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THE RAPID GENERATION OF E-LEARNING TOOLS UNDER RESOURCE CONSTRAINTS APPROACH

Enhancing the efficiency of Ukraine's security and defense sector is one of the key prerequisites for maintaining state sovereignty and achieving victory in the war. This is particularly relevant to the training and education system for specialists of the State Service of Special Communications and Information Protection of Ukraine (SSSCIP). The active phase of Russia's war against Ukraine has significantly exacerbated the contradiction between the necessity to improve the efficiency of this system on one hand and the stringent requirement to economize resources (financial, human, and temporal) on the other.

Resolving this contradiction is feasible through the intensive implementation of various e-learning tools and technologies, along with associated pedagogical methodologies. One of the factors limiting the effectiveness of e-learning is the complexity of the traditional process of creating these tools. The negative impact of this factor can be mitigated by developing approaches for the rapid generation of e-learning tools. Thus, there is a need to develop an integrated approach that enables the quick creation of educational content and e-learning tools through the use of innovative technologies. Such tools should save time and enhance the efficiency of learning material assimilation. The primary requirements for this approach include the rational use of limited resources and the adaptability of outcomes to the needs of each specialist.

The article proposes an integrated approach to the rapid generation of e-learning tools for studying hardware and software devices and systems. This approach includes the following stages:

- developing a paper version of the learning material, which is the foundation for further enhancements;
- supplementing the paper version with an eBook based on H5P, which ensures interactivity and flexibility in learning;
- introducing a simulator module that allows for the emulation of device operation, stimulates student engagement, and deepens understanding of the material;
- adding an augmented reality module that visualizes complex concepts and provides opportunities for practical knowledge application.

The implementation of the integrated approach to the rapid generation of e-learning tools is demonstrated using the educational module "Fortinet FG-60E Firewall." This module exemplifies how the integrated approach can be applied to prepare specialists in Ukraine's security and defense sector under wartime conditions. Survey results from participants who utilized the developed integrated learning approach indicate its high effectiveness.

Key words: e-learning, generation of e-learning resources, integrated approach, interactive learning tools, H5P, augmented reality, content generation.

Problem statement. The modern world of information security is rapidly changing, posing new challenges and dictating new rules of the game. Traditional training methods no longer meet the dynamic needs of the time, therefore, in the context of the legal regime of martial law, the need for effective training of highly qualified specialists of the security and defense sector of Ukraine, in particular the State Service of Special Communications and Information Protection of Ukraine (State Special Communications), is an urgent problem which requires careful analysis and a scientific approach. One of the ways to solve this scientific problem is integrating innovative educational

technologies, based on the best world practices, into the educational process of institutions training SSSCIP specialists [1]. However, achieving successful outcomes in this area necessitates careful consideration of several key aspects and requirements that underscore the strategic importance of this issue for researchers and methodological developments.

Firstly, it is important to note that the effectiveness of specialist training is directly dependent on the time available for learning. Military conflicts are characterized by limited time for personnel preparation, which affects their readiness and ability to operate under stress and danger [2]. Therefore, the development of training methodologies must systematically consider this factor and work on finding rational solutions to maximize each learning opportunity. For instance, the development of rapid and intensive training programs employing the concept of micro-learning, which provides the necessary knowledge and skills in a short period, can be a crucial direction in this field.

Secondly, it is worth focusing on the development and implementation of innovative teaching methods and technologies. The rapid advancement of digital technologies and the opportunities provided by e-learning and blended learning open up prospects for enhancing the quality of specialist training. This allows for preserving and disseminating information in conditions where access to traditional educational resources is limited [3]. This is particularly important for ensuring training and supporting the professional development of military personnel. The use of virtual and augmented reality (VR/AR), interactive training simulations, and other cutting-edge technologies can significantly improve the effectiveness of learning and ensure a deep understanding of the material. For example, the creation of cyber ranges will allow specialists to gain practical experience in virtual reality, thus enhancing their readiness for action in emergency situations.

