Web information educational assistant service with focus on artificial intelligence and smart systems technologies

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Abstract

In the 21st century, massive online courses and digital educational platforms have gained huge popularity and are widely used by many educational establishments worldwide. smart data and artificial intelligence-related technologies have been sufficiently developed and researched for their usage in other industries. This paper presents a modern take on the potential usage of artificial intelligence-related and smart data-driven technologies, with the focus on educational platforms. The study outlines the smart system design and provides as in-depth data classifications for educational processes and methodologies. The Educational Assistant web-service software model that had been designed consists of data-centered smart sub-systems, such as knowledge, recommendation, assessment, and expert feedback components. Platform-relevant data structures and algorithms were designed using educational assistant communication system architecture. As a result, the platform-specific algorithm for grading and course content recommendation has been outlined in model, equation, and algorithmic flow representation. The presented platform is not meant to replace teacher or teacher-student interaction, its goal is to help overcome present obstacles due to the nature of online education and help both parties with the process. The novel smart educational platform can be further enhanced after sufficient data testing and appropriate AI/data algorithm adjustments. Both educational establishments and researchers in the field of educational technologies can use this AI teacher and student assistant platform.

Keywords

educational technologies, MOOC, artificial intelligence systems, data-driven service, information system design

1. Introduction

Today, artificial intelligence is widely used in various fields of science and technology, including production automation, transport, medicine, the gaming industry, education, etc. It has already become a part of our lives, as it is actively used in mobile devices, including for photo processing, voice recognition, and battery management, in the form of Google Assistant, etc.

Artificial intelligence (AI) is a branch of computer science that enables the creation of programs and systems that can perform tasks that require substantial intellectual abilities. Various approaches are currently used to create it, including neural networks, machine learning, genetic algorithms, evolutionary strategies, etc.

As for the use of AI in the educational sector, it has a huge potential for significant improvement of educational systems both at the level of schools and higher education institutions [1]. The rapid development of AI in the educational environment is ensured by its ability to significantly transform a significant number of important aspects of teaching and learning processes. Taking into account the fact that AI can create unique virtual environments [2, 3] and the so-called "smart content", apply game-based forms of learning [4], break down difficult language barriers, fill in the gaps between teaching and learning [3], form an individual educational trajectory for each higher education student,

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it has already become a multibillion-dollar global market that significantly changes the educational environment.

In our country, the "Concept for the Development of Artificial Intelligence in Ukraine" has been approved at the government level, which provides for the creation of specialized AI educational programs in the field of higher education, as well as the inclusion of AI issues in other educational programs, including at the master's and doctoral levels [5].

A variety of tools and technologies are currently used to create and develop AI, including data analysis and processing – statistical methods, machine learning algorithms, probabilistic models, specialized software libraries and frameworks are important tools [6], etc.

The article aims to substantiate and develop a conceptual model of AI – a personal pedagogical assistant for teachers and students.

Artificial intelligence systems have been used not only for complex systems but for application development [1] and as a part of educational platforms [2]. Content search [4] student content personalization [3] and evaluation system using deep learning algorithms[5] has already been included as part of AI-related smart-systems in MOOC platforms [6, 7]. More complex and multilayered educational real-time platforms can be further enhanced with the addition of data-related AI systems [8, 9, 10, 11, 12]. Knowledge smart service systems [13], expert recommendations [14], and chatbot communication platforms [15, 16, 17] have been sufficiently studied and can be implemented in any modern software applications, educational use case included. In addition to the above-mentioned systems rise of video game popularity and extensive use of gamification techniques have reached the education industry as well [18, 19, 20]. Gamification can prove to be an important component of student-related system design and will be included in future iterations of the AI teaching assistant platform development [21, 22, 23, 24].

2. Materials and methods

The field of AI-related technologies is vast and provides many opportunities for researchers and developers alike. While the complete overview of existing AI systems, tools, and technology frameworks is outside of the scope of present research work, several important systems are helpful and have been used for the AI-assistant platform design and concept modeling. Table 1 highlights five smart data-related systems as well as communication systems that are imperative for educational platform design. While the first column lists systems and their components; column two outlines important tools that are used white the system scope, and column 3 lists research methodologies and components of the present system. While most of the presented systems had been used for AI-tech aging assistant platform design, Expert, Data and Communications systems can be considered foundational for the presented research work.

System design and development of a smart (AI-related) technology or software relies on data, data models, analyses, and algorithms. Data and algorithms are used to build smart systems. With it the scope of the smart teacher-student assistant platform several important algorithms are directly related to systems presented in table 1. Among all of the available AI research, the most beneficial algorithms for designing and Developing AI Teaching assistant systems are as follows:

- Rule-based algorithms;
- Fact and truth check;
- Fuzzy logic;
- Content-based Recommendations;
- Association Rules;
- Matrix Factorization;
- LambdaMart;
- Context-aware Recommendations;
- Similarity-based recommendations and others.

Table 1
Classification of tools, systems, and methodologies in the field of AI.

System	Tools	Methodology
Recommendation Systems: - Data - Baises - Engine	Software and Development: - Cross-platform/Application - Distributed - Data and algorithms	API Connection Interface
Expert Systems: - Data set - Knowledge base - Expert System	Data: - SQL/NoSQL - Tables - Big Data/Warehouse - Model Data - Metadata	Patterns Recognition Personalization Anomaly detection
Data Driven Systems: - Data mining - Edge computing - Prediction and Modeling	Infrastructure: - Cloud - Grid/Parallel/ - Virtualization	Autonomous systems Goal Driven systems Predictive and analytics systems
Objects and Patterns Recognition: - CV - ML/DL	Hardware: - CPU/GPU/TPU/FPGA - ML/CV specific architecture - DL processors	Human Conversation and Interaction Modeling and Visualization
Generative Systems: - GAN - VAE - NLP	Embedded and sensor devices Peripheral hardware	Data – model, evaluation, preparation, optimization
Communication: - Chat bot - Conversational AI	Computer and Communication Networks	Model training, transformation, interpretation and implementation

Even though the presented assistant platform doesn't directly generate the content, it relies heavily on the input data, as well and output data is important for the system to operate and fulfill its design purpose. The platform operates based on input requests from the students, as well as gets the parameters set by the lecturer. The list of the data sources used by/for educational assisting smart software is as follows:

- Manual input GUI – lecturer, teaching assistant;
- Historical data – automated collection and processing based on algorithm and software functions;
- Online materials, links, and resources – hyperlink;
- Real-time data – course interaction, assessment and updates;
- Existing Data models and semi-structured data.

The potential number of systems, algorithms, and data that need to be processed and implemented is tremendous. Within the scope and limitation of the research work, not all the above-listed systems and data sources had been fully processed and analyzed in the systems design and modeling phase. The focus of the presented system design is on the teacher-student communication platform with several key functionality features, as outlined in the results section of the article.

