The Application of Multimedia Aimed at Improving the Acquisition of Typical Topics in Natural and Social Science Programs in High Schools

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Abstract

The issue of natural and social science courses in high schools, as well as in grammar schools, is very important not only on a global level. Therefore, the aim of this study is to address the issue of improving the process of learning with an emphasis on those subjects which students of a certain program find difficult.

By means of its application in teaching, multimedia – being a combination of various media – has enabled the introduction of new channels in the information transfer process, i.e. the reception of information through multiple sensors. At the same time the mentioned fact represents the advantage of multimedia materials over classical textual materials.

The research was conducted on the sample of 121 students, namely two social science classes (62 students) and two natural science classes (59 students). Ultimately, the result of the study is the quantification of the effect of multimedia on various student groups, as well as the recognition of differences when it comes to subject preferences, learning styles and attitudes towards learning.

Keywords: social science high school courses, social science subjects, multimedia teaching, natural science high school courses, natural science subjects, traditional teaching

1. Introduction

The development of information and communication technologies (ICTs) led to their incorporation into everyday human life, as well as into the lives of students. In fact, ICTs are making personal computers more available to the public, just as the set of various media called *multimedia*. Multimedia can be defined in many different ways. Elsom and Cook [15] defined multimedia as the combination of a variety of communication channels into a co-ordinated communicative experience for which an integrated cross-channel language of interpretation does not exist. The mentioned definition acknowledges the fact that multimedia is composed of a number of different media, and that the combination of different media channels requires unification.

However, as multimedia is introduced to classes, the question that naturally emerges is its effectiveness in relation to traditional teaching methods. For this reason, many authors conducted surveys among students from all age groups [17], which in most cases recognized significant improvement regarding the acquisition of teaching materials following an ICT-based class. Naturally, the impact of multimedia is necessarily affected by a number of parameters such as learning style, preference towards a certain subject, the quality of multimedia teaching materials, interactivity, teachers' expertise and impact on the students etc. The mentioned parameters will be the subject of discussion in this study.

When discussing education, it is crucial to define the term *learning*. Learning can be defined as a set of activities that include gathering information, jotting down information, organizing information, understanding information, memorizing and using information [13]. On the basis of the mentioned definition it can be concluded that multimedia, as well as information

and communication technology (ICT), along with their inherent properties can significantly contribute to learning process.

Furthermore, it is necessary to point out that the research described in this paper was conducted on high school students who had presumably chosen their respective programs when enrolling to the school on the basis of their affinities for a particular group of subjects. Consequently, it is expected that the results following the traditional classes and multimedia classes will be different in social and natural science subjects.

The bibliography quotes many papers [5, 6, 9, 13, 14, 18, 19] which deal with multimedia and different types of subjects. However, a small number of papers address the comparison of the effects of multimedia with reference to teaching social and natural science group of subjects. Due to the scarceness of data related to the above mentioned areas, it is difficult to determine with precision the possible benefit of the use of multimedia in teaching social and natural science groups of subjects, which ultimately calls into question its use altogether.

2. The aim of investigation

The aim of this study was to determine the influence and the extent to which the application of multimedia teaching materials influences the effectiveness of learning in natural and social science programs. Also, the paper is aimed at defining the specific factors that further influence the successfulness of the application of multimedia in teaching. This goal will be reached through the following steps:

1. quantitatively measuring the extent to which multimedia affects the perception of the quality of teaching in comparison to traditional techniques, according to different learning styles,
2. determining the impact of multimedia on topics that certain learning styles find problematic,
3. analyzing the profiles of students who will benefit most from learning, and
4. acknowledging the fact that students in social and natural programs are different, and recommending the use of multimedia to improve teaching.

3. Research methodology

The research methodology can be divided into 3 parts which include:

- the preparation of materials,
- data collection, and
- data analysis and model development.

3.1. The preparation of materials

The first step was to choose 4 classes; 2 classes from the social science program, and two classes from the natural science program. The classes were chosen at the end of school year 2009/2010, and special care was taken in order to conduct the research on classes that were similar with reference to variables such as the total number of students in the class, the number of male and female students, and the GPA of the tested subjects according to *e-Matica*. *E-Matica* is a specialized application that stores all personal data of Prva gimnazija Varaždin (www.gimnazija-varazdin.hr) students as well as their grades which were obtained at the end of the first term and at the end of the school year. Another variable that was taken into account was the fact that the same tested subject was taught by the same teacher, if such case was possible, in order to prevent the influence of certain pedagogical factors on the outcome of the experiment at issue. The selected tested subjects were English language and History from the social science group, while Physics and Biology represented the natural science group.