Additionally, it's crucial to consider the individual characteristics of each specialist during their training. Every person has their unique abilities and needs, so it's important to create flexible training programs that allow for adapting the material to individual needs [4]. Addressing this task may involve personalized learning paths, advisory support, and the use of various methods and forms of learning for each specialist.

The development of an integrated approach for the rapid generation of e-learning tools for highly qualified specialists in the security and defense sector of Ukraine during wartime presents a significant scientific and practical challenge. This approach must meet the following requirements:

- optimal utilization of limited time for personnel training;
- utilization of innovative teaching methods and technologies;
- adaptation to the individual characteristics and needs of each specialist.

The analysis of recent research and publications. The analysis of scientific and specialized literature indicates that there is currently no single viewpoint regarding the definition of e-learning. UNESCO experts consider e-learning to be learning through the use of the Internet and multimedia [5].

Don Morrison provides a more detailed characterization of e-learning. In his definition, "e-learning is the continuous assimilation of knowledge and skills by adults, stimulated by synchronous (video conferences, virtual classes, instant messaging) or asynchronous (email, textual materials, audio and video recordings, etc.) means, implemented and regulated through the use of Internet technologies" [6]. By "adults," the researcher refers to anyone who has completed compulsory secondary education and desires to pursue higher or professional education, i.e., to join lifelong learning programs. Therefore, let's define "e-learning" as a learning system that utilizes information and communication technologies, including the Internet network.

N. Morse and O. Glazunova classify modern information and communication technologies as follows: Internet technologies, multimedia software tools, office and specialized software, electronic manuals and textbooks, distance learning systems (computer-assisted learning systems) [7].

Electronic learning is successfully utilized in the most advanced countries in the world due to numerous advantages it provides, including [8]:

1) *Autonomy*. Learners can independently determine the pace of studying the learning material, choose when they want to engage in learning, and decide which specific sections of the learning material they need to study and in what sequence;

2) *Cost-effectiveness*. Despite the need for initial high investments, e-learning proves to be significantly cheaper compared to traditional (face-to-face) learning;

3) *Accessibility*. Providing access to quality education for individuals who are limited in their ability to study in a traditional form due to various reasons. For example, individuals residing in areas experiencing active combat;

4) *Personalization*. The ability to combine learning content to create various educational programs tailored to individual learners, among other benefits.

Furthermore, nearly all researchers recognize the benefits of interactive online learning as it allows for a competent interdisciplinary approach to education based on scientific knowledge, thus promoting a practical orientation of the learning process [9].

Therefore, the application of e-learning in wartime conditions contributes to the development of resilient and adaptive educational systems that can quickly respond to changes in the socio-economic environment and ensure the continuity of the educational process during crisis situations. However, it's worth noting that there is currently a lack of research on the rapid generation of e-learning tools under the legal framework of martial law.

The aim of the article is to develop an integrated approach for the rapid generation of e-learning tools for highly qualified specialists in the security and defense sector of Ukraine during wartime conditions.

The exposition of the main research material. For the elaboration of methodological approaches to the development of an integrated approach for the rapid generation of e-learning tools in the training system of specialists in the SSSCIP, the FortiGate 60E network firewall was chosen as the object of study.

There are numerous models of software development life cycles and associated methodologies. One of the most well-known and thoroughly researched is the spiral model, which was adapted for the task of rapid e-learning tool generation during this study. As is known, this model reflects the iterative nature of development stages with refinement of details and addition of new functionalities at each turn (see Figure 1) [10].

