

# Experience of Developing and Implementation of the Virtual Case Environment in Physics Learning by Google Services

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**Abstract.** The development of information and communication technologies (ICT), artificial intelligence, cloud computing, data science, digital platforms etc., causes changes in methodical means of teaching to increase the use of educational computer systems. Today, open information systems, global educational networks, digital resources going beyond the boundaries of separate educational institutions are developed. For example, Google services allow teachers to design the virtual educational environment with electronic educational resources, taking into account the individual characteristics of the students, the geographic region and the social structure of the country. In recent years, the education of Ukraine is oriented on the STEM education. The STEM centers, courses, curricula, information resources are developed. It promotes the choice of young people in engineering and technological professions. In the article, we analyze the particularity of Physics as a STEM discipline, and describe the experience of developing and implementation of the virtual case environment in the Physics learning by means of Google services. It promotes the involvement of students in research, the use of digital technologies in Physics learning. The implementation of the ideas of STEM-education on the basis of the Laboratory of Physics and Educational Technologies of the Kherson State University is presented.

**Keywords:** STEM education, case method, Google services, virtual case environment, informational computer technologies (ICT), Life Long Learning (LLL), curriculum.

## 1 Introduction

The international community defines education as one of the main global priorities, the main driving force of people's empowerment [1]. The goals of the National Strategy of Ukraine Education Development for 2012 - 2021 are: increasing the access to qualitative, competitive education for Ukrainian citizens in accordance with the requirements of society's innovative development, the citizen's economy; ensuring personal development in accordance with individual inclinations, abilities, and needs

based on lifelong learning [2]. Understanding of the research potential development and strengthening of the system of natural sciences and engineering education contribute to a sustainable future of the countries [3]. STEM education is developed and used all over the world. Case method as a learning tool can help attract students to research in any disciplines, particularly in Physics, using interdisciplinary connections with natural sciences, mathematics and computer science.

The aim of the article is to present the experience in developing and implementing of a virtual case environment in Physics learning by Google services and results of improving the students' learning quality in Physical education.

## **2 Related Works**

The analysis of Internet resources states there are a number of organizations, platforms and educational resources that help teachers to implement STEM education in different disciplines.

The largest and most popular ones are: 1) STEM.org is an American private organization. It serves schools, organizations in more than 25 countries of the world. It develops the curricula, content, manuals, course's materials for commercial and non-profit organizations [4]. 2) STEM learning works with the support of the UK Government, charitable foundations and employers. It seeks to increase the involvement of young people in STEM. It has the network of 19 Centers of STEM Ambassador Hubs throughout the country; it coordinates the work of volunteers who provide support and help in STEM education implementation [5]. 3) Inclusive Stem (I-Stem). It is the group of blind and visually impaired scholars from India. They aim to make natural science education more accessible by applying of STEM education. The main goal is to help people with special abilities to participate in new technologies development [6].

These resources provide services aimed at helping teachers and anyone to develop STEM education. There are a lot of practical resources, thematic magazines, upcoming events that will be held in STEM-education (hackathons, courses, seminars). Many companies offer scholarships for teachers, lecturers. There are a lot of STEM contests, competitions: "Student Spaceflight Experiments Program", "TOMATOSPHERE", "The FIRST Robotics Competition", "NASA Swarmathon University Challenge", "MUREP Aeronautics Scholarship and Advanced STEM Training and Research Fellowship", "MUREP Aerospace Academy", "MUREP Institutional Research Opportunity" [7]. It is worth to identify the scientific festival "CITY OF STEM" in Los Angeles. It is designed to show the importance of science, technology and engineering not only during the festival, but throughout the year. It brings together all the LaSTEM communities (Louisiana Advisory Council). It is promoted and monitored by STEM education programs [8; 9].

Introduction of STEM education in Ukraine is presented as the main direction of the education reorganization according to the concept of New Ukrainian School (NUS). "Plan of the implementation of STEM education in Ukraine" and "Methodical guidelines of STEM-education applying in general education and out-of-school

educational institutions of Ukraine” was developed by the STEM Educational department of the Institute of Education Content Modernization [10].

