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Ontology-Based Recommendation System Using GitHub Classroom and Bookwidget

Munkhtsetseg Namsraidorj [1], Battushig Namsraidorj [1], Amirlan Enkhtur [2]

[1] *School of Information Technology and Electronics, National University of Mongolia, Ulaanbaatar, Mongolia*
[2] *Computer Science and Engineering, J.B. Speed school of engineering, University of Louisville, USA*

Abstract **– If technology is handled efficiently, every teacher has the opportunity to easily provide education to everyone anywhere, anytime using a radically different technology solution. Nowadays, many tools, technologies, and instructional designs are being invented and implemented to assist the teacher in sharing their knowledge with others. A teacher should be a producer, processor, distributor of knowledge, a guide to the right path, and an active examiner. Therefore, in addition to technological solutions and accessibility, the quality and assessment of e-learning are important issues. The evaluation of e-learning depends on many factors, such as the content of the course, the methodology, the technological environment, the teaching materials, and the participation of both the teacher and the students. It is not clear what knowledge is in itself, however, it is possible to know what abilities a student has mastered with certain tools, and the ontology based on the results of using this tool creates the graph of knowledge about that student. At present, the technology of building ontology is widely studied and used in most fields. Ontological studies in the field of education are mostly used to monitor the interaction of learning objects and to solve problems such as the modeling and enrichment of learning resources, optimal evaluation of learning, and integration of educational content recommendations into student learning methods.**

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Corresponding author: Battushig Namsraidorj,
Department of Information Computer Sciences, National University of Mongolia, Ulaanbaatar
Email: battushig.namsraidorj@gmail.com

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In this article, a simple learning environment at a low cost is aimed to be created while still providing high-quality education to the students. To reach that aim, we expanded the GitHub Classroom and Bookwidget systems with other software, constructed an ontology on each student to evaluate the efficiency of the teaching system, and created a graph of each student's understanding.

Keywords **– E-Learning, infrastructure, Google Classroom, Bookwidget, GitHub classroom, Microsoft Teams, Active learning, Knowledge graph, Ontology.**

1. Introduction

Across the globe, educational technology is being innovated and utilized in diverse ways, including computers, smart devices, television, radio, web-based platforms, game-based learning, learning management systems, and virtual learning environments. While these technologies vary in multiple aspects, software remains their core component. To give personalized learning, matching each person's uniqueness, these technologies are in constant need to be improved. Organizing a course that considers language, visual impairments, and mental problems complicates the development of educational technology [1]. In this time, where teaching and learning using technological advances are given high emphasis, it has become important for teachers to constantly learn and improve themselves.

Teachers are no longer assessed only on their knowledge, not having the ability to manage the lesson competently considers the teacher unqualified [2]. In today's competitive field, to remain established in the profession, it is necessary to do and perform many tasks, such as creating e-learning objects, developing teaching plans, conducting research, and self-development. This article describes how to create and use e-learning infrastructure in the classroom in the easiest way. This infrastructure is designed to enable instructors to create effective interactive learning for any online course that is complementary or blended learning [3]. The constant development and need for technologies are costly. The goal is to construct an e-learning environment that meets the student's needs and the teacher's expectations while saving this cost.