One of the main parts of the educational process is communication and interaction between teacher and student. Figure 1 illustrates this process as a linear flow where the teacher (lecturer) is the initiator of the communication flow. In this scenario and context of use, the lecturer uses existing MOOC platforms, such as e-learn (Moodle) for instance. The electronic educational portal is a very convenient modern tool for interaction between the teacher and students in the study of each academic discipline. Before the start of the school year, the teacher creates a new training course or updates an existing one. To provide students with everything necessary for mastering the course, the teacher prepares lecture materials, notes, or text content using various sources of information – textbooks, manuals, Internet sources, their own practical experience, etc. Also, the teacher needs to prepare all the methodological materials for conducting laboratory, and practical classes, and materials for the independent work of students. After that, when the teacher has developed all the materials, he places them on the electronic learning portal, which will not be difficult for him. In addition, it is necessary to compile and post on the portal control questions for each content module, as well as exam questions and test tasks. After being filled with the materials of the e-learning course, the teacher provides access to each student who has chosen such a course to study or such a course is normative for the specialty in which the student is studying. Immediately learning and full interaction between the teacher and the student can begin using the electronic learning portal.

The algorithm of communication between the student and the scientific and pedagogical worker in the process of using the e-learning course in the discipline and questioning or evaluation regarding the assimilation of course materials and the acquisition of competencies is an important aspect of the educational process, which has a deep scientific basis and requires serious research. Considering this process in more detail, it is possible to determine the following aspects of the theoretical basis of this process. Firstly, communication in the educational process is based on several key aspects – interaction between the student and the teacher for effective learning; the active role of the student in the knowledge science through interaction with the teacher and the environment; the importance of timely and constructive feedback from the student to the teacher to improve learning outcomes.

The list of main educational communication and interaction activities is presented in figure 1 (top image). While this process has its uses and was very common with the emergence of digital web-based educational platforms (MOOC) new software and technological advancement in areas of AI, chat-bots and smart data processing, cloud computing, etc. opened a new pathway for real-time communicating where the teacher is not the only one who can start the communication process. Figure 2 showcases the conceptual scenario where the smart platform is at the center of interaction, which is no longer linear but iterative and cyclical, under this scenario students as well as other university staff can take an active part in the communication process [25, 26, 27, 28].

3. Educational Assistant concept

The new era presents new opportunities to gather with challenges. The education industry is no exception to this. With huge leaps in digital technology advanced, reduced end-product costs also to every human can have access to a mobile phone, the internet, and some type of computational device (own or rent or use it in unit space). At the same time new challenges arose, climate-related natural distaste, military conflicts, viruses, and many more. Both of these opportunists and clan ages had a tremendous impact on modern higher education. Many of the world's institutions switched to complete online or mixed education (offline and online education). To help with this Massive online course platforms have been deployed and are in use. With online classes, teachers and students communicate via online platforms. While MOOC and online education provide its benefits, there are setbacks as well. Namely real-time communication, course assessment and feedback, and others. To help solve present issues we study the potential usage of AI-related technologies as part of the online (and partially mixed) educational process.

In the process of electronic (distance or blended) learning using an e-learning course, there is an interaction between the student, the teacher, and the academic discipline in the process), which is a complex system and has its characteristics. They must be taken into account by the teacher for the effective assimilation of the course materials by the student. The student, as an active participant in the educational process, independently organizes his/her e-learning at a convenient time and in a convenient way for him/her, and interacts with the educational material, the teacher, and other students.

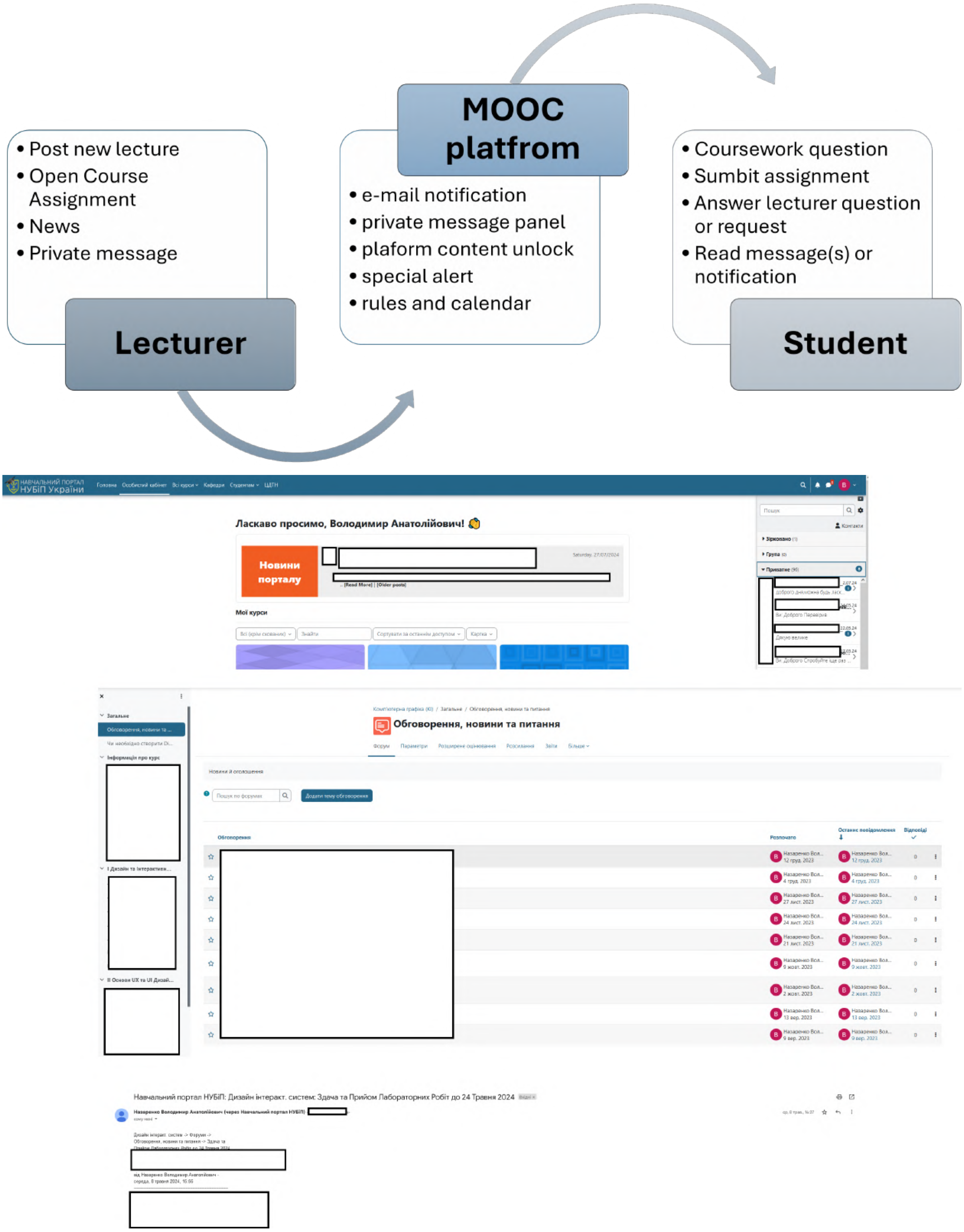

Figure 1: Typical lecturer-to-student communication flow using MOOC platform.

