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An Innovative Approach in Teaching Mathematics in Elementary and High Schools by Using the Software Package GeoGebra

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The constant progress of society, economics and even modern multimedia technology permanently affect the development of systems for improving education. One of the main problems of today's school system is how to maintain focus, concentration and interest of students for learning during classes. An important feature of modern teaching is multimedia. However, the use of multimedia brings a certain transformation in the teaching process. Given the fact that the focus of the teaching process has been shifting from the curriculum and teacher to student, multimedia undoubtedly have a major contribution to the modernization of traditional teaching. It is real to expect that in the near future the multimedia will represent daily routine in teaching . In this work, an innovative approach in teaching mathematics in elementary and high schools by using the software package GeoGebra is introduced. It is demonstrated on the example of 'surface area'. The goal is to increase interactivity between professors and students and to improve the quality of teaching.

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Key Words: interactive learning, multimedia, GeoGebra applets, student motivation, teaching methods, surface area, geometric figures.

1. Introduction

The future of the school cannot be understood without understanding its development and history [1]. One of the key needs of the human race is education which is reflected in the maintenance of the species. In order to achieve that, adult community members cared about youth. As the knowledge and skills that were to be transferred to the next generation accumulating, it was clear that the care of young people have to stand apart from everyday life and to be organized differently. Over time, education and teaching the young have become a special social activity which gradually professionalizes and institutionalizes. A concern

about young people in the form of survival and maintaining the species grows in organized education of youth. The school is one of the oldest institutions of society. Old is about seven thousand years, there is from Sumerian empire to China, Greece and the Roman Empire, created in the various religions, during the civil wars, developed during the 19th and 20 century, to today's school. There is even remotely developed community which had its own school. The school is able to survive so long because it is constantly changing, adapting and harmonizing its work with the needs and demands of the community within which it existed. The school has changed and continued to act in a new form, always transforming into a new school - school that meets the needs of the community. For all those concerned with education in any way, no significant issues of what changes should be made in the modern school that she could successfully achieve its social role in the future, in the future society.

Social development, progress of technology and economics certainly entail the development of the current educational system. The problems that we will encounter in the future, the direction of technical advances, the development of economic systems could no longer be predicted using past experience. Currently we cannot even be aware that the world will look like in ten or twenty years, when these students, which we are teaching today, will work and have families. Our goal as teachers is to prepare students properly to face problems that await them in the future. On the contrary to the previous school system, where it was required to be submissive and obedient to reproduce the stored information, we now ask from the students to understand, think, and choose the correct answers. With them we must care about creativity and freedom of thought, which is very often neglected.

Before we start talking about the development of the current education system, we must look at its shortcomings. Perhaps the greatest one is the lack of attention and concentration of students during each lesson. The goal of every teacher is to make lessons fun and interesting enough so that more students were motivated to be attentive to the classes, think and follow the presented material. However, when it comes to math classes, especially with abstract mathematical topics, this is not an easy task. Teachers can use the modern technology and educational software [2] and present abstract mathematical concepts in a virtual environment where students feel very safe. In this way, the place where students are accustomed to playing and having fun turned into a place where students can train and learn [3].

Current classes are designed to fit the needs of average students. This is another drawback of the traditional education system. The use and implementation of multimedia and educational software classes may significantly contribute

to the modernization and individualization of learning [4]. Educational software that is designed with good didactic and methodical preparation of materials is able to corresponds to the current knowledge, abilities and skills of each student. Instruction is adjusted to each student and his/her individual needs, since the progress of a student does not have to be conditioned by the progress of the whole class, but his/her own work and opportunities. The flow of the teaching process is shifted from teachers and teaching materials to the student. The student is finally in the center of teaching.

The main task of teachers is to approach a problem to a student, to make it more understandable and to prepare interactive worksheets that enable students to research individually and verify new properties of known objects. In this sense, software package GeoGebra as a tool for modeling and dynamic structure, can develop learning through discovery to the students, the ability to research the problems, and what is the most important, individual learning.

GeoGebra is a mathematical software developed by Markus Hohenwarter for teaching mathematics in schools. It was created as his master work and then became a software package that is used around the world. The author has continued to improve the program through his doctoral dissertation. Dr. Hohenwarter has won many European and international awards in the field of educational software. GeoGebra is a software package that connects algebra, geometry and analysis, and on that basis comes its name. It is free and available in over 50 languages. You can download it from `www.geogebra.org` as well as user guide and lots of examples. GeoGebra is written in Java, such that operating system is not a prerequisite for its use. In addition, it is possible to run it from any web browser. At the same address there is a forum designed to gather various experiences while working with the program. GeoGebra is a software package that combines two different approaches of visualizing mathematical objects. More precisely, geometry and algebra are completely equally represented, i.e. it is possible to assign objects to equations, and the change the graphics objects and observe how the equations change when these objects are changing and reverse.

Besides enabling the construction of geometric shapes to record as a picture, we can use GeoGebra to create interactive Web pages, so-called dynamic drawings. Easy implementation and publication on the web is another benefit of GeoGebra. Without knowledge of HTML language and creating Web pages, using GeoGebra "Wizard" after a few clicks and entering the name, title, page description and name of the author, we create web page that is ready to share with other GeoGebra users. This method is suitable to approach the material to the student, attract attention and awaken interest for individual work [5].

Interactivity of applets in web pages is increased if javascript buttons are present on the site, allowing the interaction of text and applets. Having this prepared together with related page, we get a powerful tool of every teacher in bringing abstract mathematical concepts to students of all ages [6].

