

The development of students' critical thinking in the context of information security

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Abstract. The problem of students' critical thinking development in the context of information security becomes important in international and national educational policies as a means of fostering active citizenship and in turn sustainable development. The purpose of the given research is to introduce theoretical substantiation and experimental approbation of students' critical thinking development in the context of information security. The skills of critical thinking help students to cope with the bulk of information they daily receive. However, there is still no conventional methodology for critical thinking development in university students. In our study we suggest possible ways to develop critical thinking in university students via introducing some special courses into the curriculum, and consider the results of the experimental study conducted on the basis of two Ukrainian leading universities. In order to improve the students' skills of critical thinking the author suggested implementing the special course "The specifics of students' critical thinking in the context of information security", and an optional distance course on optimization of students' critical thinking on the background of information and communication technologies. After the implementation of the suggested courses the indicators of students' critical thinking development showed positive changes and proved the efficiency of the special courses as well as the general hypothesis of the study.

Keywords: critical thinking development, information security.

1 Introduction

In the course of substantiating the terms of information security, let us mention the interpretation of the "critical thinking" concept. It is a type of human intellectual activity characterized by high level of perception, understanding, and objective approach to the surrounding information field.

We believe that the modern globalization processes and the rapid development of information technologies in the multicultural world have led to negative consequences for humanity, and also affect the mission of higher educational institutions. For that

reason, these days the mission of modern universities is to develop the information culture of students in order that they could critically evaluate the events in the world and appropriately respond to them. Accordingly, a critically thinking student is able to adequately analyze information, verify its accuracy, data contradictions, select and evaluate arguments to prove.

It should be noted that “critical thinking” concept is quite common in both psychopedagogical periodicals, and technical publications. Moreover, there is no unique interpretation of “critical thinking” concept because it is multifaceted, so each researcher is focused on a particular aspect of the concept. An active study of this concept can be found in the context of foreign language learning. The explanation for this phenomenon is quite simple. Such strong interest of foreign language methodologists can be explained by the fact that the first scientific researches of this concept belong to foreign scientists and researchers. The definitions given by different authors have some differences and depend on their own approaches to the formation and development of critical thinking.

The researches of critical thinking began in the 1960s. Researchers made attempts to explain critical thinking via philosophical and psychological approaches. Richard Paul made attempt to give a definition for critical thinking. He argued that critical thinking included skills, such as spotting conclusions, examining premises, forming conclusions and diagnosing fallacies [16]. Consequently, he put forward the idea that critical thinking may be regarded as disciplined, self-directed thinking which exemplifies perfection of thinking appropriate to a particular mode or domain of thinking [16]. Tracy Bowell and Gary Kemp published a concise guide to critical thinking, where they introduced and discussed the main concepts related to critical thinking, gave examples and provided exercises and techniques of how to become a critical thinker [2]. Ian Wright regarded the problem of critical thinking in the context of the social world of the young learner [19], and Carol Ann Giancarlo, Stephen W. Blohm and Tim Urdan studied the issue of secondary students’ disposition toward critical thinking [5]. Margaret Lloyd and Nan Bahr researched critical thinking in the context of higher education [13]. Emily R. Lai gives a literature review on critical thinking; she explores the ways in which critical thinking has been defined by researchers, investigates how critical thinking develops, learns how teachers can encourage the development of critical thinking skills in their students, and reviews best practices in assessing critical thinking skills [11]. Murat Karakoç (2016) regarded the significance of critical thinking ability in terms of education process and the importance of thinking critically for a student who attends any education programme [9]. However, the problem of students’ critical thinking development in the context of information security has not been the subject for scientific discussion yet.

The purpose of the article is to introduce theoretical substantiation and experimental approbation of students’ critical thinking development in the context of information security.

Mass media as intermediaries and repeaters of information play a decisive role in the perception and reproduction by consumers of information messages of the real picture of the world. The information of the mass media is the most massive and accessible, so it is able to manipulate public opinion and create a so-called “informational picture of

the world”, which does not always correspond to reality. In the context of information security of society, the media play an ambiguous role: depending on the semantic content of the message, the information in them can help protect national interests and national information space, or vice versa, lead to destructive processes within society [14].