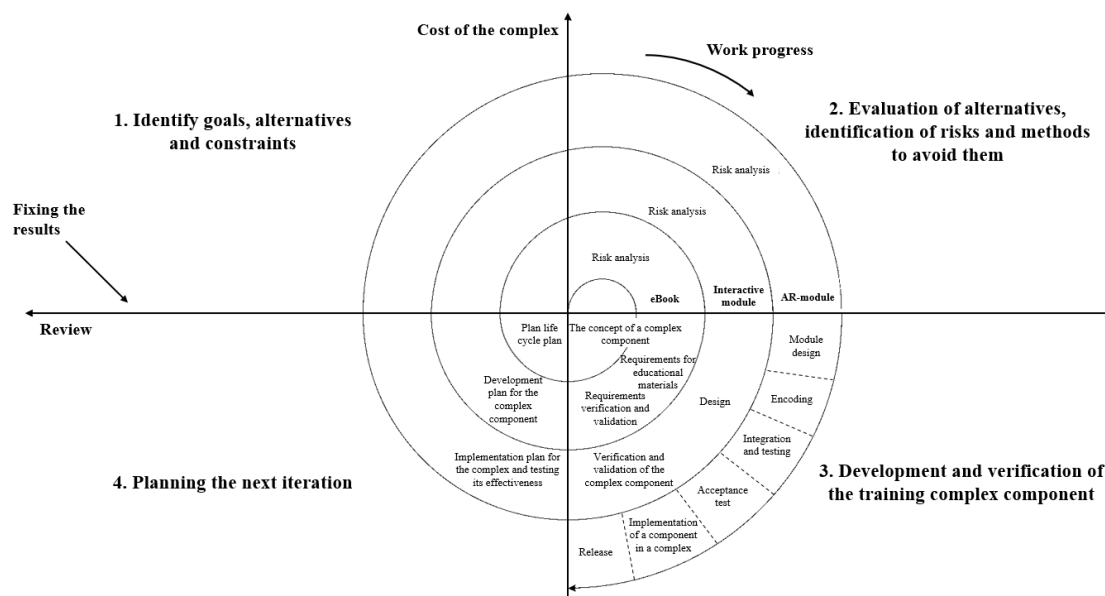


Figure 1 – Adapted spiral model for generating e-learning tools

The main stages of the adapted spiral model are as follows:

1) *Requirements analysis and formalization*: Starting from the first turn of the spiral, a thorough analysis of the needs of the target audience is conducted, and the main requirements for the educational content (learning tools) are defined. At this stage, the scope, structure, and functionality of the interactive educational complex are clearly defined;

2) *Design*: The next sector of the spiral involves the development of a detailed plan for creating learning tools. The methodology for presenting information is determined, technological solutions for implementation are chosen, and mechanisms for evaluating effectiveness are established;

3) *Testing*: In the third sector, learning tools are tested and evaluated on a test audience. This allows identifying possible shortcomings and making corrections and improvements for subsequent iterations;

4) *Development*: The final sector of the spiral involves the complete realization and implementation of the interactive educational complex. All components are developed, tested in real conditions, and prepared for use.

Thus, with each turn of the spiral, a new component of the interactive educational complex is developed, enhancing its functionality:

- paper-based manual;
- eBook using H5P tools;
- interactive simulator module;
- augmented reality module.

The development of a paper-based manual is a critically important stage in the process of creating an interactive educational complex and serves as the starting point for the developed integrated approach to rapid generation of educational content. This stage defines the creation of basic textual material that will be used as a foundation for further expansions in the form of electronic and interactive components.

At the initial stage of developing the paper-based manual, it is necessary to define the target audience and the main training objectives. Due to the specificity of the FortiGate 60E firewall, the target audience consists of professionals responsible for configuring and effectively using this equipment in the security and defense sector. The main training objectives include mastering the principles of working with the FortiGate 60E firewall, configuring network security, and effectively managing information security.

The starting point for creating the interactive educational complex for micro-learning "Fortinet FG-60E Firewall" was the methodical development for conducting practical sessions in the discipline "Anti-Malware Technologies" (Figure 2).

Transitioning from a paper-based manual to an electronic manual created on the H5P platform signifies the implementation of interactive and adaptive learning principles. The initial paper-based manual, containing key concepts and essential information about the firewall, serves as the foundation for further development on the H5P platform. This electronic manual allows participants in the educational process to engage more actively with the material, thus enhancing accessibility and effectiveness in assimilating the educational content (Figure 3) [11].

