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PAPER

An Adaptive M-Learning Usability Model for Facilitating M-Learning for Slow Learners

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ABSTRACT

Mobile devices have evolved from communication tools to versatile platforms for various purposes, including learning. Usability is crucial for practical mobile learning applications, ensuring ease of use and expected performance. However, existing research on mobile educational apps has primarily focused on typical learners, neglecting the specific requirements of slow learners who face cognitive limitations. In this work, we fill this research gap by proposing an adaptable learning-oriented usability model (ALUM) for mobile learning apps specifically tailored to support slow learners. The research conducts a detailed usability analysis and systematic review to identify the problems users face and investigate how slow learners respond to learning apps in terms of efficiency, effectiveness, satisfaction, and learning outcomes. Twenty-four participants classified as slow learners evaluated the usability of 25 HTML-based learning apps. The evaluation revealed critical deficiencies in existing learning apps concerning the needs of slow learners, particularly in user-friendliness and learnability, leading to their dissatisfaction. We propose a model that leverages a hybrid recommendation system to address these challenges. The model incorporates a navigational graph, ontology, and item matrix to provide personalized topic recommendations, tailoring the content and delivery of educational materials based on individual needs and preferences. By enhancing the learning experience for slow learners, the proposed model aims to improve their learning outcomes. This research bridges the gap between academic research and practical applications in interactive mobile technologies. The adaptable learning-oriented usability model presented in this paper offers a framework for supporting slow learners, emphasizing its essential components and their interactions to enhance the learning outcomes for this user group.

KEYWORDS

mobile learning apps, adaptive approach, personalized recommendations, virtual environment, M-learning

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1 INTRODUCTION

Usability [1] refers to the ease of use and overall satisfaction a user experiences when interacting with a product, system or service. This concept is critical in designing and developing user-centred products, as it helps ensure that the intended audience can use the product effectively and efficiently. Good usability [2] considers user needs, cognitive processes, and feedback mechanisms to create an intuitive and user-friendly experience. Usability engineering [3] involves designing and evaluating interactive systems to ensure they are user-friendly, efficient, and meet user needs, resulting in enhanced user satisfaction and engagement. User experience (UX) [4] refers to a person's overall perception and attitude about using a particular product, system, or service. It encompasses all aspects of a user's interaction with a product, including the design, functionality, and usability, as well as their emotions and attitudes. UX design considers the user's needs, expectations, and satisfaction to create a product that meets their requirements and provides a positive and enjoyable experience [5]. The goal of UX design is to create products that are easy to use, efficient, and aesthetically pleasing, which can ultimately lead to increased user satisfaction and loyalty.

Learning disabilities impact a person's ability to learn and process information, despite having average or above-average intelligence. These difficulties can affect skills such as reading, writing, speaking, and problem-solving, making it challenging for individuals to succeed in school and life [6]. Some common examples of learning disabilities include dyslexia, dyscalculia, ADHD, and dysgraphia. These conditions are often neurological and do not result from insufficient effort or motivation [7]. People with learning disabilities may require specialized support and accommodations, such as extra time for testing or technical instructional methods, to succeed in their education and careers. The hierarchy of learning disabilities is shown the Figure 1. Gamification [8] can effectively enhance the learning environment for e-learning students. The study results confirm that gamification, consisting of elements, game dynamics, motivation, and game mechanics, significantly impacts e-learning usability. Furthermore, instructional design plays a partial mediating role in the relationship between gamification and e-learning usability.

Slow learners [9] need help to keep pace with their peers in acquiring and retaining information and skills. This can be due to various reasons, including learning disabilities, attention difficulties, socio-economic challenges, or limited prior educational experiences. While slow learners may require additional support and resources to succeed, it is essential to recognize that they have unique strengths and abilities [10]. Teachers and educational support professionals may use various strategies to support slow learners, such as providing additional one-on-one instruction, educational technology, and incorporating hands-on learning activities. Emphasizing the strengths and interests of slow learners can also help increase their motivation and engagement in learning [11]. With proper support, slow learners can make meaningful progress and succeed in their education and beyond. Recent years have seen a sharp increase in the global mobile app market. Downloads of mobile apps increased from 140.68 billion in 2016 to 230 billion in 2022 [12]. Mobile learning refers to delivering educational content and assessments through mobile devices such as smartphones and tablets. Mobile learning aims to provide learners access to education anytime and anywhere, making learning more flexible and convenient. Mobile learning can take various forms, such as self-paced online courses, gamified educational apps, and instant assessment feedback [13]. With the increasing availability and accessibility of mobile devices, mobile learning has the potential to revolutionize the way we think about and deliver education, providing opportunities for personalized and collaborative learning experiences.

ChatGPT's integration [14] in education highlights both its positive applications and potential negative impact. The findings emphasize the significant role ChatGPT and its derivatives can play in reshaping the education landscape. Incorporating ChatGPT into learning apps has the potential to revolutionize educational processes and create a new paradigm in education. The parents [15] are actively seeking to support their children's learning at home using mobile devices. However, it was also observed that parents generally need more knowledge about educational apps' developmental appropriateness and additional guidance in this area.

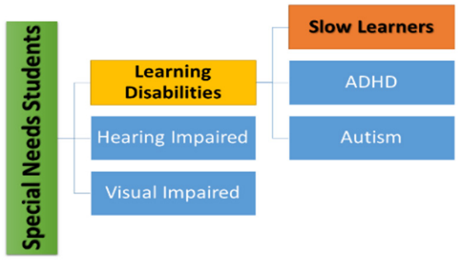

Fig. 1. Hierarchy of disabilities

Existing educational apps must improve their design to tackle slow learners' usability and learnability needs. Learnability is one of the most critical problems slow learners face, which is generally tackled through repeat exercises and more visualized content in usual pedagogical practice. However, mobile apps, especially educational apps, need to consider these issues in their design. The main objective of this work is to propose a learning-oriented usability model for slow learners. In addition to this, we aim to identify the significant issues faced by slow learners in existing educational apps. This paper is structured as follows: Section 2 describes the literature review and systematic review, section 3 shows the usability evaluation, section 4 shows the proposed usability model, and section 5 presents the conclusion.

2 LITERATURE REVIEW

The definition of usability is "the degree to which specific users can use a system, product, or service to achieve specific goals with effectiveness, efficiency, and satisfaction in a specific context of use [2]." Three criteria—effectiveness, efficiency, and satisfaction—were used to assess usability (as specified by ISO 9241). Generally, usability is an essential feature of mobile apps and software. To achieve the goal, usability cannot be ignored. One of the main reasons for the apps and software failure is a usability problem.