FM radio stations remain an effective tools of informational influence, which, thanks to the combination with musical accompaniment, significantly increase the suggestiveness and uncritical perception of any information directed at Ukrainian youth.

Thus, there is a separation and development of a new direction of intersectional research, namely – *information and psychological security*, in connection with the further development of information technology, which will significantly solve the possibilities of the media, and the power of this government will increase even more [18]. In the context of our research, the problem of forming information and psychological security of student youth is an urgent and priority task, especially in the context of informational-hybrid war [17].

Scholars emphasize the influence of the mass media on the course of any social processes with the development of Internet technologies continues to grow and is transformed from passive to active [15]. At the present stage, it is impossible to fully protect the consciousness of student youth from the negative impact of media influence, so there must be other means of protection against such influence on the consciousness of youth.

Confirmation of the relevance of our work is the opinion of scientists who are among the priority measures to ensure information and psychological security – is the development of critical thinking of students, including personal ways of active and passive protection from dangerous information influences and instilling skills of technologically competent information production [18].

Information security is a state of protection of information needs of the individual, society and the government, which ensures their existence and progressive development, regardless of the presence of internal and external information threats [6]. Some scholars understand the concept of information security as a value dimension of the object of security, that is, when it comes to human information security – it is primarily human needs, the possibility of which is enshrined in the legal field through its rights and freedoms [21].

From the political and legal point of view, the threat to the information security of Ukrainian government remains the threat of enemy influence on the information infrastructure, information resources, society, consciousness and subconscious to impose its own system of values, views, interests and decisions in vital spheres of public and government activity. The information component of informational influence is a psychological war, the purpose of which is not the destruction of millions of people, but intimidation, demoralization, worldview, spiritual and moral, national mutilation of Ukrainians [8]. Undoubtedly, in the context of the educational process at the university is the formation of national consciousness and sustainable national values in student youth, so in this period, ensuring information and psychological security is a strategic task of higher education in Ukraine.

Speaking about the informational and psychological security of student youth, then there are interrelated categories that will provide information and psychological security. The antonymous term “informational security” is the concept of “informational danger”. According to the logic of determining the content of antonymous concepts, we note that the means and mechanisms that cause information and psychological danger are means to be avoided or the definition of means and technologies that would counteract informational danger and ensure the formation of informational culture of student youth.

Such a tool is the category of “informational and psychological influence”, which is understood as the impact on the consciousness of the individual and the population in order to make changes in their behavior and worldview. The basic methods of information and psychological influence are persuasion and suggestion.

Persuasion is addressed to one’s own critical perception of reality. It has its own algorithms of influence:

- the logic of persuasion must be accessible to the intelligence of the object of influence;
- persuasion must be based on facts known to the object;
- persuasive information should contain general suggestions;
- persuasion must consist of logically consistent theses;
- the reported facts must be appropriately emotionally colored.

Suggestion, on the other hand, is aimed at subjects who are uncritical of information. Features of suggestion are:

- purposefulness and planned application;
- specificity of the definition of the object of suggestion (selective influence on certain groups of the population, taking into account the main socio-psychological, national and other features of these groups);
- uncritical perception of information by the object of suggestion (suggestion is based on the effect of perception of transmitted information as instructions for action without its logical analysis);
- certainty, specificity of the initiated behavior (the object must be instructed to carry out its specific reactions and actions that meet the purpose of the impact).

In today’s globalizing world, the first is the informational and psychological impact on the population, the second – economic and political (trade, gas, diplomatic) confrontation. And force operations, which are used in parallel, are aimed not so much at the conquest or retention of territory, as chaos, continuous conflict and the constant generation of provocations and staged military events for the zombie media [3].

The consequences of information effects are appeared in a number of effects, which are classified as follows:

- cognitive effects are appeared in changing the level of awareness, increasing the amount of knowledge (both in conscious and unconscious forms); formation of new cognitive schemes, ways of understanding reality, handling information;

- emotional effects are expressed in the change of emotional state, the appearance of some and the disappearance of other feelings, in changing the general emotional and psychological background of human existence, the emergence of impulses to active reflection, processing, transformation of information, the desire to obtain or create new, etc.;
- value effects are expressed in the formation of new or strengthening or weakening of existing interests, tastes, attitudes, evaluations, value orientations, guidelines about the world, individual objects, phenomena, about other people or themselves [12].