Based on the mentioned characteristics, classes 2b and 2c were chosen to represent the social science program, and 2g and 3f were taken from the natural science program. All

collected data about the classes and GPAs for the selected subjects at the school level can be found in Table 1.

	Social science courses		Natural science courses	
Class	**2b**	**2c**	**2g**	**3f**
Number of male students	10	10	18	19
Number of female students	21	21	11	11
Total number of students	31	31	29	30
English course – average grade	4,15	4,00	4,55	4,21
English course – school average grade	4,21			
History course – average grade	4,71	4,29	3,59	3,77
History course – school average grade	4,03			
Physics course – average grade	3,48	3,42	3,31	3,73
Physics course – school average grade	3,44			
Biology course – average grade	3,81	3,84	3,38	4,00
Biology course – school average grade	3,84			

Table 1. Data about tested classes

Unfortunately, it was not possible to take into account the variable of having the same teacher teaching the same course in each tested class, except in the case of Biology. See Figure 1.

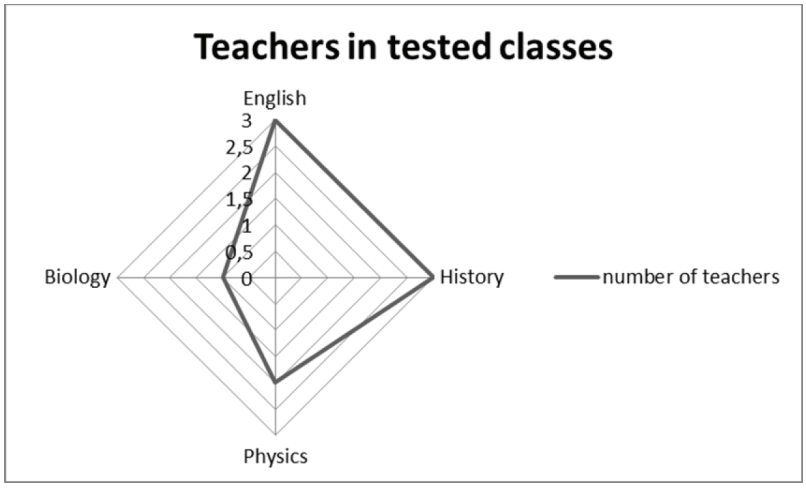

Figure 1. Numbers of teachers in tested classes

Prior to the study, two standardized questionnaires and tests called "Pre-test" and "Post-test" had been prepared. Thereby, a standardized questionnaire on "learning style", based on Gardner's theory of multiple intelligences [4], was used to identify dominant learning styles and affinities of each student. The mentioned theory was selected because it can provide the

most accurate profile of each student due to the fact that it consists of seven basic styles. The quality of multimedia teaching materials was tested using the "CMLES" questionnaire, according to CMLES (Constructivist Multimedia Learning Environment Survey) standard [11]. This standard is based on the constructivist approach to learning developed at Murdoch University in Perth, Australia, and it proved to be extremely effective in research. In addition, in collaboration with colleagues who teach each tested subject, the pre-test and post-test were elaborated and conducted in order to check students' knowledge prior to the lessons as well as after the lessons had been taught.

3.2. Data collection

The research itself was carried out in the academic year 2010/2011 through experiments on a group of students from two classes belonging to social science and natural science classes in Prva gimnazija Varaždin high school.

In consultation with subject teachers, typical themes were selected, i.e. those topics which the teachers considered to be of adequate complexity for specific, tested classes, at the same time bearing in mind those topics which formed a regular part of the subject curriculum at the time of testing. Each selected class was taught the lessons in the four selected subjects using traditional methodology as well as using the methodology which relies on multimedia, all in strictly controlled conditions. It is essential to emphasize that the students and even teachers were not familiar with the aim of investigation so that it would not affect the final results. Regardless of the teaching methodology, the initial knowledge was tested at the beginning of the lesson by means of the pre-test, while the acquired knowledge was checked using the post-test. Both the pre-test and the post-test were done on a sheet of paper, and their contents were identical.