The Plan provides the development of STEM centers/laboratories on the basis of general education (regional support schools), out-of-school educational institutions, and scientific laboratories. They should have the appropriate material, technical, scientific and methodical base, and specialists for organizing of the effective educational and scientific project activities. The activity of STEM-centers/laboratories should be aimed at supporting and developing of STEM-education. There are recommendations of the development of the All-Ukrainian Scientific STEM Center on the website of the Institute of Education Content Modernization. It contains the regulatory documents and information sheets for upcoming events. There are no methodical guidelines (materials, curricula) for teacher’s use, etc. [11]. The list of NUS trainers, Internet marathons, and online seminars for advanced learning of primary school teachers were approved, but STEM-education for teachers of a general school has informal form [12]. It is at the initial stage of development. It needs to be improved in order to ensure the fulfillment of the new legislation norms.

As for STEM curricula in other countries, they include real life situations and problem’s solution to increase the learning impact. Learning technology of description of real life situations is called “case method”. This technique is the best suited for the NUS concepts implementation; it enables to bring the learning process closer to the real needs of specialists in different activities. The teachers should properly use this technique, have special skills and the thematic cases in the discipline or be able to develop them.

The analysis of Internet sources suggests: the problem of active methods use, in particular the case method in Physics learning in secondary and high school, is being studied by scientists to improve Physics learning quality [13, 14]; there are special centers, in which the cases in various disciplines, including Physics are developed and disseminated.

For example, Stanford University uses “Case Method Teaching”. It is widely used in many disciplines: students analyze real situations (cases). They are decision-makers and propose the problem’s solution. Students should understand and analyze the data of the case, consider the relevant theory, make conclusions and present solutions [15].

The mission of the National Center for Case Study Teaching in Science (NCCSTS) is the use of active teaching methods in natural sciences, with particular emphasis on case study technology and problem-based learning. The reviewed case collection contains more than 786 cases in all areas of science [16].

Virginia University engages students in the discussions using the case study method. At MBA program, students have possibility to explore more than 500 real business cases. Each case is a set of decisions that should be made, and student, as a decision-maker, should analyze the situation and express the opinion [17].

However, the cases used in foreign educational institutions should be adapted for Ukrainian curricula of education institutions. It is a problem. The dimensions of physical quantities used in the cases are unusual for Ukrainian students. Analyzing the literary and Internet resources, there is no platform or virtual environment that would have ready-made cases and methodical recommendations for their use.

The purpose of the research is to develop a virtual case environment that will help teacher and student to interact with each other by case method. The introduction of the competence approach and STEM education in the educational process requires the development and application of innovative teaching materials. They should meet the following requirements [18]: to be professionally oriented: to ensure a close connection of education, life and future professions by updating the life experience by setting tasks of real life (professional) situations; to be interesting for the student: to stimulate cognitive interest by formulating tasks in the form of a problem, which represents a real practical (life) tasks, the student will have in life and professional activity; to stimulate students to creative work in the future profession, to form decision-making skills in specific life situations by formulating tasks of different types - from reproductive to research and creative ones; to provide the opportunity to choose the problem and the way of its presentation by developing a system of problem tasks of an open, divergent, pluralistic type (several variants of answers competing with each other in terms of truth) [19].

Our research shown that in Physics learning within the framework of STEM-education, the definitions “Situational Learning” (a method for analyzing specific situations) [20], “Case-method” [21], [19], “Case study” [22], “Casus method” (it was written in the 20s of the 20<sup>th</sup> century), “Case-technology”, “Situational Analysis Method” [23], “Case Method Teaching” were required to process [15]. The name of method comes from the English “case” – “case, situation” and “suitcase for storing papers, magazines, documents” [19]. The essence of the case method is to analyze of specially designed Physical situations, ways of the solution, to assess and predict of consequences of the decisions. This method is widely used in business, marketing, finance, etc. In recent years, it is widely used in school didactics, in particular, to popularize the disciplines of the natural and mathematical cycle. In Physics study, this method is useful and expedient. Students think Physics is an incomprehensible, complex, not interesting, not necessary, “routine” science. The purpose of Physics study is to obtain a good mark and get the certificate. It becomes more and more difficult for a teacher to motivate students. Many schools do not have the necessary material support (multimedia, laboratory and demonstration equipment); it causes problems in Physics study. In case-method the student offers the variant of problem solving, based on the knowledge, practical experience and intuition and own individual abilities [23]. In the general case discussion, students identify the most significant problems, analyze the information, select the most important information, offer the possible solutions based on Physical knowledge and evaluate the probability of success. Consequently, the application of the system of practical-oriented cases in Physics study satisfies the above mentioned requirements. Students are able to solve not only abstract tasks from the textbook, but apply the gained knowledge in practice. They accumulate practical skills; develop analytical, creative and communication skills, volitional qualities, purposefulness, creativity, ability to compete. Case-method helps students to disclose the personal meaning of any educational material by themselves; it is one of the basic requirements of the new Ukrainian educational standards.