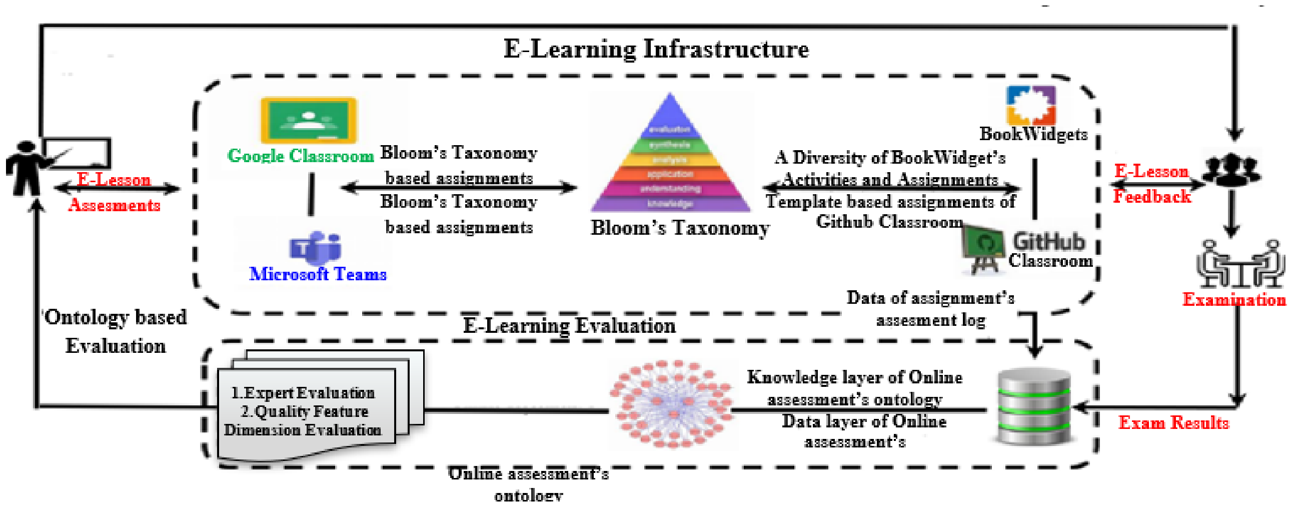


Figure 1. Proposed system architecture for recommendation based on ontology evolution

The structure of the online learning system that has been constructed has 2 main parts, e-learning infrastructure and e-learning evaluation [4]. The e-learning infrastructure part consists of tools and online objects needed to run the course. The e-learning evaluation section's purpose is to evaluate the results of the class usinginfrastructure, plot a knowledge graph of the student's understanding of the course, and create a recommendation system based on that graph to improve the student's participation and ability to understand [5]. The essential components of e-learning infrastructure include:

- Course management systems
- Digital learning resources
- Strategies for delivering online courses
- Assessment and evaluation of e-learning effectiveness

To determine the most suitable platform, open-ource online learning platforms such as Moodle, Canvas, Open-edX, Google Classroom, or GSuite can be utilized. Google's GSuite for education and Microsoft's Microsoft Teams software have the great advantage that educational institutions can freely use their web-based and mobile versions at no cost or minimal cost to install any software. Therefore, Google Classroom and Microsoft Teams were used as Learning Management Systems to create the learning infrastructure. Google Classroom and Teams were used to conduct the training, but since these are limited in terms of functionality, we conducted the training with the infrastructure shown in Figure 1, which was extended to activate the training process with the Bookwidget system as additional software and to collect and evaluate programming course assignments using GitHub Classroom.

In an eLearning platform, "LTI" stands for "Learning Tools Interoperability," which is a standard that enables seamless integration of third-party learning tools and applications within a learning management system (LMS) [6], allowing users to access external content or functionalities without leaving the main platform and needing separate logins; essentially, it acts as a bridge to connect different educational tools and platforms smoothly.

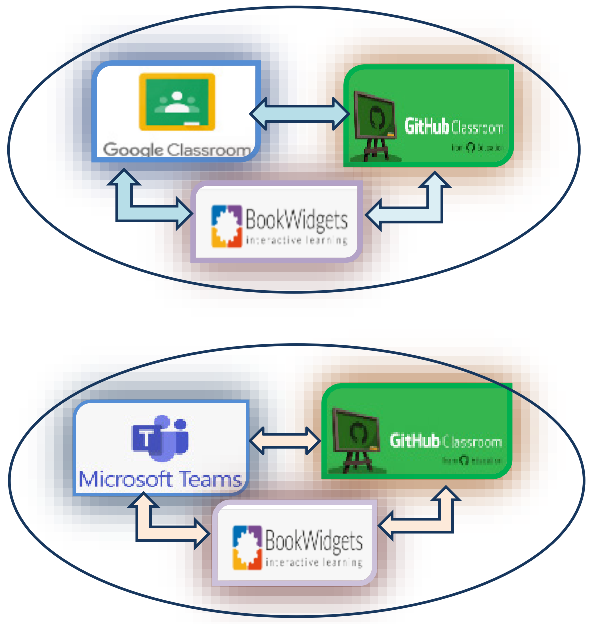


Figure 2. Infrastructure with Google Classroom and Microsoft Teams

Thus, additional software alongside them, using the Bookwidget system to initiate the course process and GitHub Classroom to collect and evaluate programming course assignments (See Figure 2).

