Cloud-based complex of computer transdisciplinary models in the context of holistic educational approach

Liudmyla I. Bilousova[1[0000-0002-2364-1885]], Liudmyla E. Gryzun[1[0000-0002-5274-5624]], Daria H. Sherstiuk[1[0000-0002-5330-2905]] and Ekaterina O. Shmeltser[2]

[1] H. S. Skovoroda Kharkiv National Pedagogical University, 29, Alchevskyh Str., Kharkiv, 61002, Ukraine
{Lib215, Lgr2007, DSerstuk}@ukr.net
[2] Kryvyi Rih Metallurgical Institute of the National Metallurgical Academy of Ukraine, 5, Stepana Tilhy Str., Kryvyi Rih, 50006, Ukraine

Abstract. The paper represents the authors' cloud-based complex of computer dynamic models and their transdisciplinary facilities. Proper theoretical background for the complex design is elaborated and the process of the computer models development is covered. The models in the complex are grouped in the sections according to the curriculum subjects (Physics, Algebra, Geometry, Biology, Geography, and Informatics). Each of the sections includes proper models along with their description and transdisciplinary didactic support. The paper also presents recommendations as for using of the complex to provide holistic learning of Mathematics, Science and Informatics at secondary school. The prospects of further research are outlined.

Keywords: holistic education, cloud-based learning environment, computer dynamic model, transdisciplinary tasks, didactic support of holistic learning.

1 Introduction

Contemporary education at all of its levels is currently experiencing the period of necessary transformations. It is connected with complicated social processes, tendencies to globalization, integration of science branches, and incredible growth of new knowledge amount. As a result, it causes challenges to education and training at schools and universities. Mainstream educational paradigm (considered today to be static and split up [9]) tends to be transformed with holistic educational approach which tries to build dynamic, harmonized, and interconnected pedagogy.

This approach aims to form students' concentrated conceptual knowledge and the complex of transdisciplinary skills. It will allow to establish in the trainees' memory greater amount of strong links between concepts and notions, and as a result, to encourage students to investigate and apply what they know and can do to other subject areas. In order to provide such an approach we need to elaborate special teaching strategies and arm teachers with effective aids appropriate for different students and learning situations.

Thus, it is really urgent today to develop and implement special learning tools in order to facilitate implementation of holistic educational approach.

Analysing recent research papers on the theory of holistic education, we could distinguish main characteristics and peculiarities of the approach. According to some authors, holistic education should be considered as a paradigm (not as a technique, strategy or method) that provides educators with a system of principles which can be used in various ways [9; 14; 15].

The core idea of holistic education is the cohesive development of the whole person both at the intellectual and emotional levels [22]. At the same time this cohesive development should base on strong links between personal experience and real life problems.

Among basic principles of holistic education the studies (in particular, [9; 13]) point out several pillars which seem to be really important and significant in the context of contemporary requirements to the education. The first pillar expects students' freedom and autonomy. So, within the holistic paradigm any trainee is considered to be really active participant of the learning process who is ready to interact with reality via his own cognitive activity, via his own ups and downs.

Next important facet of the holistic approach is necessity to establish connections and relationships between the object of learning and existing knowledge. The more links trainees have, the stronger memories are formed in their minds and better understanding of the whole they obtain.

Similar to the establishing links is the principle of transdiciplinarity which focuses teaching and learning on ruining boundaries between subject fields themselves as well as between subject areas and reality.

Researchers also point out that holism helps both the connection facet and transdiciplinarity, because it seems to be fruitful to learn separate things which in fact are not separate. However, at the same time it is necessary to understand how they work together.

The analysis of the holistic education basis reveals a need to apply efficient learning tools enabled to provide holistic approach to nowadays teaching and learning.

One of such tool seems to be computer dynamic models (CDM). The learning of recent studies on their didactic facilities testifies that CDM have quite powerful potential as for revealing transdisciplinary connections and facilitating their understanding by schoolchildren. In particular, researchers point out that CDM are typically based on the mathematical model of a concept (process, phenomenon, etc.), and enable to visualize its essence at real time operation, learn dynamic changes, and investigate the concept or process via active cognition. In such a way CDM help to form and develop students' techniques of mental activity including transdisciplinary ones [1; 18].

Characterizing advantages and facilities of CDM using in the context of holistic education, it is important to emphasize that they encourage students to learn objects independently and actively. In addition, they reveal and demonstrate in action the wholeness of the learnt concepts (phenomenon).

The special attention must be paid to the cloud-based complex of CDM as a potential mean of holistic approach realization. According to recent studies, cloud-based learning environment for teaching STEM disciplines opens wide horizons for holistic education due to its important features. Among them researchers call support for various processes of learning and research activities; great level of learning resources flexibility; integration of variety of educational components based on innovative technologies [10; 12; 19; 20; 21].

On balance, cloud-based complex of CDM (as an integral part of the learning environment) with transdisciplinary didactic support is able to enhance the advantages of CDM usage and to facilitate implementation of main pillars of holistic education.

The purpose of the article is to describe the authors' cloud-based complex of computer dynamic models and their transdisciplinary facilities. The paper also presents recommendations as for using of the complex to provide holistic learning of Mathematics, Science and Informatics at secondary school.

2 Theoretical framework

During the research, the set of theoretical, empirical, and modelling methods were applied. Theoretical background for the cloud-based CDM complex elaboration made deep and comprehensive analysis of the proper subject areas, held by the authors beforehand. In order to meet the main pillars of holistic approach (covered earlier) it is necessary to reveal key objects of learning in the subject areas, establish connections between them, and build chains of proper transdisciplinary links.

Researchers distinguish different types of transdisciplinary connections. However, scientists (in particular, [2; 5; 11]) recommend to base the connections classification upon the set of three main grounds: information content of the subject, structure of learning activity, and organization of educational process. As a result, considering the transdisciplinary connections from the standpoints of holistic education, we have to reveal key concepts of subjects, detect their place in the current curriculum, consider peculiarities of their mastering and proper cognitive activity.