For this reason, usability testing or evaluation is used to find the usability problem, and it is helpful for the developer to improve the usability [16]. There are different methods for usability assessment, but the most famous forms are SUS (system usability scale) and SA (sentiment analysis). Criollo and his collaborators concentrate on the teacher's function in mobile learning. They point out that most innovation projects, such as the design and conceptualization of mobile applications, disregard the teacher's perspective, namely, if the teacher has received training to use mobile devices in the classroom [17]. However, they demonstrate the necessity of integrating mobile technology right from the start of the curriculum. A more extensive definition of learning anywhere and anytime, accessing content via any mobile device, is provided by Correa and colleagues (2021) in their overview of the context-aware study of m-learning and u-learning processes [18]. The next generation of systems can customize content and educational strategies based on students' traits and learning preferences thanks to the ongoing advancement of mobile device technologies, more inventive computational techniques, and deep learning in virtual learning environments. An augmented reality application [19], "Atomik-3D", enhances the teaching of chemical elements to 5th-grade students. The Mobile-D methodology was used for development, and functional tests demonstrated positive results for surface recognition and usability.

To help slow learners become familiar with current technology usage, tablets are presented. It is intended to introduce tablet technology to slow learners to increase their desire for learning and help them develop a love of learning. They are unique children, so directing the slow learners toward a better quality of life is necessary. The study intends to do something other than accelerate the learning for slow people. Nevertheless, it encourages daring technology use daily and makes slow learners feel part of the most recent technological advancements [6]. The ability to learn "on the go" through mobile learning encourages student engagement and success [18]. Although mobile devices are simple to use, they are less practical for learning than desktop computers. Some learning management system (LMS) tasks could call for a more involved engagement procedure, which might be challenging to carry out using mobile devices. The small screen size is the primary cause of this problem. On mobile devices, typing and searching are challenging due to the limited screen size [20]. Small font size, dense text, and small text over complicated graphics are only a few examples of readability-related issues it causes. Reading and finding the necessary information on a little screen takes up too many cognitive resources. Three conditions must meaningfully satisfy children's mobile app development: development stages, content design, and digital engagements [21]. When increasing the number of functions, usability will decrease [22]. Learning app usability decreased as the age of the slow learners increased [23]. The PACMAD model defines three factors: user, task, and context of use [24]. For mobile applications, the model is an extended version of the Nielsen or ISO usability model [25]. The usability model comparison is described in Table 1. SentiML++ has undergone enhancements, including the incorporation of several new functionalities. These additions encompass the identification of targets at the sentence level [32], recognizing holders of sentiments, identifying topics, and distinguishing informal sentence structures. These improvements aim to provide annotators with greater flexibility, allowing them to choose from various taxonomies when annotating the subject of a sentence.

Using a mobile application with Augmented Reality technology substantially impacts elementary school students learning astronomy, significantly influencing the teaching-learning process [33]. Papadakis examines [34] the impact of four coding apps on young children's learning of Computational Thinking (CT) and Computational Fluency (CF). The author emphasizes the need for researchers and designers to make challenging decisions in creating software products that effectively facilitate CT and CF for young children. The developed game [35] significantly improved science learning outcomes for fourth-graders in Theme 1. Recommendations include proper use based on teachers' instructions, optimization and enhancement by teachers and provision of ICT facilities. CoSinE (Computer Simulation in Education) is an internationally peer-reviewed workshop [36] that focuses on the theory and practice of computer simulation in education. It seeks to investigate the utilization of AI, smart data processing, cloud-based personalized open education tools, adaptive learning environments, and intuitive learning platforms to foster creativity and ICT competency in line with European Research Area development. The study by [37] demonstrates the significant positive impact of the SMART-P training program on parenting knowledge and children's cognitive development. The quiz length strongly affects the quantity of work completed in mobile-assisted language learning (MALL), with question sets between lengths 8 and14 being the most optimal [38].

Table 1. Comparison of usability models

Usability Model	Usability Factors	Description
Condos [26]	Navigation, content, information architecture, error prevention, presentation, input rate and visualization.	Content and presentation are not directly usability factors [27]. Used in the domain of e-commerce.
Coursaris and Kim [28]	The proposed usability dimensions are comprehensive.	This model is not tested to determine its accuracy and applicability.
mGQM [29]	Effectiveness, efficiency and satisfaction.	This model is based on goal questions metrics, so questions may be challenging to interpret for usability factors correctly.
Tan, Ronkko and Gencel [30]	This model is designed with nine usability factors and sixty- three criteria.	This framework is designed for companies who wish to develop usability and user experience instruments.
PACMAD [31]	Efficiency, effectiveness, learnability, satisfaction, memorability, error, and cognitive load	The addition of cognitive load is the main contribution of this model. The extended version of this model has 21 factors. All factors did not test to check their validity.

2.1 Systematic review of HTML learning apps

- **Searching and Screening Method**

The first step in usability testing and analysis is data collection. The two most popular and widely used operating systems for mobile devices are iOS and Android.

- **iOS and Android**

For its iPhone, iPad, and iPod touch devices, Apple Inc. developed the iOS operating system. The platform for managing and running native iOS applications is provided by proprietary software [39]. Android is an open-source operating system for mobile devices developed by Google. It is based on the Linux kernel and designed primarily for touchscreen mobile devices like smartphones and tablets. Android is widely used on many devices and supports many applications on the Google Play Store [40]. The apps storage size of iOS, apps rating and downloaded HTML learning apps from the Android platform are shown in Figures 2, 3 and 4, respectively.

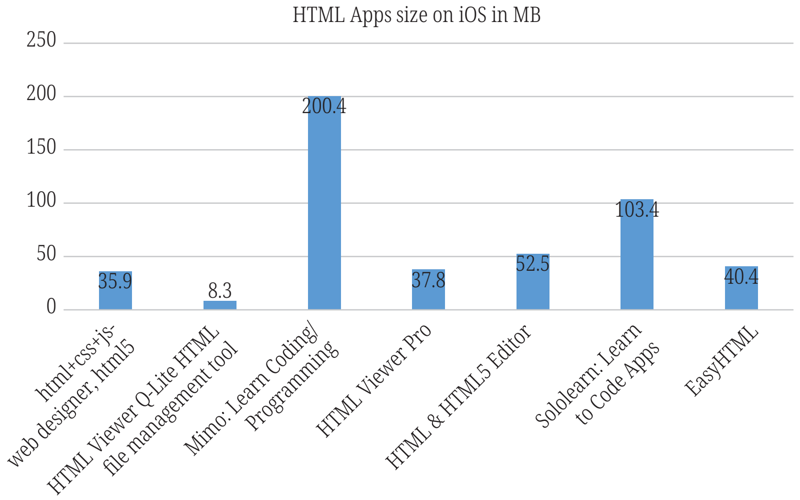

Fig. 2. HTML apps space required (IOS)