### 3 Practical Implementation of Virtual Case Environment in Physics Study

The literary sources analysis of the case-method introduction in Physics study allowed distinguishing the structure of the training case and didactic requirements.

There is plot, informational and methodical parts in the structure of training case. The plot is a description of a situation that contains information allowing understanding the context of the situation, indicating the source of data acquisition.

The information part of the case contains information that allows to understand the algorithm of steps: a) a brief description of the problem, it is desirable to give some different points of view; b) a certain chronology of the situation development with the indication of actions or influential factors, it is desirable to evaluate the results of their actions; c) the actions taken to eliminate the problem (if any); d) what resources can be allocated for solving this situation.

The methodical part of the case explains the place of this case in the structure of the discipline, formulates the tasks for students and a guides for the teacher. Teaching guide is not provided to students. The authors of the case should provide the specific recommendations for the analysis of situations, the author's analysis of situations, and the recommended methodology for conducting classes [23].

The didactic requirements for the case are following: a) to be written in an interesting, simple and profitable language; b) differ “dramatic effect” and problem; clearly define the “core” of the problem; c) to show positive examples and negative ones; d) meet the needs of the students, contain the necessary and sufficient information; e) the text of the case should not propose any decision of the problem [23].

In our research, we followed this structure of training cases. For example, the case “Efficiency of Simple Mechanisms”, studied in the 7<sup>th</sup> class of secondary school is presented (Fig.1).



The screenshot shows a web interface for an education platform. At the top, there is a navigation bar with the text "education platform" and "Главная" (Home) and "Дополнительно" (Additional) with a dropdown arrow. Below the navigation bar, there is a header section with the title "Efficiency of simple mechanisms" and an illustration of a person in a blue uniform using a pulley system to lift a large grey object. The main content area contains the following text:

**Plot block.** Inventor Ivanov Sergey Pavlovich argued that he created a simple mechanism for lifting loads with efficiency = 100%. Protecting his development, he said that the vain work that was spent on friction parts heating at lifting, he excluded.

**Information block.** For this purpose, the usual ropes was replaced by silk ones, which constantly were moisturized by wetting them with water. His opponents were the master of the department and the economist of the plant, who proved that his invention was not seriously thought out and it needs to be finalized.

**Question to the case:**

- 1) what arguments could be put forward by the master of the department and the economist?
- 2) what physical inaccuracies are in the text?
- 3) what is your advice for Sergey Pavlovich?

**Equipment:** textbook of Physics; additional information from the Internet.

**Methodological block.** To increase of the work group intensity it is divided into subgroups, the moderation method is used. It further increases the effectiveness of the case-method. It is advisable to use the role-playing game, to offer students the following roles: "economist";

Fig.1. Training case “Efficiency of Simple Mechanisms” without Google services

In our research we developed the training cases (real life situations) in Physics. They were divided into the following types: situations requiring an experiment, situations of computation of tasks solution, case studies of historical nature (with the help of instructions of teacher, students repeat experiments or imitate events that allowed making the significant physical discoveries), video cases, combined (combining several types). In order to form science and natural sciences competence, we developed a system of cases. They were developed by Google services. In order to be able to use the cases in any place and time, the problem of effectively cases' presentation was arisen. It was effective to develop the virtual environment. It gives access to study cases on the lesson and in any time. It enables the teacher to use different organization forms of student's educational activities (individual, group, collective, self-study). According to V. Bykov, the "learning environment" is an artificially constructed system, the structure and components contribute to the achievement of the goals of the educational process [24]. "Virtual case environment" is the software or platform used to provide educational services using case-method. The authors' experience in developing and using the electronic learning environment in the methodical students' learning (future Physics teachers [25]) allowed highlighting the advantages of the virtual educational environment. In particular, its advantages as a means of implementing the case-method are: Visibility (the possibility of using illustrations, diagrams, video); Research activities organization (students can use search engines to find answers to specific questions); Accessibility and remotability (students have the opportunity to work at home and in classrooms, from phone, tablet, PC etc.); Communicability (the connection between the teacher and the student, the students in the group); Ability to check homework and self-study activity of the student.