2. Interactive educational material

In this chapter an interactive educational material is presented, related to the term surface area of figure, in the elementary and high schools. The whole content is publicly available at `http://alas.matf.bg.ac.rs/~ml06125/index.html`. The material is in the form of web pages with GeoGebra applets. Dynamics and interactivity is achieved by using JavaScript and PHP functions, MatJax function enabled the writing of mathematical text and formulas using standard LaTeXcommands.

All educational materials are written primarily for students (students can independently learn, expand their knowledge and enable better individual progress) and teacher (as well as ideas for their multimedia classes). The whole material is divided into classes in which are studied mathematical topics related to surface area of figure, according to educational standards issued by the Ministry of Education of the Republic Serbia. Each class there contains four different sections of interactive materials which are mutually complementary.

The first section concerns the aspect of learning. By using interactive GeoGebra applets and dynamic web pages, geometric figures, objects and their basic properties are represented to students in an interesting way, as well as the motives and different ways to calculate the surface of the figure. The main feature of this presentation of education material is that it allows students to individually explore and discover relationships between observed objects.

By moving objects, points and slider on the applets, the students notice the changes that occur and in this way make conclusions. In every Web page with applets included, there is a mathematical text that introduces the students to an event which takes place on the applet and later explains to the students what they should conclude.

The second part refers to the tasks for exercises. When the students learn the material that concerns the properties of geometric objects and the ways in which compute surface of figures, the next step is the confrontation with the problem assignments.

By opening the link "Interesting tasks" within each class, we get a web page with the problems that need to be solved. The problems are divided into several groups depending on the difficulty or type of tasks. If students have some problems while solving the tasks, they may simply click on the "solution"

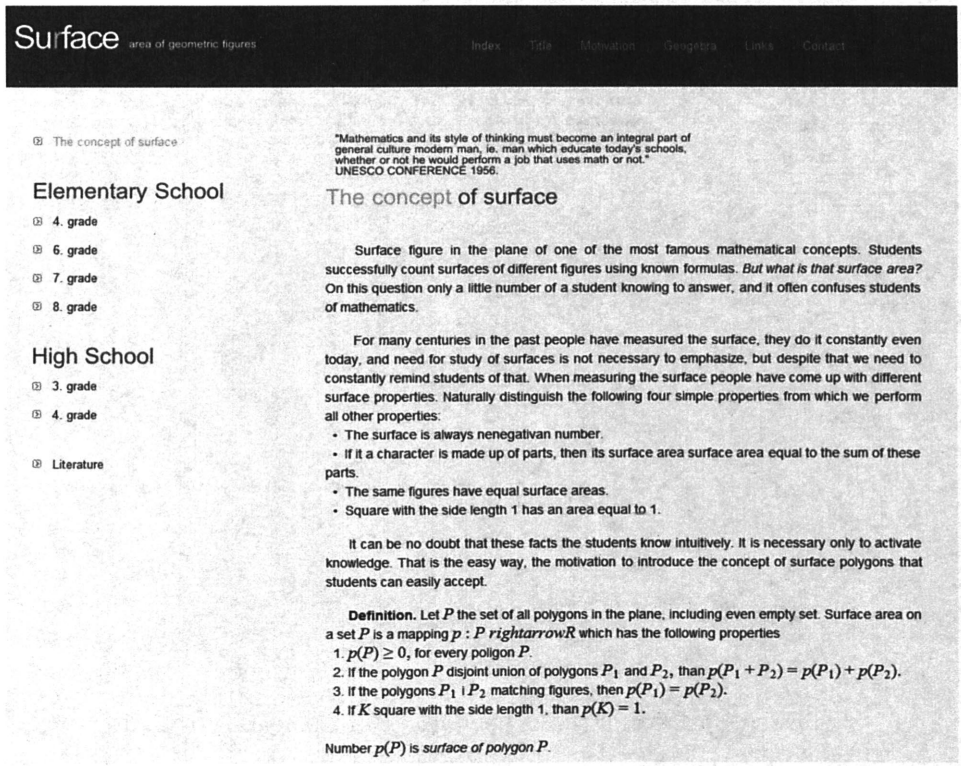


Figure 1: Site Surface area of figures,
http://alas.matf.bg.ac.rs/~ml06125/index.html

button that appears below each task. This button opens a field in which the steps of the solution are explained in details and exact result are given. This type of initiation of the problem allows students to solve tasks independently and (if needed) simultaneously check if are they working well or if there is another, perhaps more simple, way of solving problems.

The third section is related to the self-test knowledge. Students who have successfully done tasks in the part of site dedicated for the exercise, can further test their knowledge by solving test. By clicking on the "Test" button within each class, we open the web page with the instruction for students and selection of the level of assignments. The tasks are grouped in three tests, arranged by difficulty, as instructed by "Educational standards for the end of compulsory