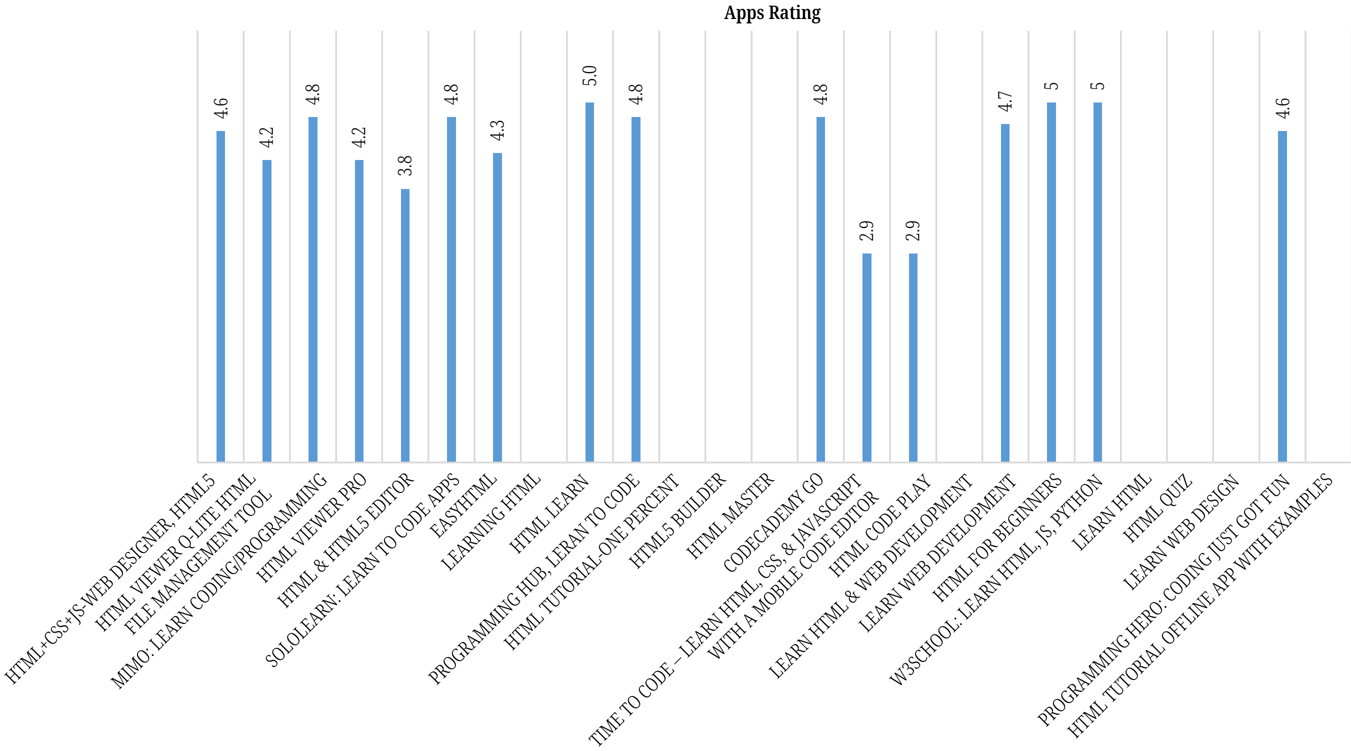

Fig. 3. HTML learning apps rating

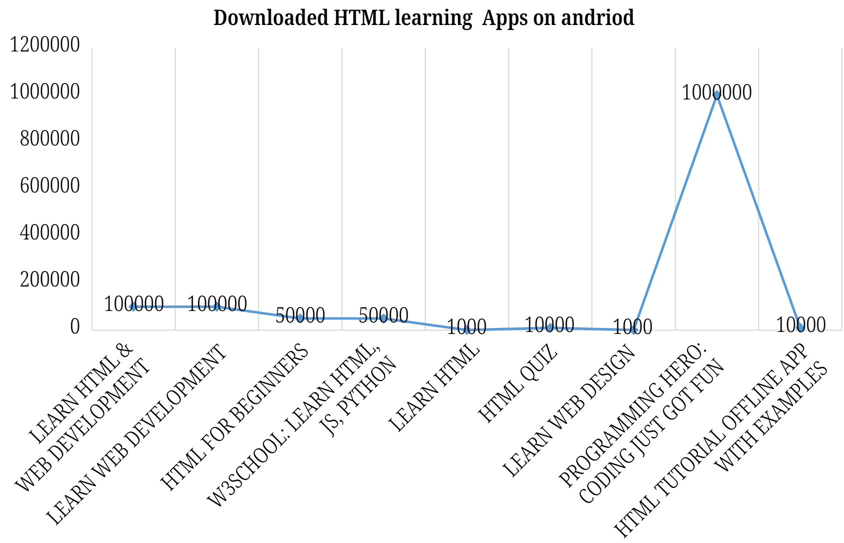

Fig. 4. Downloaded HTML apps review

3 USABILITY EVALUATION OF HTML LEARNING APPS

Usability evaluation measures a system's ease of use and user satisfaction [41]. It involves testing and evaluating a product or website's interface design, functionality, and overall user experience. The goal of usability evaluation is to identify areas for improvement and make recommendations for enhancing the user experience. Usability evaluation is an essential aspect of the design process, as it helps to ensure that a product is user-friendly and meets the needs of its intended audience [42]. A study showed that 71% of usability evaluations of apps were conducted in laboratory settings due to the complexity of data collection in the field as users move physically [43]. An experimental usability evaluation method evaluates the HTML learning apps with users and experts. In this study, four groups (G1, G2, G3, and G4) were formed based on age limits, ranging from 16 to 55. Each group had three male and three female participants, resulting in 24 participants evenly split between genders, as suggested by Nielsen [44]. This study aims to evaluate the usability of learning apps for slow learners. HTML learning apps from iOS and Android are listed in Table 2, which are used for usability evaluation, and in Table 3 the questionnaire for usability criteria is presented. Table 4 shows the learning base task list with task code. The participants are given a Likert and dichotomous scale questionnaire and must respond with their responses [45].

Table 2. HTML learning app name for ios and android [46] [47]

HTML+CSS+Js-Web	Sololearn: Learn To Code Apps	HTML Tutorial – One per cent	HTML Code Play	Learn HTML
HTML Viewer Q – Lite HTML	EasyHTML	HTML5 Builder	Learn HTML & Web Development	HTML Quiz
Mimo: Learn Coding	Learning HTML	HTML Master	Learn Web Development	Learn Web Design
HTML Viewer Pro	HTML Learn	Codecademy Go	HTML For Beginners	Programming Hero
HTML & HTML5 Editor	Programming Hub	Time To Code – Learn HTML	W3school: Learn HTML	HTML Tutorial Offline App

3.1 Results and interpretation

This section discusses the results and their interpretation for usability evaluation according to the proposed guidelines suggested by ISO 25062:2006. The data analysis and graph generation are conducted using SPSS and R language in a Microsoft environment. Figure 5 represents the learning graph data showing mixed opinions on the suitability of educational apps for different learners. While a small percentage agreed (8%) or strongly agreed (21%) with their compatibility, a significant portion disagreed (23%) or strongly disagreed (22%). A considerable percentage remained neutral (27%). This highlights the need for further improvements in designing educational apps to cater to diverse learning needs. Figure 7 shows the standard deviation of six questions about learning, quality, stress and experience; the standard deviation measures the variability or dispersion of data points around the mean. This study's calculated standard deviations provide insights into participants' varying opinions and experiences. Figure 6 represents the UI engaging features, with most participants disagreeing (37%) or strongly disagreeing (5%). Only a tiny percentage agreed (3%), while the highest rate strongly agreed (32%). Figure 8 shows the mean score of nine usability factors navigation score is maximum, and the operability and help score is minimum; improvements are needed to enhance user engagement and experience.