These procedures were done through the learning main content threads of the said curriculum subjects [16; 17], author's didactic analysis of each subject (covered in [6; 7]) and detailed analysis of the subject areas.

Main content threads of Mathematics, Science subjects (Physics, Chemistry, Biology) and Informatics enabled us to reveal some transdisciplinary chains. We would like to point out a paramount role of penetrating content threads in revealing transdisciplinary concepts and links between them. According to the Concept of the New Ukrainian School, there are four penetrating content threads - "Ecology security and sustainable development", "Civil responsibility", "Health and security", "Financial literacy" – which are seen as a mean of key competences integration of all curriculum subjects. The penetrating threads are considered to be socially important super themes that focus teaching and learning on the trainees' holistic understanding of the world. They are recommended to be regarded during the learning environment creation [8].

Analysis of subjects' content threads in the terms of four penetrating threads enabled us to build the following set of connection chains between curriculum subjects:

- Algebra – Geometry – Informatics;

- Algebra – Physics – Geometry;
- Physics – Algebra – Geometry – Biology;
- Chemistry – Biology – Informatics;
- Physics – Biology – Geography.

Subsequent detailed analysis of the subjects standards [16; 17], textbooks, and subject areas resulted in establishing of transdisciplinary links between learning elements (LE), representing concepts and phenomena which are co-explored by several subjects. In particular, the effective semantic analysis was held with the help of specialized software, such as: TextAnalyst 2.0, Text Miner 12.1 (its Text Parsing Node), Trope 8.4. Such a “smart” analysis of the subject areas enabled to distinguish the weightiest LEs of the specific subject along with their conceptual links.

Basing on the depicted analysis, for the revealed weightiest LEs of a subject it was built a graph, representing their transdisciplinary links with exact learning elements (LE1...LE*n*) of other subjects, according to the chains of connections mentioned earlier. The general scheme of the graph and the example of the graph for selected physics LEs, representing the transdisciplinary links for the chain: Physics – Algebra – Geometry – Biology, are given on the Figures 1, 2. Graphs also contain information about the school grades (from the 5^{th} to 9^{th}) in which the LEs are studied according to current curriculum standards.

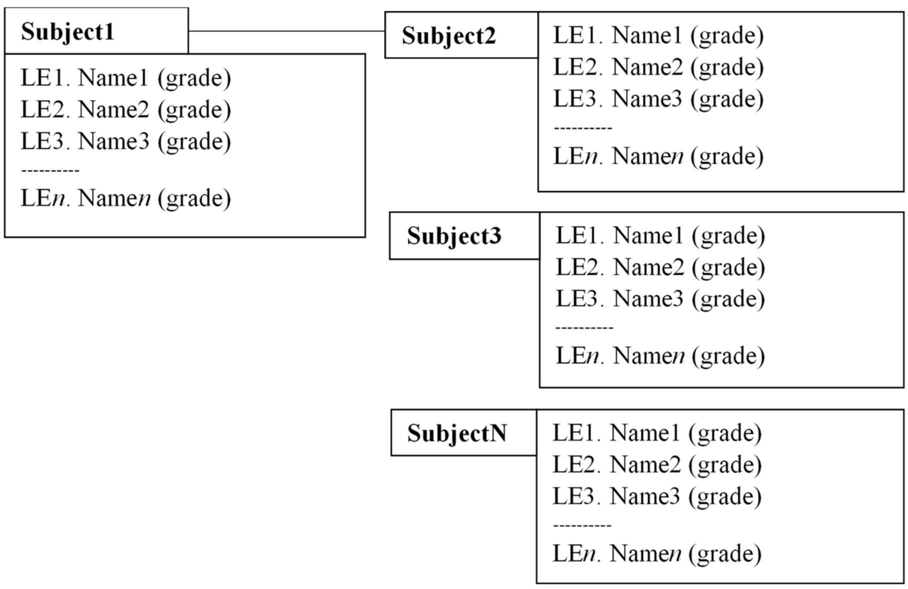

Fig. 1. The common scheme of the graph, representing their transdisciplinary links with exact learning elements (LE1...LE*n*) of other subjects and grades numbers

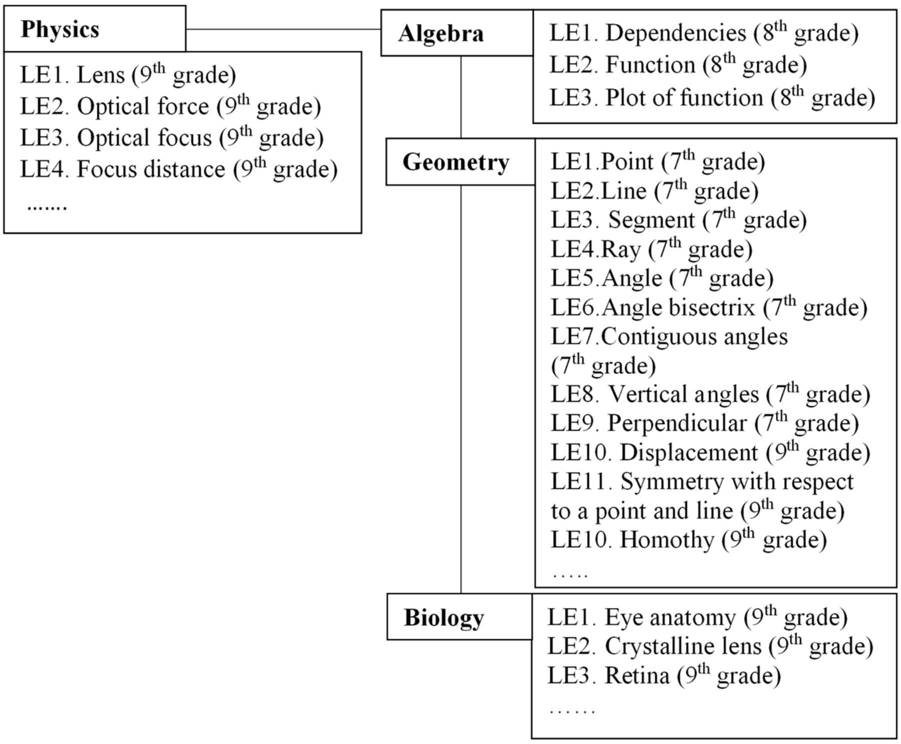

Fig. 2. The example of the graph for selected physics LEs, representing the transdisciplinary links for the chain: Physics-Algebra-Geometry-Biology (Section “Physics”. Model “Lens”)

3 Results and discussion

The results of theoretical framework were used at the design of cloud-based complex of computer transdisciplinary models.

