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Development of a Methodology for Creating Training Materials for the Digital Environment

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Abstract. *The design of digital instructional content in educational organizations is a crucial factor in the development of the modern information-educational environment. This study aims to analyze existing standards for digital instructional materials and develop a methodology for creating such materials based on the SCORM 2004 standard. An analysis of existing standards for developing digital instructional materials has shown that SCORM is the most effective. This study presents a comparative analysis of the structural components of SCORM across various versions. An algorithm for creating instructional materials based on SCORM 2004 has been developed, including stages of development, selection of tools and technologies, as well as methods for quality control and effectiveness assessment. The outcome of the study is a methodology for forming digital content considering the specifics of the SCORM 2004 standard. The results of testing this methodology are presented through the development and evaluation of the online course «NIS. Computer Science».*

Keywords: *digital educational materials, methodology for creating digital content, SCORM, LMS, content objects, Content Aggregation Model (CAM), Run-Time Environment (RTE).*

Introduction

The rapid advancement of digital technologies is precipitating changes within the educational sphere, necessitating the development of methodologies for crafting electronic instructional materials. Electronic instructional materials afford educators and students the utilization of interactive teaching methods, enabling the customization of materials to suit each student's individual needs, thereby fostering more effective knowledge acquisition [1]. Furthermore, it is noteworthy that digital instructional materials significantly reduce time and financial expenditures in the educational process, as they can be reused and updated at minimal expense [2]. Moreover, the digital environment facilitates the swift and convenient dissemination of information, a particularly crucial attribute in the context of contemporary fast-paced lifestyles. Analysis of existing standards for the development of digital instructional materials has revealed SCORM (Shareable Content Object Reference Model) to be the most efficacious, comprising a set of standards and specifications for the creation, packaging, and exchange of educational content [3]. In its updates, SCORM developers strive to enhance the content aggregation model and runtime environment to ensure more efficient and convenient utilization of the standard. Similar to many software products, SCORM undergoes continual updates and augmentations, resulting in multiple versions of the standard. This study is aimed at analyzing the available versions of this standard and developing a methodology for the creation of educational content within the digital environment that meets the requirements of adaptive learning.

Research methodology

The methodological foundation of the study is comprised of systems analysis and knowledge management methods, which encompass a comprehensive approach to analyzing, designing, testing, and evaluating educational

content, taking into account the specifics of the SCORM 2004 standard and the needs of the target audience:

1. Study of the SCORM 2004 standard: Investigating the fundamental principles, structure, capabilities, and limitations of SCORM 2004 will help determine which functionalities of the standard can be utilized for creating educational resources and what technical requirements need to be considered.

2. Development of a methodology for creating educational resources: Within the scope of the research, it is necessary to develop a clear plan for creating educational materials based on SCORM 2004, including stages of development, selection of tools and technologies, as well as methods for quality control and effectiveness assessment.

3. Experimental testing: Conducting experimental testing of the developed methodology on the target audience will help assess its effectiveness, ease of use, adaptability to different needs and levels of learners' knowledge.

Theoretical justification

There are several primary types of e-learning standards, which delineate the manner of content packaging, the method of data exchange between data repositories (LMS, LRS), content composition, transmitted data composition, and content launch mechanism [4]. The comparative outcomes of technical characteristics of these standards according to these criteria are presented in Table 1.

SCORM is a standard for exchanging educational materials based on adapted specifications from ADL, IEEE, IMS, Dublin Core (DCMI), and vCard [5]. SCORM comprises three primary components [6]: the Content Aggregation Model (CAM), responsible for packaging, sequencing, navigation, and describing instructional content; the Run-Time Environment (RTE), which manages the execution of educational content and the learner's environment; and Sequencing and Navigation (SN), which delineates possible navigation methods through the content [7].

Similar to many software products, SCORM undergoes continuous updates and enhancements, resulting in several versions of the standard [8]. During updates, SCORM developers strive to improve the Content Aggregation Model and the Run-Time Environment to ensure a more efficient and user-friendly utilization of the standard (see Table 2).

The analysis of data versions has revealed that the most suitable version is SCORM 1.3, an updated working draft of the application profile complementing the original SCORM model by structuring it based on the simple sequencing specification. This addition allows course developers to define the learning path of students through a series of educational modules depending on their performance, thereby rendering the SCORM model more flexible and adaptable to diverse educational needs [9]. SCORM 2004 exists in various editions, each distinguished by updated functionalities (Table 3).

