

ONLINE CONTEST “MATHEMATICS AND ART” FOR THE DEVELOPMENT OF KEY COMPETENCIES

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Abstract. The online contest “Mathematics and Art” is organized by Tonediko since 2015. Participation in it creates the opportunity to develop almost all key competences. In addition, the competition is a means of promoting digital mathematical tools to a wide audience. In the paper, in the context of the research of the ability to use the provided dynamic files (directly or after modification), to create a composition on a given topic, the following will be presented: the competition regulation; main activities of the participants; opportunities to use the competition in IT lessons, fine arts, labor and equipment, mathematics and related teacher activities; results of passed competitions, some challenges and options to overcome them.

Keywords: online competition; key competencies; mathematics and art; STEAM

Introduction

The development of information technology provides new opportunities for both the creation of artistic works and the study of mathematics and information technologies through fine arts. In (Chehlarova et al., 2012; Chehlarova & Chehlarova, 2013; Chehlarova & Chehlarova, 2014; Chehlarova, 2015) are presented results of studies related to the use of the style of artists such as Andy Warhol, Escher, Mondrian, and specialized software for learning specific subjects of school mathematics. Applying the educational resources described there facilitates the formation of basic ICT skills for finding, evaluating, storing, producing, presenting and exchanging information, communicating, confidently and critically using information society technologies for work and communication (Petrova et al., 2016). According to the European Commission's strategic documents, these are models for the simultaneous development of digital competence, mathematical competence and cultural awareness and expression. The competitions are an effective tool in education for expanding knowledge, identifying talent, and motivating for learning. Conferences and competitions are organized in Bulgaria for the development of digital competence, for the forma-

tion or development of the skills for using specialized mathematical software for solving of applied tasks (Chehlarova & Kenderov, 2015; Kenderov et al., 2015; Kenderov, 2018). Here we will present an online competition “Mathematics and Art”¹⁾, organized by EOOD “Tonediko”.

The objectives of the online competition "Mathematics and Art" are related both to the development of digital, mathematical competences and cultural awareness and expression of the students, as well as to the support of the teachers in mathematics, information technologies, graphic arts and others. The task is to motivate students and to organize teaching in a technological environment.

1. Regulation of Online Competition “Mathematics and Art”

To enter the competition, fill in the data and attach a photo of an author's work on a topic. There is no limit to the number of works that anyone can participate in. There is a limit to the size of the file. Each entry is self-registered. There are no age restrictions for the participants. The deadline is specific for each topic.

Help files are provided to participants and can be used to create an artwork. For example, in the “Embroidery” are recommended files from the Virtual Mathematics Laboratory^{2,3,4,5)} (Chehlarova et al., 2014)

These files have the role of tools that can create an artwork – either directly or after modification.

For some of the past competitions there is an additional help. For example, the “Rosette” competition has been given the following insights: “Watch carved ceilings, disco decorations, candy decorations, ornaments, flowers, and you'll find a variety of inspiring examples of rosettes”.

In addition to three awards chosen by a jury, encouraging awards and an audience award are given. The encouraging awards are based on specific categories related to the topic, the technology, such as a real object photo, an animated file, a context-based intuition. The prize of the audience is determined by the number of likes received within one month of the end of the contest. For this purpose, the works are displayed in an e-gallery with the possibility of voting.

2. Main activities in the online competition “Mathematics and Art”

For successful inclusion in the online competition, the participants perform some of the following activities:

- Study the topic.
- Building an idea.
- Investigate the dynamic files provided in the competition. If the participant has not used the software product so far, it must be installed. The most frequently uploaded files are developed with *GeoGebra* dynamic software.;
- Consider proposals from previous competitions, which are in the Gallery section (Fig. 1).



Figure 1. Gallery section⁶⁾

- Select technology to create the model and a tool to represent it in the requested format.
- Create an image.
- Edit in a graphics editor, for example, cropping parts of the resulting image, rotating to a certain degree, receiving a mirror image, multiplying.
- Export the finished image to any of the file formats specified in the competition.
- Application of knowledge and skills for editing a graphic image: changing orientation, contrast, luminance resolution.
- If necessary, reduce the size of the file according to the competition requirement.
- Registration, including and attachment of a file.