The process of the models elaboration embraces some phases. At the first phase mathematical model of the future computer model is built. At this point it is done: (1) revealing and learning of the transdisciplinary essence of the proper concept (See theoretical framework); (2) defining of the mathematical dependencies which can illustrate and investigate the concept; (3) determination of the fixed model parameters and changeable ones along with the range and step of their changes; (4) picking up proper graphic elements which are able to illustrate dynamic changes; (5) revealing of transdisciplinary tasks and real-life problems which might be solved by the model.

At the second phase the mathematical model is built by the means of GeoGebra. In particular, the set of standard GeoGebra tools are used (*Points, Lines, Special Lines, Polygon, Circle and Arc, Measurement, Transformations*) as well as the CAS components (*Calculations and Analysis Tools*). For realization of dynamic transformations, the *Action Object Tools and Movement Tools* are used [18].

In order to make the use of the complex more flexible and available to a wide community of students and teachers, we organized it in the form of GeoGebra Book. GeoGebra Book is a cloud service which enables to gather GeoGebra resources, to enhance them didactically, and to share them easily. Due to this fact, our complex of models is oriented to be a component of a cloud-based learning environment.

The third phase is devoted to the testing, debugging and improving of the model.

The models in the complex are grouped in the sections according to the curriculum subjects (Physics, Algebra, Geometry, Biology, Geography, and Informatics). Each of the sections presents proper models along with their description and transdisciplinary didactic support. Main page of the complex and some of its sections are shown on the Figures 3-5.

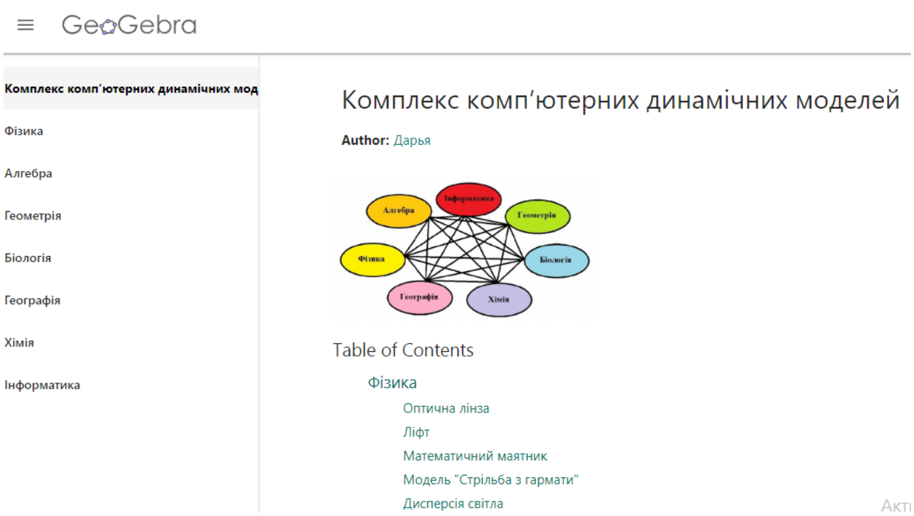

Fig. 3. Main page of the complex of computer transdisciplinary models

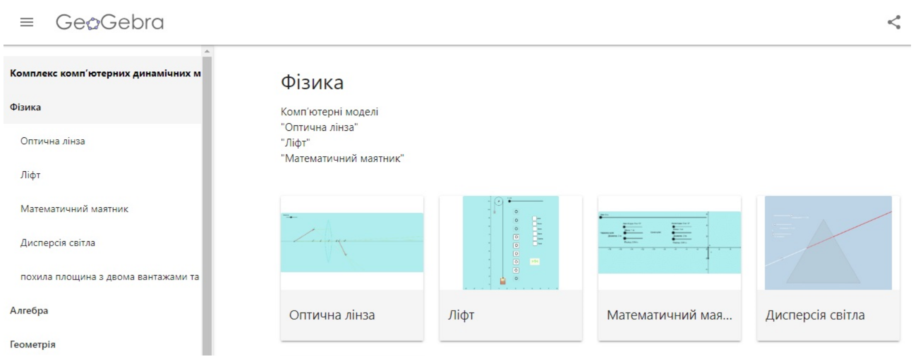

Fig. 4. Computer models of the Physics section

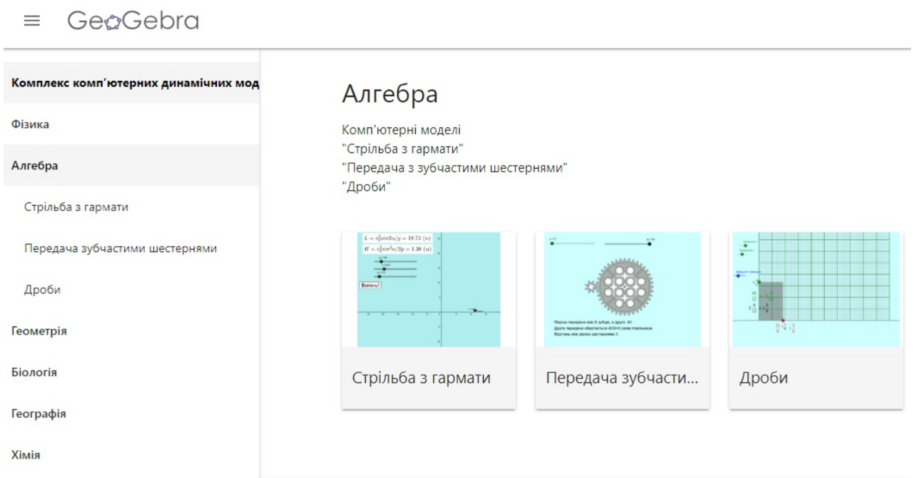

Fig. 5. Episode of work with Algebra section of the complex

Each of the models is presented in the complex according to the general scheme.