Thus, informational and psychological influence is directed to both individual and public consciousness by informational and psychological means, which causes a change of views, opinions, attitudes, values, motives, stereotypes of the individual in order to influence its activities (or inactivity) and behavior. Such influences involve the achievement of a certain reaction, behavior (activity or inactivity) of the individual, which meets a certain goal of informational and psychological influence.

Today, no drastic measures have been developed to counter informational attacks. This means that in the informational world success will be ensured through the increasing improvement of informational technologies [4]. Therefore, we believe that in the context of the current globalization situation in the world it is necessary to develop informational security technologies and develop informational and psychological technologies to prevent informational and psychological influences of the media by forming critical thinking of student youth.

Undoubtedly, the government must constantly improve the informational security system, taking care of the development of critical thinking of students, improving educational programs, carrying out educational and counter-advocacy activities in society and beyond. Therefore, we believe that the formation of critical thinking should take place at the student age, so in the educational process it is necessary to introduce technologies that contribute to the formation of informational and psychological security and national identity of student youth.

Despite the generally accepted concept of “critical thinking”, there is still no conventional methodology for critical thinking development in university students, so we shall suggest and experimentally test the methods and technologies for its testing. Presently, it is essential to organize and summarize the accumulated experience of scientists as to this concept.

Scientists suggest several stages of students’ critical thinking development. Particularly, in the first stage the students’ attention is focused on the problem, and they get interested in the topic under discussion; the second stage involves setting the goal and task of the lesson, checking the previously learned educational material; the third stage provides practical mastering of the educational material, achievement of the goal set; the last stage (reflection) involves analysis of the lesson, advantages and disadvantages in the classroom activity, elimination of possible mistakes in future educational activity [10].

More frequently, critical thinking is regarded as a person’s ability to think independently, to analyze information; the ability to realize mistakes or logical

violations in partner's statements; give reasons for their thoughts, change them if they are wrong; the presence of a mental part of skepticism and doubt; striving to find optimal solutions; courage, commitment to principle, bravery in defending their position; open-mindedness to different views [20].

In the course of scientific research, many scholars try to identify the key factors for critical thinking development in university students. Consequently, researchers believe that the major requirement is that the information should not be fully provided to the students, teachers should create conflicting and problematic situations in certain disciplines, which will activate students' critical thinking. Such strategy motivates students to find new information that is not sufficient for their complacency. The specifics of the educational discipline can also influence the development and consolidation of skills which teach students to logically build the methodology of gaining scientific knowledge in their professional field.

In the course of professional training a teacher should demonstrate a tolerant attitude towards any student's position, since such a position is personal and most vulnerable for the further personal development of the student. A positive attitude towards dissidence from both the teacher and the students is the principal condition for students' critical thinking development.

The most important and fundamental factor is to provide students with the basic necessary methods for the development of critical thinking, that is, to acquaint students with the basic thinking operations that inspire critical thinking [7].

In our opinion, the background of critical thinking is the pedagogical educational activity of students and the development of such skills as: analysis, synthesis, evaluation, comparison, correlation, etc. Students have to set themselves a series of goals to overcome difficulties, develop an improved working plan and realize that they can enhance their professional competence by means of internal resources.

The scholars in the field of education have also participated in discussions about critical thinking. Benjamin Bloom and his associates are included in this category. Their taxonomy for information processing skills is one of the most widely cited sources for educational practitioners when it comes to teaching and assessing higher-order thinking skills. Bloom's taxonomy is hierarchical, with "comprehension" at the bottom and "evaluation" at the top. The three highest levels (analysis, synthesis, and evaluation) are frequently said to represent critical thinking [1].

The term "taxonomy" means the classification and organization of objects, based on natural interrelationship, which is used to describe the categories arranged in order of their increasing complexity. One of the main principles of taxonomy is that it should be an effective tool, both in learning and evaluating learning outcomes. Bloom's taxonomy is presented in table 1.