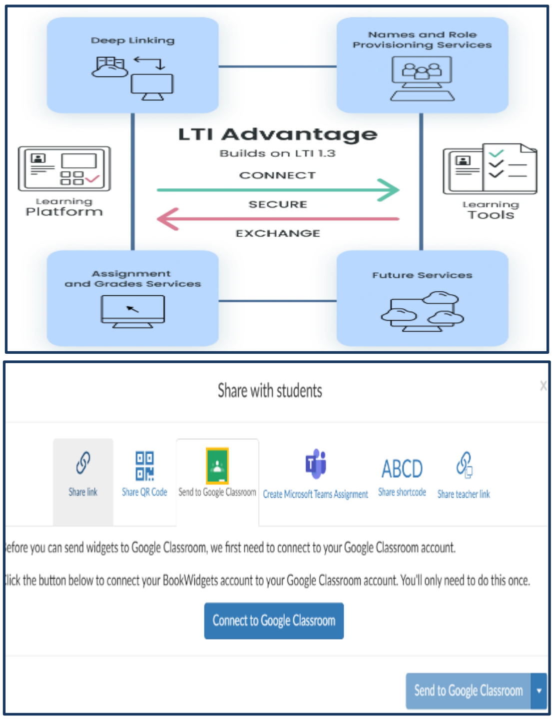


Figure 3. LTI component into GitHub Classroom & Microsoft Teams

In the modern digital era, systems serve as a fundamental component in the field of education. To ensure their effectiveness, these systems must incorporate essential features:

- Ability to manage user access rights
- Ability to easily change the model for your needs
- Ability to determine your learning method
- Ability to create a plan that reflects the characteristics of various professions
- Flexibility in the organization of lessons
- Multiple ways to take students' attendance
- Ability to communicate with each other
- Ability to receive and assign files and assignments
- Support for multiple variances of tests
- Supports SCORM (Sharable Content Object Reference Model [7]) and other standards
- Supports teamwork

GitHub Classroom has a few of the modules from above. Due to this reason, its authors created GitHub Classroom to support Canvas, Google Classroom, Moodle, and Sakai learning systems in accordance with LTI - Learning Tools Interoperability (LTI).

The Learning Tools Interoperability (LTI)® specification allows learning management systems (LMS) or platforms to integrate remote tools and content in a standard way. Google Classroom is used with learning management systems (LMS).

Pages created in LMS have mechanisms to access or integrate GitHub content. It works together by either providing links from the course page to GitHub repositories or by providing the link of the courses in the GitHub Classroom to the HTML page. As the most learning management systems support web-based systems that support HTML and JavaScript, this relationship is possible. Google Classroom with GitHub Classroom via LTI - Learning Tools Interoperability, and Microsoft Teams via web interface were used (See Figure 3). All widgets in the Bookwidget system can be exported directly to Google Classroom and Microsoft Teams.

2. Tools Used for Creating e-learning Objects

An extensive study of various software solutions was conducted to identify the most efficient and user-friendly method for teachers to create e-learning objects. During the study, BookWidgets, Wizer, GitHub Classroom and Liveworksheets emerged as the most widely utilized software platforms [8]. Liveworksheets and Wizer.me enable the transformation of traditional worksheets (DOC, PDF, JPG, etc.) into interactive online assessments. These platforms allow both teachers and students to fully utilize interactive worksheets, leveraging modern technologies to enhance the educational experience [9].

2.1. Use of GitHub Classroom

A common use of GitHub is to manage various levels of programming projects and use it as a version of control system. GitHub Classroom was used in learning infrastructure to collect the finished assignments from course students, programming data structures, software design, and architecture. GitHub is a more efficient code repository platform than traditional LMS platforms. Students upload the source code files of the program to the GitHub-created repo and submit the assignment according to the GitHub Classroom teacher-created template, which is automatically graded. As for the teachers, they had access to tasks completed by the students, to view, edit, and give comments on their source code submitted. It was also possible to save the time needed to grade the student's work due to the task being automatically checked whether it is done correctly or not.

GitHub allows teachers and students to track each member's contributions. Using GitHub Classroom, around 40 different tasks on data structure were assigned, software design, and architecture courses and received more than 2000 source codes from 120 students (duplicated count). Around 80% of these source codes were evaluated as passed based on the template of the assignment.

2.2. Usage of Bookwidget

BookWidgets, a web-based platform originating from Belgium, facilitates the timely and effective delivery of electronic content and learning materials, tailored to the student's age and learning style [10].

It offers the possibility of creating interactive e-learning objects and can be used by single or multi-user organizations for a monthly fee.

Moreover, it is supported on all types of smart devices. BookWidgets consists of three main parts. It has tools and choices for creating multiple-choice tests, tracking learner's progress, and creating interactive contents such as games [11].The main advantage is the ability to import interactive materials created directly into Google Classroom.

3. Methods for Implementing E-Courses

The development of educational technology to maintain the quality of education in the diversity of education is a human-computer integration of research in several fields, such as teaching methodology, educational technology, and software engineering [12].

Technology and teaching style are the main factors that affect the quality of e-learning mostly. Implementing e-learning courses through traditional methods presents challenges in maintaining learners' attention and engagement with the content. According to the National Center for Biotechnology Information, the average concentration span of people has decreased from 12 seconds in 2000 to 8 seconds in 2013.