It includes (see examples below):

- model title;
- chain of the transdisciplinary links which are illustrated by the model;
- model description which explains concept (phenomenon) that is a prototype of the model;
- dynamic model itself with a proper functionality;
- procedure of cognitive activity on the realizing the essence of the concept (phenomenon);
- didactic support as a set of transdisciplinary tasks and real-life problems for forming holistic image of the said concept (phenomenon);
- graph of the revealed transdisciplinary links for the visualization and remembering this holistic representation.

As it was mentioned above, holistic education expects students' personal cognitive activity. In order to facilitate it we elaborated procedure of cognitive activity which includes some tips on changing the parameters of the dynamic model, monitoring the results, investigating, making conclusions etc. Such a procedure is aimed to streamline understanding the essence of the concept (phenomenon).

Our didactic support for each model is developed to involve students into the solving special problems and real-life tasks which encourage them to obtain holistic understanding of the basic concepts via special cognitive activity based on work with dynamic models. All of the tasks focus students on the revealing and realizing transdisciplinary links.

Some of the models with their description and functionality are included into more than one subject section. However, didactic support as a set of transdisciplinary tasks for each model is specific in each section and focuses on the subject essence of every concept and different transdisciplinary connections.

Below we demonstrate fragmentary some of the models from various sections of the complex (according to general scheme of model presentation depicted above) and offer recommendations as for their using to provide holistic learning of Mathematics, Science and Informatics at school.

Example 1. Section "Physics". Model "Lens"

Chain of the transdisciplinary links: Physics – Algebra – Geometry – Biology.

Model description: The model illustrates principle of operation of a lens as a simplest optical device that focuses or disperses a light beam. A lens consists of a single piece of transparent material (e.g. glass or plastic). A lens can focus light to form an image which differs it from prism (See Section "Physics". Model "Optical dispersion"). A lens has its optical axis, two focuses, main optical center and plane (you can find their definitions in your textbook). Lenses are classified by the curvature of the two optical surfaces. The model demonstrates the operation of exactly biconvex lens.

Procedure of cognitive activity with the model (selected tasks):

1. Operate the model. Change curvature with the slider. Monitor the focuses positions and image positions. Find and formulate dependences.
2. Fix the lens curvature and change the object position relative to the focus. What is happening with the image of the object?
3. Fix the object at the distances: $d = 2F$, $d > 2F$, $d < 2F$. Analyze changes and make conclusions.
4. Analyze changes of the image's size and position when the object is between $2F$ and F, between F and lens center.

Fragment of didactic support as a set of transdisciplinary tasks and real-life problems for forming holistic understanding of the optical device (might be offered trainees during both Physics, Algebra (Geometry), and Biology lessons):

1. Operate the model. What is mathematical dependence between object distance to the lens and focus distance? How is it called? Write the formula of the dependence.
2. What geometrical figures describe the object, its image, light beams and the phenomena of light penetration through the lens?
3. What geometrical facts and properties are revealed by the device operation?
4. Which angles are equal at any values of the model parameters? Why? Which rays are parallel? Why?
5. Working with the model, detect the parameters of the model which provide the highest optical power of the lens.
6. Operating the model and using the scheme of the optical system of a human eye (Figure 6), answer the questions: (1) what are the components of the eye optical system? (2) what is the difference between real and virtual image? (3) what are the basics of a human eye functioning from the standpoint of physics? (4) can you explain eye-sight disorders (short sight, long sight, etc.) via physical concepts and phenomena? (5) compare the principles of human eye operation and work of a digital camera.

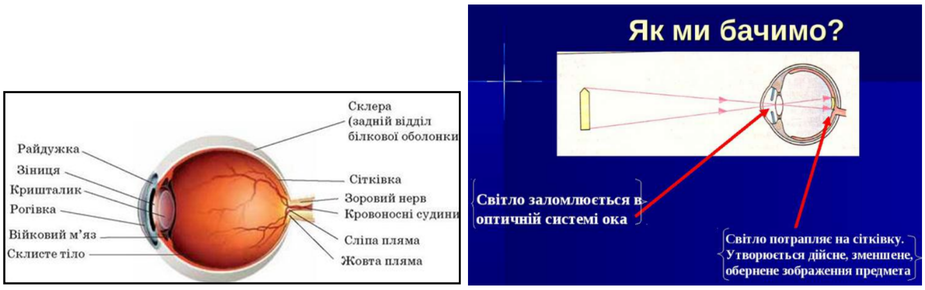

Fig. 6. Scheme of the optical system of a human eye

Episodes of transdisciplinary tasks doing and the model operating are shown on the Figure 7.