The teacher is a developer of educational content, moderator of online discussions, and consultant and directly evaluates all educational achievements of the student. The teacher presents each academic discipline in the form of electronic content, structures it following the learning objectives, and adapts it for independent study by the student.

At the same time, the teacher offers the following forms of interaction between the student and the

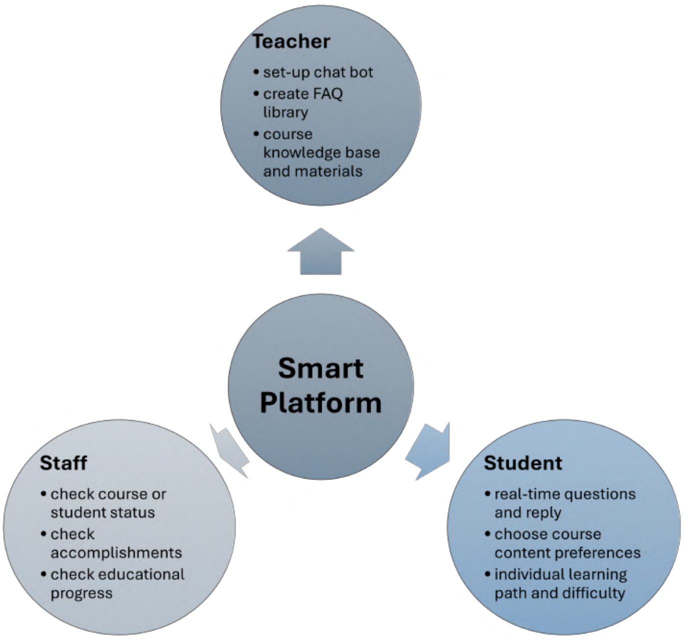

Figure 2: Conceptual representation of lecturer to student communication flow using smart educational platform.

academic discipline: independent study of electronic materials, interactive tasks, passing online tests, etc.

Thus, in the course of the study, it is established that the interaction between the student, the teacher, and the academic discipline in the process of e-learning is a dynamic system that requires new approaches to the organization of the educational process. Its effectiveness depends on the right balance between the technological capabilities, pedagogical strategies, and the individual needs of participants, which will ensure high-quality education in an online learning format.

AI teacher-student assistant platform is a software system, and as such there is an established roadmap for its design, development, and implementation. List of the Educational Teaching Assistant requirements, features, and functionality (list had been made based on personal research and present educational process flow):

- General requirements – automated reply and FAQ, locate and add useful materials, help assess assignments, build an educational plan, and attach content;
- General Functions – CreateNewCourse, GenerateUI, ConnectTo, TransferData;
- Lecturer side – InitializeChatBot, CreateAssessmentRules, AssessStudentWork, WorkFeedback;
- Student side – CreateLearningPlan, LearnNewMaterials, SubmitWorkForReview;
- Smart systems – generate text content (multimedia in future), search for materials and links, grade course and content, automated feedback, and notifications.

The Educational Assistant system is a larger-scale software system that consists of many sub-systems and modules. For testing and AI-modeling purposes, the first component is the Simulation app; while the main functional part is the Interactive Communication Bot platform. The educational platform is meant to assist teachers with real-time course assignment assessments and quickly respond to student course-related inquiries. For students, such systems are helpful as they can provide real-time responses based on specific assignments or answer course/study subject-related questions. Among all the available smart systems, the following four are part of the proposed AI-based assistant system – Expert, Assessment and Recommendation Systems, and Knowledge-base module. The detailed representation of the AI assistant model is in figure 3 and figure 4 (the image above highlights system functionality; the second image outlines four smart systems that are part of the platform and are used to make the platform "smart" and data-driven).

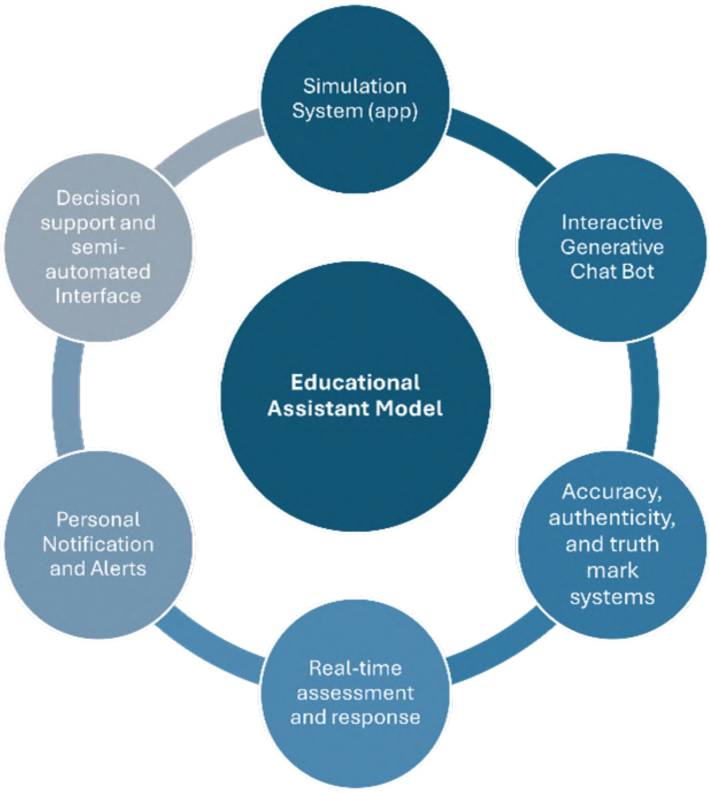

Figure 3: AI Educational Assistant concept model and smart systems.

AI educational assistant systems can be classified as distributed software services. As such, there are a number of stages that need to be completed, as well as requirements to be fully filed for the systems to be developed and implemented. Table 2 highlights six key stages (software development phases) with a list of relevant system requirements and components. It should be noted that the present system stages and requirements outline the end-user application part of the smart AI platform.

Figure 5 presents a generalized educational system model, and outlines three key system user types – Professor, Teaching Assistant, and Student. The designed system consists of three layers of abstraction – user interface, main application service, and smart management system.

The smart part of the personal educational assistant is data data-driven software system, that relies heavily on the appropriate data sets, structures, as well as data processing for further system usage. AI-based systems have different development stages and requirements to the standard applications. For the AI educational assistant system, we adhered to the following system development plan and (smart) algorithm design:

1. List – functions and data;
2. User side requirements;
3. Data structures and Models;
4. Smart-system based algorithms;
5. Software components architecture;
6. Initial software application prototype development and testing;
7. AI-system architecture and model review; further validation and evaluation.