People switch screens 21 times an hour when using digital devices. Also, according to international studies, only 4 – 8 minutes lectures are listened to with concentration. Therefore, people's concentration span is very low when watching long videos.

According to Ebbinghaus's forgetting curve, a learner initially comprehends and retains 100% of the information during the learning process. However, after six days, only 25% of the information remains (See Figure 4).

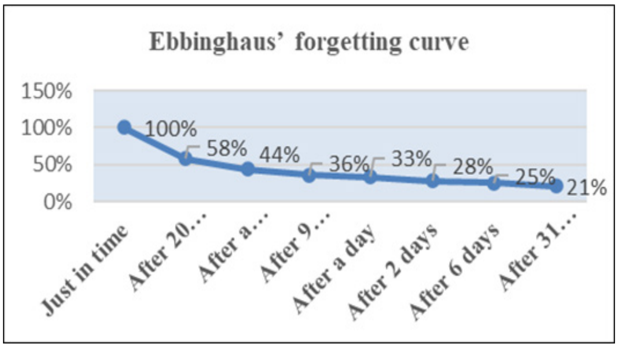


Figure 4. The Ebbinghaus's forgetting curve

Consequently, frequent repetition is necessary for learners to retain information as knowledge. Furthermore, in the process of transforming information into knowledge, scientist V. Maine emphasized that "the knowledge acquired by students varies depending on how the teacher delivers the information and knowledge." This concept is illustrated in Figure 5, which represents students' understanding of the lesson. Micro-learning techniques were employed to conduct the lessons, involving the division of lesson content into multiple smaller segments to enhance comprehension and retention. Considering the total course content as 100%, it was structured based on the method of knowledge delivery to students: 15% through reading books and lecture materials, 15% through listening to lectures and additional audio materials, 20% through interactive assignments such as drawing, identifying differences, solving puzzles, completing word grids, and watching relevant videos, 20% through discussions, presentations, and debates, and 30% through multi-level tasks utilizing GitHub Classroom.

