Analysis of Ergonomic Indicators and Compliance with the Principles of the Instructional Design of Education Courses in Adaptive Learning Systems

Hanna Chemerys[1][0000-0003-3417-9910], Kateryna Osadcha [2][0000-0003-0653-6423], Viacheslav Osadchyi [3][0000-0001-5659-4774], Iryna Naumuk [4][0000-0001-6804-9191], Hanna Ustiuhova [5][0000-0002-0502-0073]

Bogdan Khmelnitsky Melitopol State Pedagogical University,
Hetmanska str.20, 72300, Melitopol, Ukraine
[1,2,3,4]{Chemeris, okp, osadchyi, naumuk.irina}@mdpu.org.ua
[5]annalike17@gmail.com

Abstract. The article is devoted to the research of the instructional design features of the education courses in the adaptive training systems. The instructional design as a modern didactic direction in the use of modern information technologies has been considered and investigated. The increasing role of the instructional design has been defined in conditions when the learning environment and learning itself are transferred into the electronic environment, when it is necessary to develop the most efficient, comfortable and at the same time, effective training systems and methods.

The position that instructional design can be considered an essential component should be taken into account when designing modern education courses in the electronic environment has been justified. The compliance with the principles of usability and user interface ergonomics of the developed educational materials by means of adaptive learning systems Knewton, RealizeIt, CourseArc, Brightspace LeaP, Revel, Open Learning Initiative, and the Generalized Intelligent Framework for Tutoring has been reviewed. The conditions of the designing of electronic educational resources based on the instructional design that enable to convey the educational material more effectively and to create the conditions for better learning by students have been defined.

Keywords: Adaptive Learning System, Instructional Design, User Interface, Usability, Ergonomics.

1 First Section

1.1 The Statement of Issue

The issue of improving the teaching methodology in educational institutions remains highly relevant for a long period of time, particularly the teachers attention is focused on e-learning itself and adaptive learning systems. With the transition to electronic learning, educators need to introduce new forms and methods of information, consid-

ering that information in its visual perception can be adsorbed in easier and prolonged way.

The instructional design plays an important role in providing a more efficient, productive and qualitative process of learning. The instructional design forms a coherent system of goals, learning material and available knowledge transfer tools. The instructional design is primarily aimed at filling the course with meaningful information, forming a sequence of presentation and introduction of modern ways of presenting educational material. However, the indicators of usability and ergonomics are equally important in the instructional design of educational materials for the electronic environment in correspondence with existing dependency between easiness of the education courses using and the quality of the material acquisition by the students. This is especially important in e-learning, where interaction between students, teachers and content is ensured not face-to-face, but through information and communication technologies [1].

The appropriate attention should be given not only to the content of the course, the methods and techniques to be used in the e-learning process, but also to the visualization of the educational content, to the indicators of ergonomics and usability of the platform on which the course is located. These elements should act in harmony in order to ensure high quality training. Taking into account the relevance of e-learning, the relevance of usability, ergonomics and instructional design in the development of e-learning materials for education courses is becoming increasingly important, especially in the context of the Stanford University research of the identifying factors that affect people's trust [2].

Nowadays, the field of adaptive learning is relevant in pedagogy, which involves the use of appropriate software, that allows the formation of personalized learning. Due to the fact that the methodology for using adaptive learning systems remains poorly developed, and based on the foregoing, it is necessary to study the existing adaptive learning systems for compliance with indicators of usability and ergonomics in the instructional design of educational materials.

1.2   Problem State of the Art

Thorough research into the study of instructional design has been reflected in the works of many foreign and domestic scholars, in particular S. Denysenko [3], A. Uvarov [4], B. Mergel [5], V. Tymenko [6] and others. The use of instructional designers with expertise in pedagogical strategies and technology for eLearning has been considered in the research [7]. The work [8] is devoted to the implementation of Universal Design for Learning (UDL). Visualization of educational information as a tool for the development of cognitive learning actions is proposed to use in the researches [9; 10]. The issue of the basics of visual design has been addressed in [11, 12; 13] and in the online course design guideline [14, 15, 16]. Usability issues in instructional design of Massive Open Online Courses were considered in the research [17]. The use of learning environments in traditional and distance learning has been discussed in works [18, 19, 20] and others. Researches that address some aspects of the use of ICT in the educational process [21, 22, 23, 24].