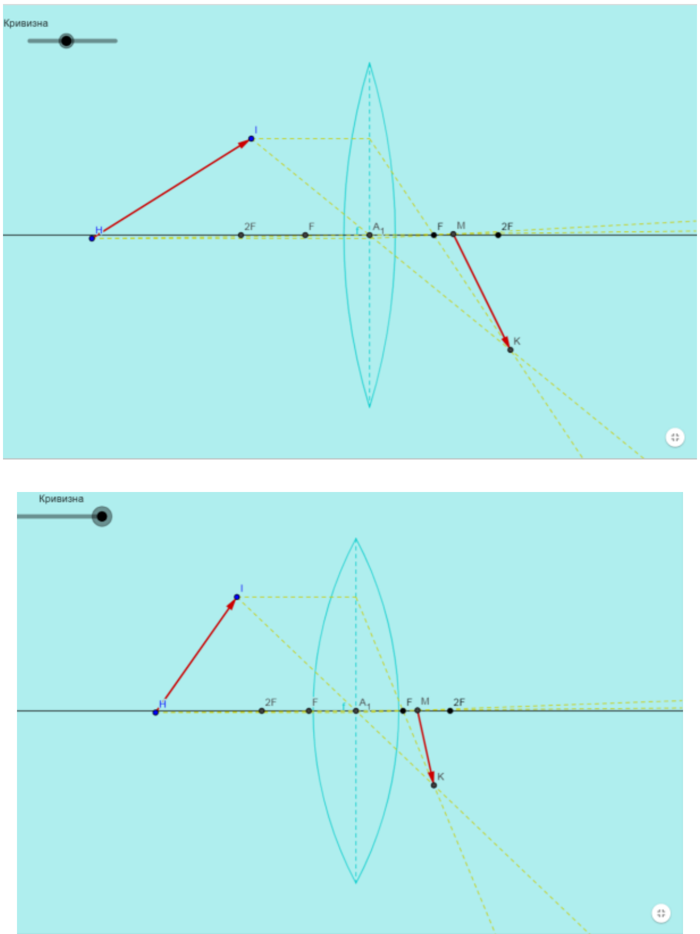

Fig. 7. Episodes of transdisciplinary tasks doing and the model “Lens” operating

Graph of the revealed transdisciplinary links for the visualization and remembering this holistic representation (presented on Figure 2 above).

Example 2. Section "Geometry". Model "Clock"

Chain of the transdisciplinary links: Geometry – Algebra – Physics.

Fragment of didactic support as a set of transdisciplinary tasks and real-life problems.

1. Operate the model, turn the clock hands, set the time (See Figure 8) and detect degree measure of the angles made by the hands.

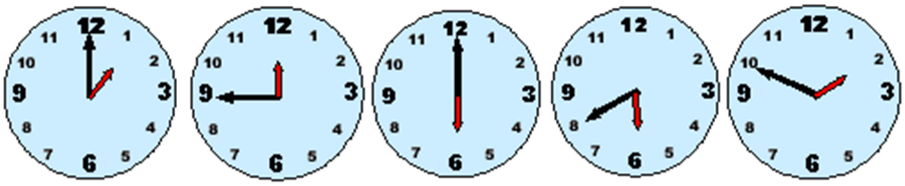

Fig. 8. Various moments of time to measure the angles between clock hands with the help of the model

2. Use the model with different parameters and calculate degree measure of: (1) the angel which makes tree fifth of the right angle, (2) the angle five sixth of which make a right angle, (3) the angle which makes 30% of a flat angle etc.
3. Operate the model to express the given values of speed in the measure of m/c: 7,2 km/h; 3600 cm/min; 6 m/min; 36 dm/h etc.
4. You know that clock is a device which measures time that is really precious thing for real life. Try to solve the real-life task like this one: Vira and Lara decided to send messages to his friend Igor to greet him with his birthday. Vira can text 24 words per 4 min, whereas Lara - 35 words per 7 min. Who is quicker, and whose greeting will Igor receive earlier if Vira sent a message of 30 warm words, and Lara texted 20 ones?

Episodes of transdisciplinary tasks doing and the model operating are shown on the Figure 9.

Presented transdisciplinary tasks done with the model, focus on forming holistic understanding of (1) a clock as a physical and geometrical device, (2) time as a physical concept and social phenomenon, (3) geometrical, algebraic and "clock" sense of degree measure of an angle.

Graph of the revealed transdisciplinary links (Figure 10).

Examples of transdisciplinary tasks doing with the different models operating are shown on the Figures 11, 12.

Our monitoring trainees' cognitive activity testified that they often do offered transdisciplinary tasks, applying two or three dynamic models together. It helps students to visualize cognitive connections and makes the investigation process more attractive and motivating for them [3]. The results of trainees' exploring with the models “Binary tree” (Section “Informatics”) and the model “Similarity” (Section “Geomentry”) are given on the Fig. 13.

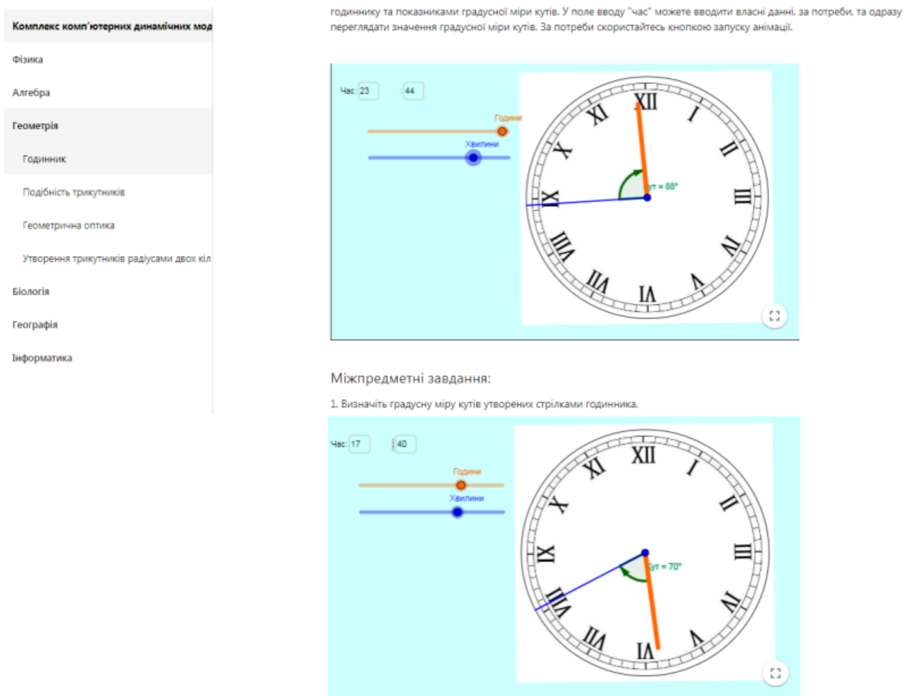

Fig. 9. Episodes of transdisciplinary tasks doing and the model “Clock” operating