H5P is an interactive platform that provides a toolkit for working with HTML 5.0 [12]. It allows creating various interactive and multimedia exercises, quizzes, presentations, and other educational materials that complement and expand upon the basic textual content.

The main advantages of using the H5P platform for creating interactive educational materials that complement the paper-based version include: [13]:

- more active role of students in learning the material;
- facilitating the process of mastering the material;
- low "entry cost" into the development process of interactive educational content;
- ease of developing interactive content;

- increased learning efficiency.

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Завідувач спеціальної кафедри № 5
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Ігор СУБАЧ

МЕТОДИЧНА РОЗРОБКА

Для проведення практичне заняття
3 навчальні дисципліни Технології захисту від шкідливого програмного забезпечення

Тема 10. Системи виявлення та попередження вторгнень

Заняття 2. Міжмережевий екран Fortinet FG-60E

Обговорено та узгоджено
на засіданні спеціальної кафедри № 5
Протокол № _____
від " " " " 20__ р.

2020 рік

Навчально-виховна мета.
- вивчення механізмів захисту даних, реалізованих у брендмаурі Fortinet FG-60E.

Навчальна група С63 **Час** 90 хв. **Місце** _____

Навчальна література:
Основна література:
1. FortiGate FortiWiFi 60E Series. Data Sheet. URL: https://www.fortinet.com/content/dam/fortinet/assets/data-sheets/FortiGate_FortiWiFi_60E_Series.pdf
2. Базова настройка Fortinet Fortigate 60e. URL: <https://linkaa.ru/articles/nastroyka-fortigate-60e>.

Додаткова література:
1. Система попередження вторгнень (IPS). URL: <https://fortiservice.com/news/systema-predotvazhchennya-vtruzheniy-ips>
2. Fortinet Getting Started v6.0. Активізація та IPS. URL: <https://www.icsinfo.ru/blog/companiy/solution/347666.php>
3. Fortinet Getting Started 6.0. URL: https://www.youtube.com/watch?v=PLqj0-3dnMW5_x1dPvMkXBgZCXXGU_F8mL.

І. НАВЧАЛЬНІ ПИТАННЯ ТА РОЗРАХУНОК ЧАСУ		
№ з/п	Назва навчальних питань та їх ґрунтовне висловлення	Час
I.	Вступна частина - прийом роботи членом групи; - перевірка наявності, зовнішнього вигляду студента; - оголошення теми, цілі, порядку проведення заняття, навчальних питань та списку літератури.	10
II.	Основна частина 1. Основний функціонал та технічні характеристики. 2. Налаштування системи попередження вторгнень. 3. Попередження DoS-атак засобами Fortinet FG-60E. 4. Практична частина.	75
III.	Заключна частина - підсумок візуалізації заняття; - відповіді на запитання; - завдання на самостійну роботу; Завдання на наступне заняття.	5

Навчально-матеріальне забезпечення: обладнання навчального ситуативного центру з кібербезпеки, апаратно-програмний комплекс Fortinet FG-60E, технічна документація по Fortinet FG-60E.

Figure 2 – Methodological development for conducting a practical lesson on «Міжмережевий екран Fortinet FG-60E»

Figure 3 – Home page of the eBook

One of the key advantages of eBooks is the ability to implement a branched learning path [13]. Thus, users can choose a learning path according to their needs and level of knowledge. For example, beginners can use basic materials and videos, while experienced users can delve deeper into technical

aspects and practical product usage. This ensures individualization and adaptability of learning to the needs of each participant.

In general, supplementing the paper manual with an electronic one developed on the H5P platform allows for a more accessible and interactive learning environment. This, in turn, contributes not only to deepening knowledge but also to increasing the level of material mastery, especially in the context of learning complex hardware and software devices such as the FortiGate 60E firewall. Additionally, the variability of learning trajectories implemented in the electronic manual allows users to choose the optimal path for understanding and learning information according to their needs and requirements. Such an approach ensures a more profound understanding of the material, facilitating an active and efficient learning process in a virtual environment.