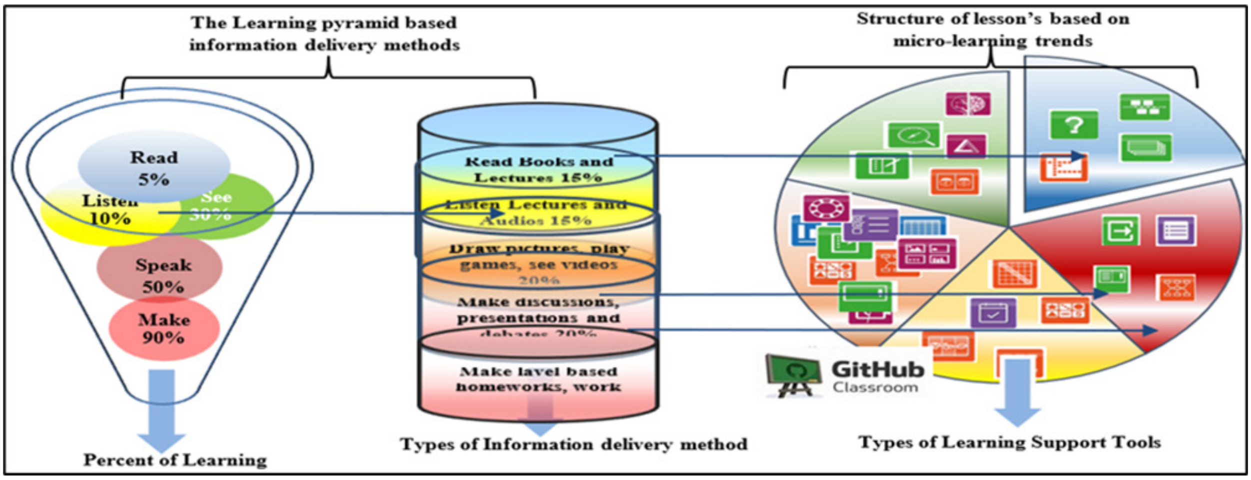


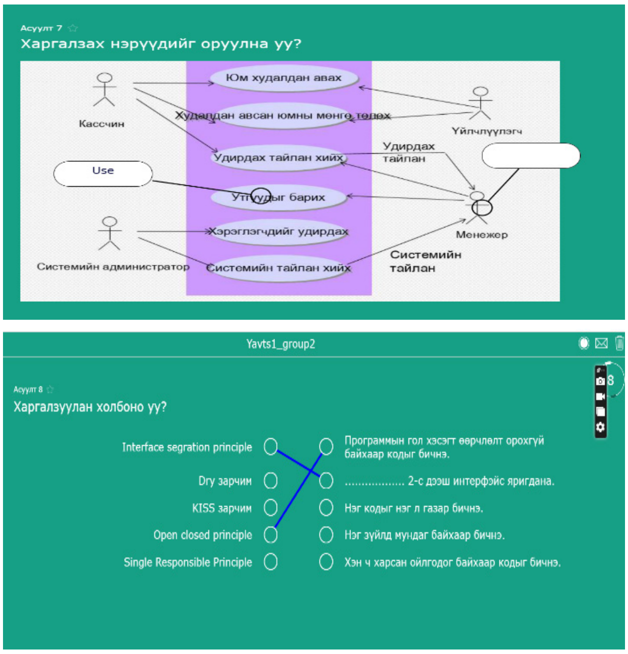
Figure 5. The learning pyramid with learning support tools

Based on this distribution, small widgets and tasks were created on BookWidgets and GitHub Classroom, facilitating the course through these prepared tasks. The scheme in Figure 5 illustrates the alignment of V. Maine's ideas with the electronic representation of the course content.

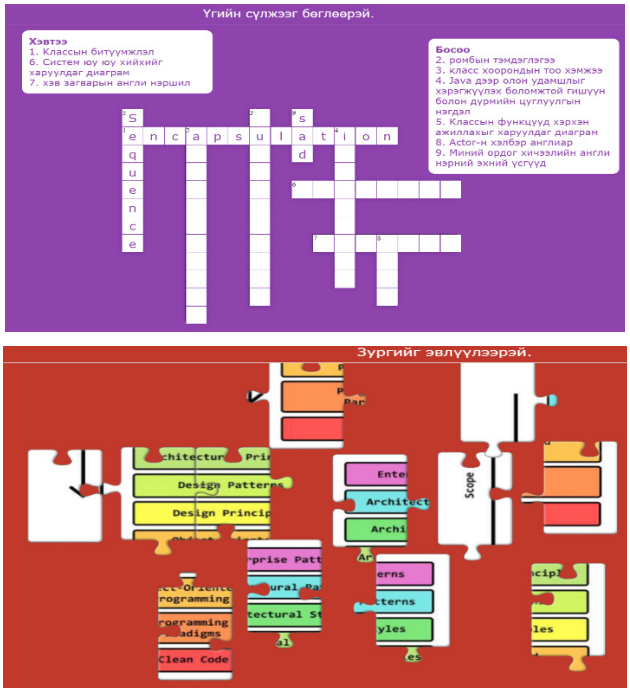
Short videos: Studies have shown that video learning has many positive effects, including increased motivation and deeper learning. Moreover, the usage of short videos in teaching would increase the student's understanding level, making it easier for learners to remember and recall the content of the course. Also, students can rewatch the video multiple times.

3.1. Tests and Quizzes

Tests and quizzes play an important role in e-learning and provide instant results. This allows students to see their understanding level of the lesson by directly showing the mistakes and allows them to retake the test and see their progress. Therefore, in each lesson, a self-test with 6 single-choice, multiple-choice, and matching questions using Bookwidget has been included (See Figure 6 (a) and Figure 6 (b)). The questions were designed to test the learner's knowledge, deliver the knowledge, apply the knowledge, judge and evaluate a problem, and create knowledge based on what they understand, corresponding to the levels of Bloom-Anderson's taxonomy.



(a)



(b)

Figure 6. Some widgets and questions of quiz

3.2. Homework and Exercises

These are exercises designed to help students understand and internalize the lesson, as well as help improve their general knowledge. Research shows that homework and exercises affect students' self-discipline, learning attitude, and problem-solving skills.

By doing homework, students will reinforce the knowledge they have acquired in the course and improve their ability to work independently.

Students complete their homework code and send their finished assignments to GitHub classroom to check whether they have passed automatically. This has the advantage of improving students' knowledge and ability to work on projects and work on program code as a team.

3.3. Gamification

This is one of the most effective and widely used methods to increase student engagement in e-learning. Each of our e-courses includes in-game exercises to make learning interesting and rewarding and to increase student engagement. Many types of games have been included to suit the learning content.

4. Evaluation of E-Learning

Many specialists are required to conduct and prepare e-learning.

1. Teacher has to plan e-learning content
2. Instructional designer for e-learning object and design
3. Technical expert for creating e-learning objects

The role of the instructional designer is crucial important in the delivery of e-learning. However, due to the growing use of e-learning and the time constraints, it is difficult to design instruction that is suitable for each teacher and each subject.

4.1. Instructional Design

The activity of creating a learning object with a specific teaching method to deliver knowledge to students effectively, attractively, interestingly, systematically, and without boring the students is called instructional design. (recently known as learning experience design).