In Chehlarova & Petkov (2018) there are presented opportunities for using the online competition “Mathematics and Art” in the IT lessons: creating a computer presentation, creating a text document containing a graphic image, working with cloud services for team work on a common document, creating a web page, sharing resources, presenting results to audiences.

The main activities of the teacher in preparing and conducting an IT lesson with participation in the online contest are: detailed study of the conditions of the competition, review of the results of previous editions, if any, installing specialized software if it is necessary.

3. Analysis of results from online competition “Mathematics and Art”

It is noteworthy that there are groups of participating students from some settlements around teachers. Such groups exist in Sofia, Plovdiv, Razgrad, Mezdra and others. Information Technology Teachers greatly appreciate the opportunities for realizing many goals for different age groups. They say that the availability of

supporting files is essential for their decision to use the on-line competition at school hours. More than half of the author's works have been created with them.

Modification of provided help files can take place in different parameters.

In the file at⁷⁾ you can make a change of placement of the main objects for getting the original embroidery, the colors, the type of the coordinate system (cartesian, isometric, polar), point style, etc. (Fig. 2).

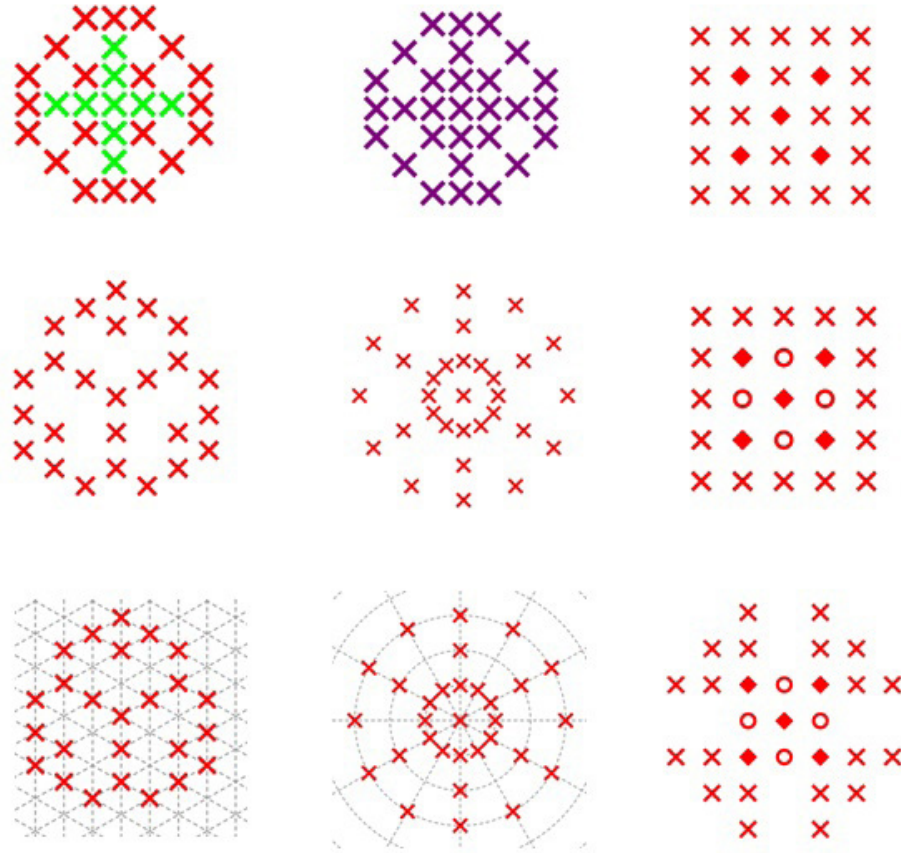


Figure 2. Modifications of the file⁷⁾

In the file⁸⁾ below the rotation symmetry, the colors, the mutual position of the objects can be changed, as well as the addition of similar objects to the same rotational symmetry by analogy (Fig. 3).