Considering the success of supplementing the paper manual with an electronic one developed on the H5P platform, the next logical step in expanding the functionality of the interactive educational and methodical complex is to introduce a simulator module. Its main purpose is to develop practical skills for students. The simulator module can also be developed on the H5P platform. The FortiGate 60E firewall simulator allows for two usage modes [15]:

- learning mode;
- testing mode.

In the learning mode, students have the opportunity to familiarize themselves with the basic controls of the FortiGate 60E, its operating modes, and configurations.

The simulator can also be used for knowledge assessment. For example, tasks can be developed where students need to select the correct settings for the FortiGate 60E firewall using the interface and verify their actions for accuracy [9]. This makes learning more practical and contributes to better understanding and retention of the material.

Research has demonstrated that expanding the functionality of the interactive educational and methodical complex by adding a simulator positively impacts the quality and effectiveness of learning [9]. Students can experiment with the material, test their knowledge, and receive instant feedback. This approach allows for the creation of a learning environment that not only encourages active student participation but also promotes deeper learning by acquiring practical skills with complex hardware and software tools.

The next step in the development of the interactive educational and methodical complex "Fortinet FG-60E Firewall" was the addition of an AR-module. This marks another stage in the integrated approach to rapid generation of educational content (see Figure 1).

AR is a technology that allows combining the virtual world with the real world, providing users with the opportunity to interact with educational material in a practical, visual format [16]. The experience of using AR technology in education indicates several advantages [17]:

- provides a sense of reality;
- makes the educational process even more interactive;
- contributes to better understanding of the subject;
- stimulates creative thinking;
- provides flexibility to the educational process;
- offers an experience that is difficult or impossible to obtain in real life;
- does not require additional equipment.

Additionally, according to experts, one of the key advantages of augmented reality is its ability to create an immersive learning environment where participants can interact with content in real time and space [16], [17]. This enhances student engagement and interest as they get the opportunity to explore and study the material more deeply and interestingly.

AR enables the creation of interactive scenarios and simulations that can be beneficial for practicing practical skills and solving real-world tasks. For example, in the context of the FortiGate

60E network firewall, AR can provide the opportunity to visualize various aspects of its operation, structure, and functionalities.

The success of implementing an augmented reality module largely depends on the choice of tools for developing AR objects. These tools must meet a complex set of requirements, the main ones of which are outlined below:

1) *Platform compatibility*: The tool should work with both iOS and Android devices. It should also be compatible with various types of devices, including phones, tablets, and smart glasses;

2) *Feature set*: The tool should provide the ability to create high-quality 3D graphics, understand the surrounding environment, track objects, create interactive AR objects, and enable collaboration with multiple users in AR space;

3) *Pricing*: The tool should offer affordable pricing plans for different user categories, including a free version for beginners and special plans for large companies and corporations (enterprise solutions);

4) *Ease of use*: The tool should be easy to learn and use, with accessible instructions and documentation for training. It should also provide options for no-code development and include ready-made templates and examples for quick startup;

5) *Cloud storage*: The tool should have the capability to store data in the cloud;

6) *Support and community*: Availability of forums and communities where users can help each other and receive support from developers. It's also important for the tool to have a system of updates and active maintenance.

During the research, an analysis of 7 tool environments designed for developing AR objects was conducted. The initial data for comparative analysis is summarized in Table 1. The results of the comparative analysis using a 10-point scale (1 point corresponds to the lowest level of compliance with requirements, and 10 points - the highest) are presented in Table 2. These results are summarized in the form of diagrams.

For a visual representation of the analysis results based on the evaluation of AR development tools on a 10-point scale (see Table 2), a radar diagram was constructed (Figure 4), which vividly demonstrates the correspondence of each of the analyzed tools to each of the defined requirements.