This process covers a wide range of areas, including determining the learner's status and needs, the ultimate learning goals, and assisting with transitions between courses. The results of this instruction can be directly observed, scientifically measured, and predicted. There are many instructional design models, but most are based on the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) [13], which has five phases: analysis, design, development, implementation, and evaluation. In the history of instructional design, it was based on cognition, behavior, and psychology, but recently, there has been a growing tendency to create learning objects based on creativity. The e-learning trend of 2000-2020 is based on games and micro-learning, using machine learning and software to define personalized learning methods.

In implementing e-learning courses, the "Goal-Based Style" was followed and assessed the cognitive levels of Anderson's taxonomy with the tools used in the training (See Table 1).

Table 1. Instructional design style

Context approach Develop instructional design based on culture, lifestyle, and local characteristics	**Goal-based approach** Develop instructional design based on taxonomy such as Bloom, Anderson, and Gag	**Activity-based approach** Develop instructional design based on ADDIE and PBL
Content-based approach Develop instructional design based on text, images, and videos	**Evaluation-based approach** Develop instructional design based on evaluation forms such as Bloom and Summary	**Environment-based approach** Develop instructional design based on classrooms, computers, the web, mobile phones, and smart devices

Knowledge was provided to students through learning activities where each learning topic meets the objectives of the Bloom Taxonomy (See Figure 7).

When evaluating the students, according to the formula (1), the performance of the students on the tasks and learning activities of each subject were assessed.

$$S_{ID}(n,m,k) = \sum_{i=1}^{n} Sub_i \sum_{j=1}^{m} obj_j \sum_{e=1}^{k} T_e \quad (1)$$

<ID, Sub_i, obj_j, Tk> ID-Student ID
n: number of subjects of course's
m: number of learning objectives(currently use Bloom Taxonomy that means 6 was used)
k: number of supporting tools of learning activity for Learning objectives.
Sub: a specific subject of the syllabus
obj: each objective of Bloom Taxonomy
T: a specific tools to obj_j

The course consisted of N = 15 topics and m = 6 learning objectives, with each objective supported by 2 to 4 tools.

Approximately 20 tasks and learning activities of varying complexity were developed using GitHub classroom, and more than 300 (15 × 6 × (2, 3, or 4)) widgets were prepared for each objective using BookWidgets.

Additionally, an achievement matrix was designed to assess students' learning outcomes throughout the course, as shown in Table 2.

In this matrix, the columns represent learning objectives, while the rows correspond to individual students. Each cell has a value representing the degree of achievement of a certain student against a specific learning objective (See Table 2).

Table 2. Achievement assessment matrix of Syllabus

	LO_1	LO_2	LO_3	LO_4	LO_5	LO_6
S_1	a_{11}	a_{12}	a_{13}	a_{14}	a_{15}	a_{16}
S_2	a_{21}	a_{22}	a_{23}	a_{24}	a_{25}	a_{26}
S_3	a_{31}	a_{32}	a_{33}	a_{34}	a_{35}	a_{36}

From the achievement matrix, it can be figured out students who have a lower achievement for each learning objective than a specific threshold which means a minimum requirement. These unfulfilled students can be guided to study the unachieved topics by the generation of adaptive learning paths. As shown in Figure 7 the adaptive learning paths can be generated in different granularity. The high-level learning path can be created using syllabuses and their relationships.

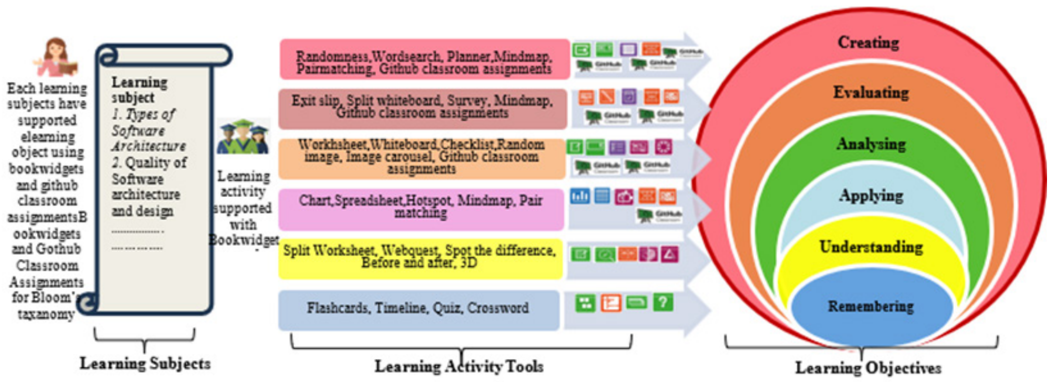


Figure 7. Evaluation of the learning pyramid with learning

The low-level learning path can be created using learning concepts and their relationships defined in the subject ontology.