Thus, pupils learn the specific software and can use it to solve problems from other areas.

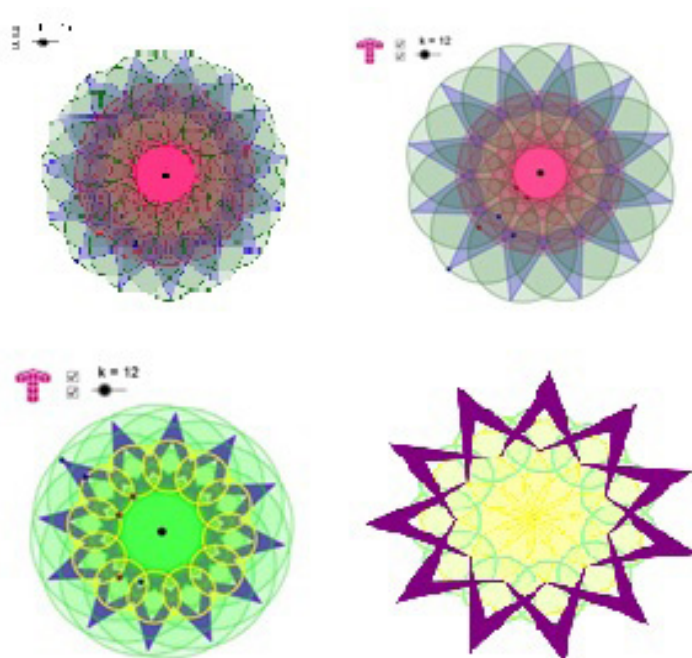


Figure 3. Modifications of the file⁸⁾

Tracking the work of regular participants shows their development. On the one hand there is a formation of skill in using a particular technology, as well as combining different technologies. On the other hand, there is directing their attention to the idea.

The educational effect of the competition is very high.

After the first Rosette competition, it is a great impression to reduce the percentage of participants with unsuccessful file upload attempts, as well as the number of duplicate proposals. Only 1 failed to attach a file out of a total of 852 works in the “Embroidery” competition. Of all the attachments, 59% of the participants used the help files and part of the authors files were entered as an element of the overall composition.

In the first competition (Rosette) there are a large percentage of badly shaped pictures. In 48% of the photos there are cut parts of the rosette, which in most cases disturbs the harmony in its overall perception. 38% of the photos have redundant elements that are helpful in creating the composition or side elements that are part of the dynamic file used. Most often these are a square grid, points with which dynamic composition is managed, some help lines, coordinate system axes, logo (Chehlarova, 2016). In the following competitions, these instances of inaccuracy are single.

In the first contest there is only 1 animated file, in each subsequent competition there is a significant increase in their number. As a good example, we will also point to an adequate use of effects such as water surface, combining several effects (Fig. 4).

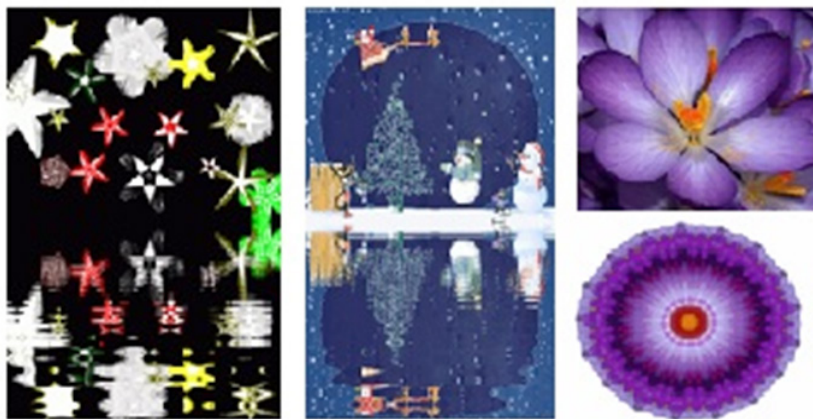


Figure 4. Using effects^{9,10,11)}

Ideas from artistic works from passed competitions are transferred to the next. Technologies and software applications are naturally distributed by competition participants.