4. Educational assistant system architecture and data structure

Table 3 denotes an extended classification list of the data set of the educational system. The list is presented as follows; each data type is classified based on the system module it is used in; data source

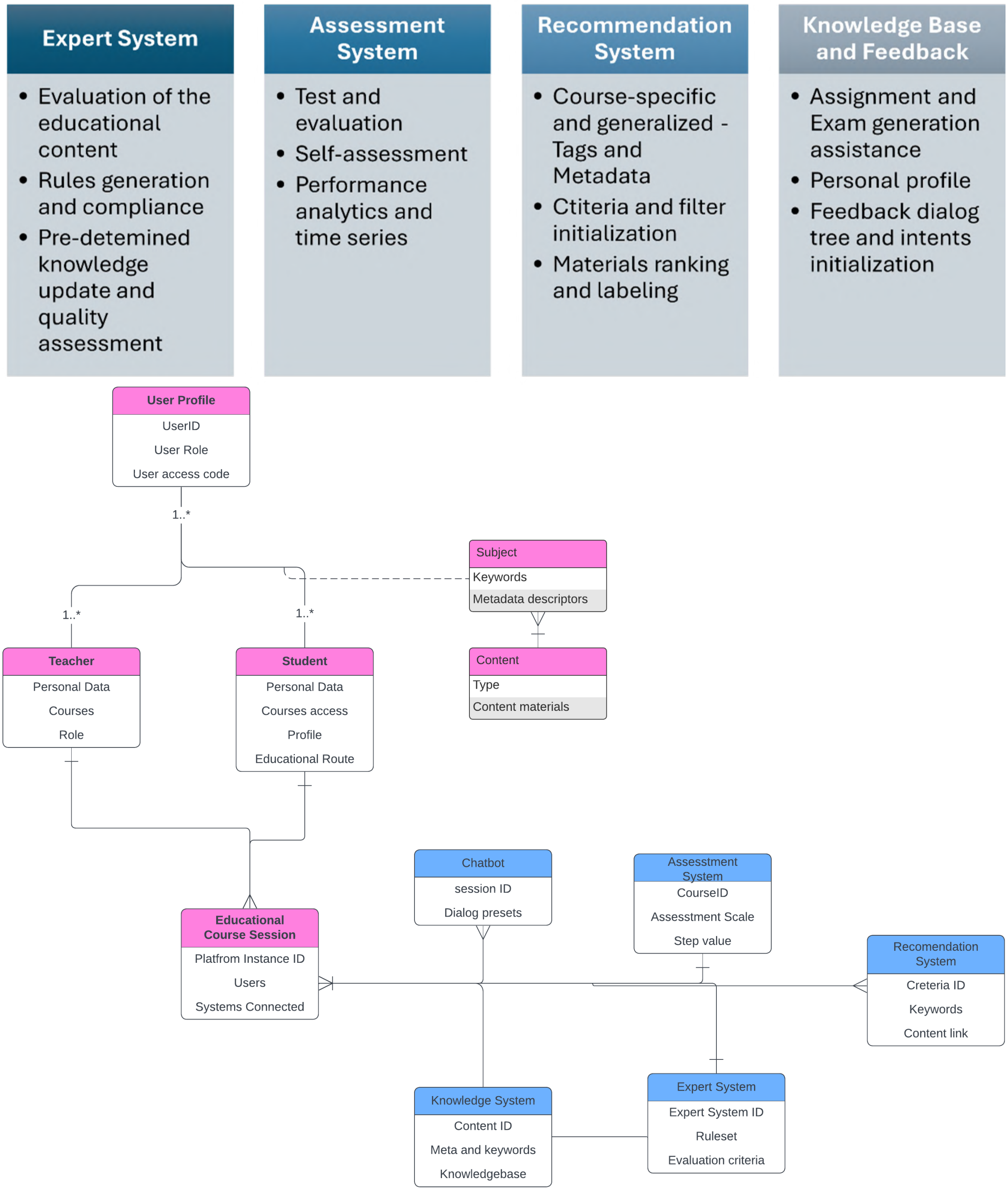

Figure 4: AI Educational Assistant smart systems.

and presentation format; the third column provides sample data formats or software code for the appropriate data type.

Sample algorithm data code snippet for Table 3 Algorithms data field:

```
{
    "id": "seed_task_1",
    "name": "complete_algo_code",
    "instruction": "In1.",
    "instances":
```

Table 2
AI Assistant System components.

Stages	Requirements	Components
Initial concepts	User and functional requirements	Use case diagram Main functions User experience
Research and knowledge system concept	Existing systems and Data	Data rules Knowledge base Links and materials
Concept requirements	Technical requirements and infrastructure	Software stack Hardware system
Data and algorithms	Data model Database model	ML/DL/NLP algorithms Mathematical representation
UI and UX	Student GUI Lecturer GUI	Functional requirements UI menu and elements
Application and next stages of development	First application iteration Demo application for testing	Training models Software prototype Database and data set

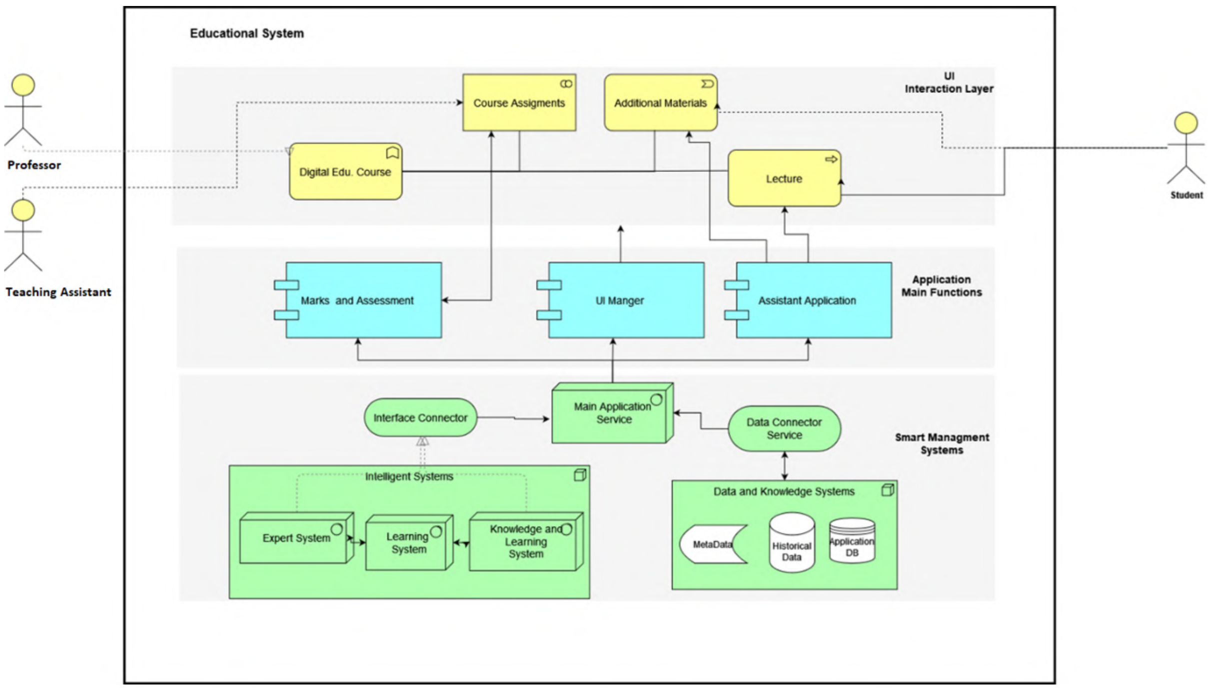

Figure 5: AI Educational Assistant concept diagram.