5. Creating an Ontology for Evaluating Student Knowledge

By developing and using the Semantic Web, ontologies, and knowledge graphs, it is possible to focus on improving the quality of education, which is a key issue in the field of education. It is possible to determine what to focus on in the next course by developing an ontology that integrates the main concepts of the course and transfers it to the graph database using the data and information of the results of the previous training and with the help of a quick query.

The knowledge imparted to students can be enhanced by improving the e-learning infrastructure. To achieve this, the ontology of student learning was developed, and the following steps were undertaken to construct a knowledge graph capable of evaluating student knowledge:

1. Identifying domains related to the course.
2. Extending existing ontologies or developing new ontologies.
3. Determining the relationships and characteristics between classes and subclasses.
4. Streaming course data to RDF (Resource Description Framework).
5. Creating a Graph Database.
6. Conducting course evaluation.

5.1. Identify Learning-Related Domains and Develop New Ontologies

In this step, a semantic model was developed by defining the terms and concepts of the academic learning environment and the purpose of the evaluation of learning quality. 6 ontologies related to previous academic studies were obtained and studied using search engines. It includes [14]:

1. Bowlogna Ontology. This ontology defined the structure of the learning organization rather than focusing on learning activities [15].

2. BBC Curriculum [16]. This is an ontology that describes course topics and content.

3. The Academic Institution Internal Structure Ontology [17] provides classes and properties to describe the internal organizational structure of an academic institution.

4. University ontology [18] defines elements for describing universities and the activities that occur at them. It includes concepts such as departments, faculty, students, courses, research, and publications.

For the above 4 ontologies, they were not choosen because they were not compatible with the ontology of constructing a knowledge graph for evaluating student knowledge. Instead, An Ontological Approach for Semantic Modeling of Curriculum and Syllabus in Higher Education was used [19], The Curriculum, Lessons, and Content ontologies were structured. However, as these existing ontologies lacked a relevant framework for evaluating learning content based on Bloom’s taxonomy using appropriate tools, the development of a new ontology was deemed necessary.

To enhance the effectiveness of the proposed learning infrastructure, student participation data was collected, and the ontology presented in Table 3 was created to analyze the impact of various tools on students' comprehension. This ontology also aims to support the development of a recommendation system to optimize learning outcomes. Furthermore, learning subjects should be aligned with learning objectives and activities to effectively assess students' academic achievement. To create interlinks between learning objectives and assignments, identifiers of learning objectives were added to the related assignments. For exams and learning subjects, the same process to align with learning objectives was done [20].