Increased motivation of the students for learning the IT content using online competitions, as well as opportunities for transformation of the external motivation related to the assessment and the result of the ranking into internal ones, has been reported.

Correspondence after each contest with students, teachers and parents is filled with gratitude and sharing of their joy from communication and creativity, inspiration during the creation of works and their evaluation.

Organizing the online contest is accompanied by difficulties of a different nature.

The requirement to attach their own author work is not respected by all participants. Verification of distinguished works is an obligatory element. With some participants, there is also an interim correspondence about clarifying the authorship condition.

Forming a self-assessment and evaluation skill is a lengthy process and there are deviations in the vote of the audience.

4. Administrating “Mathematics and Art” competition

The administration of the competition process starts with posting the regulations. As is shown below, for every new topic we write the rules for participating and add help files. The regulations and opportunity to take part in a competition are available both in English and Bulgarian language.

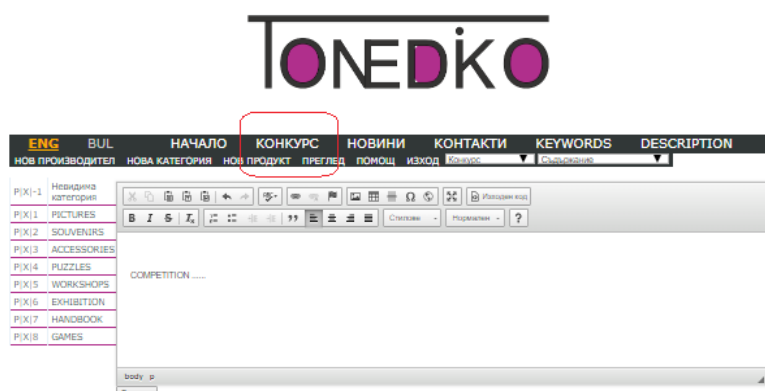


Figure 5. Posting “Mathematics and Art” competition regulations

After the deadline for participation every attached work goes through verification for authorship. Gif, ggb and other format files are viewed again if they need any processing for the next stage of the competition. The second part is the public voting. Every author work is being shown by making it visible separately as it is shown on fig.6.

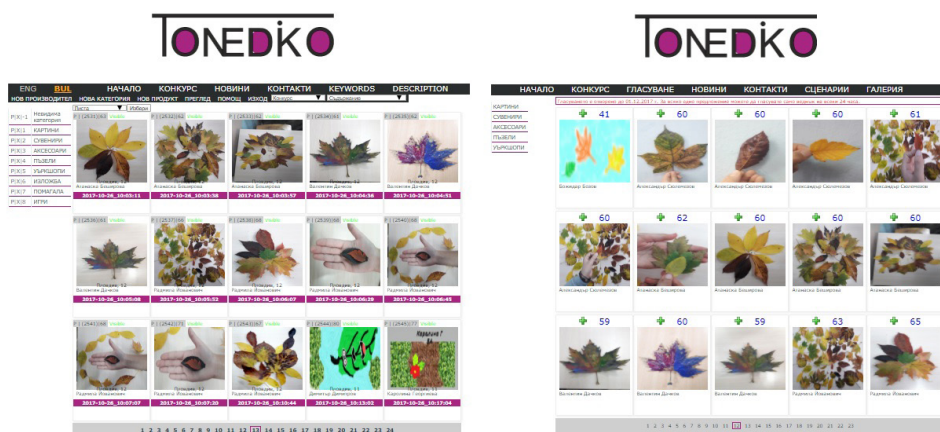


Figure 6. Publishing author works and public voting

During this second stage everyone can freely visit the site and look through the published works. Among the first prizes chosen by a jury and the winner who has the most votes from the public is announced. All competitions regulations, help files and winners can be found in the news field of the site. When a competition is

over all works form the finished topic remain on the site on section “Gallery” (Fig. 7). They can be viewed, examined and be inspiration for making art works.