Unfortunately, in today's Ukrainian school the virtual learning environments are hardly used by Physics teachers, because of the inability of most teachers to develop the virtual learning environment. In order to provide the methodical assistance to Physics teacher in designing the environment, we developed the virtual learning environment for the implementation of case-method in a general school (Fig. 2).

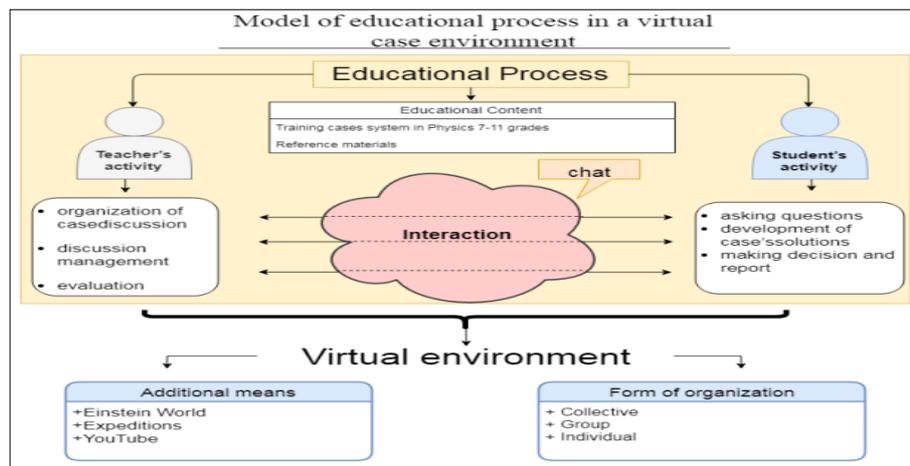


Fig.2. Model of educational process in a virtual case environment

The virtual case environment will allow organizing work efficiently, providing visibility and dialoguing between teacher and students.

The virtual learning environment for case-method implementing in Physics learning was developed in our research. It is based on the use of Google-services that are widely known to the Ukrainian community, students and teachers. But, despite the daily use of these services, most users are not familiar with the full potential of Google products.

To develop a virtual learning platform with cases, we used Google sites. To develop a site, the user should have the Google account. The mode of site's developing has a simple and intuitive interface. The main page of the virtual learning environment "Education platform", based on Google site is presented (Fig. 3).



**Fig.3.** The main page of the virtual learning environment "Education platform", based on Google site

It is divided into two thematic blocks. In the first block, the cases are divided according to the classes and the curriculum in Physics.

So, the class is presented as a functional button, after clicking on it the page containing a list of cases according to the topics in Physics is opened. The second block "Thinking Physics" presents interesting situations that are not theoretically related to the curriculum, but can be used as additional tasks. In "Development" mode, the teacher has the ability to add presentations, documents, tables, calendar or learning videos from YouTube, and preview the site. The site automatically adapts to the user's viewing on a phone, tablet, or PC.

Teacher has possibility to develop cases of two types: cases, the answers will be automatically sent to the teacher; cases, the student should answer orally or writing the solution in a notebook.

To organize the verification of the cases' correctness, it is expedient to use the Google-forms. This service allows conducting surveys in the classroom and in extra time (students' responses are sent to the teacher's e-mail).

We distinguished the benefits of cases, made using Google forms. Firstly, responses of the surveys can be presented in the form of a table or diagrams. Teacher and students are able to analyze, compare the results, develop problem situations, and discuss situations. Secondly, teacher has the ability to check the level of mastering of the learning material. Settings of this service allow the teacher to make time-based response, to choose the answer from multiple questions or to set up the transition to the next question based on the previous answers. For example, if the student chose the incorrect answer (the wrong solution to the situation), then the link with theoretical material is opened (Internet connection is required). Google forms provide an opportunity to accompany the case with photos and video materials.