In the context of our research we are interested in the highest possible level of critical thinking development (4, 5, 6 levels in the table 1), namely: analysis, synthesis, evaluation of information received. Consequently, the fourth level (analysis of the information received) involves such students' activity as dividing information into related parts. The activity of the tutor/curator includes the following: he accompanies, teaches, helps to make attempts, and finds the sources of information.

Table 1. Bloom's taxonomy.

<i>Thinking skills</i>	<i>Definition</i>	<i>Curator or tutor activity</i>	<i>Students' activity</i>
Evaluation	Evaluation based on criteria	Evaluation based on criteria	Evaluate, assess, argue, give evidence, determine give preference; make choice, support, draw conclusions,
Synthesis	Combining information to create a new entity	Expands, evaluates, reflects, influences	Systematize, combine, connect, create, design, invent redistribute, modernize, suggest hypotheses
Analysis	Dividing information into related parts	Accompanies, teaches, assists, tries to find the sources of information	Analyze, arrange, systematize, compare, establish correlation organize, ask questions, relate, separate
Usage	Using of concepts, ideas in new situations	Observes, draws attention, promotes, helps, criticizes	Use, consume, calculate, demonstrate, give examples, interpret, relate, make a list, describe in general terms
Understanding	Understanding	Verifies, correlates, demonstrates	Discuss, recognize, retell, explain, make messages, demonstrate examples
Knowledge	Identification and retelling	Tells, shows, manages, points	Memorize, learn, master, recognize, remember, name; cite, identify, register, put to a certain category

As a result, students should adequately analyze, arrange, systematize, compare, establish correlation (between words, parts of a whole), contrast, distinguish, differentiate, separate parts, draw (conclusions), organize, ask questions, relate, and separate.

At the fifth level (synthesis) students should combine information to create a new entity. The activity of the curator in the course of thinking skills development is to expand, evaluate, reflect and influence the activities of students.

As a result, students must learn to systematize, combine, connect, create, design, invent, construct, generate (principles, rules), integrate, enlarge, elaborate, transform, modify, correct, arrange, work up, rearrange, redistribute, modernize, use instead of something, suggest hypotheses, etc.

The highest level (evaluation) gives the student an opportunity to determine the value based on criteria. In this case, the activity of the curator/tutor is accompanying, because he clarifies, concludes, admits, recognizes, agrees, leads to agreement as to one or another piece of information.

As a result students should evaluate, assess, argue, give evidence, determine (rate, significance, benefit, harm), give preference; make choice, support (requirements,

standards, criteria), draw conclusions, persuade, make decisions, uphold, justify (actions, deeds, etc.), judge, attribute (class, rank), become arbitrators, anticipate, predict, distribute places, provide recommendations, corroborate evidence, argue for (something/somebody).

2 Methodology

To achieve the goal of the given study we have used such theoretical methods of research as analysis of philosophical, psychological and pedagogical literature on the problem of research in order to determine the conceptual and categorical apparatus and to consider the state of theoretical and practical elaboration of the problem of students' critical thinking development. Also, we have applied the following empirical methods: observation, interviews, questioning, testing to diagnose the level of students' critical thinking development; pedagogical experiment to test the effectiveness of the proposed educational conditions; statistical methods for processing the results of experimental work.

Students of two Ukrainian leading universities have participated in the pedagogical experiment. We have selected Luhansk Taras Shevchenko National University and Volodymyr Dahl East Ukrainian National University as two universities which relocated during the years of the information-hybrid war in Ukraine.

According to the first task of the second stage of the observational experiment, a total sample of 130 students was selected. The sample consisted of a total of 63 students of the specialty "Ukrainian language and literature and English language", "Biology", "Geography", "Music", "Physical education", "Physics", "Mathematics" and "Informatics" in control group and 67 people in experimental group.

The experimental study was conducted during 2016 and 2019. It covered several stages of scientific and pedagogical research.