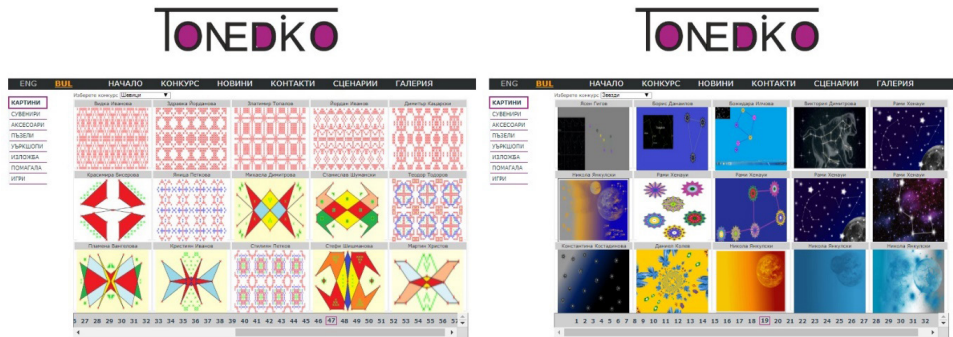


Figure 7. “Mathematics and Art” competition Gallery

5. Tonediko CMS – principles of operation

Tonediko is a Content Management System (CMS). Operation of the CMS can be explained on a four layer communication model (Fig. 8). The steps of operation are:

1. The users and administrators publish content by their respective interfaces. The whole publishing process is moderated through Admin interface.
2. The Event layer collects the interface action data and returns the resulting Engine response through the Presentation layer

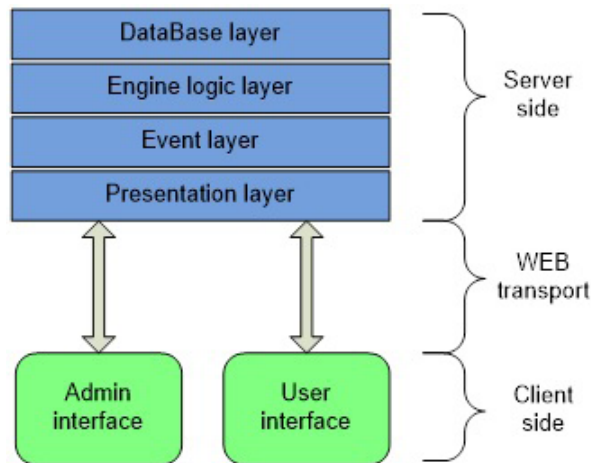


Figure 8. Basic scheme of Tonediko CMS

3. Interface action data is transformed to requests which in turn are passed to the Engine logic layer. The requests are processed by the Engine logic and returned to the Presentation layer. Main Engine logic layer functions are:

- a. Access control on the publishing process.
- b. Identifying and profiling of the user activity by “fingerprinting” of the web clients
- c. Analysis of the voting process

Necessary data is stored and retrieved by the Engine logic in DataBase layer.

Tonediko CMS is built over PHP, Java, JavaScript, MySQL technologies. It is custom and has no shared components from other CMS. The reason is that custom systems are more flexible and better fit to contracting authority emerging requirements.

6. Vote and activity analysis

The rating of each published artistic work is determined by public voting. The voting is opened for a given period of time. During this period public users can vote for preferred works. The only limitation is that a single user can vote once per work in 24 hours. The number of works that user chooses for voting is not limited. Public users are anonymous. No login is required, and no personal data is collected. The identification of voting users is based on session combination of unique browser identifier and IP address (Trifonov et al., 2017). Thus a user can vote only once for a piece of work per day from a browser installed on a given device.

The online contest “Mathematics and Art” has built in system for collecting of user activities data. Below in Table 1 is a summary of nine competitions held by now. There are total of 3672 published pieces of work. The amount of published works per competition and publishing intensity are indicators for students’ interest on a given topic. The number of votes per competition and vote intensity per work are indicators for public user interests.

A positive correlation exists between the duration of publishing period and the pieces of work that have been submitted (Fig. 9).