Table 3. Usability evaluation criteria for HTML learning apps for slow learners

Main Factor	Questionnaire	Main Factors	Questionnaire
Efficiency	1. Does the application take extended load time? 2. Does the App hang, crash and freeze? 3. Is the time given to the user to respond appropriate? 4. How much time is required to complete individual tasks? 5. How much effort is required to complete individual tasks? 6. Error message is easily understandable in case of wrong Input	**Effectiveness**	1. Is it easy to interact with the UI? 2. Are options easy to use for slow learners? 3. Is the main menu or Home Page button available on all subsequent screens? 4. Does UI offer a visual representation of the loading process? 5. Does the app offer audio instructions?
Navigation	1. Slow learner can easily navigate across the interface? 2. The navigation keys are well understandable? 3. Does UI specify easy scrolling if such information is present? 4. Does UI provide an easy main menu for navigation? 5. Navigating through this app is easy. 6. This app provides good navigation facilities for information contents.	**Usefulness**	1. This app makes me more productive. 2. This App is useful. 3. App gives me more control over the activities in my life. 4. The app makes it simpler for me to complete the tasks I want to. 5. When I use this app, it saves me time. 6. App satisfies my needs 7. The app performs all of the tasks I would need.
Ease of Use	1. This app is simple to use. 2. This app is simple to use. 3. This app is user-friendly. 4. App requires the fewest steps possible to accomplish what I want to do with it. 5. The app's contents are clear and easy to understand. 6. I do not notice any inconsistencies as I use this app. 7. I can recover from mistakes quickly and easily. 8. I can use this app successfully every time. 9. I find the graphic interface easy to use. 10. This app is flexible.	**Learnability**	1. I learned to use this app quickly. 2. I easily remember how to use this app. 3. I quickly became skilful with this app. 4. Are the icon used in the UI related to the task? 5. Can the slow learner recognize the functions and their corresponding actions? 6. Is the UI using familiarized terms and easy language? 7. Does the app provide easy ways to return to the previous activity? 8. Is UI correlated with other apps and hence easy to learn? 9. Is proper information provided for various functions? 10. It was easy for me to start and learn how to use this app. 11. The information provided by the app is easy to understand. 12. I could use the app without reading the user manual. 13. Learning to operate the app is easy for me.
Satisfaction	1. To the best of my ability, I followed the instructions telling me how to code the HTML 2. I was able to write the code as instructed. 3. I found that coding on this app was unnecessarily complicated. 4. I used this app correctly. 5. I am satisfied with this app. 6. I recommend this app to a friend. 7. This app works the way I want it to work. 8. This app helps me be productive. 9. Are the user happy with the App layout? 10. Are all the screens consistent? 11. Does the UI provides features to engage slow learners?	**Operability**	1. Does the app offer the ability to change colour? 2. Does the font used in the app is appropriate and readable? 3. Does the app provide background music? 4. Does the app provide options to mute the audio? 5. Does the main menu button easily operable? 6. Does the main menu contain a link to all valuable tasks? 7. Is the icons' size set appropriately to be operable easily? 8. Does the app provide easy access to the mobile home screen? 9. The login section was straightforward and intuitive.
Help	1. The video tutorials on the app are helpful and precise for help. 2. Does appropriate help provided in UI where needed? 3. Does the app contain a help icon which is visible and understandable? 4. Whenever I make a mistake using this app, the help tab will appear. 5. The app helps to contact advisors.		

Table 4. Learning based task list with task code

Task Code	Task	Task Code	Task	Task Code	Task	Task Code	Task
T1	Open code editor	T2	Search HTML topic	T3	Add heading with subheadings	T4	Add paragraph
T5	Insert Table	T6	Insert marquee	T7	Insert input box	T8	Run the code
T9	Apply CSS	T10	Insert Line Break	T11	Insert Image	T12	Insert hyperlink
T13	Insert password filed	T14	Insert upload field	T15	Insert button	T16	Apply text formatting