The components of e-course content are developed and packaged into SCORM packages, which provide a standardized format for the management and delivery of educational content. These SCORM packages are subsequently integrated with Learning Management Systems (LMS), which utilize SCORM specifications to ensure compatibility, track progress, and manage the educational process.

Results

When developing a methodology for the formation of digital content, the following im-

Table 1 – Comparative table of technical characteristics of standards

Characteristic	AICC CMI	SCORM	xAPI	CMI5
Content Packaging Method	Zip, Txt	Zip, IMS Manifest	Not defined	Zip (cmi5.xml)
Data Exchange Method	Http(s) protocol-based	JavaScript, invoking SCORM player functions from content	Http(s) protocol-based, REST API and JSON	Built on xAPI
Transmitted Data Composition	Scores, Status, Location, Time, Objectives, core_lesson	Scores, Statuses (2), Location, Time, Objectives, Exercises, suspend_data	Arbitrary statements	xAPI statements, but in a defined format
Launch Method	Session ID in URL	Content launched along with SCORM player	Minimal specification	Defined (parameters in URL)

Table 2 – Comparative table of structural components of SCORM across different versions

Component	SCORM 1.1	SCORM 1.2	SCORM 1.3
CAM defines the structure of educational blocks and packages of educational material	**CAM:** Metadata + Binding	**CAM:** Metadata + Binding; Adds: Content Packaging & Content Organisation	**CAM:** Metadata + Binding; Content Packaging & Content Organisation (updated/fixed)
RTE defines the interaction between SCO and LMS through the API	**RTE:** API + Data Model	**RTE:** API + Data Model (updated/fixed)	**RTE:** API + Data Model (updated/ fixed)
S & N (SN) - defines the sequence and navigation			**S & N** Rules and Behaviours (new)

Table 3 – Differences in SCORM 2004 Editions

№	SCORM 2004	Updated features
1	2nd Edition	● the ability to specify an adaptive ordering of activities using content objects (called a Public Content Object, or a Shareable Content Object – SCOs). ● the ability to share and use success status information for multiple learning goals or competencies through content objects and courses for the same student
2	3rd Edition:	● ordering and navigation paths
3	4th Edition	● elimination of ambiguity in the sequencing specification ● several new features have been added to the sequencing specification, which will expand the capabilities available to content authors.

portant aspects were taken into account:

1. The instructional design process.
2. The capabilities of the SCORM 2004 standard upon which the digital content relies.
3. The basic repository of learning objects.
4. The technology utilized in the development of digital content.

Within the SCORM package, educational material is composed of two types of blocks: Assets and SCO. Assets are elements that do not interact with the LMS server; these may include HTML pages, images, audio files, or Flash objects, among others. SCO, on the other hand, are elements that interact with the LMS server, reporting on the progress and results of learning, receiving and transmitting additional data, etc.

In this research, SCO composition is defined as comprising descriptions and terms, theoretical material in the form of video lectures, assignments, and assessment tests. Packages are furnished with information known as a manifest, which delineates the structure of the content, types, and location of educational materials. The manifest provides a hierarchical description of the structure with references to educational material files. SCO will be stored in shared repositories of learning objects (LOR). Courses will be integrated into LMS. The relationship between SCO and the learning management system is illustrated in Figure 1.

Thus, the methodology for creating digital educational materials based on SCORM 2004 will involve:

1. Defining educational goals and content: Establish the instructional goals and content to be covered.
2. Selecting tools and technologies: Choose appropriate tools and technologies for creating SCORM-compliant materials, such as authoring systems like Articulate Storyline or Adobe Captivate.
3. Creation of instructional modules: Develop individual instructional modules (content objects) that correspond to specific educational goals.
4. Using selected tools: Create interactive presentations, videos, tests, assignments, and other learning elements.
5. Integrating with SCORM 2004 2nd Edition: Ensure each module conforms to the SCORM 2004 2nd Edition standard, including