Table 3
AI Assistant System Components

Data type	Source	Data samples

Application Data	Realtime data and Users
	
	UI data Main application
	
	Data Base
		SQL/NoSQL/Table DB
		
		CREATE DATABASE eduDB;
		
		> db.user.insert({name: "Teacher Surname", age: 26, Subject: 'Math'})
		
		public Table importTableFromDataTable(DocumentBuilder builder, DataTable dataTable, boolean importColumnHeadings) {
		Table table = builder.startTable(); //...
		builder.endTable();
		return table; }

Knowledge base	Data labels Metadata Knowledge graphs	Meta descriptors: • course title • subject • lecturer • table of content • tags • labels

Chat bot data	Rules
	
	Dialog tree
	
	Interns catalog
		{
		"intents": [
		{
		"tag": "help",
		"patterns": [
		"feedback",
		"search",
		"content"
		],
		"responses": [
		"searching for...."
		]
		}
		}

Algorithms data	Set of instructions Model set Training and Validation results Parameters	json code (listed below the table)
System unique data	Course materials Grading and assessment criteria Library and dictionary	data representation (listed below the table)

```
        [{"input": "import json\n\ndef read_task_from_jsonl(data_file):\n
"This function will...",
        "output": "import json\n\ndef read_task_from_jsonl(data_file):\n
"This function will read ..."\n    with open(data_file) as fin:\n
        return [json.loads(line)['task'] for line in fin]"}],
    "is_classification": false
}
```

Grading data representation code snippet for Table 3 System unique data field:

```
student_data <- data.frame(
  StudentName = c("Name1", " Name2", " Name3"),
  ExamScore = c(25, 87, 100, 94)
)
grade_exam <- function(score) {
//...
}
display(grade);
```

Teacher-to-student communication is the essence of the educational process. Figure 6 showcases the system model diagram of the Communication module from the educational platform. The system model showcases two main use-system interaction types – GUI or via chat-bot interface. At the heart of this system architecture are connector and routing sub-system modules. Smart communication systems provide three functional components – Course assessment, course/assignment help, and student real-time communication.

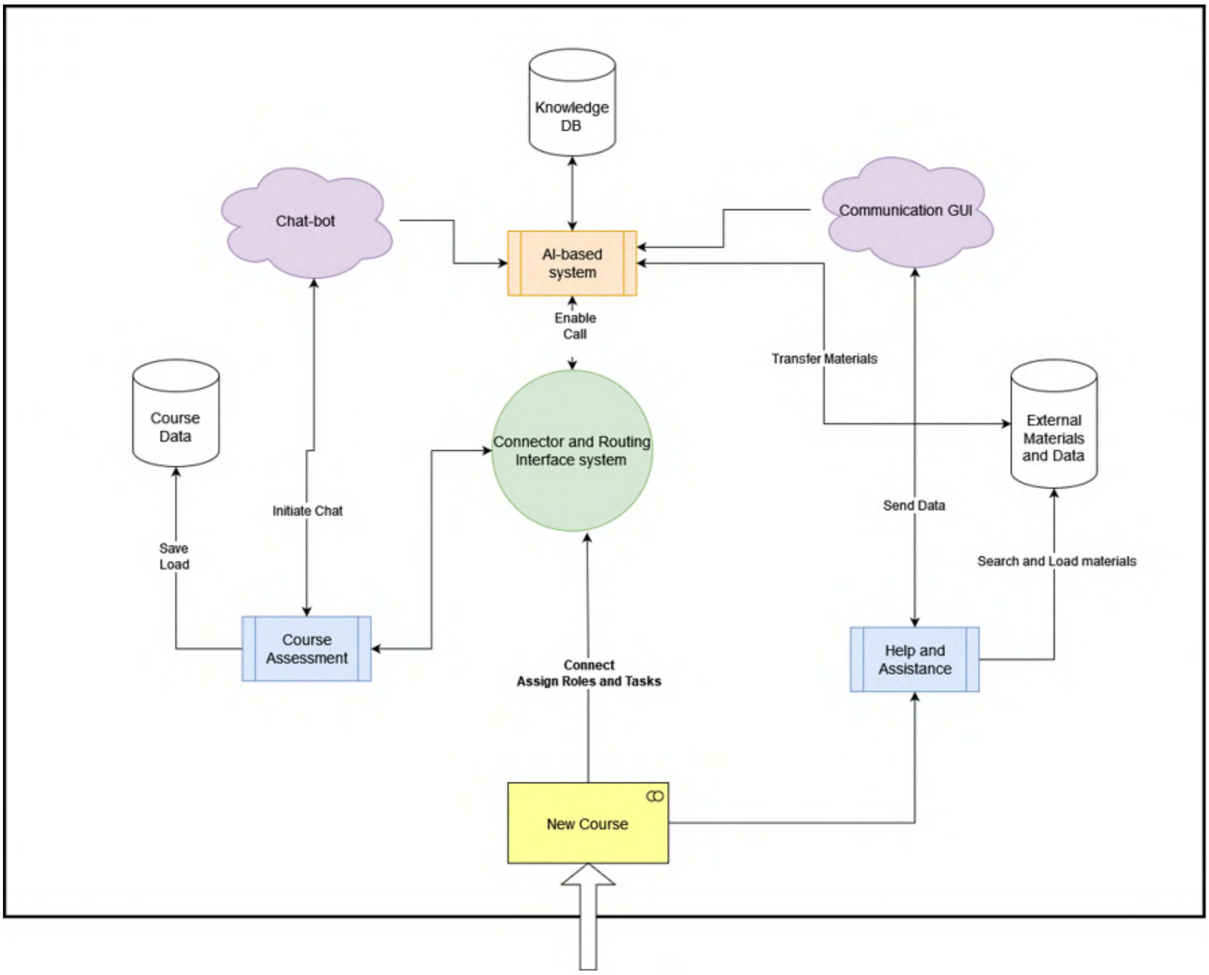

Figure 6: AI Educational Assistant communication system architecture.

The end product is an application or web-service plug-in that both student and lecturer can access via the web browser application. The mock-up of the user interface is presented in figure 7. The student will be able to enable chat-bot communion via the appropriate side panel, as well as view grading and assessment Infographic visualization of current standing; and other activities as presented on the mock-up image.