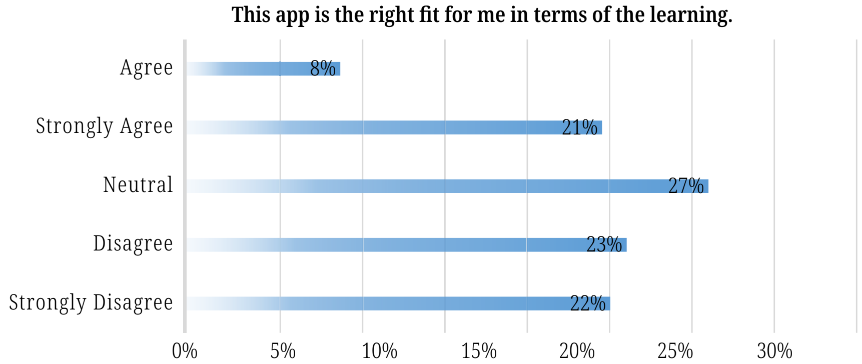

Fig. 5. Learning status

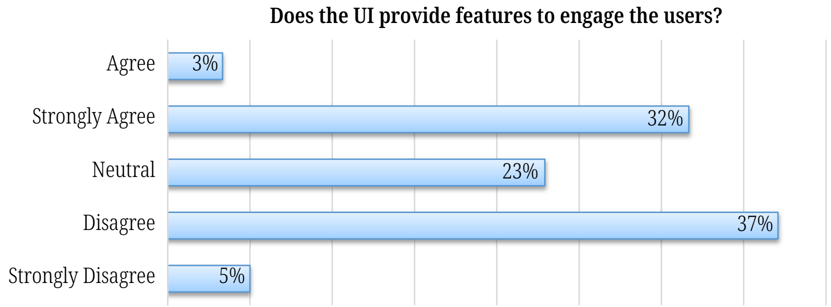

Fig. 6. Engagement status

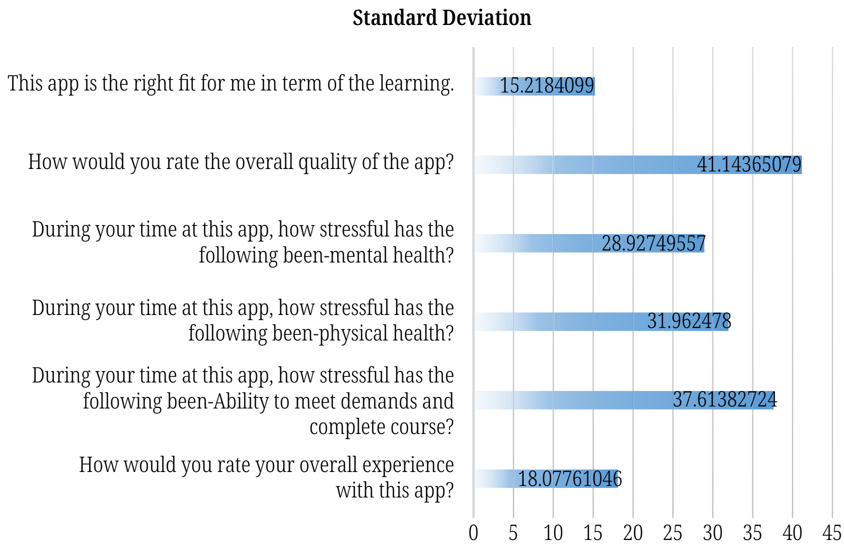

Fig. 7. Calculated SD

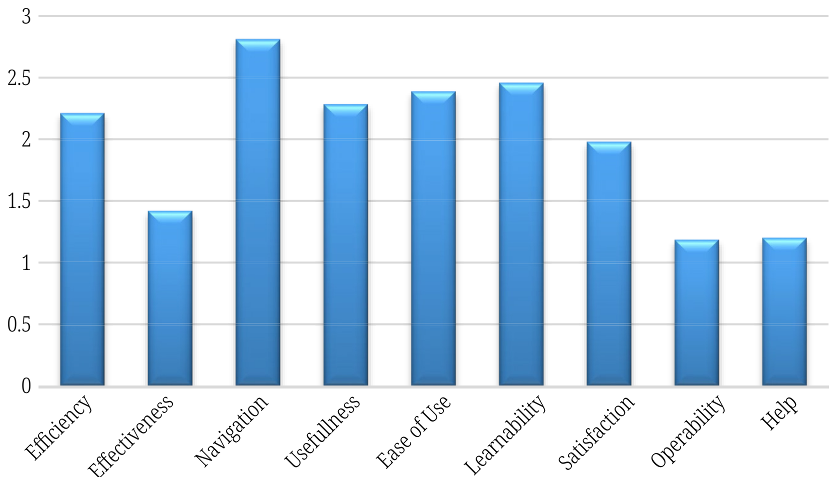

Fig. 8. Mean score of usability factors

3.2 Completion rate

The completion rate can be used to determine effectiveness. Effectiveness is considered a fundamental attribute of usability. Binary values '0' and '1' measure the point, '1' if users complete the task, or '0' will be used. Therefore, using this straightforward equation (equation 1), effectiveness may be expressed as a percentage.

$$Effectiveness = \frac{Number\ of\ tasks\ completed\ successfully}{Total\ number\ of\ studies\ undertaken} \times 100\% \tag{1}$$

Although a 100% completion rate should always be the goal, research [48] found that the typical task completion rate is 78%. (Based on an analysis of 1,100 tasks). Furthermore, it was found in the same study that the context of the work being evaluated had a significant impact on the completion rate.

3.3 Calculation of effectiveness

To calculate the effectiveness, there are 24 participants with 16 defined tasks, and Table 4 shows the details of the task. Figure 9 shows the successful completion rate; the minimum success rate is 21% for charge no 15, and the maximum success rate is 59% for task no 12. The overall average task success rate is 42%.

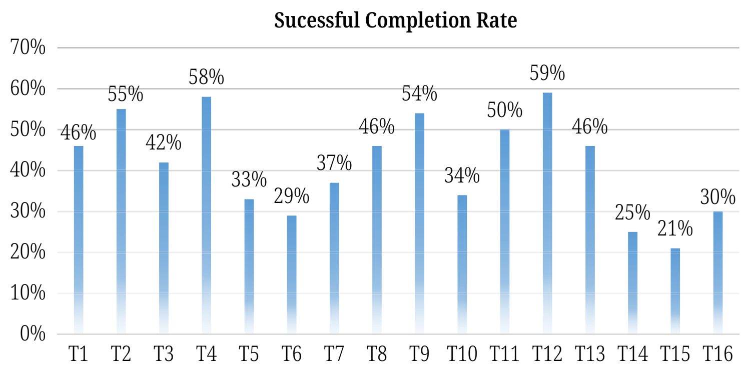

Fig. 9. Completion rate

3.4 Overall relative efficiency

The overall relative efficiency is calculated by dividing the time spent on a task by the number of people who finished it successfully. According to ISO-9241, product efficiency is defined as "resources spent by the user to ensure accurate and complete achievement of the goals". Table 5 represents the calculation of overall relative efficiency, and equation 2 illustrates the overall relative efficiency calculation. Figure 10 shows the overall efficiency. The equation is defined as

$$Overall\,Relative\,Efficiency = \frac{\sum_{j=1}^{R}\sum_{i=1}^{N} n_{ij}t_{ij}}{\sum_{j=1}^{R}\sum_{i=1}^{N} t_{ij}} \times 100\% \qquad (2)$$

Where:
N = The total number of tasks (goals)
R = The number of users
n_{ij} = The result of task i by user j; if the user successfully completes the task, then N_{ij} = 1, if not, then N_{ij} = 0
t_{ij} = The time spent by user j to complete task i. If the mission is not successfully completed, then time is measured till the moment the user quits the task

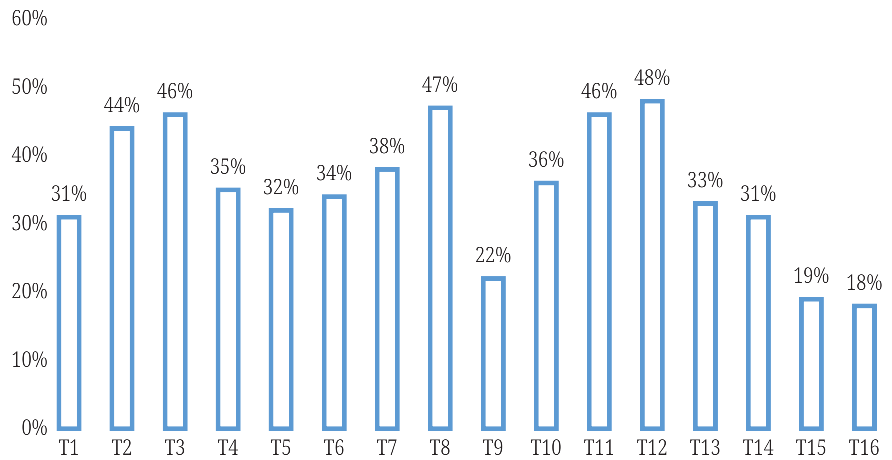

Fig. 10. Overall relative efficiency

Table 5. Calculation of overall relative efficiency

P#	N_{ij}	T_{ij}	P#	N_{ij}	T_{ij}	P#	N_{ij}	T_{ij}	P#	N_{ij}	T_{ij}
1	0	21	2	1	7	3	1	12	4	1	9
5	0	22	6	0	25	7	1	10	8	1	6
9	0	19	10	0	34	11	1	11	12	1	20
13	1	17	14	0	33	15	1	16	16	0	32
17	0	33	18	0	34	19	1	34	20	1	18
21	0	21	22	0	22	23	0	33	24	0	32