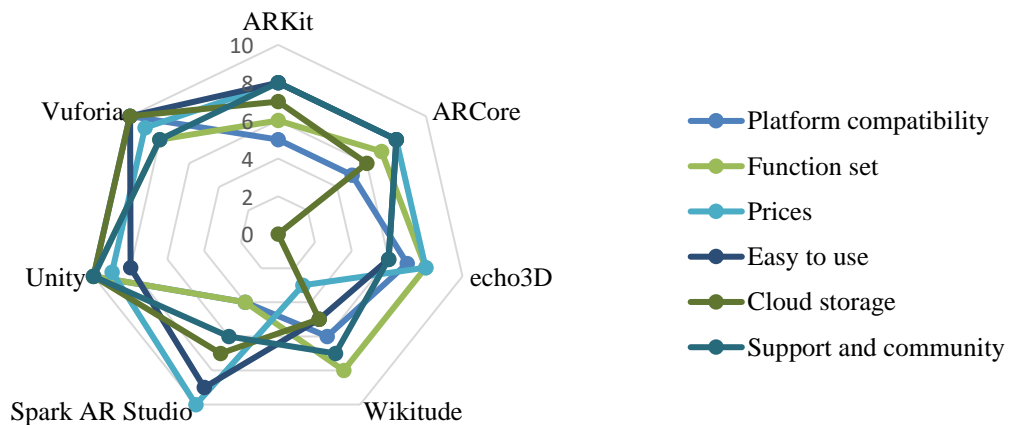


Figure 4 – A radar chart comparing AR tools

Additionally, based on the same data, a grouped bar chart was developed (Figure 5). This chart complements the radar chart, allowing for a more detailed analysis of the obtained results according to individual criteria. Such an approach to data visualization provides a deeper understanding of how the tools correspond to the requirements.

Table 1 – Baseline data for comparative analysis of AR development tools

Tool name	Platform compatibility	Function set	Prices	Easy to use	Cloud storage	Support and community
ARKit	iOS	High-quality visuals, multiplayer experience, object recognition and tracking	Free, for placement on the App Store - \$100/month	Convenient for Apple app developers, works with Xcode/Swift	Integrates with Apple cloud services	Large developer community, forums and official Apple support
ARCore	Android, limited functionality for iOS	Tracking user movement, facial recognition, predicting light behaviour, understanding the environment	Free, for placement on Google Play Market - \$25	Convenient for Android application developers, works with Android Studio/Unity, code samples	Integrates with Google cloud services	Google forums and official support, forums, blogs, tutorials, regular updates
echo3D	iOS Android	Image recognition and tracking, integration with multiple platforms and programming languages	Free - limited functionality 99\$ - full functionality	Can be used from a web browser, templates and code examples available	Lack of integration with cloud storage	Official support via email, regular updates
Wikitude	iOS Android Windows	Image, object, location recognition, geolocation tracking, ability to create AR without coding	Free trial for 1 month, 1990\$ - full functionality	Online project hosting, simple editor, examples and templates	Integration with Wikitude Cloud Recognition	Official support, forums, tutorials, regular updates
Spark AR Studio	Facebook/ Instagram	3D effects, animation for social media, face filters	Free	User-friendly for smartphone users	Integration with Meta cloud storage	A large community of developers, official support
Unity	Cross-platform moulded	3D applications, the most extensive functionality on the AR market, creation of 3D objects multipatform	Free – 450\$	Requires encoding	Integration with Google, Meta, and Vuforia cloud storages	Largest developer community, forums, tutorials official support, regular updates
Vuforia	Cross-platform (integration into Unity)	Object/image recognition, cloud-based trigger storage, interactivity, text reading, virtual elements	Free – 99\$	Intuitive interface, works with Unity/. Android Studio/Xcode, uses triggers	Integration with Vuforia Cloud Recognition	Official support via email, regular updates, training documentation

Table 2 – Evaluation of AR development tools on a 10-point scale

Tool name	Platform compatibility	Function set	Prices	Easy to use	Cloud storage	Support/ community	Rating
ARKit	5	6	8	8	7	8	42
ARCore	5	7	8	8	6	8	42
echo3D	7	8	8	6	0	6	35
Wikitude	6	8	3	5	5	7	34
Spark AR Studio	4	4	10	9	7	6	40
Unity	10	10	9	8	10	10	57
Vuforia	10	8	9	10	10	8	55