The first stage (October 2016 – February 2017) – the study of psychological, pedagogical and methodological literature in terms of a particular problem; analysis of normative and methodical literature on the formation of critical thinking of students; defining the purpose, object, subject and general terms of the study. The hypothesis was formulated; the tasks and the program of scientific research were defined.

The second stage (2017 – 2018) – the main theoretical and methodological approaches to the research problem were established; criteria, indicators and levels of formation of students' critical thinking were substantiated and determined; developed a special questionnaire for students and experts-teachers-methodologists "The specifics of students' critical thinking in the context of information security" to study the initial and final state of the control and experimental group, as well as the required number of students; the duration of the experiment was chosen, and the real state of the level of formation of critical thinking of students of the control and experimental group was determined during the ascertaining stage of the experiment.

The third stage (2018 – 2019) – the formative stage of the experiment was carried out, which provided for a direct experiment to form critical thinking of students. At the same time, considerable attention was paid to testing the probability of our hypothesis,

which involved determining the pedagogical conditions that affect the level of formation of critical thinking of students. At this stage, the special course “The specifics of students’ critical thinking in the context of information security” was introduced. This course was developed on the basis of an optional distance course on optimization of students’ critical thinking on the background of information and communication technologies.

The introduction of the pedagogical condition for the optimization of students’ critical thinking on the background of information and communication technologies through the use of modern web technologies was carried out in order to provide purposeful guidance to the tutor of this process. This condition was aimed at forming students’ critical thinking and providing counseling in the process of raising their awareness of the search, retrieval and critical analysis of certain information; to increase the ability of students to independently create and develop new knowledge based on the information obtained; on the development of the ability to information insight, the ability to design and build possible consequences based on the information obtained. To fulfill this condition, during the period of implementation of this condition, a special eight-week course was created on the Moodle platform for the formation of critical thinking of students who could join the project optional.

At the first stage of the project on the formation of students’ critical thinking by means of web technologies was provided by information and cognitive web resources special course on the platform Moodle, which would contribute to the formation of skills of critical analysis and media literacy of students; secondly, it was necessary to involve and motivate students to participate in an experimental project on the formation of informational culture. In the second stage, the content of the special course was filled with web resources that were used in the experimental study.

Let us proceed directly to the detailed characteristics of each criterion of students’ critical thinking development in the context of information security.

We have developed the criteria and indicators of students’ critical thinking (table 2):

1. *motivational* (motivation to search, retrieve and critically analyze certain information; constant motivations to achieve success, self-fulfillment in professional activity);
2. *content-related* (basic knowledge about information resources, information systems, information technologies, informatization of society; the ability to independently create and develop new knowledge based on the information received);
3. *activity-based* (the ability to operate following the sequence of actions and complete awareness of the actions for critical analysis of new information; information insight, the ability to plan and predict possible consequences based on the information received);
4. *resultative* (self-assessment and self-reflection concerning the critical analysis of the information received; the ability to predict the result through critical thinking due to the information received).

In order to evaluate the effectiveness of the formation of students’ critical thinking, we developed a self-assessment questionnaire for the teaching staff. Let us consider its

contents. Questionnaire to identify basic knowledge about information resources, information systems, information technologies, informatization of society:

1. What do the “new opportunities of the 21st century” mean to you? How, in your opinion, the 21st century is radically different from the 20th? Why, in preparing students for life in the 21st century, should we teach them differently today? Think about these questions and write down your answers.
2. What qualities must a person have in the 21st century in order to be successful in professional activities, public and private life? Think for five minutes and write down your answers.
3. Learn about different approaches to identifying the most important human qualities of the 21st century. What is the similarity and what is the difference? Which of the following skills were not named in groups? Why do you think so? Write down your thoughts.
 - a. Educators have long discussed what is more important: factual knowledge or practical and conceptual knowledge. Those who believe that factual knowledge is more important usually believe that there is a set of facts that can be memorized that will prepare students to become active participants in the social system. Others say that conceptual knowledge and practical experience are most important, and argue that knowledge alone is not enough. Moreover, they believe that knowledge is only valuable when it is useful, and that it is only useful when it is understood in conceptual terms and can be applied creatively and critically.
 - b. No one doubts the importance of factual knowledge. People need to know a lot in order to be successful in their daily activities. However, the idea that there is a set of knowledge that will give students practical preparation for the future as changes in society accelerate is becoming less popular. The difficulty of describing such a set of wise ideas becomes clear when you begin to realize that 100% of what we know today is only 10-15% of the knowledge that will be relevant in 25 years. Moreover, this rapidly growing knowledge base will soon become more and more accessible to everyone.
 - c. Now that electronic communication systems cover almost all countries of the world, the school and home are becoming a kind of information centers with access to world information.
 - d. In order to operate successfully in a changing world, students must be able to sift through information and make decisions about what is important and what is not. They will have to understand how different pieces of information can be related to each other, learn to look at new ideas and knowledge in an appropriate context, make sense of new meetings, reject information that is irrelevant or incorrect. Students must learn to critically, creatively and productively evaluate the part of the information universe that they encounter.
 - e. To manage information well, students will have to master practical thinking skills. This will enable them to efficiently sort information based on the idea; the selected information will lead to the correction of the idea and can be transformed into practical forms of behavior. In short, they will have to become critical thinkers. However, this does not happen automatically. Experience in reviewing,

processing and appropriating useful information and ideas should be accumulated. The critical review process should be systematic.

4. Which of the computer technologies, social services, graphic packages, technical means of training of the new generation known to you can be used for formation of the successful person skills?
5. Which of the computer technologies, social services, graphics packages, technical means of learning of the new generation known to you are available to you? What do you not wield, but would like to learn? Write down the most interesting ideas.
6. Are you ready to meet the new opportunities of the 21st century? Whereby.
7. Are you ready to take a new look at the subjects you have been taught?
8. Are you ready to rethink your way of thinking to help your students do the same? Why?
9. Are you ready to learn to think critically to pass on this desire and then the skills to your students?

Table 2. Criteria and indicators of students' critical thinking development in the context of information security.

<i>Criteria</i>	<i>Indicator</i>
Motivational	1) motivation to search, retrieve and critically analyze certain information; 2) constant motivations to achieve success, self-fulfillment in professional activity;
Content-related	3) basic knowledge about information resources, information systems, information technologies, informatization of society; 4) the ability to independently create and develop new knowledge based on the information received;
Activity-based	5) the ability to operate following the sequence of actions and complete awareness of the actions for critical analysis of new information; 6) information insight, the ability to plan and predict possible consequences based on the information received;
Resultative	7) self-assessment and self-reflection concerning the critical analysis of the information received; 8) the ability to predict the result through critical thinking due to the information received.

Questionnaire to identify skills in working with information data and the ability to independently develop new knowledge based on the information obtained:

1. Students today receive most of the information not in books, as it was before, but on the Internet. How do you think reading a book differs from reading from a monitor screen?
2. Are there any problems reading the book and reading from the monitor screen?
3. How does reading a book and reading from a monitor screen affect the perception and understanding of information?
4. Think about how the technology of developing critical thinking through reading and writing can be used when reading from electronic rather than paper media?

5. Read the proposed text. How do you see the prejudication and bias of the author? Why did you decide so?
6. How reliable can this source be? What is the criterion of reliability for you?
7. What is the point of view of the author of this material? Why do you think so? Is it possible to trace the logic of reasoning as the author comes to his conclusions and inferences?
8. How the author's position is strongly argued? Or does he invite you to take his judgments on faith? How did you come to this judgment?
9. How accurate is the information in this material? What did you do to make sure it was accurate?
10. Does the author give alternative points of view? How does he relate to the arguments of his opponents?

After the control stage of experiment, we came to the conclusion that motivational skills appeared to be the most developed in students. Their average rate in Control group (CG) is 33% and in Experimental group (EG) is 32%. Cognitive skills are less developed, their average rate in CG is 22% and in EG – 27%. We must admit that the data for this criterion in the experimental group is higher than in the control group. It indicates that the experimental group has a higher success rate than the control group. However, the success rate is not vital to critical thinking development, so it will not have a significant impact on the general indicator of critical thinking in the process of its development.