3.5 Identified usability issues

After usability evaluation, we found different usability problems that exist in the current HTML learning apps like no appropriate help being provided, poor icons which are not understandable, no interaction for maximum engagement, maritime issues, no learning assessment, no proper feedback and no proper learning contents, due to said issues, all said problems leading to the slow learner's dissatisfaction.

4 PROPOSED USABILITY MODEL

We summarized from the literature review that there is no usability model for specific users or users with learning disabilities, and no learning model exists for users such as slow learners. ALUM (Adaptable Learning-Oriented Usability Model) is proposed for the learning disabilities of 'slow learners' to enhance the learning experience using a hybrid recommendation system approach. Four usability factors are offered, including users, tasks, devices, and learning environment, all of which adhere to Human-Computer Interaction (HCI) principles. The dimensions are proposed on four factors: interface, content, icon, and navigational usability. Content usability and the learning environment factor are crucial components for designing learning apps. ALUM is addressing the learning needs of slow learners in the domain of learning apps using different features like users, devices, tasks, and learning environments. Figure 11 shows the proposed usability learning model for slow learners. Learning [6] through apps is more effective for slow learners than traditional learning. ALUM highly supports developers and stakeholders working on educational apps for slow learners. The aim of developing this model is to enhance the learning experience of slow learners through smartphone apps that provide easy access to educational content. Research has demonstrated that smartphone apps can significantly increase the motivation of slow learners in various learning environments, including classrooms. In this context, "user" refers to the individuals utilizing the apps for learning, while "task" pertains to the specific activities performed within the learning apps.

Additionally, "devices" refers to the actual devices used for learning. The learning environment is a critical and fundamental aspect of any successful learning system. The model also emphasizes crucial usability elements, including interface, content, icon, and navigational usability, all essential dimensions for effective learning apps. These components have been derived from the existing literature on learning app usability. Usability pertains to the ease and efficiency of using any product, and nowadays, various apps cater to diverse types of users and learners across different devices. Our target users are slow learners who face educational challenges. They need special attention for learning. They can be motivated to use other apps for learning if apps are easy to use.

The motivational model [29] is used for motivational purposes in learning. This model is known as the ARCS motivational model. As [29] mentioned, four major human characteristics motivate people: attention, relevance, confidence, and satisfaction. Slow learners' evaluation can be done using these elements by teachers or researchers for any learning task. Table 7 represents these motivational elements. The cognitive model is also integrated with mobile app learning usability. The mental model represents the learners' thinking, intellectual, reasoning, and decision-making capacities. These are task-driven and goal-oriented qualities. We can measure the learning environment's cognitive model [30], as mentioned in Table 6.

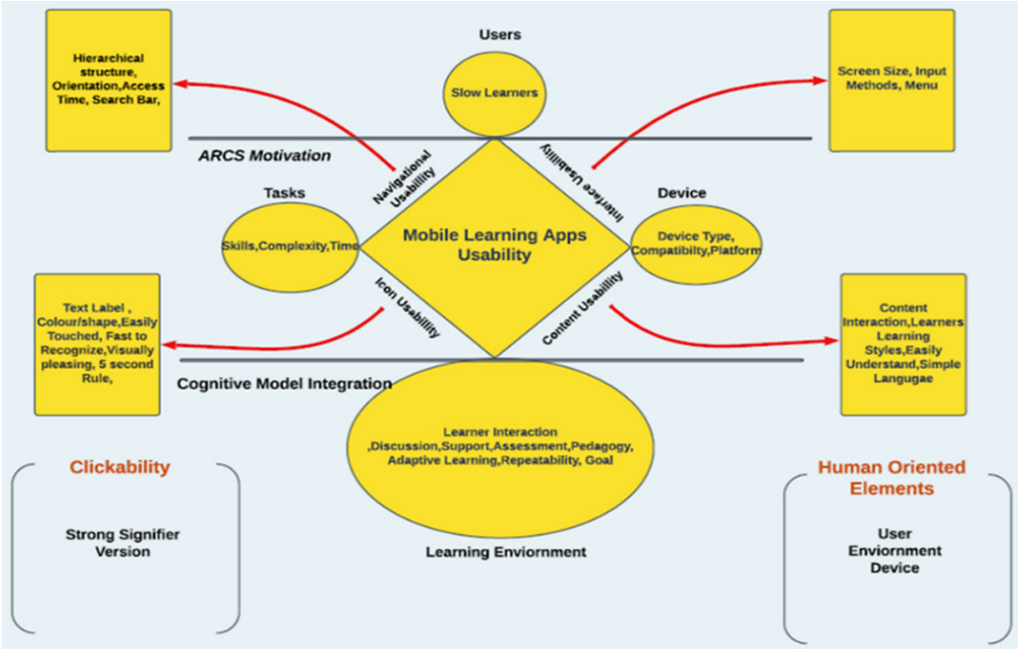

Fig. 11. Proposed usability model (ALUM)

Table 6. Cognitive model measuring quality units

Quality Unit	Explanation
Ease of Learning	This quality measures how easy or difficult it is to learn in/with a learning environment. This defines the cognition of learning app users/learners.
Knowledge Discovery	This quality measures the level at which a learning environment supports learners to learn and construct their knowledge through sense-making independently. This explains how cognitive a learning environment is to learners.

Table 7. Motivational elements

Major Categories and Definitions			
Attention	Capturing the interest of the learners	**Confidence**	Helping the learners believe/feel they will succeed and control their success.
Relevance	Meeting the personal needs	**Satisfaction**	Reinforcing accomplishment with rewards.

Users, environments, and devices are considered human-oriented elements [49]. Users or learners can use any smart device for learning in the learning environment. Clickability indicates the "strong" signifier versions for better execution. A robust signifier version makes the text readable to the users by clicking, so a strong signifier is recommended for fast and understandable execution. It is essential to consider the end users of the apps during the development phase. A user's previous experience must also be reflected in the development phase. Experienced users think of the shortcuts to complete the task, and novice users may prefer the simple way to navigate and find the function they need. Major components of the proposed learning usability model are described in Table 8.