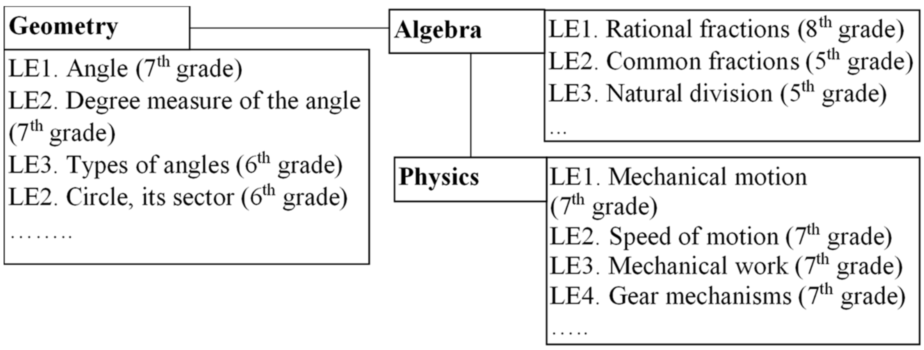

Fig. 10. Graph for selected Geomety LEs, representing the transdisciplinary links for the chain: Geometry-Algebra-Physics (Section “Geometry”. Model “Clock”)

Characterizing our didactic support to the models it is important to emphasize that it offers the transdisciplinary tasks of various types. In particular, there are tasks on establishing connections between concepts from different subjects. The aim of these tasks is to specify and generalize mentioned connections; to form the system of the notions of different level of generalization and subordination; to illustrate casual relations of phenomena. This type tasks and problems are directed on the forming of the set of transdisciplinary skills: to understand the links between the notions of different subjects and to formulate them verbally; to explain processes and phenomena of one science branch with the help of concepts of other branch; to make outlook conclusions based on common concepts, and others.

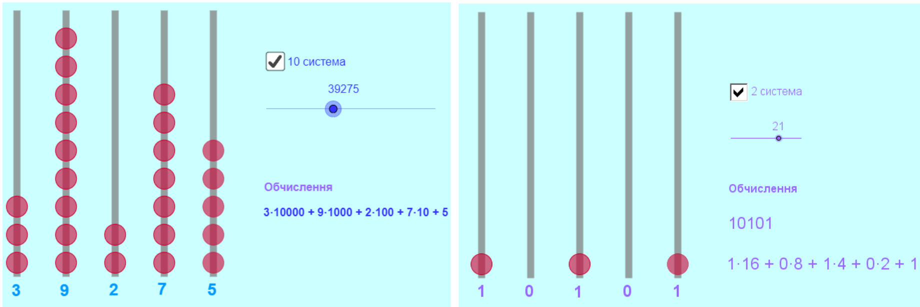

Fig. 11. Episodes of transdisciplinary tasks doing and the model "Number systems" operating. Connections chain: Informatics-Algebra

Besides, our didactic support proposes students transdisciplinary tasks on the determination of community of the facts from different subject areas. They help to specify learning material, to form new concepts and explain them from the standpoints of other branches of science, to use some facts to illustrate other ones. Such tasks are aimed at the forming students' skill of facts' analysis, generalization and explanation from the standpoint of general scientific ideas; skill to integrate generalized facts into the existing knowledge system; skill to apply generalized knowledge into practice.

In addition, into the didactic support there are included the tasks on the establishing connections between theoretical knowledge and methods, and their practical use. Mostly they are real-life problems which focus on the ruining boundaries between subject fields and reality. They might help to form the students' skill to see scientific subtext in pure practical tasks, to attract generalized knowledge from surrounding areas, and to apply them to resolving the problem.

Designing learning activity with the complex of models, we would recommend offering described transdisciplinary tasks of the didactic support after students' learning the model description and procedure of their cognitive activity with the model. It will also promote wholeness of the learning elements understanding.

Thus, the cloud-based complex of computer transdisciplinary models as for their functionality provides main principles of the holistic education, such as connections establishing, personal cognitive activity, focus on the ruining boundaries between subject fields and reality. It seems to be relevant to predict positive influence of the complex application on the forming of trainees' holistic system of knowledge and skills. Elaboration of proper methodology of its diagnosing [4] and estimation is a prospect of our further research.