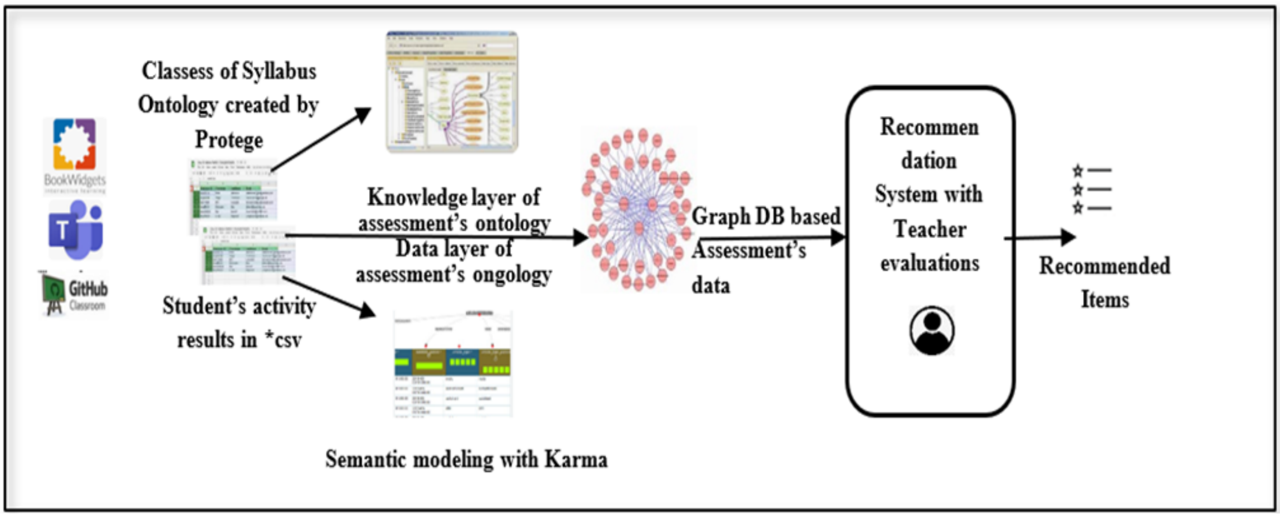


Figure 8. E-Learning Evaluation Based Knowledge

Table 3. The classes of syllabus ontology

Class	Label	Superclass	Subclassof	Definition
Syllabus	Course Syllabus	Course	Instructor	Core concept of course
Instructor	Instructor	Syllabus	Teacher, Assistant	Course instructions
Subjects	Learning Subjects	Syllabus	Objectives	Learning Subjects
Objectives	Bloom Taxonomy	Subjects	Support Tools	Learning Objectives
Support Tools	Learning activity tools	Learning Objects	Activity Tools	Implementing tools learning activity
Activity Tools	Tools	Support Tools	Score	Any widgets , Assignments tool
Score	Quantity score	Support Tools		Niteral score of any widgets, Assignments tool
Description	Quality Evaluation	Support Tools		Description of any widgets, Assignments tool

The e-learning infrastructure shown in Figure 8 was used to conduct the course and get the activity performance result of the assignments of students in a CSV file. Using the Protégé 5 system from Stanford, the CSV file was converted into *.owl, *.ttl files shown in Table 3: An OWL file contains data written in Web Ontology Language. Such data is usually written in XML-like syntax and used to describe taxonomies in software development. In the process of developing the e-learning evaluation ontology, the researcher employs OWL2 as the ontology language and utilizes diagrammatic representations for visualization. The ontology is structured by defining relevant classes, subclasses, and object properties that establish relationships among entities. Protégé 5.0.0 serves as the primary development tool for constructing and organizing the ontology. Additionally, the OntoGraf plug-in is utilized to facilitate the graphical representation of the ontology. OntoGraf gives support for interactively navigating the relationship of the OWL ontologies.

Various layouts are supported for automatically organizing the structure of the ontology. To implement the ontology, it should be prepared first.

The e-learning evaluation ontology consists of 30 classes, which are subjects of course, widgets of Bookwidget, and a level based assignments of GitHub Classroom, etc. It contains about 50123 class assertions, 46 logical axioms, and 30 declaration axioms. The Karma tool was utilized to generate RDF files. By processing these files with the GraphDB program to structure the Knowledge Graph and employing SPARQL to determine which student is unable to meet specific levels of Bloom's learning objectives in a given subject, it became possible to provide the teacher with targeted information on the student's participation and comprehension levels based on this data.

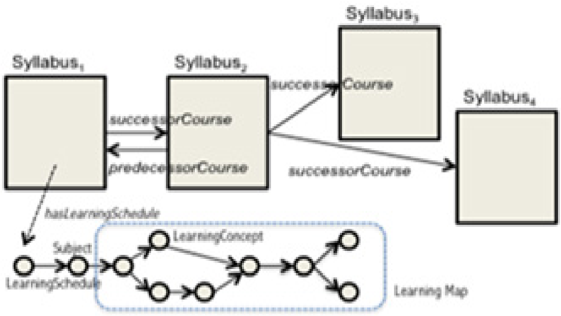


Figure 9. Relationships created between syllabuses

Our learning infrastructure meets non-functional requirements of software operations and is designed to be scalable and deployable in a distributed features and which is designed to enhance coherence within the curriculum and establish foundational log data for an advisory system that informs teachers about the specific topics each student struggles with and their corresponding levels of cognitive understanding, as illustrated in Figure 9.

6. Conclusion and Future Research

According to scientist G. Attwell, the results and quality of training do not depend only on the characteristics of the materials, but also on 5 groups of factors such as the readiness factors of the student for e-learning, learning environment factors, technological factors, hardware, software, socialization factors, and teaching method factors. In terms of conducting e-learning, the research on the above factors will have a great impact on the results of e-learning. Google Classroom and Microsoft Teams are very advantageous because the teacher can create and use the e-learning infrastructure of his/her choice without the need for an IT specialist or a place to host the course content on the Internet. By using Bookwidget and GitHub Classroom, a teacher can create a competent electronic learning object based on his/her knowledge and work experience without the support of an instructional specialist or an IT employee. In the future, this infrastructure is planned to be used to further improve the recommendation system, create a learning path for the unit student, and develop the possibility of conducting training on it. It is concluded that the e-learning infrastructure proposed by us is easy to create, and it is possible to evaluate the learning activities of the students using many tools and to improve the learning activities based on the evaluation.

This is achieved by generating log data to assess knowledge acquisition through small electronic content based on Bloom's Taxonomy pyramid, thereby supporting the student learning process. The next step involves developing a recommendation system to assist teachers by utilizing students' course understanding log data.

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