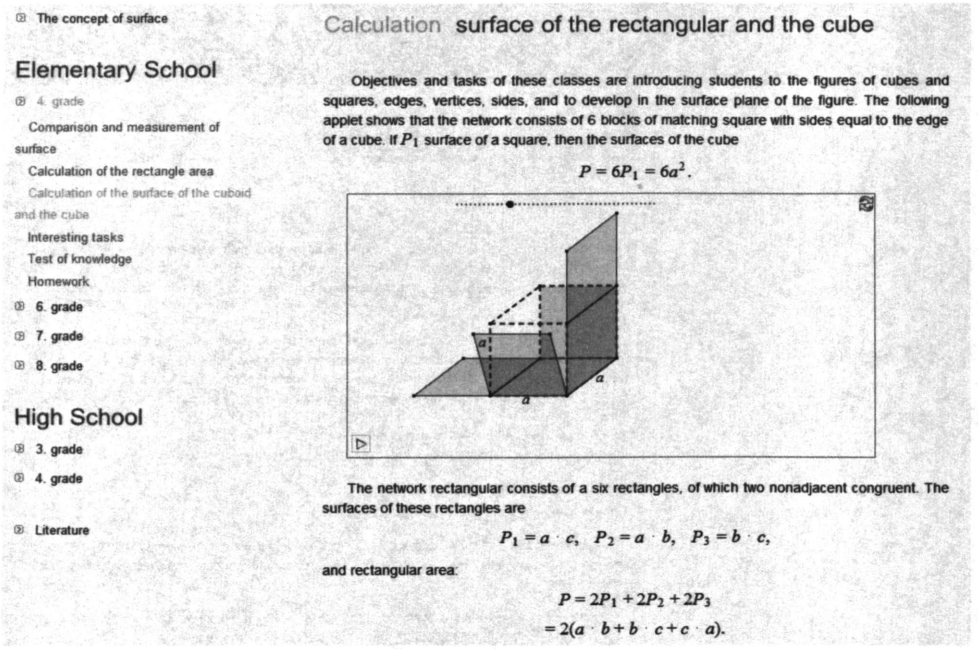


Figure 2: Surfaces of the cube, 4 grade of elementary school.

education for mathematics," the Ministry of Education and Institute for the Evaluation of Education of Republic Serbia.

When the test is opened, the measuring of time starts. At the end of each question, the number of points that carries the correct response is written and there is place to enter the correct answer. When a student is done with the tasks, by clicking on the "Check" button, his/her answers are evaluated and he/she wins certain number of points. The student can win a total 100 points.

The "Check" button opens a new page where all tasks are reviewed and where the student can read information about the test - which tasks are correct, the number of points he/she has won, which grade got, the time spent solving test and the exact solutions of tasks (in order to realize its mistakes).

The fourth part refers to homeworks. This part of the site is dedicated to students who work at home and whose knowledge teachers want to check by using an e-mail.

When student opens a homework, before he/she starts to work, it is

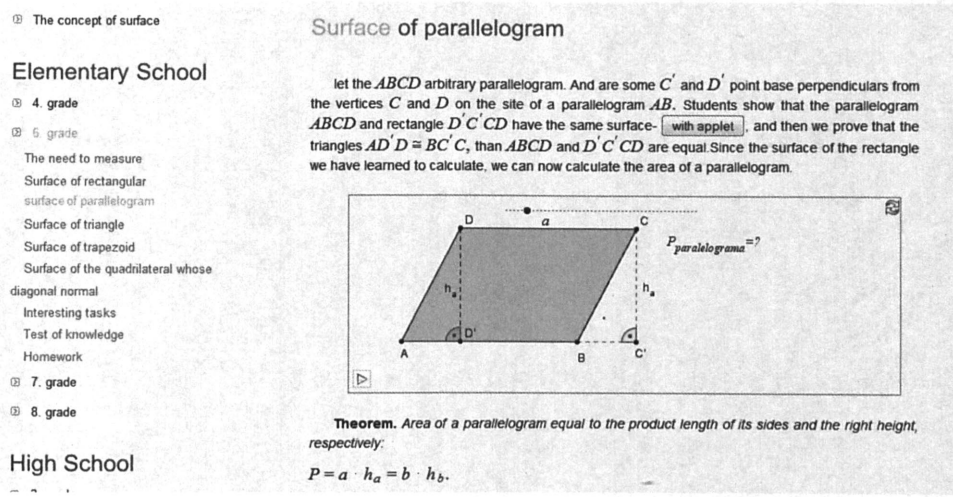


Figure 3: The area of parallelogram, the 6th grade of elementary school.

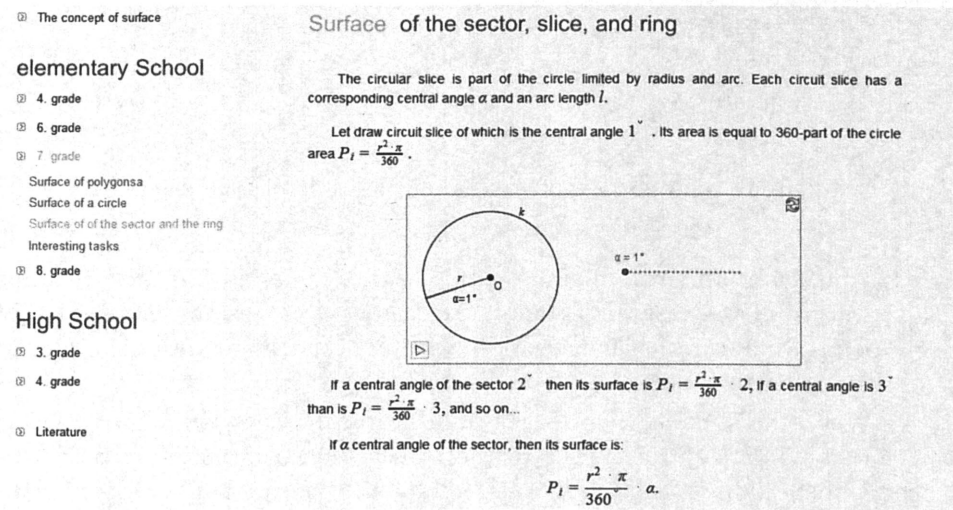


Figure 4: Surface area of the sector, slice and ring, 7 grade of elementary school.