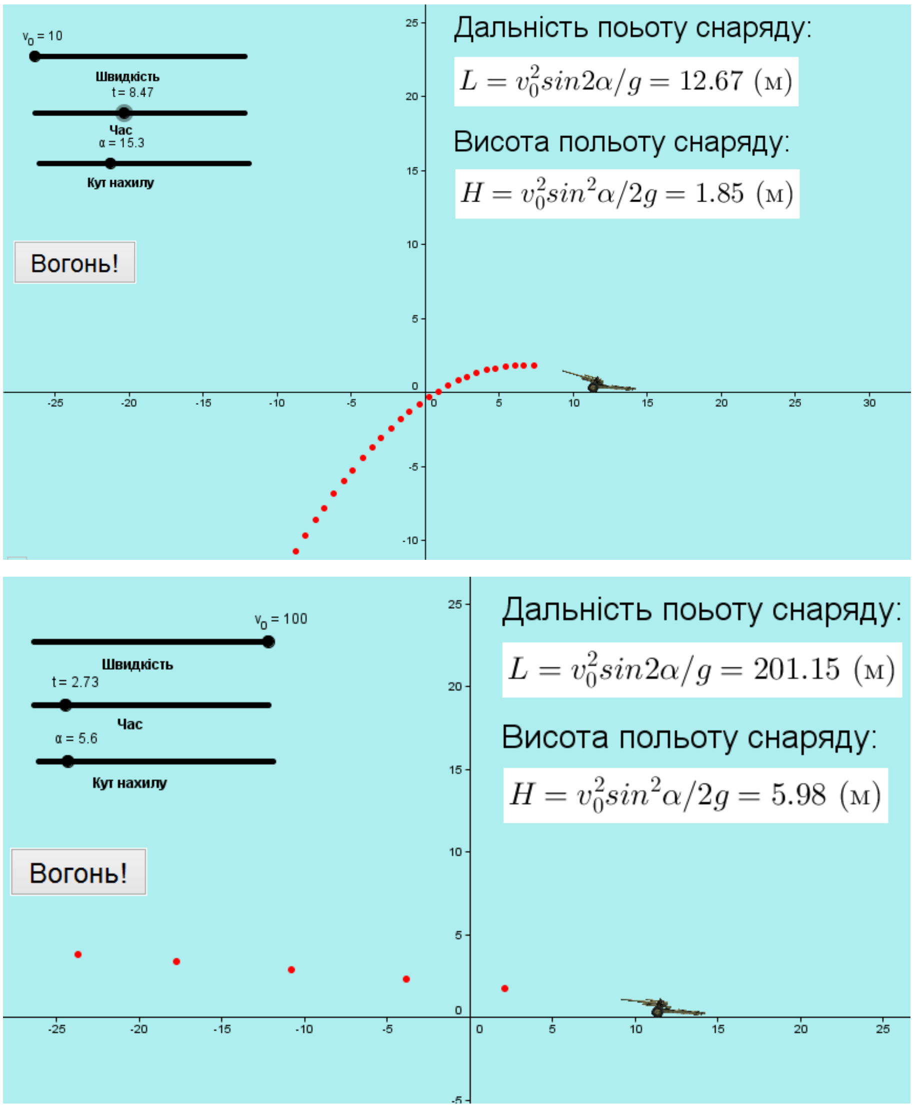

Fig. 12. Episodes of transdisciplinary tasks doing and the model “Cannon” operating. Connections chain: Algebra-Physics-Geometry-History

4 Conclusions

In accordance with its goal, the paper represents the authors’ cloud-based complex of computer dynamic models and their transdisciplinary facilities. Proper theoretical background for the complex design is elaborated and the process of the computer models development is covered. The models in the complex are grouped in the sections according to the curriculum subjects (Physics, Algebra, Geometry, Biology, Geography, and Informatics). Each of the sections includes proper models along with their description and transdisciplinary didactic support. The paper also presents recommendations as for using of the complex to provide holistic learning of Mathematics, Science and Informatics at secondary school. The prospects of further research are outlined.

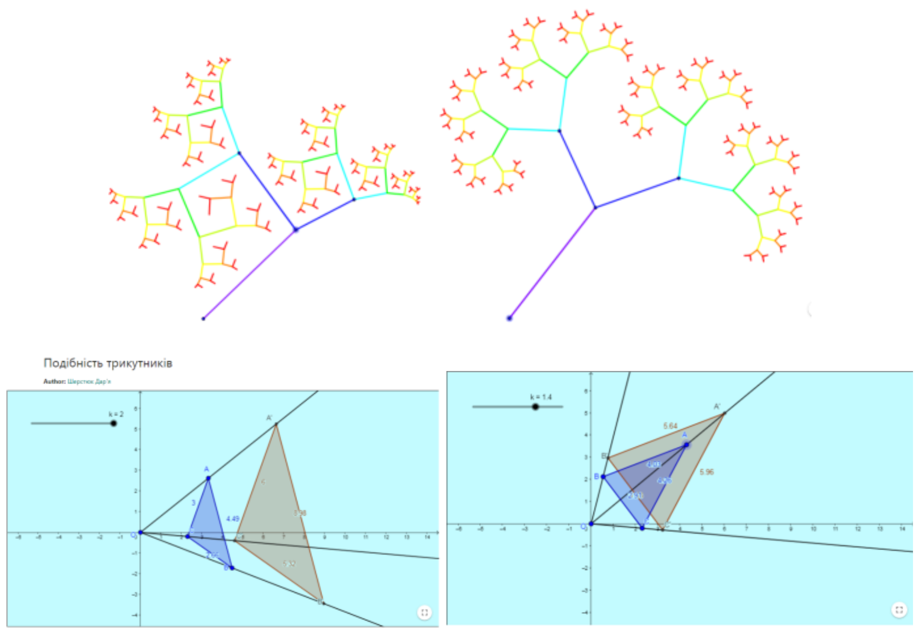

Fig. 13. Results of trainees' exploring with the models "Binary tree" (Section "Informatics") and the model ""Similarity" (Section "Geomentry")

References

1. Alessi, S.: Designing Educational Support in System-Dynamics-Based Interactive Learning Environments. Simulation & Gaming **31**(2), 178–196 (2000). doi:10.1177/104687810003100205
2. Bevz, V.: Mizhpredmetni zviazky yak neobkhidnyi element predmetnoi systemy navchannia (Transdisciplinary connections as a necessary element of the subject system of learning). Matematyka v shkoli 6, 6–11 (2003)
3. Bilousova, L., Gryzun, L., Zhytienova, N., Pikalova, V.: Search algorithms learning based on cognitive visualization. In: Ermolayev, V., Mallet, F., Yakovyna, V., Mayr, H.C., Spivakovsky, A. (eds.) Proceedings of the 15th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer (ICTERI, 2019), Kherson, Ukraine, June 12-15 2019, vol. I: Main Conference. CEUR Workshop Proceedings **2387**, 472–478. http://ceur-ws.org/Vol-2387/20190472.pdf (2019). Accessed 30 Jun 2019