The useful methodical feature is to create links in the text of the case. For curious students (or as additional information for case solving), teacher is able to configure the transition to additional educational sites. The useful links used in case solving are presented on the site. To provide feedback between the teacher and the student, we added the button "Ask the Teacher" on the virtual case environment. It works with the help of Google Hangouts.

Possibilities and advantages of case-method using and its implementation in Physics study were presented to Physics teachers of Kherson and the Kherson region. The teachers had advanced training courses in the Higher Education Institution "Kherson Academy of Continuing Education". Teachers were acquainted with the organization of educational process in the modern fully-equipped "Laboratory of Physics and Educational Technologies" of the Kherson State University. In particular, the possibilities of the virtual learning environment based on Google services were considered and the website (in test mode) with Physics training cases was presented. Teachers had the opportunity to solve case studies and test the site. Teachers underlined the importance of development of case studies in Google forms. Teachers pointed the necessity of designing the methodical guidelines of the virtual case environment.

The survey of 23 Physics teachers in the Kherson region to determine the level of awareness and interest of teachers in the virtual case environment using was conducted. The survey was conducted using the Google-forms, which allowed seeing the statistics of responses and demonstrating them. For example, Question № 1, "Are you familiar with the case method?" The positive answer was given by 78, 3%, but 21, 7% respondents are not familiar with the case method (Fig. 4). So, the case method needs to be more popular among teachers.

Are you familiar with the case method?

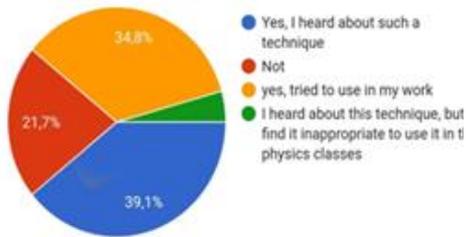


Fig.4. Distribution of respondents' answers (Question 1)

I would like to see it in more detail to use in my lessons and ...

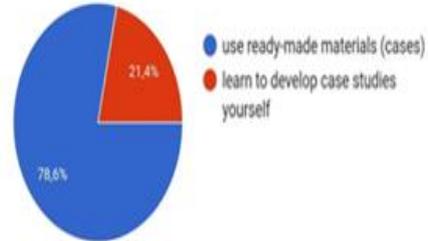


Fig.5. Distribution of respondents' answers (Question 2)

The results of the questionnaire gave reason to assert that 34, 8% of respondents tried to use the case-method in their lessons: but 78, 6% would like to use ready-made cases, and only 21, 4% seek to learn how to develop cases studies (Fig. 5).

91, 3% of respondents noted the feasibility of the virtual case environment developing. 4, 3% of teachers heard about this method, but they consider it inappropriate to use in Physics classes. 43 % of respondents didn't want to use case studies in Physics classes because: low awareness of this teaching method (20%), lack of ready-made cases studies (50%), difficulties in case lessons organization (30%) (Fig .6). 82, 6% of teachers are in need of methodical support of using this method in professional activity (Fig. 7).

I do not want to use this technique .....

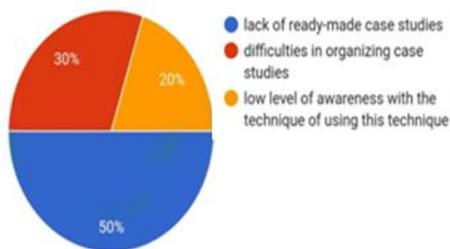


Fig. 6. Distribution of respondents' answers (Question 3)

Do you need methodological support for using this method in your lessons?

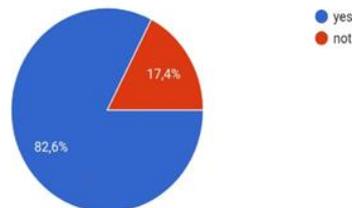


Fig.7. Distribution of respondents' answers (Question 4)

The analysis of the answers showed the use of the virtual case environment for the implementation of the “case-method” technology in Physics learning is actual, desirable for teachers, but teachers need methodical assistance in organizing of learning process.