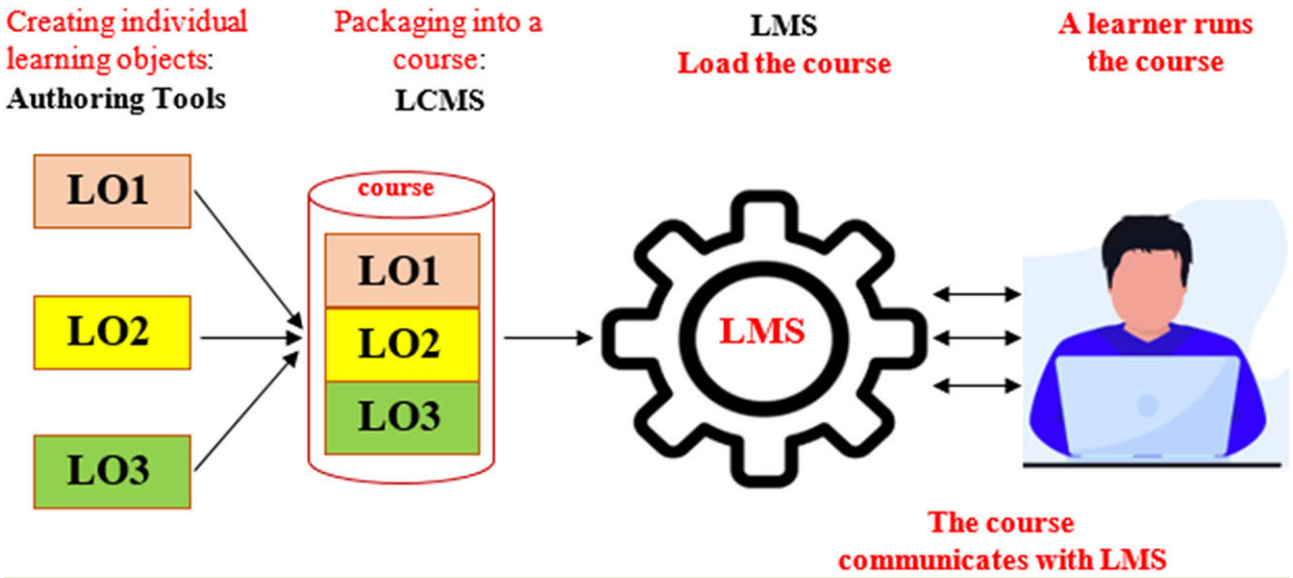

Figure 1 – The scheme of interaction between LMS and SCO (adapted from the resource [10])

necessary metadata.

6. Testing and debugging: Verify SCORM compatibility and functionality within the target LMS, and debug as necessary.

7. Assembling and publishing: Compile modules into a SCORM-compliant package and publish it on the LMS platform.

8. Monitoring and updating: Track usage, gather feedback, and update materials based on user needs and feedback.

9. Evaluating effectiveness: Assess the effectiveness using feedback and metrics like the Kirkpatrick model, Completion Rate (COR), and Net Promoter Score (NPS).

Based on the proposed methodology, the lifecycle of digital content development can be visually represented (Figure 2).

This algorithm enables the systematic creation of high-quality and standardized digital educational materials based on the SCORM 2004 2nd Edition, ensuring their compatibility and effectiveness for use in the e-Learning environment. The viability of this methodology was assessed through the development of digital content for the online course «NIS. Computer Science» (https://stepik.org/109060), designed for high school students. The «NIS. Computer Science» course comprises 8 modules and 24 lessons, encompassing 176 steps (Figure 3).

At the course's start, terms and definitions are provided. Each lesson includes brief descriptions, videos, assignments, and feedback. The first page presents key terms, helping learners quickly grasp fundamental concepts. Lessons consist of:

- Lesson Description: Clear explanations of key topics.
- Video Materials: Tutorials to enhance understanding.
- Assignments: Practical exercises to apply theoretical knowledge.

A notable feature is the feedback mechanism, allowing users to assess material quality, share insights, and ask questions, helping course authors improve content.

To assess the effectiveness of the proposed methodology for creating digital content, metrics such as Completion Rate (COR) and Net Promoter Score (NPS) were selected. COR, representing the completion rate of courses, is measured as a percentage (students who completed the training divided by those enrolled). This metric indicates how well the course meets user needs. Average COR values range from 3% to 80%. Currently, 990 learners have completed the course, with a COR of 68%, showing its popularity.

NPS, an index of customer loyalty, reflects the willingness to recommend the course. It is calculated using the formula NPS = P – N, where P represents positive ratings (9-10) and N represents negative ratings (0-6). Ratings between 7 and 8 are neutral. This metric is informative in terms of dynamics, and results are presented at different stages of the course's operation (Figure 5).

The analysis of the results of the NSE indicator in dynamics shows 36%, which is considered an average result and shows a fairly stable level of product viability.