This fact is indication for sustained creative mathematical

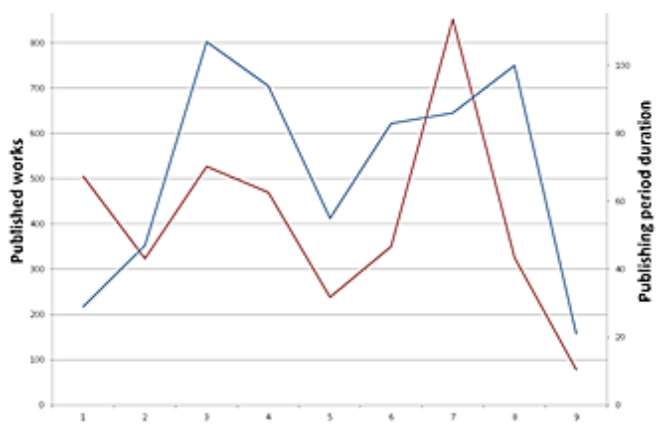


Figure 9. Positive correlation between publishing period and the number of published works

interest of students regardless of competition topic. Students enjoy mathematical art working on daily basis. Their involvement in such activity is not declined over time. Hence it is appropriate to offer students of online place where they could be engaged in continuous or overlapping periodic activities.

The parameter – “publishing intensity” represents an equivalent of creative power (Table 1).

Table 1. Publishing intensity

No	Title	Published works	From date	To date	Publishing duration, days	Votes	Publishing intensity pieces/day	Specific vote intensity vote/work
1	Rosette	505	14.01.2016	12.02.2016	29	23548	17	47
2	Dreams in purple	324	15.03.2016	01.05.2016	47	52406	7	162
3	Moments from the summer	527	07.06.2016	22.09.2016	107	24222	5	46
4	Stars	470	23.09.2016	26.12.2016	94	53336	5	113
5	Holiday	239	06.02.2017	02.04.2017	55	22077	4	92
6	Leaves	350	09.08.2017	31.10.2017	83	50931	4	146
7	Embroidery	852	07.11.2017	01.02.2018	86	42471	10	50
8	Shadows	326	04.02.2018	15.05.2018	100	4676	3	14
9	Valentine	79	31.01.2019	21.02.2019	21	3979	4	50
	Total	3672			622	277646		

Let’s think of published works as for creative energy. The ratio of total creative energy over the time this energy was released is power. Thus the students’ interest of different topics could be quantified and distinguished. The measure is the creative units made for a given unit of time. In this case this is the number of published works per day. The data of corresponding column in Table 1 suggests that the competitions “Rosette” and “Embroidery” have more power and much more attention from students than other topics as they have created more pictures for a given period of time.

Conclusion

Our expectation that the competitions motivates students to learn new knowledge and to create their own environments and artworks confirmed. Teachers

in Information Technology and Mathematics share their satisfaction with the results of using the competition. Here is what Eli Stefanova, a teacher of mathematics, says: “For me, art is always before mathematics. The competitions of Tonediko give a wonderful opportunity for students to create something beautiful, which later compare with the other participants. The competition is a race, but I have seen many times how they appreciate the best drawings. In each of our competitions we had favourites – and we're looking at them again in the gallery. Registration is very affordable. The themes are only marked and that's a big plus - everyone sees things in their own way... It is a wonderful way of appearing for everyone who wants to express their opinion on the topic. The awards highlight the fact that we are on a real race. For me personally, the greatest benefit was that I could catch up through competitions some students for whom mathematics was not a priority, and later than the established informal relationships between us to make a breakthrough in favour of mathematics. And in school we always make an exhibition of all the pictures that have participated in the competitions...”

Information technology teachers put the specific ability to form digital competency in real-world conditions within the classroom. Ivan Petkov, teacher on IT told: „The rich palette of topics offered by online competition “Mathematics and Art” organized by Tonediko give me the necessary freedom and the opportunity to choose the most appropriate topic, organization and method of teaching related to the learning objectives set in the respective unit of study. Using online competitions, I quickly and easily implement the use of new technologies in the learning process in an attractive and interesting way for the students. This in turn helps to increase their motivation for learning and develops their digital skills. Last but not least, the online competitions “Mathematics and Art” are the field of expression that students need without limiting their individual abilities.”