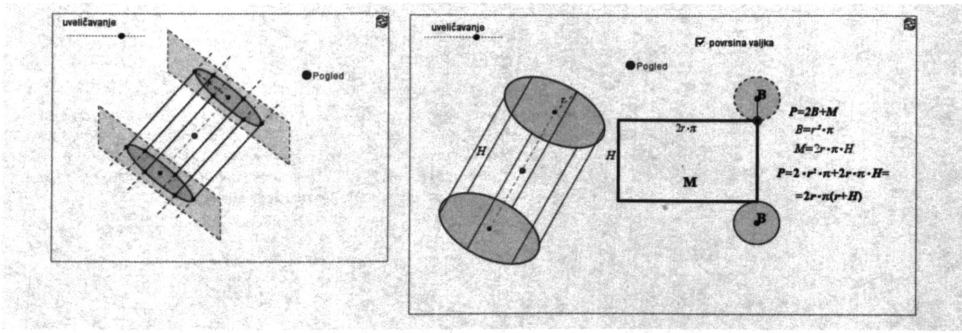


Figure 5: The area of the cylinder, the 8th grade of elementary school.

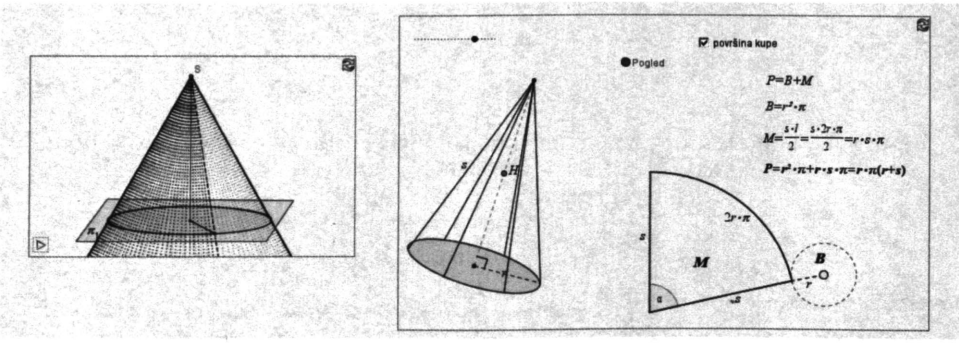


Figure 6: The Surface of cone, the 3th grade of high school.

necessary to enter a name, an e-mail and teacher's e-mail in the corresponding fields. When all the tasks are completed, the student fills the last field that refers to the comments on homework, clicks on "send homework" in order to send the answer to the teacher.

When the student clicks on "send" button, he/she gets a confirmation e-mail that his homework is sent to the teacher and also needs to verify the teacher's mail address The teacher also gets mail with the homework title, the student's name, the e-mail address, the text of the tasks, the correct answer and the student's answer in a table format. The teacher needs to review the mail and to inform the students about the reception of the e-mail and the grade of the homework tasks.

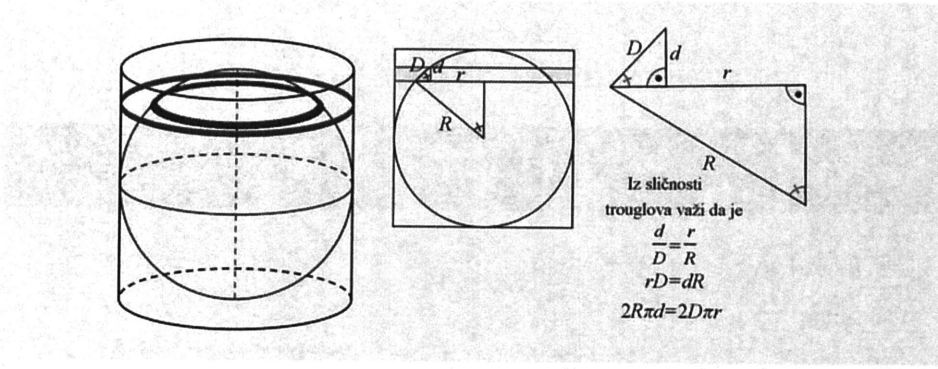


Figure 7: Surface of the sphere, 3th grade of high school.

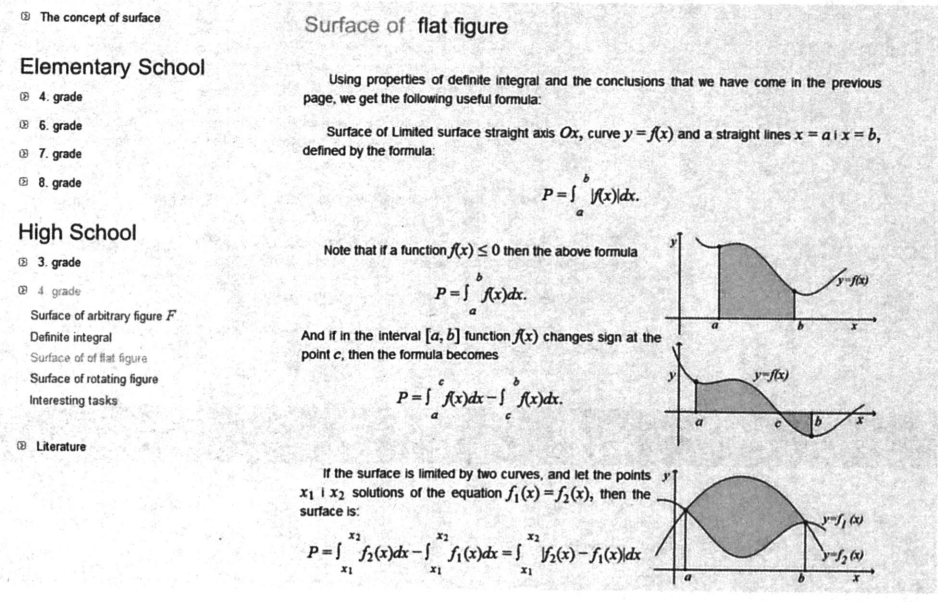


Figure 8: Surface a flat figure, the 4th grade of high school.