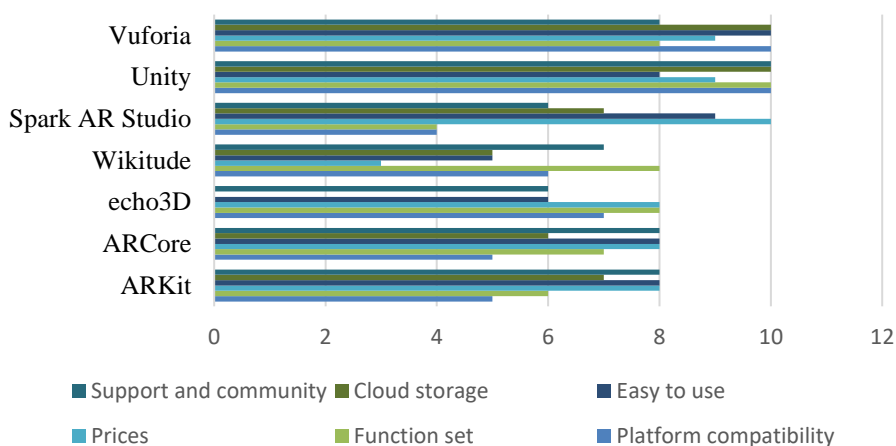


Figure 5 – Line chart with grouping of AR tools comparison

Based on the results of the comparative analysis of AR development tools, it was determined that the best option for implementing an augmented reality module as part of the interactive educational-methodical complex is a combination of Unity and Vuforia. Unity in this combination provides a foundation for creating 3D graphics and an intuitive interface, while Vuforia offers object tracking functionality and cloud storage. Both tools are flexible in pricing, easy to learn and use, and have active communities. The AR module developed based on this combination ensures optimal functional, compatible, simple, and supported usage (see Figure 6) [18].



Figure 6 – AR app to study the structure and functionality of the FortiGate 60E firewall

Returning to the adapted spiral model of e-learning resource generation (see Figure 1), we can represent the evolution of the interactive educational-methodical complex "Fortinet FG-60E Network Firewall" in the form of a spiral (Figure 7).

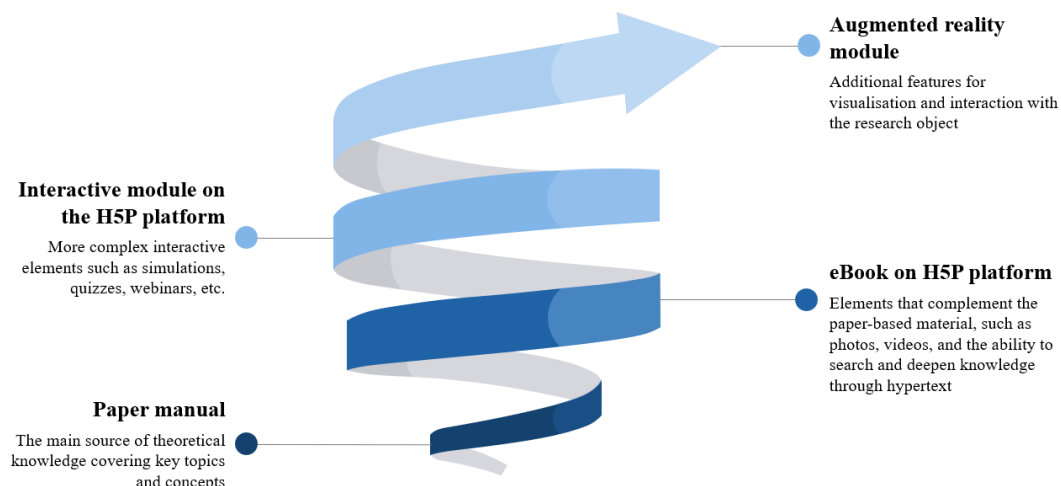


Figure 7 – A spiral representation of the evolution of e-learning tools within an integrated approach to their rapid generation

Each turn adds value and increases the effectiveness of the learning environment created based on the interactive educational-methodical complex. This thesis is supported by the previously obtained results of the feedback analysis [9]. These results were confirmed during the current study [19]. Participants in the pedagogical experiment were offered to study the Fortinet FG-60E topic using various educational resources:

- a paper manual;
- a basic electronic manual (basic interactivity);
- an extended electronic manual (eBook with simulator);
- an extended electronic manual supplemented with an AR-module.