As for the stages of the algorithm of communication between the student and the teacher in the process of studying the discipline, it can be divided into the following stages:

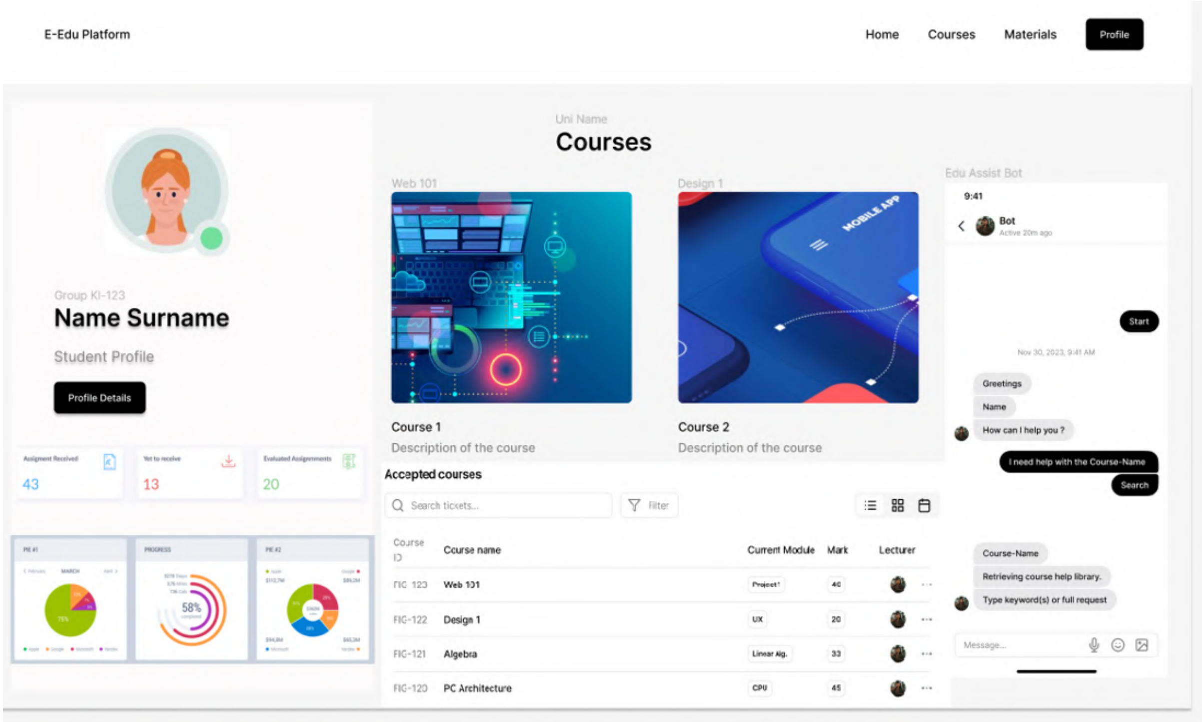

Figure 7: Mockup GUI for Educational Assistant student course panel with bot.

- preparatory: defining the objectives of the survey or evaluation; preparation of appropriate materials and tools; creating a favorable environment for communication;
- establishing contact: establishing a positive emotional background; An explanation of the purpose and procedure of the survey or evaluation; ensuring the psychological comfort of the student;
- conducting a survey or assessment: formulating questions, tests, or tasks; giving the student sufficient time to prepare an answer; attentive listening and observation of nonverbal cues;
- feedback stage: providing constructive feedback; discussion of results and possible ways to improve; use of various types of student encouragement to study the discipline;
- completion of the course: summarizing the key points; determination of further steps in interaction; positive end of interaction;
- Scientific principles of effective communication (can be used for masters and PhDs: the principle of active listening, when the teacher should listen carefully to the student, demonstrating his interest and understanding; the principle of understanding and taking into account the emotional state of the student; the principle of clarity: clear and understandable formulation of questions and comments; the principle of objectivity: an unbiased attitude to the student's answers; the principle of constructiveness: focus on positive aspects and opportunities Improve.

When interacting with students, psychological aspects should also be taken into account: individual characteristics of the student (personality type, anxiety level, motivation); creating an atmosphere of trust and psychological safety, which will improve the ability to assimilate educational materials; managing stress and emotions of both the teacher and the student.

5. Educational Assistant system algorithm

Equally important in the learning process are technological aspects, such as the use of appropriate technologies for conducting surveys or assessments (online platforms, interactive tools), ensuring confidentiality and data protection, and adapting the communication process to different formats (face-to-face, online, mixed). The course instructor should evaluate the effectiveness of communication with students in the course learning process, which includes analyzing the results of a survey or assessment, collecting feedback from students on the communication process, and continuously improving the teacher's communication skills.

The algorithm of communication between a student and a scientific and pedagogical worker in the process of questioning or evaluation is a complex and multifaceted process based on a deep scientific basis. Effective implementation of this algorithm requires a high level of professional skills, emotional intelligence, and constant self-improvement from the teacher. Properly structured communication not only provides an objective assessment of the student's knowledge but also contributes to his personal and professional development, forming a positive attitude toward the educational process as a whole.

The main educational activity of any online educational platform revolves around course-related actions. Figure 8 illustrates a step-by-step process of course-related interaction between the lecturer, student, and chant-bot platform. The algorithm diagram highlights a list of steps and main functions that the platform has, starting from course creation by the lecturer (professor) to chart-bot interface initialization followed by a series of student actions related to course help and search for useful materials for the assignment submission. At this phase when students request and search for help with educational and study materials, the smart system connects and processes data, as well as provides recommendations, content generation, and other system-specified functionality.

The essential part of the course communication and student assistance is requested content matching and search. Below is the equation (1) that is used in the recondition system algorithm to evaluate the value of requested content matches with the search-located content. Search-request-match equation for course content matching:

$$SRM(w, n) = \sum \frac{f(w, v) * ind_t}{w_{count}} * s_{ind}, \tag{1}$$

where w – search word; n – word search value (intent and priority, order strength), SRM – returns list of words with matching priority value based on input search word (s) and their calculated aggregated search values for future search-and-match content algorithm operations, $f(w, v)$ (equation 2) is calculated weight of word in each category (intent, priority and order position), ind_t – search word topic index (0 to 1), w_{count} – number of search words (less the faster the search), s_{ind} – search internal/external priority index (internal is faster and returns greater value).

$$f(w, v) = \log \frac{v}{w_i} \tag{2}$$

Search operation is an important part of the content matching and the search process. The presented algorithmic functional representation can be used in any existing software system or can be developed as a standalone software module or smart-system software algorithm. The search request system algorithm consists of the following stages, functions, and data models:

- Search flow (stages): input → filtering → assessment and measuring → quick search → grouping and intent → full search → generation → output;
- User interaction interfaces: chat bot UI; course webpage UI;
- Input: Word/Words; filter options;
- Values: wordValue; listOfWordsValue[key, value]; SearchWords[]; SearchPriorityOrder; SearchCost[key, value]; MatchValue; wordIntent;
- Output: LinksList[]; Word/Words; LinksListWordValue[key, value];
- Functions: TopicTypeClassification(); SentenceBreakdown(); WordsValue(); IntentValue(); hashFunction().