Table 8. Usability learning model components

Major Component	Subcomponents	Description
1. User	Slow learners	The person who interacts with the app. Slow learners are learners who are educationally retarded. Our target users need to be faster learners.
2. Tasks	Skill	Tasks are vital for learning to enhance the learning of slow learners. Skill is a significant factor in performing any task. The study is the goal of the user.
	Complexity	Simple to complex tasks are used for slow learners to enhance their learning.
	Time	Time is critical to check the performance of the learners learning. Time should be monitored for each task, and errors can be counted for subsequent task attempts and efficiency.
3. Devices	Device Type	It is about the device type, like smartphone or tablet with size etc.
	Compatibility	This check is used to find the compatibility of the device with apps etc., and also indicate the device model.
	Platform	It is about the operating system like iOS and Android.
4. Learning Environment	Learners interaction	Interaction is significant in the learning environment of users and systems. GUI is used for exchange. The material should be interactive and understandable. The system must have clear instructions.
	Discussion	Discussion is very important for learning. Educational resources should offer conversation, debate, dialogue and group work. Slow learners respond positively to each other during discussion and peer learning, increasing academic performance [50]. Relationship building is slow learners' most effective instructional strategy [51].
	Support	The information should be easy to find and provide help at any navigational stage. Providing support in time is beneficial for [52] slow learners' confidence.
	Assessment	An assessment should be designed to find the slow learner's learning left.
	Pedagogy	It indicates the educational contents, multimedia resources, activities, social interaction and personalization. Activity-based learning is practical-based learning; slow learners learn effectively based on practical or activity. Learning disabilities have shown great interest in activity-based learning and improved [53] their performance.
	Adaptive learning	The system should provide adaptive learning at the learners' level.
	Repeatability	The system should be able to provide the learning contents multiple times as learners need. Slow learners may need to repeat information multiple times to grasp it fully. Therefore, it is essential to allow time for repetition. More time repetition benefits slow learners in learning and give them the confidence to learn [52].
	Goal	The learners should be able to set the goal and check their learning level.

Now four major usability factors, which are interface usability, icon usability, content usability and navigational usability, are explained here. Combining these factors will make learning apps more effective for slow learners.

1. **Interface Usability:** Interface is called a way of communication. Learners will learn more effectively if the interface is simple and appealing. Detailed instructions are not required to make it more effective, and interface elements should be designed carefully to make it natural for users. The interface should hide the complexities and make it easy to use interface which will be more attractive. The task will be executed quickly if the user interface is easy to use and learnable. Interface usability components are screen size, input methods and menu, which are explained in Table 9.
2. **Navigational Usability:** Navigation should be consistent across the tasks and functionalities of the learning apps. It makes the app easy to learn and use and reduces cognitive load. Different parts of navigational usability are recommended

for learning apps: hierarchal structure, screen orientation, access time and search bar. Further details are explained in Table 9.

3. **Content Usability:** Content is crucial for any learning. It indicates the material which is part of any learning app. Clear and precise contents are more effective for effective learning. Content should be understandable and written in simple language. Poor quality content would not sustain the learners' interest nor pay for effective education. Content usability is the combination of content interaction, the learner's learning style, and easily understandable and straightforward language which are explained in Table 9.
4. **Icon Usability**: Icon is a pictorial object on the screen used for interaction. Understandable and easily touched icons contribute to effective interaction and sustain the learners' interest. Icons with no text label would create a disturbance for the learners. Icon usability components are text label, colour/shape, easily touched, fast to recognize, visually pleasing and 5-second rule, explained in Table 9.

Table 9. Usability sub factors

Major Usability Factors	Sub Usability Factors	Explanation
1. Interface Usability	Screen size	Screen size impacts user behaviour and effect on user psychology.
	Input methods	The traditional keyboard is not available on most mobile devices. Simple data-entering options can be more effective for Input.
	Menu	The menu is the list of links. Options and sub-options should be in a series so users can use the menu for the desired function.
2. Navigational Usability	Hierarchal structure	A user may start from the home page and will go to the desired page. If the page hierarchy makes sense, this process should be easy. If not, the selected page will never be found.
	Screen orientation	Screen orientation is an essential factor in mobile app usability. For effective learning, landscape interaction is better than portrait.
	Access time	Minimum steps will increase the user's confidence to find the desired information. access time should be minimum.
	Search bar	The search bar allows users to enter a query and get the most relevant results.
3. Content Usability	Content interaction	"Content is King" by Bill Gates. Straightforward content engages the learners. Easily shareable content encourages learner engagement [54].
	Learner's learning style	Contents should meet the learner's level and learning style. The repeatability of contents should be available on the same page if desired.
	Easily understandable	Easily understandable content is more effective for learning [54].
	Simple language	Simple language engages the learners for a long time [55].
4. Icon Usability	Text label	Text labels are necessary for effective communication and to reduce ambiguity. Text labels must be present with icons to clarify their meanings. "A word is worth a thousand pictures" by Bruce Tognazzini.
	Colour/shape	Colour and shape are used to appeal.
	Fast to recognize	The icon should be fast to recognize.
	Easily touched	The icon should be easily touched and finger-operated.
	Visually pleasing	If the icon is visually pleasing, then it will be appealing.
	5-second rule	Take at most 5 seconds to understand the icon for effective communication.

4.1 A hybrid recommendation system approach

The proposed model leverages a hybrid recommendation system to provide personalized topic recommendations, incorporating a navigational graph, ontology, and item matrix.

- **Navigational Graph**

The navigational graph represents the learning materials, with nodes representing topics and edges indicating their relationships. Each bite is assigned a weight, reflecting the difficulty level of transitioning between subjects. Figure 12 shows the navigational graph with difficulty level.

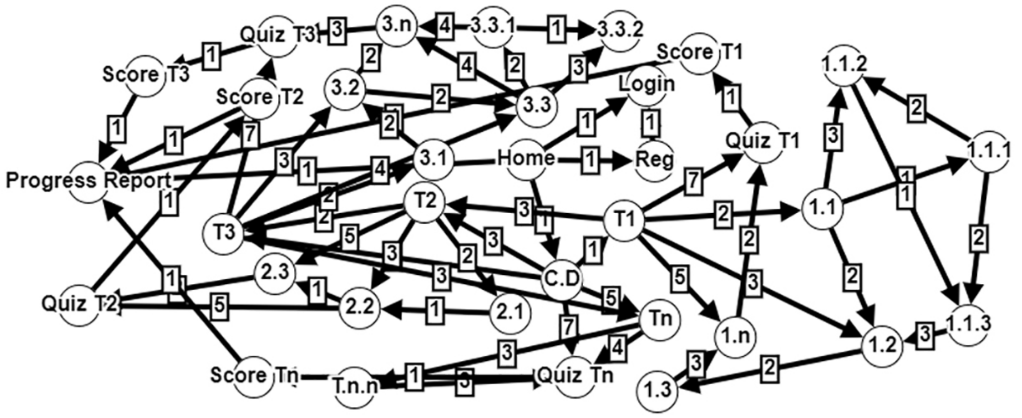

Fig. 12. Navigational graph

The graph lets the model determine each user's most suitable learning path, considering their previous knowledge and performance. The weight of an edge represents the difficulty level of the transition between two nodes. The importance of the border from node i to node j is defined as w (i, j). Then, the overall difficulty level of a given path in the navigational map can be computed as the sum of the weights of all the edges along that path. In mathematical notation, this can be written as:

$$\text{difficulty} = \Sigma w(i, j)$$

where the summation is over all edges (i, j) along the path.