The results of the survey regarding the effectiveness of learning are presented in the diagram (Figure 8).

На Вашу думку, який з перелічених варіантів представлення навчального контенту є більш **ефективним** (на прикладі вивчення Fortinet FG-60E)?

52 відповіді



Figure 8 – Survey results on the effectiveness of training using the developed AR module

Conclusions. The developed integrated approach to rapid e-learning resource generation has demonstrated its effectiveness under resource constraints (human, financial, time). Specifically, it is capable of creating sufficiently effective learning complexes, the functionality of which expands as constraints soften, increasing the efficiency of learning with each iteration. The use of interactive elements and augmented formats, such as H5P informational manuals and augmented reality modules, enhances material assimilation and develops the necessary skills of professionals.

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ВЯЧЕСЛАВ РЯБЦЕВ,
ПАВЛО ПАВЛЕНКО

ШВИДКА ГЕНЕРАЦІЯ ЗАСОБІВ ЕЛЕКТРОННОГО НАВЧАННЯ В УМОВАХ РЕСУРСНИХ ОБМЕЖЕНЬ

Підвищення ефективності сектору безпеки та оборони України є одною з ключових передумов збереження держави та перемогу у війні. Значною мірою це стосується системи навчання та підготовки фахівців Державної служби спеціального зв'язку та захисту інформації України. Активна фаза війни Росії проти України суттєво поглибила суперечність між необхідністю підвищення ефективності зазначеної системи з одної сторони та жорсткою вимогою економії ресурсів (фінансових, людських, часових) – з іншої.

Розв'язання цієї суперечності можливе за допомогою інтенсивного впровадження різноманітних засобів та технологій електронного навчання та пов'язаних з ними педагогічних методик. Одним із факторів, що обмежують ефективність електронного навчання є складність традиційного процесу створення відповідних засобів. Подолати негативний вплив зазначеного фактору можливо за рахунок розроблення підходів щодо швидкої генерації електронних засобів навчання. Таким чином, існує необхідність розроблення інтегрованого підходу, який дозволяє швидко створювати навчальний контент та засоби електронного навчання за рахунок використання інноваційних технологій. Такі засоби мають економити час та підвищувати ефективність засвоєння навчального матеріалу. Основними вимогами до зазначеного підходу є раціональне використання обмежених ресурсів та адаптивність результатів до потреб кожного фахівця.

У статті запропоновано інтегрований підхід до швидкої генерації засобів електронного навчання для вивчення апаратно-програмних пристроїв і систем. Він включає такі етапи:

- розробку паперового варіанту навчального матеріалу, що є основою для подальших доповнень;
- доповнення паперового варіанту електронним посібником (eBook) на основі H5P, який забезпечує інтерактивність та гнучкість навчання;
- введення модуля-симулятора, який дозволяє імітувати роботу з пристроєм, стимулює навчальну активність учнів та поглиблює розуміння матеріалу;
- додавання модуля доповненої реальності, який візуалізує складні концепції та надає можливість практичного відпрацювання знань.

На прикладі навчального модуля «Міжмережевий екран Fortinet FG-60E» показана реалізація інтегрованого підходу до швидкої генерації електронних засобів навчання для підготовки фахівців сектору безпеки та оборони України в умовах війни. Результати опитування учасників, які використовували розроблений інтегрований підхід до навчання, свідчать про його високу ефективність.

Ключові слова: електронне навчання, розроблення ресурсів електронного навчання інтегрований підхід, інтерактивні засоби навчання, H5P, доповнена реальність, генерація навчального контенту.

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