The aim of article: To analyze the ergonomic indicators and compliance with the principles of instructional design of education courses in adaptive learning systems.

2   The Results of Research

Usability is a concept that can be applied to the analysis of the user interface of resources, which determines their convenience and ergonomics while using. The design processes of Human Centred design are regulated by The British Standard / ISO Standard [25] and define usability as the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.

Analyzing the usability of the user interfaces of the developed education courses in adaptive learning systems, we followed the recommendations given in J. Nielsen's classic book "Designing Web Usability" [26], in order to analyze the offered ergonomic indicators. Such features as design, especially taking into account its "flexibility" or "rigidity", page length; availability and interface of search tools; the nature and the means of the navigation procedure realization were analyzed. The proposed list of indicators and characteristics for the formation of criteria, by which the ergonomic quality of the interface was analyzed, has also been expanded with the indicators that are important due to the principles of the instructional design of educational materials. The particular attention was paid to the possibility of integration of various multimedia fragments (video and audio accompaniment, integration of presentation material, integration of interactive elements, etc.) and to the functionality of testing elements (providing an individualized interpretation of false answers, cards, etc.). Equal emphasis was placed on the possibility of individualization and the design branding of educational materials, which would help to create a positive image of the educational institution, on the basis of which the system of adaptive learning is implemented.

The indicators' characteristics of usability, ergonomics and the instructional design of education courses in the following adaptive learning systems: Knewton, RealizeIt, CourseArc, Brightspace LeaP, Revel, MyLab, Open Learning Initiative (OLI) and Generalized Intelligent Framework for Tutoring (GIFT) were analyzed and researched. Combined comparative analysis is given in **Table 1.**

The following reference designations ● - the best indicator, ▢ - fragmental availability (not perfect), ○ - absent have been chosen.

Characteristics	Adaptive Learning Systems						
	Knewton	RealizeIt	CourseArc	Brightspace LeaP	Revel	OLI	GIFT
Design							
Moderate colour scale	●	○	●	●	●	●	●
Minimalistic design	●	◐	●	●	●	●	●
Adaptation to mobile devices	●	○	●	●	●	○	◐
Course branding	○	○	●	◐	○	●	◐
Navigation							
The User Controls Navigation	●	○	●	●	●	◐	●
Search Capabilities	●	◐	●	●	●	○	●
User-Contributed Content	●	○	●	●	●	◐	●
Applet Navigation	●	◐	●	●	●	○	●
Topic hierarchy	●	●	◐	●	◐	◐	●
Skills system	○	●	○	○	◐	○	○
Progress statistics							
Progress Bar	●	◐	○	●	●	○	○
Achievement detailing	●	○	◐	○	●	○	○
Educational content							
Books Management	●	◐	●	●	◐	◐	●
Curriculum/syllabys Management	●	○	●	●	○	◐	◐
Library Management	●	◐	●	◐	◐	●	●
Image support	●	●	●	●	●	●	●
Video support	●	●	●	●	●	●	●
Audio support	●	○	●	◐	●	●	◐
Presentation support	●	○	●	○	○	○	●
Interactive elements	◐	○	●	○	●	○	○
Testing functional	●	◐	●	●	●	◐	◐
Storyboarding	○	○	○	○	◐	○	○
Educational gamification	○	○	◐	◐	◐	○	○

Consider the adaptive learning systems that were the subject of detailed review.

2.1 Knewton

Knewton is an online service for creating courses using adaptive learning technology. The main page contains a list of courses, buttons to help sorting it, and a search for courses. Search and sorting is one of the most convenient functions. This helps to find the right course quickly by spending the least amount of time. The minimal colour and inactive contrast between the background and the font do not overwhelm the user's attention.