We believe that the competition “Mathematics” and Art" developed and maintained by “Tonediko”, is a tool for the development of key competences of students in class as well as in non-formal education.

NOTES

1. <http://tonediko.com/index.php?status=competitiongallery&galpage=1>
2. <http://cabinet.bg/content/bg/html/d25334.html>
3. <http://cabinet.bg/content/bg/html/d25338.html>
4. <http://cabinet.bg/content/bg/ggb/d25339.ggb>
5. <http://cabinet.bg/content/bg/html/d25340.html>
6. <http://tonediko.com/index.php?status=competitiongallery&galpage=12>
7. <http://cabinet.bg/content/bg/ggb/d25338.ggb>

8. <http://cabinet.bg/content/bg/html/d25310.html>
9. http://tonediko.com/img/competition/2034_4_2016-12-21_11:54:53_gss.gif
10. http://tonediko.com/img/competition/2055_4_2016-12-21_14:34:23_2.gif
11. http://tonediko.com/img/competition/954_2_2016-04-23_23:42:41_anigif_kremlinal8.gif

REFERENCES

- Chehlarova, N. (2016). Online competition “Rosetka” for the development of digital competence. *Pedagogical Forum*, 3 [In Bulgarian].
- Chelharova, T. (2015). Formirane na matematicheska i digitalna kompetentnost chrez tvorchestvo v stil Mondrian. (pp. 263 – 272). In: Todorova, T., Kovacheva, E., Nikolov, R. (eds.). *ICT v bibliotekno-informacionnata nauka, obrazovaniето i kulturnoto nasledstvo*, Sofia: Za bukvite – O pismenih [In Bulgarian].
- Chehlarova, T. & Chehlarova, K. (2014). Photo-pictures and dynamic software or about the motivation of the art-oriented students. *International Journal for Technology in Mathematics Education*, 21, 1.
- Chehlarova, T. & Chehlarova, N. (2013). Dinamichni kompozicii v stil Andi Yorhol. *Pedagogicheski forum*, 2, 56 – 62 [In Bulgarian].
- Chehlarova, T. et al. (2014). *A Virtual School Mathematics Laboratory*. Ruse: Angel Kanchev.
- Chehlarova, T. & Kenderov, P. (2015). Mathematics with a computer – a contest enhancing the digital and mathematical competences of the students. (pp. 50 – 62). In: Kovatcheva, E., Sendova, E. (eds.) *Quality of Education and Challenges in a Digitally Networked World*. Sofia: Za Bukvite, O’Pismenih.
- Chehlarova, T. & Petkov, I. (2018). Online Competition in the IT Training. *Pedagogical Forum*, 1 [In Bulgarian].
- Chehlarova, T., Sendova, E. & Stefanova, E. (2012). Dynamic tessellations in support of the inquiry-based learning of mathematics and arts (pp. 570-574). In: Kynigos, C., Clayson, J. & Yiannoutsou, N. (Eds). *Theory, Practice and Impact - Proceedings of Constructionism 2012*, Athens.
- Kenderov, P. (2018). Powering Knowledge Versus Pouring Facts (pp. 289 – 306). In: Kaiser G., Forgasz H., Graven M., Kuzniak A., Simmt E. & Xu B. (eds) *Invited Lectures from the 13th International Congress on Mathematical Education. ICME-13 Monographs*. Springer, Cham.
- Kenderov, P., Chehlarova, T. & Sendova, E. (2015). A Web-based Mathematical Theme of the Month. *Mathematics Today*, 51(6), 305 – 309.
- Petrova, C. et al. (2016). Integrating of A National E-Learning Platform Clp4net. *Proceedings of Technical university of Sofia*, 66, 3, [In Bulgarian].

Trifonov, R. et al. (2017). *Intelligent Methods and Cybersecurity*, NCST.
Sofia [In Bulgarian].

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