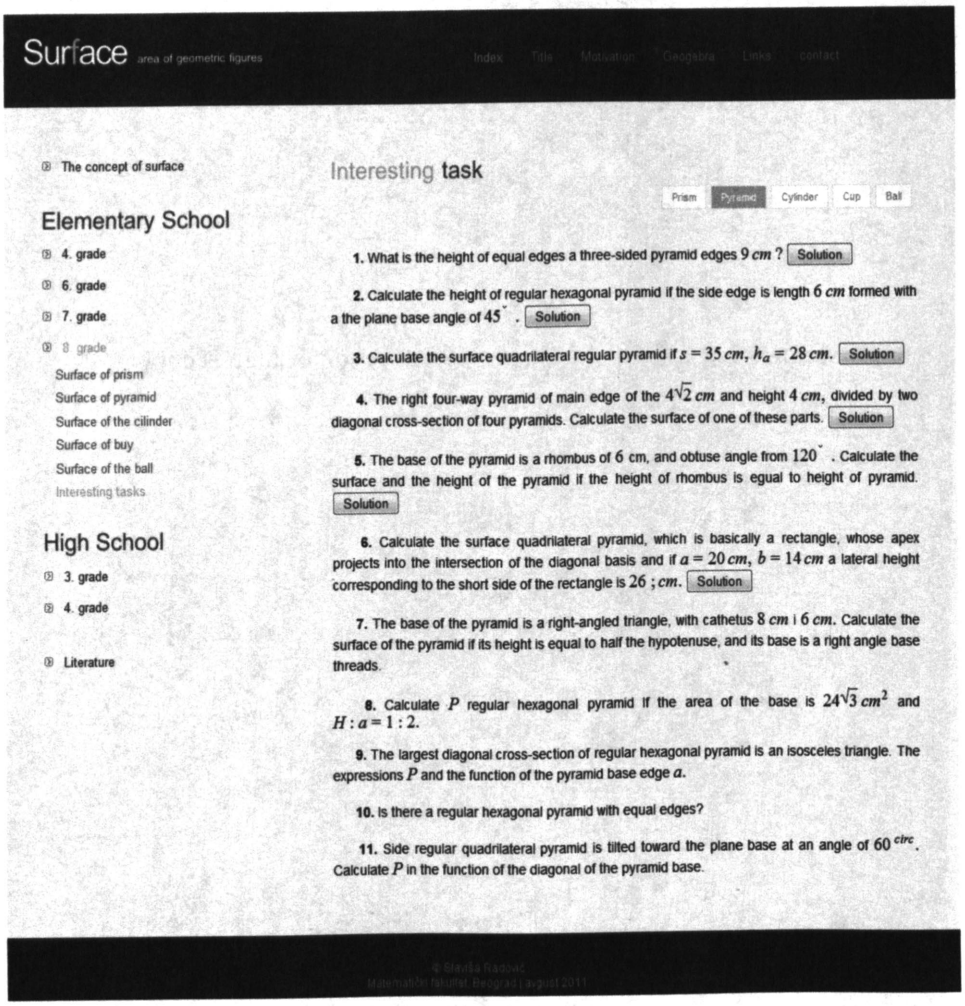


Figure 9: Interesting tasks.