4. Bilousova, L., Kolgatin, O., Kolgatina, L.: Pedagogical Diagnostics with Use of Computer Technologies. In: Ermolayev, V., Mayr, H.C., Nikitchenko, M., Spivakovsky, A., Zholtkevych, G., Zavileysky, M., Kravtsov, H., Kobets, V., Peschanenko, V. (eds.) Proceedings of the 9th International Conference on ICT in Education, Research and Industrial Applications: Integration, Harmonization and Knowledge Transfer, Kherson, Ukraine, June 19-22, 2013. CEUR Workshop Proceedings **1000**, 209–220. http://ceur-ws.org/Vol-1000/ICTERI-2013-p-209-220.pdf (2013). Accessed 21 Nov 2018
5. diSessa, A.A., Gillespie, N.M., Esterly, J.B.: Coherence versus fragmentation in the development of the concept of force. Cognitive Science **28**(6), 843–900 (2004). doi:10.1207/s15516709cog2806_1
6. Gryzun, L.: Integrative Approach to the Curriculum and Content Design for the Pre-Service Teachers' Training. PEOPLE: International Journal of Social Sciences 4(2), 1446–1462. https://grdspublishing.org/index.php/people/article/view/1572 (2018)
7. Gryzun, L.: Integrative technology of academic subjects structuring and its applications to practical didactic issues). Aktualni pytannia humanitarnykh nauk: mizhvuzivskyi zbirnyk naukovykh prats molodykh vchenykh Drohobytskoho derzhavnoho pedahohichnoho universytetu imeni Ivana Franka 16, 309–315. http://www.aphn-journal.in.ua/archive/16_2016/39.pdf (2016). Accessed 21 Mar 2019
8. Hryshchenko, M. (ed.) Nova ukrainska shkola: kontseptualni zasady reformuvannia serednoi shkoly (New Ukrainian school: conceptual fundamentals for reforming a secondary school). https://nus.org.ua/wp-content/uploads/2017/07/konczepcziya.pdf (2016). Accessed 05 Apr 2017
9. Mahmoudi, S., Jafari, E., Nasrabadi, H., Liaghatdar, M.: Holistic Education: An Approach for 21 Century. International Education Studies **5**(3), 178–186 (2012). doi:10.5539/ies.v5n3p178
10. Markova, O.M., Semerikov, S.O., Striuk, A.M., Shalatska, H.M., Nechypurenko, P.P., Tron, V.V.: Implementation of cloud service models in training of future information technology specialists. In: CEUR Workshop Proceedings (CEUR-WS.org) (2019, in press)
11. McDonald, J., Czerniak, C.: Developing Interdisciplinary Units: Strategies and Examples. School Science and Mathematics **94**(1), 5–10 (1994). doi:10.1111/j.1949-8594.1994.tb12281.x
12. Merzlykin, O.V., Semerikov, S.O.: Perspektyvni khmarni tekhnolohii v osviti (Prospective Cloud Technologies in Education). In: Proceedings of the scientific and practical workshop on Cloud Technologies in Modern University, Cherkasy, 24 Mar 2015, pp. 31–33. ChDTU, Cherkasy (2015)
13. Miller, J.P., Karsten, S., Denton, D., Orr, D., Kates, I.C. (eds): Holistic Learning and Spirituality in Education: Breaking New Ground. State University of New York Press, Albany (2005)
14. Miller, R. (ed.): New Directions in Education: Selections from Holistic Education Review. Holistic Education Press, Brandon (1991)
15. Miller, R.: Educational Alternatives: A Map of the Territory. Paths of Learning 20, 20–27 http://www.holisticedinitiative.org/wp-content/uploads/documents/ron_miller-map_of_educational_alternatives.pdf (2004). Accessed 21 Mar 2018
16. Ministerstvo osvity i nauky Ukrainy: Biolohiia 6–9 klasy. Navchalna prohrama dlia zahalnoosvitnikh navchalnykh zakladiv (Biology grades 6–9. Curriculum for general educational institutions). https://mon.gov.ua/storage/app/media/zagalna%20serednya/programy-5-9-klas/onovlennya-12-2017/15.biologiya-6-9.docx (2017). Accessed 21 Mar 2018

17. Ministerstvo osvity i nauky Ukrainy: Navchalni prohramy dlia 5-9 klasiv (Curriculum for 5-9 grades). https://mon.gov.ua/ua/osvita/zagalna-serednya-osvita/navchalni-programi/navchalni-programi-5-9-klas (2017). Accessed 21 Mar 2018
18. Semenikhina, O.V., Drushliak, M.H.: GeoGebra 5.0 tools and their use in solving solid geometry problems. Information technologies and learning tools **44**(6), 124–133 (2014). doi:10.33407/itlt.v44i6.1138
19. Semerikov, S.O., Shyshkina, M.P.: Preface. In: Semerikov, S.O., Shyshkina, M.P. (eds.) Proceedings of the 5th Workshop on Cloud Technologies in Education (CTE 2017), Kryvyi Rih, Ukraine, April 28, 2017. CEUR Workshop Proceedings **2168**. http://ceur-ws.org/Vol-2168/preface.pdf (2018). Accessed 21 Mar 2019
20. Shyshkina, M., Kohut, U., Popel, M.: The Systems of Computer Mathematics in the Cloud-Based Learning Environment of Educational Institutions. In: Ermolayev, V., Bassiliades, N., Fill, H.-G., Yakovyna, V., Mayr, H.C., Kharchenko, V., Peschanenko, V., Shyshkina, M., Nikitchenko, M., Spivakovsky, A. (eds.) 13th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer (ICTERI, 2017), Kyiv, Ukraine, 15-18 May 2017. CEUR Workshop Proceedings **1844**, 396–405. http://ceur-ws.org/Vol-1844/10000396.pdf (2017). Accessed 21 Mar 2019
21. Shyshkina, M.: Holistic Approach to Training of ICT Skilled Educational Personnel. In: Ermolayev, V., Mayr, H.C., Nikitchenko, M., Spivakovsky, A., Zholtkevych, G., Zavileysky, M., Kravtsov, H., Kobets, V., Peschanenko, V. (eds.) Proceedings of the 9th International Conference on ICT in Education, Research and Industrial Applications: Integration, Harmonization and Knowledge Transfer, Kherson, Ukraine, June 19-22, 2013. CEUR Workshop Proceedings **1000**, 436–445. http://ceur-ws.org/Vol-1000/ICTERI-2013-p-436-445-MRDL.pdf (2013). Accessed 21 Nov 2018
22. Singh, K.: Education for the Global Society. In: Learning: The Treasure Within, Report to UNESCO of the International Commission on Education for the Twenty First Century. UNESCO, Paris (1996)