Figure 9 illustrates the detailed text algorithmic representation of the search-request-match algorithm.

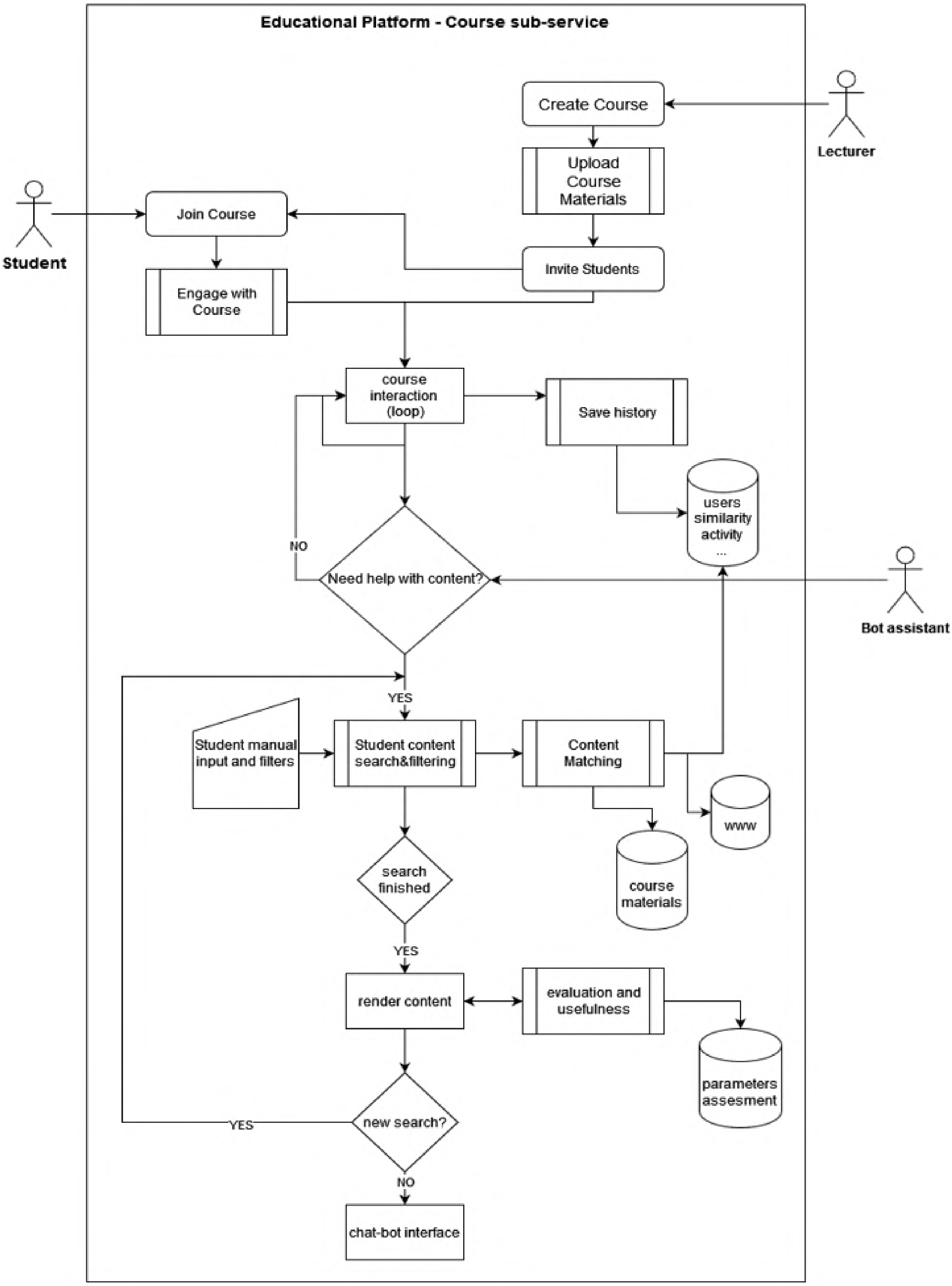

Figure 8: Grading and course content recommendation algorithm.

```
Input: list of search words, library of course topic and keywords value pairs
Output: list of search words with priority value
function accept input parameters, list of Words L (can be returned from another function that breaks down and analyses sentences into keywords) and course library keywords reference
  repeat
     pick word from L and assign it keyword = Lk
     assign value to Lw based on keyword     = Lkw
     if keyword not found assign custom value with lowest priority = Lkw const
     move to next word from the list L
  until L is empty
  repeat
     calculate priorityValue of each word based on equation SRM (1)
     sort List[word, priorityValue pairs based on priorityValue in descending order until L is empty
  until L is empty
return List[word, priorityValue]
```

Figure 9: Algorithmic pseudo-code search-request-match representation.

6. Conclusions

AI teaching assistant platform is a complex multi-layered software system. The initial assumption was that this system could be designed and developed based on existing software architecture and smart systems design patterns. However, in the process of system modeling and after breaking down the initial content into functional modules the complexity not only of the system but of its comments had risen. The platform has been divided into two parts – software end-user applications and AI-related smart data platforms. For each of the plants, the development process had been destined and presented. While the student-teaching assistant application had been designed as a web service, the smart AI assistant platform is more complex and includes four smart-system modules.

Due to the limited scope and resources available, the platform design had been catered around the educational assistance communication module. This module connects teacher, student, and system communication chat-bot interface. Coursework grading and students' real-time course assignments had been outlined as major functional parts of the educational assistance. Search, request, and materials presentation had been classified as main system functional tasks and for them, appropriate algorithms had been designed and presented.

The research efforts that had been carried out within the scope of the presented work are the first step in studying of the potential AI applicants for the educational use case. The research work on the AI educational assistance platform will be continued with the focus on further specifying smart system platform architecture to gather the algorithm's designs and evaluation for the course grading and educational content matching, as well as real-time chat-bot AI assistance students help.

References

[1] J. C. Kunz, T. P. Kehler, M. D. Williams, Applications Development Using a Hybrid Artificial Intelligence Development System, AI Magazine 5 (1984) 41–41. doi:10.1609/aimag.v5i3.447.

[2] R. Luckin, M. Cukurova, Designing educational technologies in the age of AI: A learning sciences-driven approach, British Journal of Educational Technology 50 (2019) 2824–2838. doi:10.1111/bjet.12861.

[3] H. Yu, C. Miao, C. Leung, T. J. White, Towards AI-powered personalization in MOOC learning, npj Science of Learning 2 (2017) 15. doi:10.1038/s41539-017-0016-3.