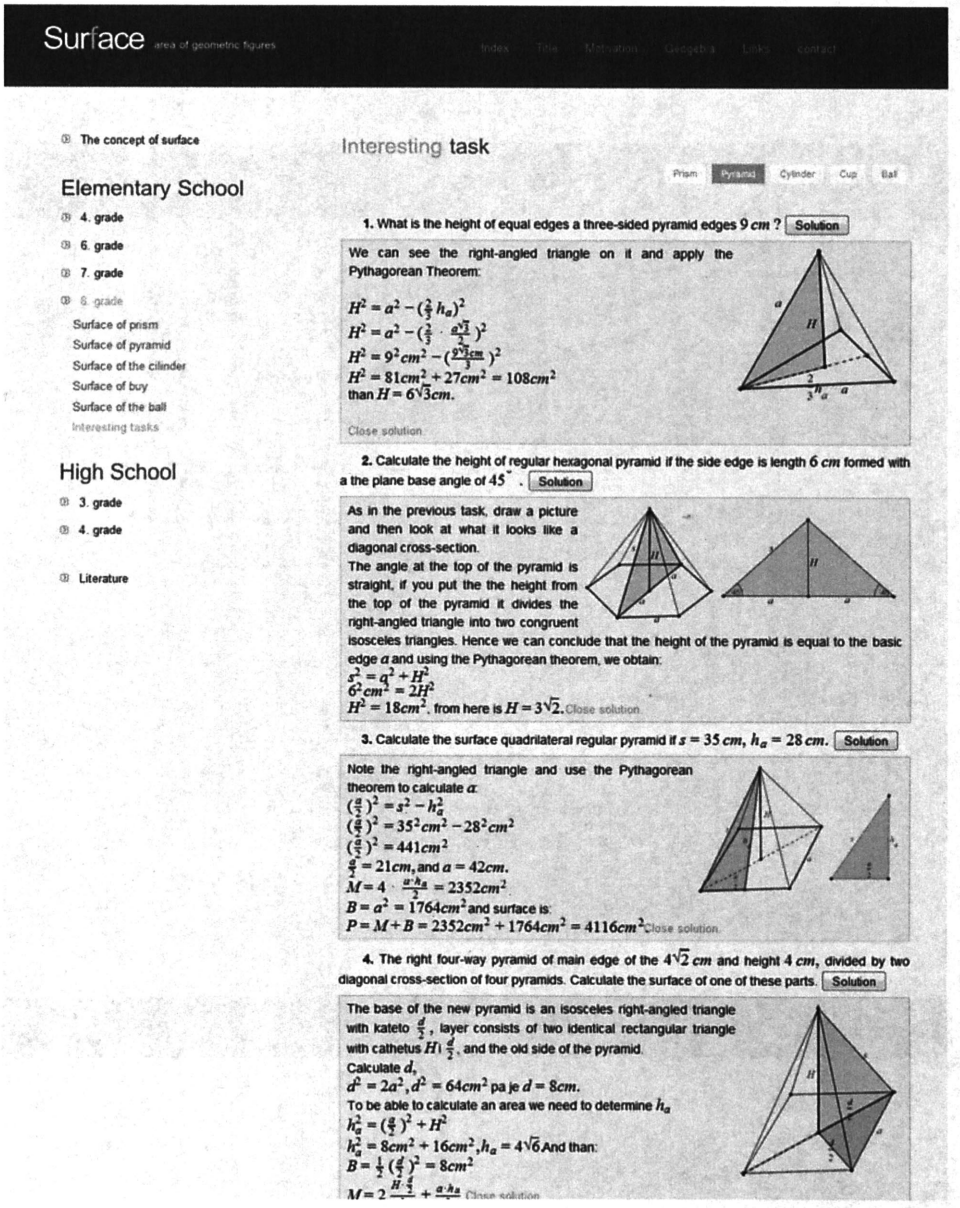


Figure 10: Interesting tasks.

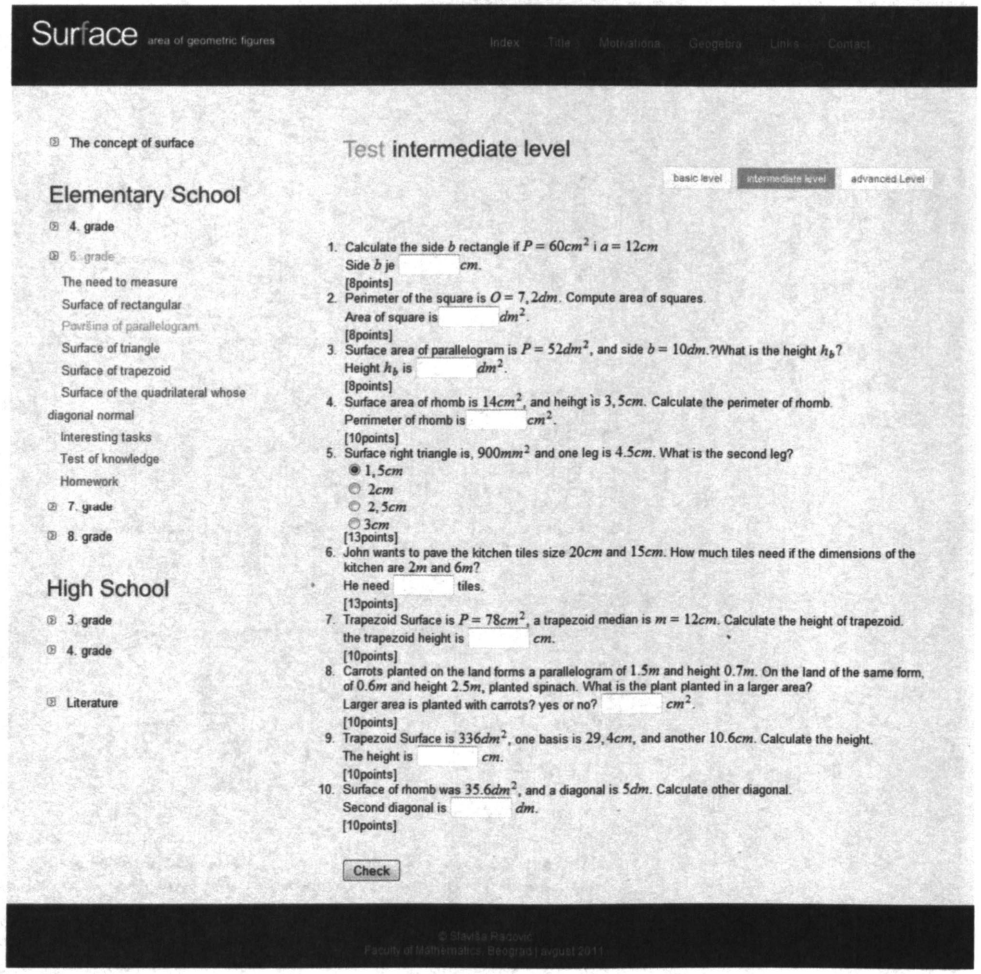


Figure 11: Test of knowledge.