It should be noted that the courses for each user are personalized (**Fig. 1.**), and depend on the answers to the tests and the number of completed tasks. Usability provides quantitative indicators of course completion.
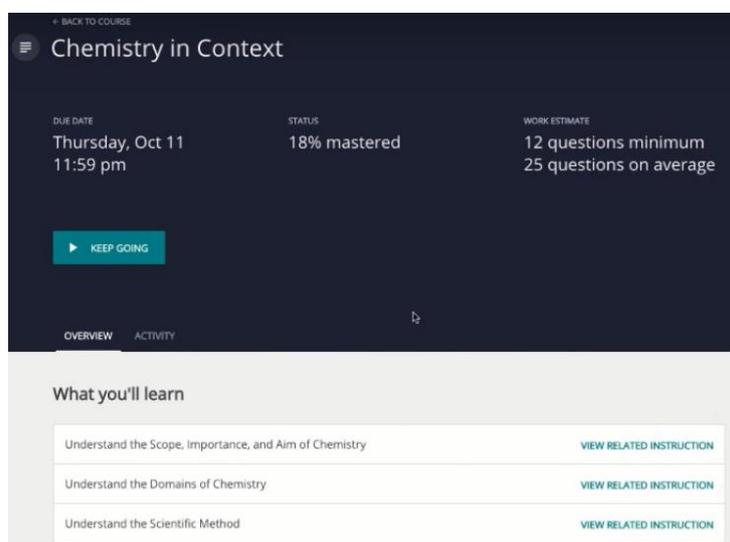
Fig. 1. A personalized page of Knewton adaptive education course

Particularly, the textual content can be accompanied with video content, graphs, charts, and other visualizations of educational materials that enhance memorization. According to the results of mastering each block of material, testing was implemented to assess the level of understanding of the educational material. In addition, the functions of Content Feedback and More Instruction have been implemented to improve understanding of the material.

In the course of testing in the case of a false answer, the student has quick access to the personalized fragment of material, which explains the correct answer and gives the opportunity for complete understanding of the context. If the false answer belongs to the priority topic or contains a key skill, the student is instructed how to study the topic, that he does not understand, more thoroughly to enhance understanding (**Fig. 2.**).

Fig. 2. A personalized page of Knewton adaptive education course

The results of testing and completed tasks determine the level of education course acquiring and define the need for additional practical tasks and tests. It is possible to increase the level of discipline acquiring before the completing the education course.

A progress bar provides the convenience for understanding your own level of course skills acquiring. It is important to note that the progress bar not only accumulates the level of professionalism in the education course, but can also decrease depending on the activity on the course. For better understanding of the shift direction of the bar progress, it is possible to detail own progress (**Fig. 3**).

Fig. 3. A personalized page of Knewton adaptive education course

Based on the analysis of usability indicators it is possible to conclude that the Knewton Adaptive Learning System is easy to use, has a friendly interface, a well-designed and thoughtful structure that matches the functional needs of users. It has a user-friendly and intuitive navigation and intuitive user interface.

2.2   RealizeIt

With RealizeIt, a user can create their own, personalized learning experiences that improve student engagement, readiness and success. Prior to the course creation, it is possible to create a curriculum that is a set of goals or skills the student must achieve during the course. It may be designed to describe the expected learning outcomes, but may also include information regarding the resources by which these results can be achieved. The curriculum can include the humanities, social sciences, STEM subjects, linguistics, used in the process of lifelong learning - actually any branch of knowledge for learning. The area of knowledge of the curriculum is defined using a hierarchical view (**Fig. 4.**).
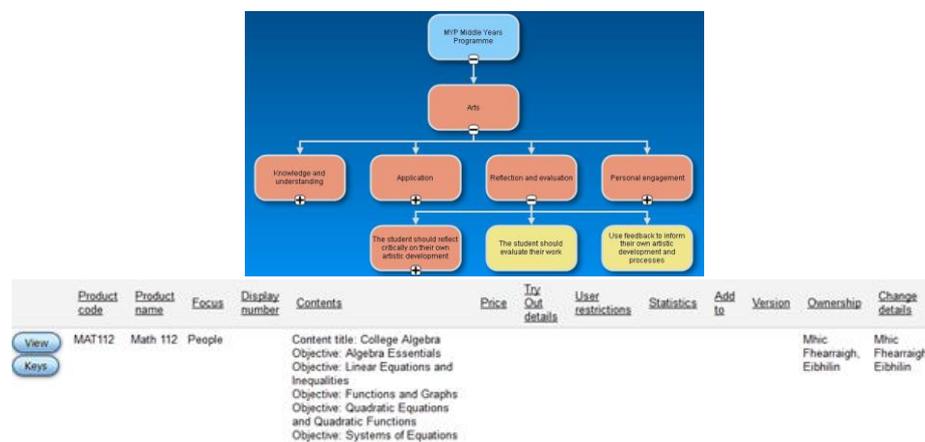
**Fig. 4.** A personalized page of Knewton adaptive education course