Conclusion

The methodology developed for creat-

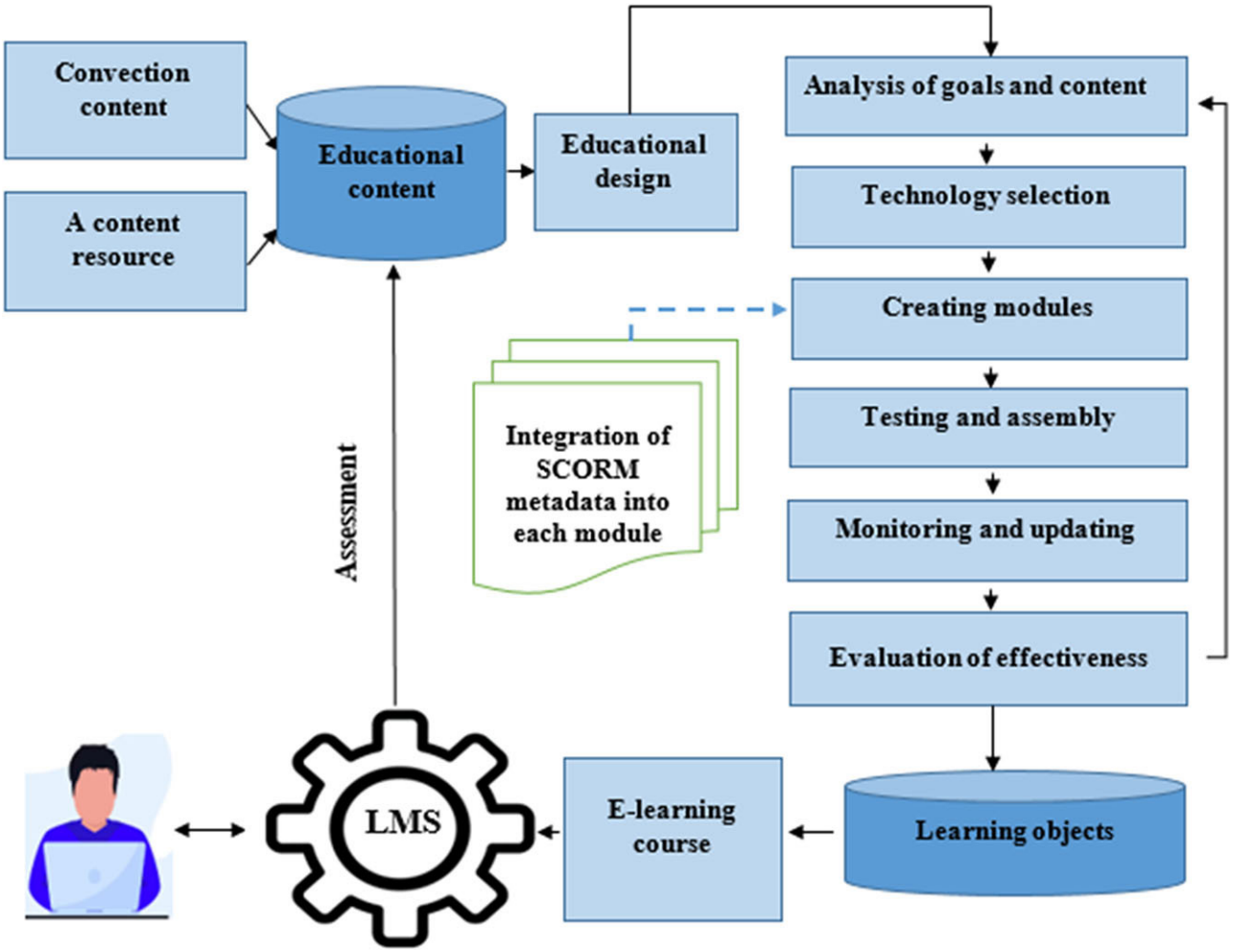

Figure 2 – The life cycle of digital content development according to the proposed methodology