The planned sample size was 30 students per class with a total of 121 students. Due to various reasons, at the time of the experiment in particular classes less students were present. The numbers of students tested per class can be seen in Table 2.

Class	Tested number of students
2b	31
2c	31
2g	29
3f	30
Total	**121**

Table 2. Tested students per class

Having collected all the data necessary for the research, this phase was finished and it was followed by the analysis of the data.

3.3. Data analysis and model development

The survey obtained a number of new insights into the differences between the representation of certain kinds of intelligence, as well as into the learning styles in the social and natural science programs. Furthermore, it revealed the impact of multimedia in natural and social science programs in relation to the natural science and social science subjects, which gives this paper a distinctive quality.

According to Gardner's theory of multiple intelligences [8], Figure 2 shows the typical differences between social and natural science program, as well as some similarities. First of all, in all tested classes it is interesting to point out the rather distinctly developed musical

intelligence (31, 30, 29, 28)[1], and a rather modestly prominent personal intelligence (12, 27, 27, 27) in all classes and all programs. Particularly prominent logical-mathematical intelligence in natural science programs (30, 30)[2], and linguistic (29, 29)[3] and social intelligence (31, 31) in social science programs can be regarded as expected and typical for the mentioned programs. When discussing multiple intelligences, many authors [1, 2, 3, 8, 10, 16] observed that there are certain differences between individual classes or groups of students, and that educators should adjust their teaching in accordance with the appropriate learning styles if we want to improve the results of teaching.

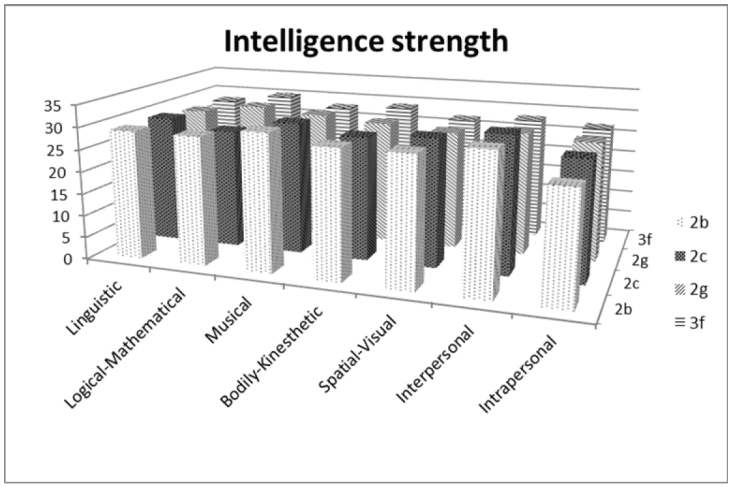

Figure 2. Intelligence strength in tested classes

Research results derived from the research, in accordance with its basic objectives, give a certain advantage to multimedia in almost every case, but the advantage is not statistically significant. This is further supported in a number of studies [7, 9, 18] conducted by eminent professionals from the field.

The first question posed was the issue of a significant difference between multimedia and traditional groups when it comes to learning styles, average grade of tested subjects, and understanding the concepts of tested subjects. Testing was conducted in each class for each subject by using two-way t-test for independent samples. The results of all tests, listed in Table 2, showed the following outcomes: (2b: 0,8201>0,05[4], 0,5693>0,05, 0,2978>0,05, 0,8420>0,05; 2c: 0,4707>0,05, 0,1297>0,05, 0,7921>0,05, 0,4063>0,05; 2g: 0,1879>0,05, 0,3483>0,05, 0,1654>0,05, 0,5294>0,05; 3f: 0,1438>0,05, 0,8178>0,05, 0,1634>0,05, 0,5698>0,05), which leads to the conclusion that there were no statistically significant differences between tested groups. In case of a statistically significant difference between some groups, further testing of these groups would not make sense because it would not lead to real results and one group would have a statistically significant advantage.