So, we conducted the experiment using virtual case environment in Physics study. Students of the 8<sup>th</sup> grade (28 students) of Kherson Academic Lyceum of Kherson State

University took part in the experiment. Learning materials of the cases were used in the topic “Change of aggregate state of the material. Heat-Engines”. The use of case materials positively influenced the mastering of material by students. We analyzed the level of students’ knowledge mastering in “Temperature. Internal energy. Heat transfer” (traditional learning methods were used) and “Change of aggregate state of the material. Heat-Engines”(case-method was used).

The results of the experiment were: the quantity of students with a low level of knowledge in Physics was decreased by 11%; the greatest changes were among students with a sufficient level of knowledge, the quantity was increased from 32% to 47%; the positive changes were among students who have a high level of knowledge in Physics, the quantity was increased by 10%. The results are presented in (Fig. 8).

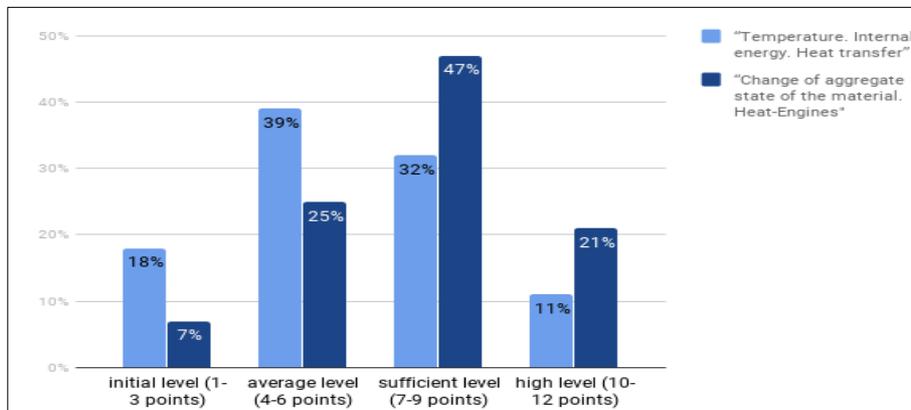


Fig.8. Students' level of knowledge at the beginning and the end of the experiment

The statistical justification of the reliability of the shift towards increasing of the level of learning material mastering by the students of the experimental group in of the case learning environment implementation was carried out using the G-criterion of signs. The results of the calculations showed that for the sample  $n = 22$  (6 null shifts were rejected)  $G_{amp} = 4$ , and  $G_{cr} = 5$  ( $p \leq 0.01$ ). The “axis of significance” (Fig. 9) was constructed, we convinced that  $G_{amp} < G_{cr}$ .

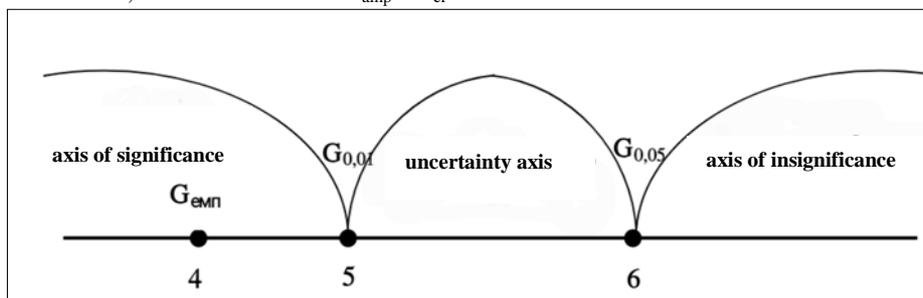


Fig.9. The “axis of significance” of the shifts in raising the level of learning material mastering by the students

So, the use of the case-method in Physics study contributes to increasing the motivation of students' learning activities and enhancement of the level of learning material mastering by students.

## 4 Conclusions and Perspectives

The results of the research indicate that in the context of the active transformation of education in Ukraine, special attention should be paid to a variety of new learning methods; technologies that will help implement the ideas of STEM-education. Case method is a learning technology, based on solving economic, social and business situations. We studied the features of this method and interviewed the teachers in Physics in cases' using on the professional activity. Many teachers are not familiar with the case-study method but they want to use it. The problem is the absence of ready-made cases in different disciplines and the methodical guides. The developed virtual case environment provides an opportunity to solve the described educational and methodical problems of case-method implementing in Physics learning.

The prospect of further research will be testing of the developed virtual case environment into the educational process of other schools and the development of methodical recommendations for ready-made cases.

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