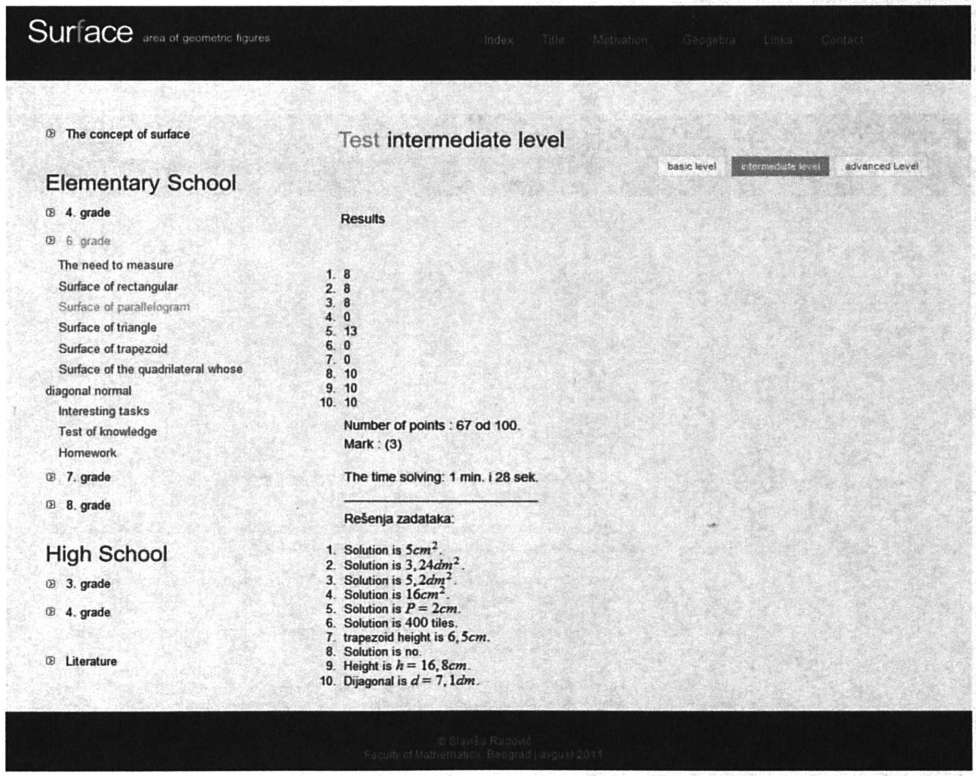


Figure 12: The solution of the test knowledge.

3. Conclusions

In this paper only a small part of the functionalities of GeoGebra and the possibilities that it offers are presented. We have demonstrated an interactive educational material related to the term surface area of a figure, in the elementary and high schools. Four aspects of created GeoGebra environment are presented: learning aspect, explanations, self- testing and homework. This approach can be applied to any mathematical topic. Teachers can use the GeoGebra educational software and the present abstract mathematical concepts in a virtual environment where students feel very safe. In this way, the GeoGebra environment turns into the place where students learn and play at the same time.

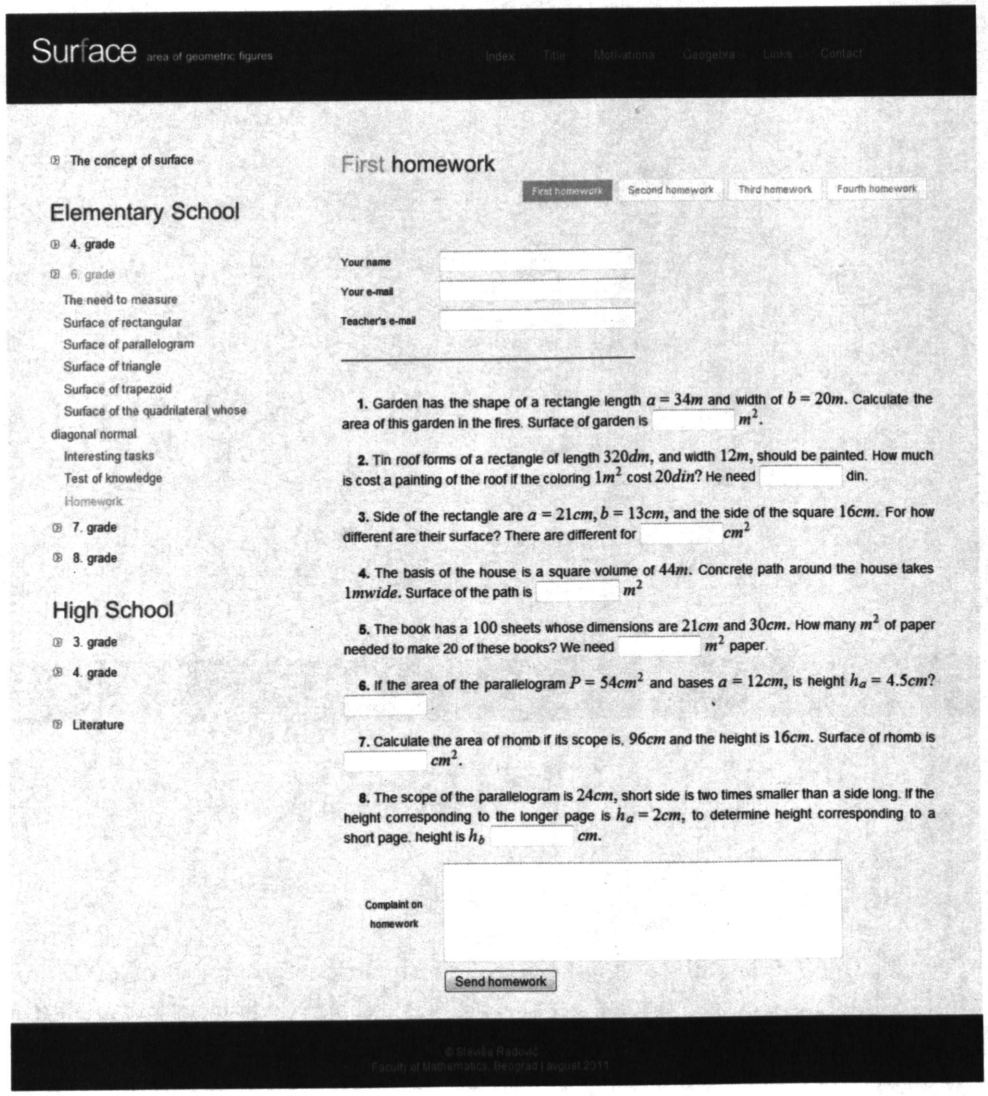
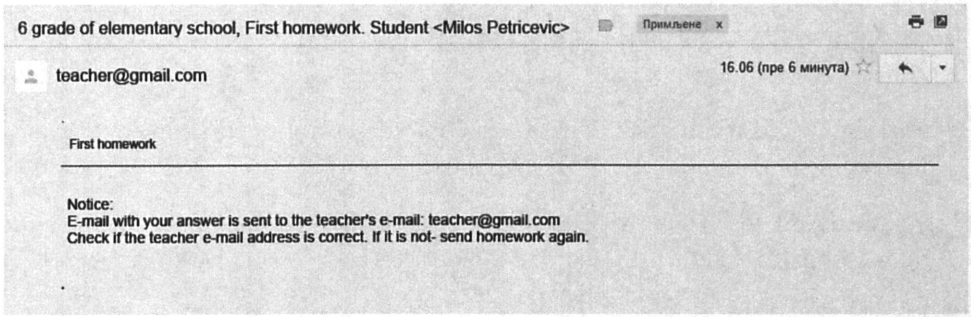


Figure 13: Homework.