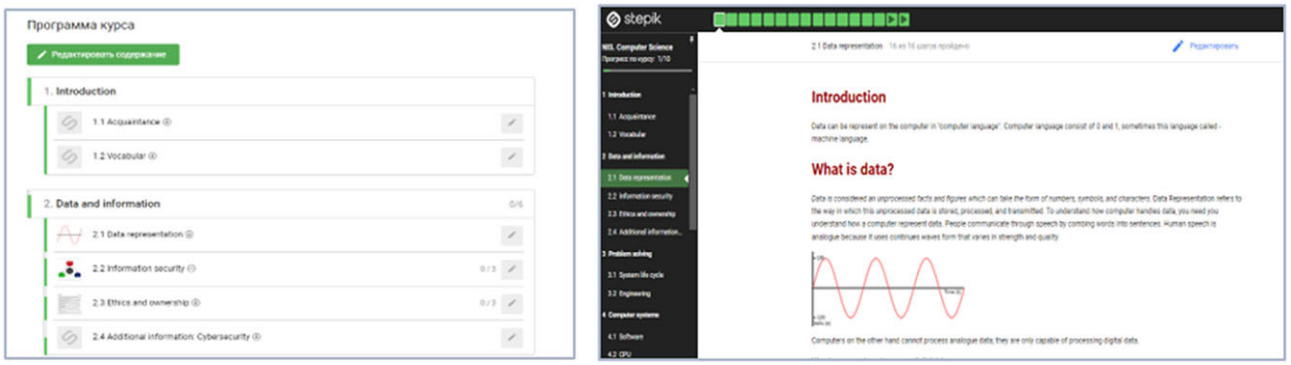

Figure 3 – Course structure (Developer and Student Mode)

ing digital educational content, based on a comprehensive approach to analysis, design, testing, and evaluation, and aligned with the SCORM 2004 standard, has demonstrated significant effectiveness. The validation through the online course «NIS. Computer Science» indicates a high level of user engagement and satisfaction, as evidenced by a completion rate (COR) of 68% and a Net Promoter Score (NPS) dynamic analysis showing a steady score of 36%. These metrics reflect the course's alignment with user needs and its potential for