When students interact with the system, it captures their progress, knowledge growth, lost knowledge, strengths and weaknesses and learning preferences in real time. They provide the teacher with a detailed understanding how each student learns the material and allow the teacher to predict their success in the future (**Fig. 5.**).
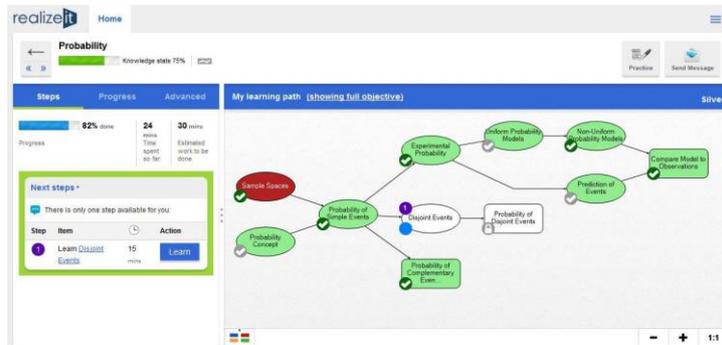
Fig. 5. The achievement progress in the course of completing the RealizeIt curriculum knowledge space

The convenience of educational material acquisition in the adaptive learning system RealizeIt is added by "My learning path" that provides information about the completed course material, its links to other topics and tasks, and the achievements after each topic completion. The individual progress bar with material acquisition dynamics is also visualized. The process of uploading the educational materials also provides the opportunity to include accompanying multimedia materials. But it should be noted that the interface of the education courses is overloaded with color scale and a large number of controls and graphs (**Fig. 6.**), which demonstrate the dynamics of the material acquisition, which creates the prerequisites for dispersing attention from the educational material.
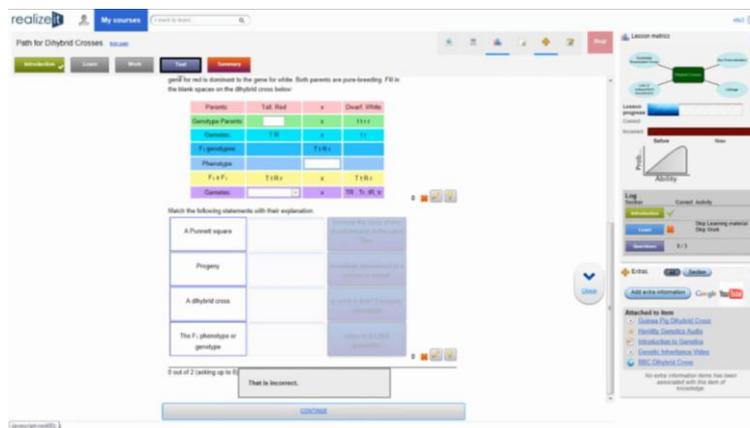