The indicator of students' activity skills is at the lowest level of development, as its average rate in CG is 10% and in EG – 16%. Resultative-reflexive skills are also underdeveloped in students, sufficient level of development is observed only in about a quarter of students and the average rate in CG is 27% and in EG – 26%.

The experimental stage dealt with the implementation of proposed special course "The specifics of students' critical thinking in the context of information security". The content of this course consisted of three modules such as:

Module 1. "Web resources for verifying information and data and its security".

Topic 1.1. Legal information (founders, signatories, date of registration, contact address and telephone number).

Topic 1.2. Public procurement system ProZorro.

Topic 1.3. How to find out about a website owner? Information about digital security; Industrial Portal (some victories against betrayals).

Module 2. "Leading Ukrainian media organizations in FB".

Topic 2.1. Media Detector – explores the entire media space of Ukraine (news, political (and not only) programs, talk-shows, movies, and TV shows), as well as a variety of text and video material on the site, results of social studies, etc.

Topic 2.2. The Ukrainian Press Academy is the first organization to develop and implement media literacy programs in education in Ukraine.

Topic 2.3. Stopfake – a project to refute the fakes of Russian propaganda "Without lies – a project to expose the lies of Ukrainian politicians and fact-checking". MEDIALAB is a brilliant project with accessible articles from practitioners and many

tests. Independent Broadcasting Association - a lot of training in the management and marketing of television companies.

Module 3. “Critical information analysis projects, guides, and films”.

Topic 3.1. Resources for information verification. “Information Security Recommendations on the Internet during the Conflict”.

Topic 3.2. How to distinguish real news from lies, manipulations and half-truths. Instruction.

Topic 3.3. European truth – information concerning European integration, visa waiver, etc.

At the final stage, the results obtained during the ascertaining and forming stages of the experiment were analyzed and statistically processed. Tables and diagrams on the dynamics of the level of formation of critical thinking of students were compiled, and on the basis of the experiment general conclusions were formulated.

Comparing the average indicators of control and experimental groups (table 3), we can see that the level of students’ critical thinking development is approximately equal in all criteria and indicators.

Table 3. Distribution of students control group and experimental group according to their level of critical thinking development according to each criterion before formative stage.

Criteria	Levels the number of people in %					
	Low		Average		High	
	CG	EG	CG	EG	CG	EG
1. Motivational	26	25	41	43	33	32
2. Content-related	32	25	46	48	22	27
3. Activity-based	34	34	56	50	10	16
4. Resultative	29	29	44	46	27	26

The analysis of the results of control stage experiment has led us to the conclusion that the level of critical thinking in students in the context of information security is insufficient. It should be taken into account when developing appropriate pedagogical conditions and modern methods for students’ critical thinking development. The insufficiency of the level of students’ critical thinking development in the context of information security is supported by several arguments. Students’ professional training is mostly focused on knowledge acquisition, while their skills remain underdeveloped. Obviously, students are expected to independently find the ways to put their knowledge into practice through critical thinking, but teacher-trainers do not control how it really happens in practice.

3 Results

During the formative stage of the experiment in the course of achieving the goal set, we proposed to develop a curriculum for the course “The specifics of students’ critical thinking in the context of information security”; to develop an optional distance course

on optimization of students' critical thinking on the background of information and communication technologies.

After the implementation of the suggested course, we have obtained the following results presented in table 4.

Table 4. Distribution of students from control group according to their level of critical thinking development according to each criterion after formative stage.

Criteria	Levels the number of people in %					
	Low		Average		High	
Experiment stage	Before	After	Before	After	Before	After
1. Motivational	26	19	41	44	33	37
2. Content-related	32	26	46	39	22	35
3. Activity-based	34	23	56	39	10	38
4. Resultative	29	19	44	30	27	51

According to the results of final diagnostics of indicators and levels of critical thinking development in students from control and experimental groups, we have obtained the data, which proved the efficiency of the implementation of the special course "The specifics of students' critical thinking in the context of information security", as well as an optional distance course on optimization of students' critical thinking on the background of information and communication technologies. We have obtained the following results presented in table 5.

Table 5. Distribution of students from experimental group according to their level of critical thinking development according to each criterion after formative stage.