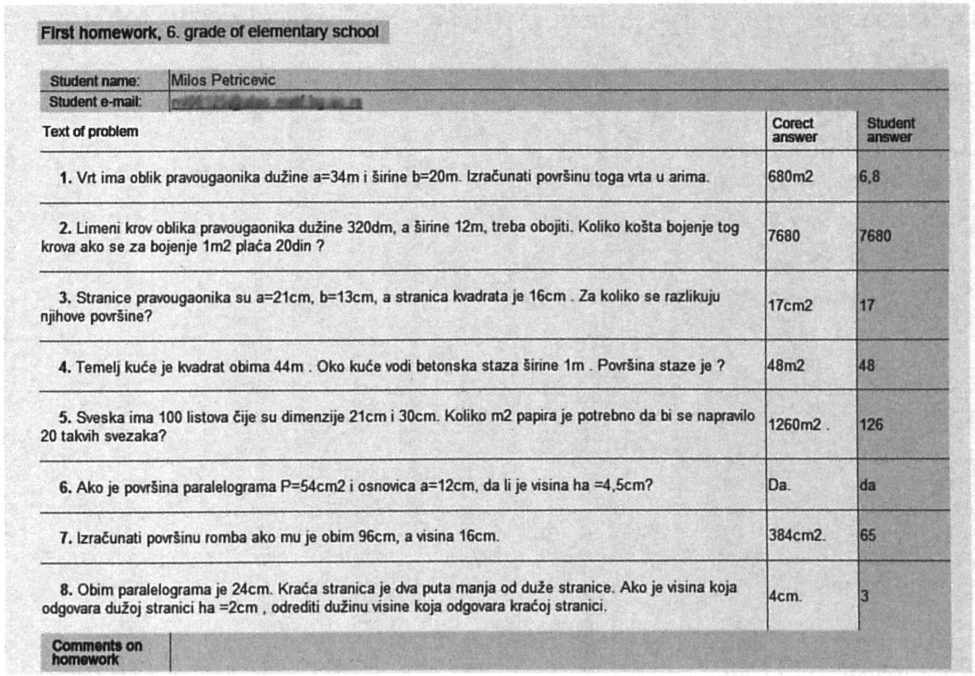

6 grade of elementary school, First homework. Student <Milos Petricevic> Примљене x

teacher@gmail.com 16.06 (пре 6 минута)

First homework

Notice:
E-mail with your answer is sent to the teacher's e-mail: teacher@gmail.com
Check if the teacher e-mail address is correct. If it is not- send homework again.

Figure 14: E-mail which student gets.


First homework, 6. grade of elementary school

Student name:	Milos Petricevic
Student e-mail:	

Text of problem	Corect answer	Student answer
1. Vrt ima oblik pravougaonika dužine a=34m i širine b=20m. Izračunati površinu toga vrta u arima.	680m2	6,8
2. Limeni krov oblika pravougaonika dužine 320dm, a širine 12m, treba obojiti. Koliko košta bojenje tog krova ako se za bojenje 1m2 plaća 20din ?	7680	7680
3. Stranice pravougaonika su a=21cm, b=13cm, a stranica kvadrata je 16cm . Za koliko se razlikuju njihove površine?	17cm2	17
4. Temelj kuće je kvadrat obima 44m . Oko kuće vodi betonska staza širine 1m . Površina staze je ?	48m2	48
5. Sveska ima 100 listova čije su dimenzije 21cm i 30cm. Koliko m2 papira je potrebno da bi se napravilo 20 takvih svezaka?	1260m2 .	126
6. Ako je površina paralelograma P=54cm2 i osnovica a=12cm, da li je visina ha =4,5cm?	Da.	da
7. Izračunati površinu romba ako mu je obim 96cm, a visina 16cm.	384cm2.	65
8. Obim paralelograma je 24cm. Kraća stranica je dva puta manja od duže stranice. Ako je visina koja odgovara dužoj stranici ha =2cm , odrediti dužinu visine koja odgovara kraćoj stranici.	4cm.	3

Comments on homework	

Figure 15: E-mail that teacher gets.

References

[1] J. Cross, An informail history of elearning, On the Horizon, Volume 12, 2004.

[2] Polya, G, Mathematical Discovery, On understanding, learning and teaching problem solving, John Wiley & Sons, New York (etc.), 1962.

[3] Pritchard A., Effective Teaching with Internet Technologies, Paul Chapman Publishing, 2007., ISBN: 978-1-4129-3094-9.

[4] Kralj L., Utjecaj obrazovnih tehnologija na poučavanje, Edupoint,2008.

[5] Hohenwarter, M., Preiner, J., Taeil Yi, Incorporating GeoGebra into Teaching Mathematics at the College Level, Proceedings of ICTCM 2007, Boston, MA, 2007.

[6] Chang M., Kuo R., Hirose M., Learning by Playing. Game based Education System Design and Development, Springer, 2009., ISBN: 3-64-203363-6.

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