Fig. 6. RealizeIt educational element interface

2.3 CourseArc

The resource has ready-made templates and icon banks that are easy to customize. The topic editor allows to upload a banner image or logo and choose the desired color solution, enabling to brand the education course for an affiliated institution (**Fig. 7.**).
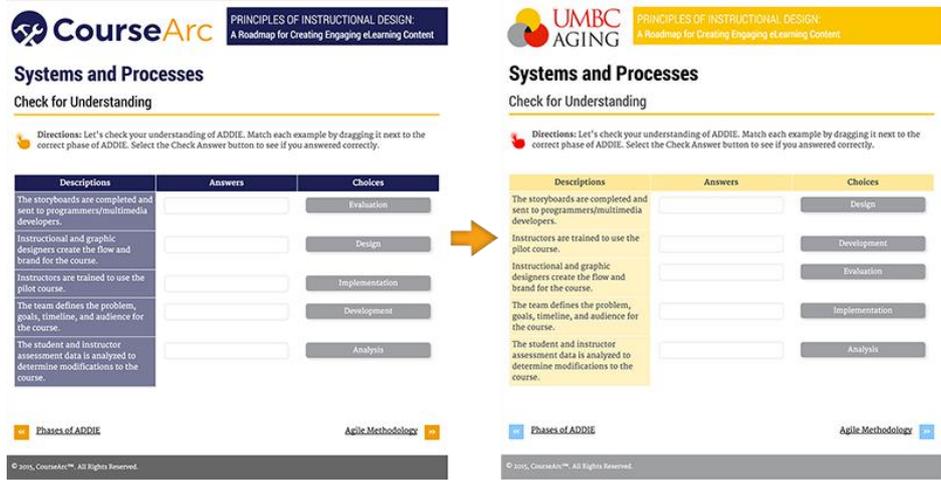
Fig. 7. The achievement progress in the course of completing the RealizeIt curriculum knowledge space

CourseArc also provides powerful capabilities for not only test controls designing but also for creating drag-and-drop interactive elements for quiz controls, which adds an additional interactive learning experience (**Fig. 8.**).
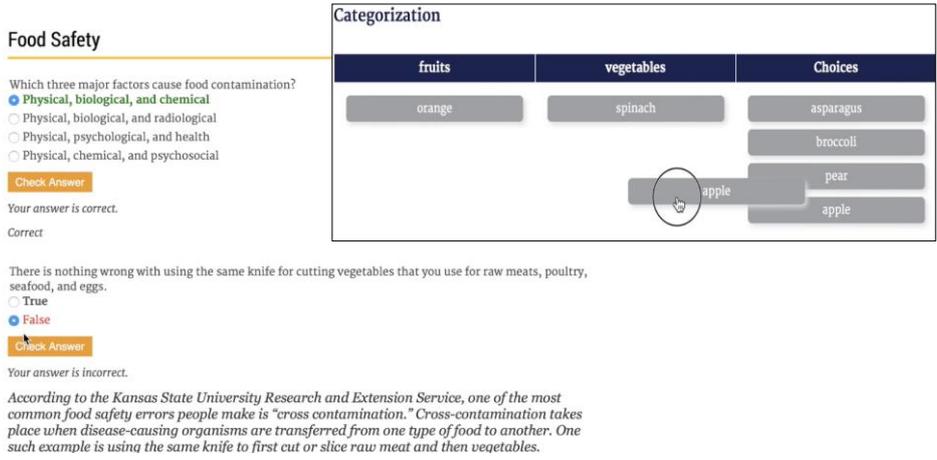
Fig. 8. Example of simple testing and interactive quiz elements in CourseArc

2.4 Brightspace LeaP (Desire2Learn)

The control of students' activities with Brightspace Leap allows to see student's weaknesses, according to his results, and automatically recommends materials that can help. The Brightspace Student Success System enables to identify potential student problems through predictive analysis and visual diagnostics, and to provide students with the help they need in a timely manner.
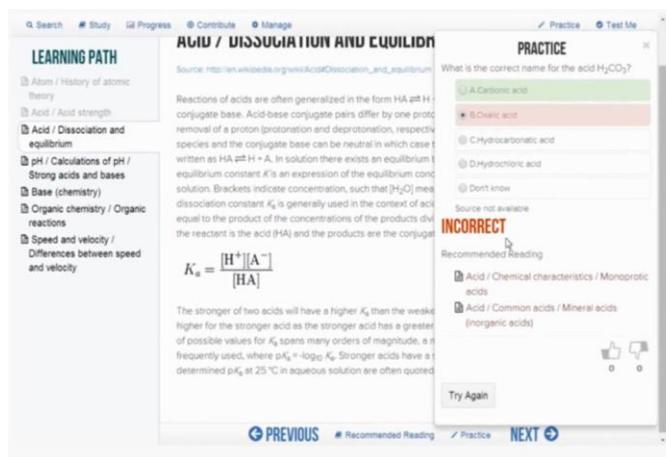
Fig. 9. Example of simple testing and interactive quiz elements in CourseArc