P-value / Subjects	P			
	2b	**2c**	**2g**	**3f**
English	0,8201	0,4707	0,1879	0,1438
History	0,5693	0,1297	0,3483	0,8178

[1] Figures indicate the values obtained on the test [4] in classes 2b, 2c, 2g i 3f.
[2] Figures indicate the values obtained on the test [4] in classes 2g i 3f.
[3] Figures indicate the values obtained on the test [4] in classes 2b i 2c.
[4] 0,05 represents the level of significance of 5% (α=0,05).

Physics	0,2978	0,7921	0,1654	0,1634
Biology	0,8420	0,4063	0,5294	0,5698

Table 3. Pre-test results per classes and subjects

Furthermore, it was necessary to check whether the multimedia group in social science program achieved statistically better results in social science and natural science subjects in relation to the traditional group. However, as can be seen in Table 3, the method applied to one-way variance analysis showed a lack of statistically significant differences between traditional and multimedia group in the first case on the post-test in English (2,0812<2,6965; α=0,05)[5]. Results from other subjects (1,1714<2,6821, 11,4950>2,6911, 0,5858<2,6871; α=0,05) indicate that only the post-test in physics showed a statistically significant difference between the traditional and multimedia group.

Subject	F_{exp}	F_{tab}**0,05**
English	2,0812	2,6965
History	1,1714	2,6821
Physics	11,4950	2,6911
Biology	0,5858	2,6817

Table 4. Results of analysis of variance in social science groups

The analysis went on to check whether the multimedia group in natural science program achieved statistically significant results in social and natural science subjects in relation to the traditional group. The results of one-way analysis of variance given in Table 4 show that in every tested case (12,9288>2,6937, 5,0470>2,6856, 6,9775>2,6903, 7,7937>2,6920; α=0,05) there is a statistically significant difference between multimedia and traditional group.

Subject	F_{exp}	F_{tab}**0,05**
English	12,9288	2,6937
History	5,0470	2,6856
Physics	6,9775	2,6903
Biology	7,7937	2,6920

Table 5. Results of analysis of variance between natural groups

After that, it was essential to determine whether the multimedia group from the social science program achieves statistically significant results when it comes to natural science subjects in relation to social science subjects. The results of one-way analysis of variance, listed in Table 5, showed that the multimedia group in all cases (5,5725>2,6955, 0,6463<2,6946, 4,2113>2,6887, 10,3712>2,6856; α=0,05) does not achieve statistically significant results in comparison with the traditional group. The reason lies in the fact that the multimedia group does not achieve statistically significant results on the post-test in Biology class, compared to the post-test in English class.

Subject	F_{exp}	F_{tab}**0,05**

[5] If $F_{exp}<F_{tab}$ then there is no statistically significant difference between groups.

English – Physics	5,5725	2,6955
English – Biology	0,6463	2,6946
History – Physics	4,2113	2,6887
History - Biology	10,3712	2,6856

Table 6. Results of analysis of variance on post-test between natural and social science subjects in social science programs

Finally, the analysis addressed the issue whether the multimedia group in natural science programs achieves statistically significant results in social science subjects in relation to the natural subjects. Based on the results showed in Table 6 (4,5741>2,6920, 6,3863>2,6928, 3,1542>2,6887, 0,3210<2,6895; α=0,05), one-way variance analysis shows that the multimedia group does not achieve statistically significant results compared to the traditional group in every tested case. Thus, the results of the multimedia group on the Biology post-test did not show any statistically significant difference in relation to the post-test in History class.

Subject	F_{exp}	$F_{tab}0,05$
English – Physics	4,5741	2,6920
English – Biology	6,3863	2,6928
History – Physics	3,1542	2,6887
History - Biology	0,3210	2,6895

Table 7. Results of the analysis of variance on the post-test between natural and social science subjects in natural science programs

The survey also addressed the quality of multimedia-based lessons and multimedia teaching materials evaluated by the students, as well as the quality of multimedia teaching materials evaluated by 3 independent competent teachers, using CMLES questionnaire [11]. As it can be seen from Figure 3, the average students' rating of multimedia-based lessons and multimedia teaching materials was [3.4] according to the Likert scale of 1 to 5, where 1 (never) represents the worst rating and 5 (always) the best.