[4] A.-J. Moreno-Guerrero, J. López-Belmonte, J.-A. Marín-Marín, R. Soler-Costa, Scientific devel-

opment of educational artificial intelligence in Web of Science, Future Internet 12 (2020) 124. doi:10.3390/fi12080124.

[5] J.-W. Tzeng, C.-A. Lee, N.-F. Huang, H.-H. Huang, C.-F. Lai, MOOC evaluation system based on deep learning, International Review of Research in Open and Distributed Learning 23 (2022) 21–40. doi:10.19173/irrodl.v22i4.5417.

[6] R. Yilmaz, H. Yurdugül, F. G. Karaoğlan Yilmaz, M. Şahin, S. Sulak, F. Aydin, M. Tepgeç, C. T. Müftüoğlu, Ö. Oral, Smart MOOC integrated with intelligent tutoring: A system architecture and framework model proposal, Computers and Education: Artificial Intelligence 3 (2022) 100092. doi:10.1016/j.caeai.2022.100092.

[7] X. Zhai, X. Chu, C. S. Chai, M. S. Y. Jong, A. Istenic, M. Spector, J.-B. Liu, J. Yuan, Y. Li, A Review of Artificial Intelligence (AI) in Education from 2010 to 2020, Complexity 2021 (2021) 8812542. doi:10.1155/2021/8812542.

[8] R. Dodhiawala, N. S. Sridharan, P. Raulefs, C. Pickering, Real-Time AI Systems: A Definition and An Architecture, in: IJCAI, Citeseer, 1989, pp. 256–264. URL: https://www.ijcai.org/Proceedings/89-1/Papers/041.pdf.

[9] D. Janjanam, B. Ganesh, L. Manjunatha, Design of an expert system architecture: An overview, Journal of Physics: Conference Series 1767 (2021) 012036. doi:10.1088/1742-6596/1767/1/012036.

[10] H.-M. Heyn, E. Knauss, P. Pelliccione, A compositional approach to creating architecture frameworks with an application to distributed AI systems, Journal of Systems and Software 198 (2023) 111604. doi:10.1016/j.jss.2022.111604.

[11] B. Hayes-Roth, An architecture for adaptive intelligent systems, Artificial intelligence 72 (1995) 329–365. doi:10.1016/0004-3702(94)00004-K.

[12] K. Lavidas, A. Petropoulou, S. Papadakis, Z. Apostolou, V. Komis, A. Jimoyiannis, V. Gialamas, Factors Affecting Response Rates of the Web Survey with Teachers, Computers 11 (2022) 127. doi:10.3390/computers11090127.

[13] X. Li, C.-H. Chen, P. Zheng, Z. Wang, Z. Jiang, Z. Jiang, A Knowledge Graph-Aided Concept–Knowledge Approach for Evolutionary Smart Product–Service System Development, Journal of Mechanical design 142 (2020) 101403. doi:10.1115/1.4046807.

[14] Á. Tejeda-Lorente, J. Bernabé-Moreno, J. Herce-Zelaya, C. Porcel, E. Herrera-Viedma, Adapting recommender systems to the new data privacy regulations, in: New Trends in Intelligent Software Methodologies, Tools and Techniques, volume 303 of *Frontiers in Artificial Intelligence and Applications*, IOS Press, 2018, pp. 373–385. doi:10.3233/978-1-61499-900-3-373.

[15] T. Lalwani, S. Bhalotia, A. Pal, V. Rathod, S. Bisen, Implementation of a Chatbot System using AI and NLP, International Journal of Innovative Research in Computer Science & Technology (IJIRCST) 6 (2018) 26–30. URL: https://www.ijircst.org/DOC/2_irp620.pdf. doi:10.21276/ijircst.2018.6.3.2.

[16] G. Hiremath, A. Hajare, P. Bhosale, R. Nanaware, K. S. Wagh, Chatbot for education system, International Journal of Advance Research, Ideas and Innovations in Technology 4 (2018) 37–43. URL: https://www.researchgate.net/publication/347902940.

[17] F. Clarizia, F. Colace, M. Lombardi, F. Pascale, D. Santaniello, Chatbot: An Education Support System for Student, in: A. Castiglione, F. Pop, M. Ficco, F. Palmieri (Eds.), Cyberspace Safety and Security, volume 11161 of *Lecture Notes in Computer Science*, Springer International Publishing, Cham, 2018, pp. 291–302. doi:10.1007/978-3-030-01689-0_23.

[18] W. S. do Monte, M. M. Barreto, A. B. da Rocha, GAMIFICATION E A WEB 2.0: planejando processo ensino-aprendizagem, HOLOS 3 (2017) 90–97. doi:10.15628/holos.2017.5759.

[19] I. Yildirim, The effects of gamification-based teaching practices on student achievement and students' attitudes toward lessons, The Internet and Higher Education 33 (2017) 86–92. doi:10.1016/j.iheduc.2017.02.002.

[20] Z. H. İpek, A. I. C. Gözüm, S. Papadakis, M. Kallogiannakis, Educational Applications of the ChatGPT AI System: A Systematic Review Research, Educational Process: International Journal 12 (2023) 26–55. doi:10.22521/edupij.2023.123.2.

[21] J. Daniel, E. Vázquez Cano, M. Gisbert Cervera, The Future of MOOCs: Adaptive Learning or Business Model?, International Journal of Educational Technology in Higher Education 12 (2015) 64–73. doi:10.7238/rusc.v12i1.2475.
[22] P. M. Moreno-Marcos, C. Alario-Hoyos, P. J. Muñoz-Merino, C. D. Kloos, Prediction in MOOCs: A Review and Future Research Directions, IEEE Transactions on Learning Technologies 12 (2019) 384–401. doi:10.1109/TLT.2018.2856808.
[23] R. Rohan, D. Pal, S. Funilkul, W. Chutimaskul, W. Eamsinvattana, How Gamification Leads to Continued Usage of MOOCs? A Theoretical Perspective, IEEE Access 9 (2021) 108144–108161. doi:10.1109/ACCESS.2021.3102293.
[24] S. Papadakis, Moocs 2012-2022: An overview, Advances in Mobile Learning Educational Research 3 (2023) 682–693. doi:10.25082/AMLER.2023.01.017.
[25] B. Williamson, R. Eynon, Historical threads, missing links, and future directions in AI in education, 2020. doi:10.1080/17439884.2020.1798995.
[26] C. Zhou, Integration of modern technologies in higher education on the example of artificial intelligence use, Education and Information Technologies 28 (2023) 3893–3910. doi:10.1007/s10639-022-11309-9.
[27] R. Deng, P. Benckendorff, D. Gannaway, Progress and new directions for teaching and learning in MOOCs, Computers & Education 129 (2019) 48–60. doi:10.1016/j.compedu.2018.10.019.
[28] F. J. García-Peñalvo, Á. Fidalgo-Blanco, M. L. Sein-Echaluce, An adaptive hybrid MOOC model: Disrupting the MOOC concept in higher education, Telematics and Informatics 35 (2018) 1018–1030. doi:10.1016/j.tele.2017.09.012.