The user interface (**Fig. 9.**) allows creating interactive lists and courses using drag-and-drop. In particular, the OpenDyslexic font, that was designed specifically for people with dyslexia, should be stressed on as it intended to make content more accessible to a wider audience: choosing this font makes the course text easy to read.

2.5   Revel

Submitting Revel courses is easy and convenient, saves time and allows students to use their courses even more effectively. On the "Recommendations" page, users can find an advice on how to plan their course (**Fig. 10.**).
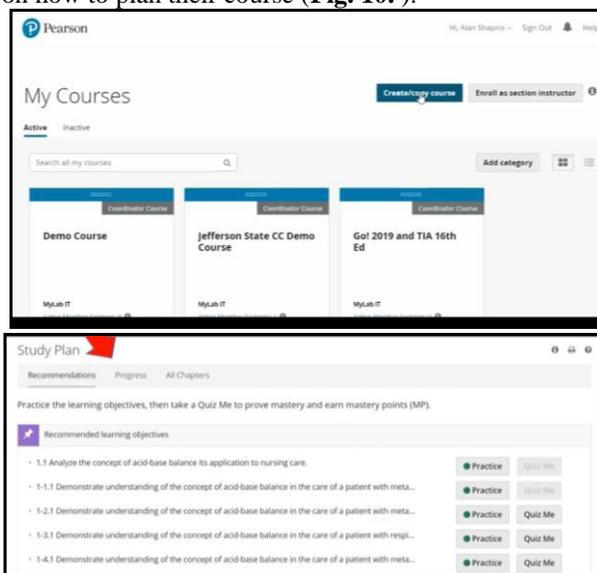
Fig. 10. The interface of the course choice page of page of the individual Revel curriculum

Among the opportunities and benefits that should be noted are effective access (single sign-on technology allows teachers and students to enter login once for all course resources); a unified assessment list with easy updates (grades for all MyLab & Mastering tasks are automatically submitted to the Blackboard Learn Assessment Center; upon request, Revel scores can be synchronized to allow teachers and students to track class progress in one location); comfortable workflow (having access to Pearson content from the course content area allows teachers to easily find and adapt content to their usual Blackboard Learn workflow) and student data confidentiality (student confidentiality is guaranteed in full compliance with student privacy standards).

In particular, a powerful and functional system of interactive quiz controls (**Fig. 11.**), the ability to create and use interactive maps, flash cards, quizzes that provide learning with the elements of gamification should be mentioned.
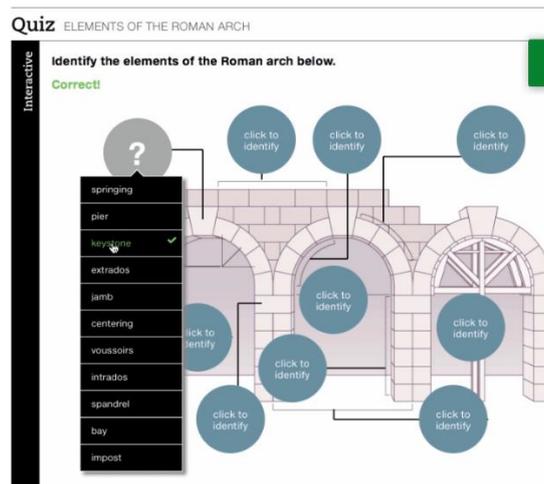
Fig. 11. An example of a Revel online quiz test

2.6 Open Learning Initiative (OLI)

The Open Learning Initiative (OLI) is presented by developers as a "cognitive mentor" and characterizes the system as a computer-based learning environment formed on cognitive principles and whose interacting with students is based on the discussion difficult questions with the mentor. The system does not stand out with bright design and is characterized by a moderate minimalistic color scale, but has a set of most necessary functions to work on the instructional design of the education courses and materials at its disposal (**Fig. 12.**).