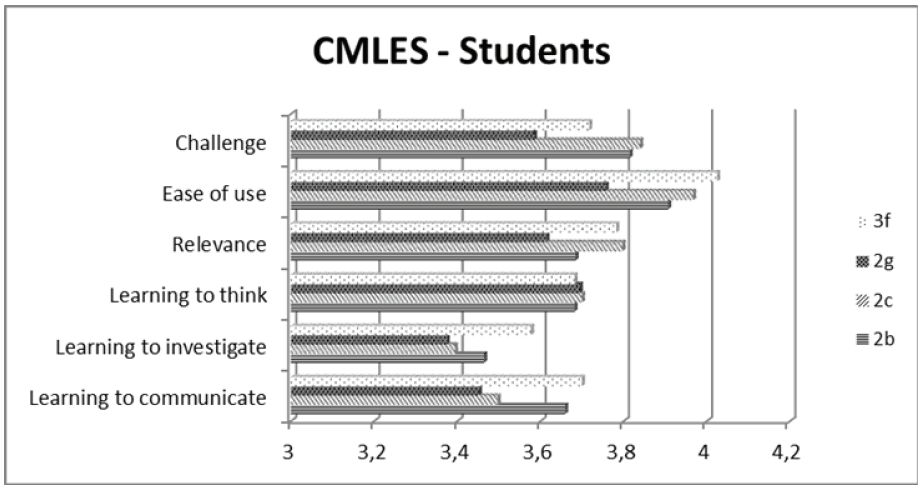

Figure 3. Average results of CMLES questionnaire for all subjects, evaluated by students

Through the CMLES questionnaire fellow teachers were evaluating multimedia teaching materials only, since they were not present at the multimedia-based lessons. Teachers' ratings

were somewhat higher than those reported by students, as shown in Figure 4, and the predominant rating was [4.5] according to the Likert scale of 1 to 5.

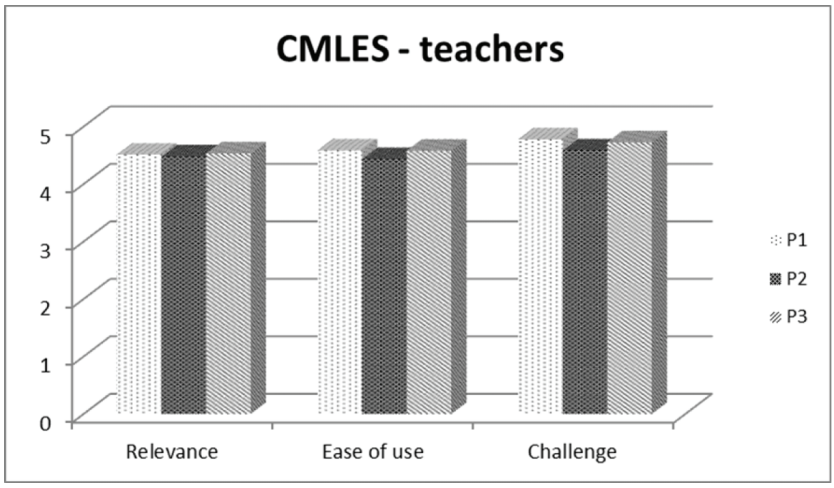

Figure 4. Average results of CMLES questionnaire for all subjects evaluated by teachers

In this way it was proved that the study used adequate multimedia teaching materials, and that multimedia teaching was well-accepted by students. All of the mentioned facts suggest that the results of the study can be considered relevant.

According to research results one might proceed with a potential model of teaching. The model comprehends the implementation of quality multimedia teaching materials in teaching, especially in natural science programs as opposed to social science subjects. In general, such kind of model should improve the results and the satisfaction of students.

Nevertheless, the conducted study has certain limitations. First of all, the fundamental limitation arises from the appropriateness and the size of the sample. The investigation included two social science classes and two natural science classes in Prva gimnazija Varaždin high school out of the total number of 34 classes which are taught in Croatian national program. Furthermore, the study was conducted on classes from the second and the third year of high school which were similar with reference to the total number of students per class, the number of male and female students, the grade average from particular, tested subjects at the end of school year 2009/2010, and according to the variable of having the same teacher teaching the subject at issue. Unfortunately, it was not possible to select classes with all of the initial parameters being the same due to the fact that such classes do not exist.