Criteria	Levels the number of people in %					
	Low		Average		High	
Experiment stage	Before	After	Before	After	Before	After
1. Motivational	25	11	43	33	32	56
2. Content-related	25	12	48	31	27	57
3. Activity-based	34	15	50	28	16	57
4. Resultative	29	6	46	29	26	65

General tendency of variability of indicators and levels of students' critical thinking is almost identical in dynamics. At the ascertaining stage of the experiment, the majority of students from CG (44%) showed an average level and thus all indicators in CG needed improvement. The data from two tables proves that in both groups there is a tendency for the predominant development of indicators of students' critical thinking in the context of information security. However, comparing the results obtained from control and experimental groups, we have noticed a certain difference. Thus, the experimental group's indicators are higher than those of the control group.

To compare the results of summative and formative assessment stages, we also used the Kolmogorov-Smirnov λ -criterion. The criterion allows to compare two empirical

distributions and conclude whether they are consistent with each other. Here is a brief summary of the calculations applying this criterion.

The Kolmogorov-Smirnov λ -criterion is intended to compare two distributions: 1) empirical with theoretical, for example, uniform or normal; 2) one empirical distribution with another empirical distribution.

The criterion allows to find the point in which the sum of accumulated divergencies between two distributions is the largest and to assess the validity of this divergency.

If, in the χ^2 method, the frequencies of two distributions are compared separately according to each category, then under the Kolmogorov-Smirnov λ -criterion firstly the frequencies from the first category are compared, then the sums of the first and the second categories are compared, then the sums of the first, the second, and the third categories are compared, and so on. Thus, each time we match the frequencies accumulated in this category.

If the divergencies between the two distributions are significant, then at some point the difference in accumulated frequencies will become critical, and we shall be able to recognize the divergencies as statistically valid. Hypotheses to be verified are the following: H_0 – the divergencies between two distributions are unreliable; H_1 – the divergencies between two distributions are reliable.

The results of the λ -criterion calculations are given in the table 6. The analysis of table 6 shows that the empirical value of the λ_{emp} criterion at summative assessment stage is less than the critical value of 1.36 for all the criteria (corresponding values are 0.130, 0.955, 0.829, and 0.278), therefore, the differences between the distributions in control and experimental groups at summative assessment stage are statistically insignificant ($p > 0.05$).

Table 6. Comparison of the distributions in CG and EG according to their level of critical thinking development according to each criterion after formative stage by the Kolmogorov-Smirnov λ -criterion.

Criteria	The empirical value of the Kolmogorov-Smirnov λ -criterion when comparing the control and experimental groups at summative assessment stage	The empirical value of the Kolmogorov-Smirnov λ -criterion when comparing the control and experimental groups at formative assessment stage
Motivational	0.130	2.605
Content-related	0.955	2.990
Activity-based	0.829	26.01
Resultative	0.278	1.906

As we can observe, the empirical value of the λ_{emp} criterion for all the criteria at formative assessment stage exceeds the critical value of 1.63 (corresponding values are 2.605; 2.990; 2.601; and 1.906); consequently, the differences between the distributions in control and experimental groups after the experiment are defined at the level of $p < 0.01$.

Consequently, the results of the processing of experimental data by mathematical statistics method prove the efficiency of the created pedagogical conditions for the students' critical thinking development in the context of information security.

4 Conclusions

Experimental and research work on students' critical thinking development in the context of information security, as well as analysis of the results obtained through the developed system of criteria, showed rather steady and positive dynamics of particular indicators and general level of critical thinking of students involved into experimental work. Consequently, the successful solution of the problem of students' critical thinking development at theoretical and practical levels has proved the general hypothesis of the study that the process of students' critical thinking development in the context of information security should be carried out via the introduction of the special course "The specifics of students' critical thinking in the context of information security", as well as an optional distance course on optimization of students' critical thinking on the background of information and communication technologies.

The given study does not cover all the aspects of the problem under discussion. Issues related to the development of critical thinking in the context of distance learning, searching the effective methods to correct the consequences of insufficient development of critical thinking in students require further study.

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