Fig. 12. Course page interface and the fragment of the Open Learning Initiative (OLI) educational material

2.7 Generalized Intelligent Framework for Tutoring (GIFT)

GIFT enables to create adaptive courses both online and in an application downloaded to your computer (**Fig. 13.**).
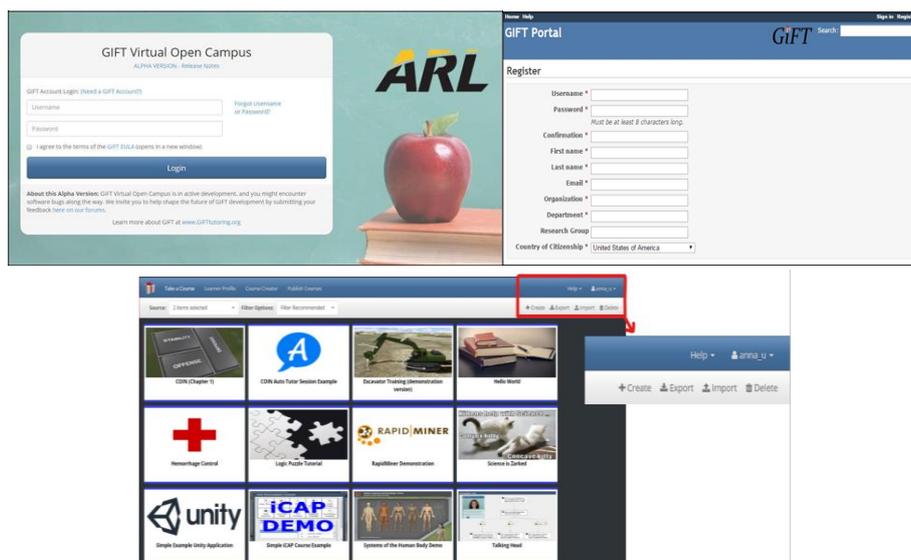
Fig. 13. Generalized Intelligent Framework for Tutoring (GIFT) interface

To the educational material content except the text block, tables and lists, links or web pages can be added. The possibility to use video and presentations makes the course more packed and entertaining. Simple GIFT tests are used to consolidate and to check gained knowledge. All list components support drag and drop function.

The main GIFT function is the possibility to add VR-Engage and Unity files to check students' knowledge.

In addition, given the analysis of the indicators of ergonomics and compliance with the principles of the instructional design of education courses in adaptive learning systems, the introduction of such education courses in the process of learning can provide more opportunities to diversify and increase the students' interest. The theoretical analysis of ergonomic indicators of the education courses, developed by means of existing adaptive learning systems, shows that the efficiency of the instructional design of educational materials is increased. Summing up, it must be recognized that the focus on increasing the level of ergonomic indicators and elements that follow the principles of the instructional design of education courses is an objective system response to the needs of modern students.

3   The Conclusion

Therefore, the use of new information technologies, in particular adaptive learning systems, provides wide opportunities for a significant quality improvement of the process of learning, increases both the level of knowledge acquisition and the learning interest itself. The instructional design of e-learning based on the principles of usability and ergonomics can be considered as an essential element that should be taken into account when designing modern learning tools. Based on the instructional design models, electronic educational resources will be able to convey educational material more effectively and create the conditions for its qualitative acquisition by learners. According to the analysis results of the ergonomic indicators and compliance with the principles of the instructional design of education courses in adaptive learning systems, it should be concluded that each of the systems has its own peculiarities and functional capabilities, so the selection of a suitable system of adaptive training for the construction of training courses should be made due to the needs that arise as a result of the instructional design of each individual education course. The prospects for further research include the establishment of methodological recommendations for taking into account the ergonomic indicators and applying the principles of the instructional design in the development of education courses in adaptive learning systems.

4   Funding

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