Another limitation was the number of subjects tested in the classes. Two subjects from the social science group were chosen, as well as two subjects from the natural science group, out of the total number of fifteen subjects which each class takes in a school year. In addition, for tested subject in each class two typical topics were selected, and they were taught in a traditional way as well as the multimedia-based way.

By increasing the number of tested students, subjects, and selected lessons, the pattern would have been more representative.

One should also take into account the fact that the answers received following the "learning style" questionnaire, according to Gardner's theory of multiple intelligences [4], and "CMLES" questionnaire elaborated under the aegis of CMLES (Constructivist Multimedia Learning Environment Survey) standard [11], were the result of subjective impressions and observations by the respondents. For this reason, there is a possibility that some answers are not realistic and do not give an objective account of one’s dominant intelligence, preferred learning style or the perception of multimedia.

With reference to the mentioned facts, the results of this study cannot be generalized, but they can be considered as guidelines that may serve as the basis for further research in this area.

4. Conclusion and future research

As one of the first such works which deals with the comparison of the impact of multimedia on social and natural science subjects, this paper expressed in a quantitative way the progress realized by specific groups, with the aim of either accepting or rejecting the established hypotheses, as well as reaching logical conclusions.

The previously defined main objective of the research was to determine the impact and the extent to which the application of multimedia teaching materials influences the effectiveness of learning in natural and social science programs, as well as to define the specific factors that also have a shared impact on the successful application of multimedia in teaching. The main goal further served as the basis for the definition of sub-goals of the research on the basis of which the set hypotheses were deducted.

Due to the existence of certain factors that might have affected the performance of multimedia applications in the classroom, they had to be recognized and kept to a minimum. For this reason it was essential to choose the classes with a similar ratio of male and female students (2b: M-10, F-21, 2c: M-10, F-21, 2g: M-18, F-11, 3f: M-19, F-11), as well as classes with similar GPA-s in the end of the school year 2009/2010 regarding the tested subjects. The biggest difference between classes from the same program was encountered in the case of Biology in natural science program (0.62). Other important factors were the subject teacher and the quality of multimedia teaching materials. Ideally, the same teacher would be teaching the same subject in the same tested classes, but this was not possible so it was necessary to quantify the quality of multimedia teaching lessons and the quality of multimedia teaching materials by the students and the quality of multimedia teaching materials by fellow teachers using CMLES questionnaire [11].

The results of the CMLES questionnaires showed fairly high grades given by students and fellow teachers, so it can be assumed that the results would have certainly been different if we had used even better multimedia materials, but also worse materials than those applied. The same goes for the quality of the held multimedia lessons.

The quantification of multimedia over traditional techniques for different learning styles was achieved by applying statistical methods through two-way t-test for independent samples and one-way variance analysis. The application of Gardner's theory of multiple intelligences [4] showed that the dominant learning styles differ in different programs (social science: human contact, communication, cooperation, teamwork; natural science: numbers and logic). Consequently, it is logical to conclude that their perception of multimedia differs insofar that the multimedia group achieved better results in natural science programs.

With reference to the dominant learning style in different programs, it is evident that the students in social science program cope better with social science subjects, and that the students in natural science program cope better with natural science subjects. However, multimedia groups in both programs do not have statistically significant differences when it comes to subjects that they normally find difficult, as shown in the results of the study.

Furthermore, the results also show that multimedia groups in all programs mostly achieved better results than those that used traditional methods, but the difference is not statistically significant. In addition, it was proved that multimedia group in natural science program achieved significantly better results than the traditional group. This shows us that students in natural science program with dominant logical-mathematical intelligence accepted multimedia better than students in the social science program with more developed social intelligence.

The diversity of students in the social and natural science program was clearly recognized using multiple intelligences test according to Gardner's theory [4], as well as through the results of the research which revealed that multimedia plays a more important role in natural science program then in social sciences program. Therefore, it is recommended that multimedia should be used more in all programs as the lectures might prove to be more interesting for today's students accustomed to modern technology, since multimedia group results are in most cases better.

This research can be considered as a basis for a larger study in the future which may dispose of a larger sample of social and natural science subjects, which would surely show more distinct variation in certain programs.

Following the increasing IT literacy of teachers and students, as well as the computerization of schools, in the future multimedia will certainly have a widespread use, and the results of this research certainly corroborate this claim.

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