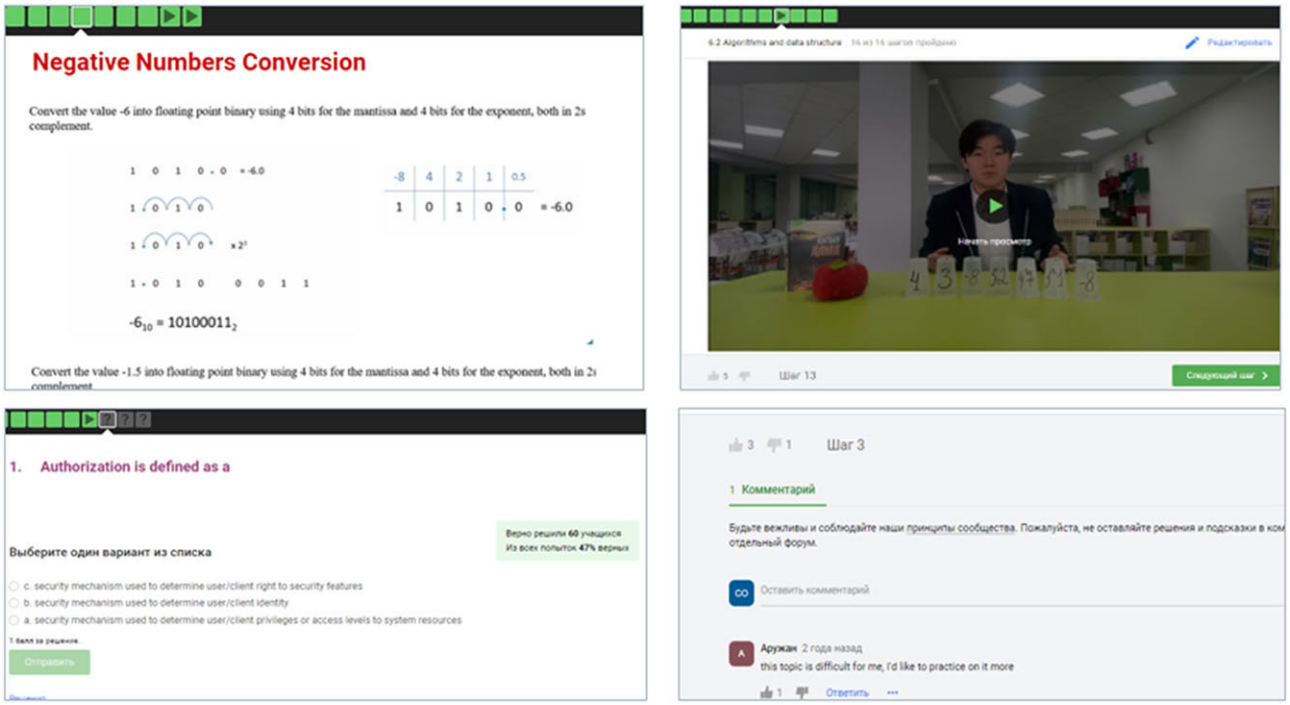

Figure 4 – Lesson materials

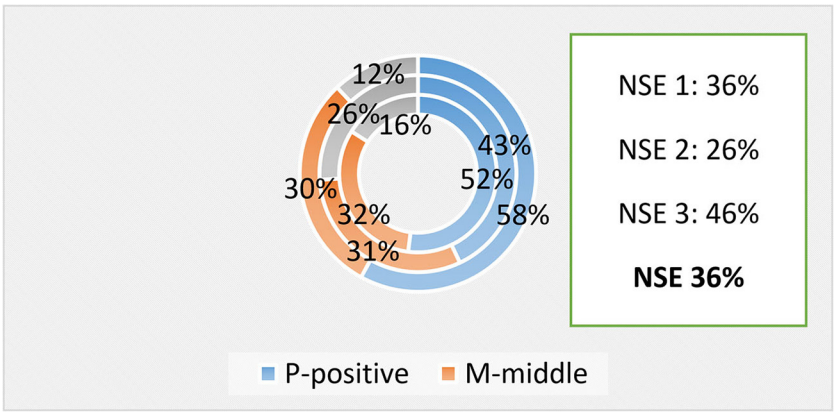

Figure 5 – NPS results in dynamics

widespread adoption. The structured approach to digital content creation ensures that educational materials are not only accessible and engaging but also adaptable to diverse learning environments, thereby enhancing the overall efficacy of digital education.

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Цифрлық ортаға арналған оқу материалдарын құру әдістемесін әзірлеу

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Аңдатпа. *Білім беру ұйымдарында цифрлық оқыту мазмұнын жобалау қазіргі заманғы ақпараттық-білім беру ортасын дамытудың маңызды факторы болып табылады. Зерттеудің мақсаты – сандық оқу материалдарының қолданыстағы стандарттарын талдау және SCORM 2004 стандарты негізінде осындай материалдарды құру әдістемесін әзірлеу. Қолданыстағы цифрлық оқыту материалдарын әзірлеу стандарттарын талдауда SCORM стандарты ең тиімді екені анықталды. Зерттеу SCORM құрылымдық компоненттерін әртүрлі нұсқаларда салыстырмалы талдауды ұсынады. Мақалада SCORM 2004 стандартының ерекшеліктерін ескере отырып, білім беру мазмұнын талдауға, жобалауға, тестілеуге және бағалауға кешенді көзқарас негізінде цифрлық мазмұнды құру әдістемесі берілген. Зерттеу нәтижесінде SCORM 2004 стандартының ерекшелігін ескере отырып, сандық мазмұнды қалыптастыру әдістемесі ретінде «NIS. Computer Science» онлайн курсын әзірлеу, тестілеу және сынақтан өткізу нәтижелері ұсынылған.*

Кілт сөздер: *сандық оқу материалдары, цифрлық мазмұнды генерациялау әдістемесі, SCORM, LMS, оқу модульдері, мазмұнды біріктіру моделі, орындалу ортасы.*

Разработка методики формирования обучающих материалов для цифровой среды

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Аннотация. *Проектирование цифрового обучающего контента в организациях образования является важным фактором развития современной информационно-образовательной среды. Целью данного исследования является анализ существующих стандартов цифровых учебных материалов и разработка методологии создания таких материалов на основе стандарта SCORM 2004. Анализ существующих стандартов разработки цифровых обучающих материалов показал, что наиболее эффективным является SCORM. В рамках исследования представлен сравнительный анализ структурных компонентов SCORM в различных версиях. Разработан алгоритм по созданию обучающих материалов на основе SCORM 2004, включая этапы разработки, выбор инструментов и технологий, а также методы контроля качества и оценки эффективности. Результатом исследования является методика формирования цифрового контента с учетом специфики стандарта SCORM 2004. Представлены результаты апробации данной методики через разработку и тестирование онлайн курса «NIS. Computer Science».*

Ключевые слова: *цифровые обучающие материалы, методика формирования цифрового контента, SCORM, LMS, обучающие модули, модель агрегации контента, среда выполнения.*

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