The generic formula for calculating the weight of an edge in an adjacency matrix representing a navigational map of a learning app:

$$W(i, j) = f(D(i, j))$$

Where:

W(i, j) is the weight of the edge from vertex i to vertex j in the navigational map

D(i, j) is the difficulty level of the transition from vertex i to vertex j

f(x) is a function that maps the difficulty level x to a weight value, such as a linear or exponential function

In summary, the edge weights and the importance of w can be used in the HTML learning app to recommend new content that is personalized to the user's past behaviour and learning goals and gradually increases in difficulty as the user progresses through the topics.

- **Ontology**

The ontology serves as a knowledge base, organizing and categorizing topics, learning resources, and user-specific data. It captures the hierarchical relationships between issues and facilitates efficient retrieval and recommendation of relevant educational materials. Ontology is shown in Figure 13.

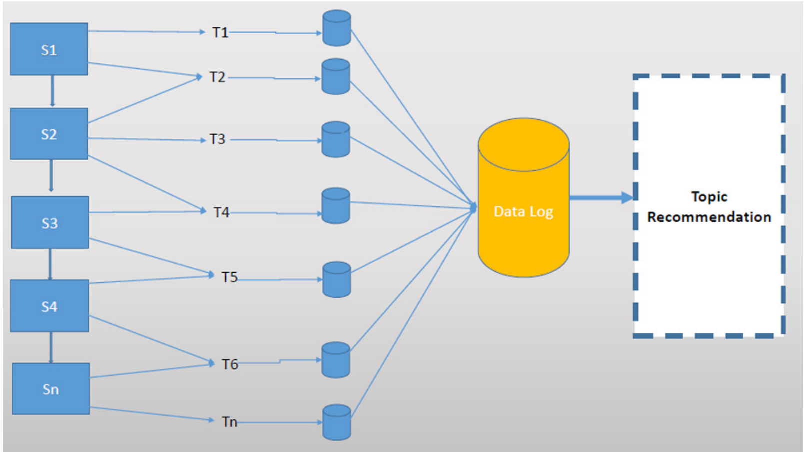

Fig. 13. Ontology

- **Item Matrix**

The item matrix stores user access data and test results over time. It tracks user progress, performance, and engagement with various learning materials. This data is utilized to assess individual learning patterns, identify areas of improvement, and personalize the recommendation process. Figure 14 shows the item matrix.

User	Topic	Difficulty	Time Spent (Module 1)	Time Spent (Module 2)	Attempts (Module 1)	Attempts (Module 2)	Quiz (Module 1)	Quiz (Module 2)	Score Test (Module 1)	Score Test (Module 2)
U1	T1(HTML Basics)	Easy	10 mints	15 mints	2	3	0	1		5
U2	T2(HTML tags)	Medium	15 mints	12 mints	3	4	1	1	8	6
U1	T3(HTML forms)	Hard	20 mints	18 mints	4	2	0	0		
U3	T4(HTML images)	Medium	10 mints	9 mints	2	5	0	1		8
U1	T5(CSS)	Hard	20 mints	20 mints	4	6	0	0		
U2	T5(CSS)	Hard	10 mints	16 mints	2	4	1	1	10	7

Fig. 14. Item matrix

- **Framework for Topic Recommendation**

The proposed model incorporates a layered framework for topic recommendation. The framework integrates collaborative and content-based filtering techniques to provide hybrid recommendations that leverage user behaviour and topic characteristics. The layers include the input layer, processing layer, recommendation generation and application layer. Explicit data refer to information like name, age and email address, and implicit data is derived from user actions like usage pattern, clicks and interaction data etc. Figure 15 shows the proposed framework for content recommendation.

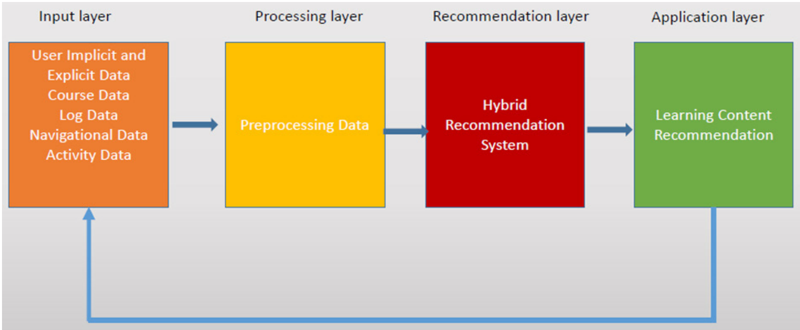

Fig. 15. Proposed framework

5 CONCLUSION

In this paper, we conducted a detailed systematic review of HTML learning apps for the mobile operating system iOS and Android. In the systematic review, we reviewed the app details like downloading space, app price, supporting languages, app rating, etc. Further, we performed the participant's (slow learners) based detailed usability evaluation of HTML learning apps using an experimental method. Slow learners participants were distributed between the age of 16 to 55, including males and females. The evaluation findings showed that the most critical issues existed in the interaction and functionality of the HTML learning apps.

Furthermore, HTML learning apps could be more effective in learnability, and proper learning help exists, leading to the slow learner's dissatisfaction. As a result of our usability evaluation, four major parts were identified: users, tasks, devices, and learning environment, with four usability dimensions: interface usability, content usability, icon usability, and navigational usability for the development of mobile learning applications of the slow learners. The proposed adaptable learning-oriented usability model offers a promising solution for supporting slow learners in their educational journey. The model aims to provide personalized topic recommendations tailored to individual learners' unique needs and preferences by leveraging a hybrid recommendation system. This paper outlines the framework and components of the proposed model and sets the stage for further research and development in this field. ALUM is expected to be a guideline for mobile app designers and developers to develop mobile learning apps for slow learners successfully. Developing M-learning for slow learners involves addressing limited attention spans and comprehension challenges. It requires individualized pacing, clear instructions, and visual aids for enhanced engagement. Personalized feedback, motivation strategies, and continuous evaluation are essential for optimizing the learning experience.

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