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IT4010 – Research Project - 2024

Topic Assessment Form

Project ID : **R24-112**

1. Topic (12 words max)

Enhancing Personalized E-Learning: A Novel Approach to Adaptive Learning Pathways for Individualized Knowledge Acquisition

2. Research group the project belongs to

Machine Learning and Soft Computing (MLSC)

3. Research area the project belongs to

E-learning and Education (ELE)

4. If a continuation of a previous project:

Project ID	R24-112
Year	2024

5. Team member details

Student Name	Student ID	Specialization
Nishshanka N.A.P.K.R	IT21033032	IT
Abeykoon R.M.S.P	IT21021602	IT
Jayasinghe K.A.K.N	IT21032806	IT
Nishshanka N.A.G.A.A	IT21032974	IT

6. Brief description of the research problem including references (200 – 500 words max) – references not included in word count.

The research problem at the core of this project revolves around the limitations of current e-learning systems in providing truly personalized learning experiences. Existing platforms often fall short in adapting to individual user preferences, relying on generic approaches that may not optimize user engagement and knowledge retention. There exists a notable gap in the literature concerning the development of a straightforward adaptive machine learning model tailored for customizing learning pathways in online education. The challenge lies in creating a system that seamlessly integrates adaptive machine learning while prioritizing simplicity and user engagement.[1][2][3]

Many studies in the field either focus on intricate recommendation algorithms without comprehensive consideration of user preferences or offer simplistic solutions lacking the adaptability required for personalized learning. The project aims to bridge this gap by crafting a user-centric approach that combines the power of adaptive machine learning with an intuitive interface. The objective is to deliver personalized learning experiences that are not only effective but also accessible to a diverse range of users.[4][5]

The envisioned research seeks to contribute to the existing body of knowledge by proposing a novel solution that prioritizes the user's learning journey. By leveraging insights from the fields of machine learning, educational technology, and user experience design, the project aims to provide a groundbreaking approach to personalized e-learning. Through the development and implementation of an adaptive recommendation engine, dynamic learning pathway generator, user profiling component, and engagement analytics with a feedback loop, the research endeavors to create a system that not only adapts to individual learning needs but also actively involves users in shaping their educational experience. The ultimate goal is to propel the field toward more effective and engaging personalized e-learning solutions.[6][7]

References:

[1] Heradio, R., Jorrín-Abellán, I. M., & Dormido, S. (2016). A review of educational resources for learning and teaching machine learning in higher education. *IEEE Access, 4, 8352-8367.*

[2] Vellido, A., & Romero, E. (2017). Educational data mining and learning analytics: An overview. *IEEE Transactions on Systems, Man, and Cybernetics: Systems, 47(6), 1186-1198.*

[3] Khribi, M. K., Jemni, M., & Nasraoui, O. (2010). Toward an adaptive e-learning system based on student learning styles. *IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans, 40(6), 1296-1302.*

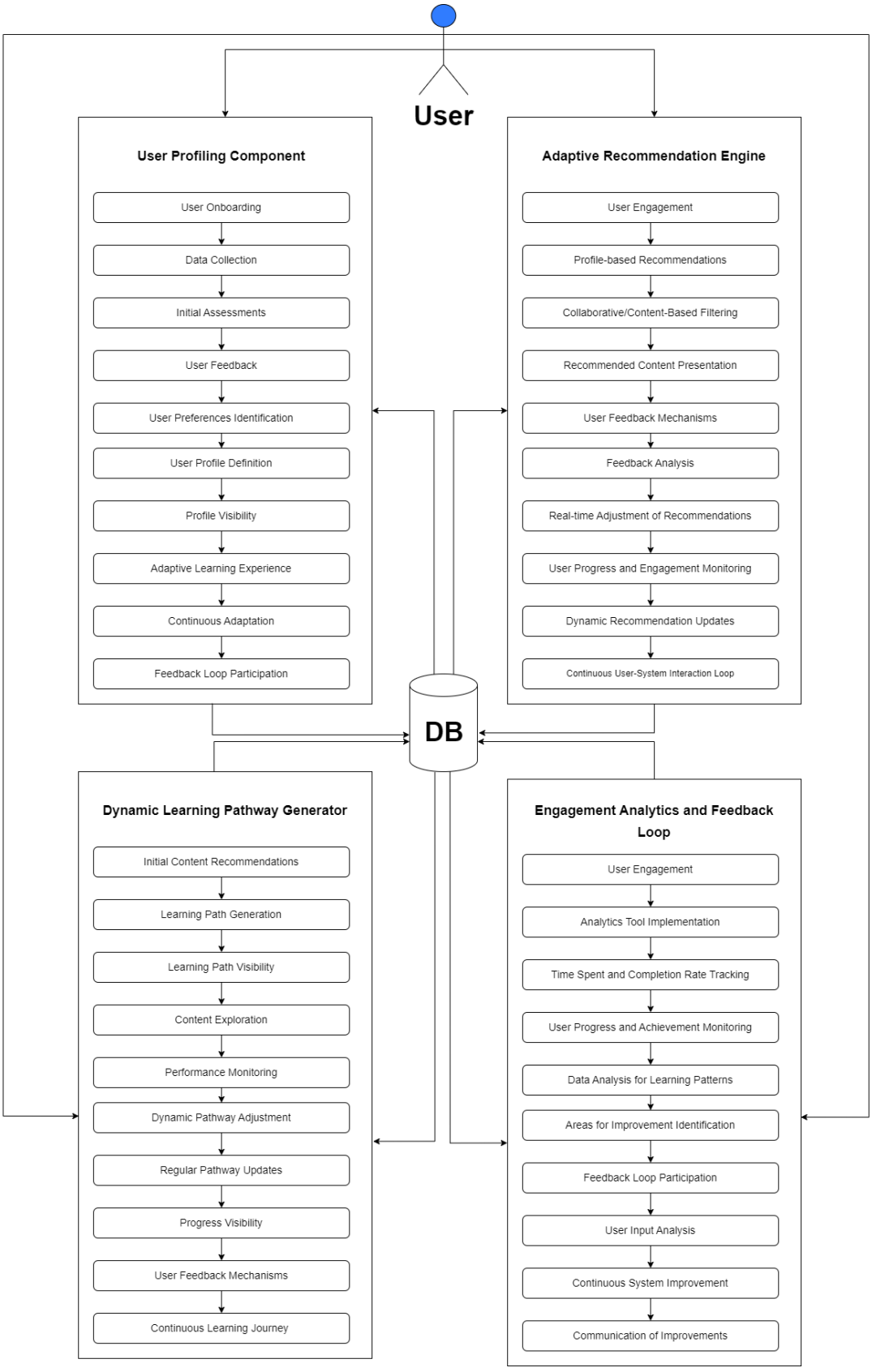
[4] Brusilovsky, P., & Peylo, C. (2003). Adaptive and intelligent web-based educational systems. *International Journal of Artificial Intelligence in Education, 13(2-4), 159-172.*

[5] Masthoff, J. (2015). Group recommender systems: Aggregation, satisfaction, and group attributes. *User Modeling and User-Adapted Interaction, 25(2), 169-206.*

[6] Nkambou, R., & Mizoguchi, R. (2017). Artificial intelligence in education: Twenty years after. *International Journal of Artificial Intelligence in Education, 27(4), 631-634.*

[7] König, C., Jucks, R., & Hesse, F. W. (2019). Adaptation of feedback in computer-based learning environments: A review of experimental and methodological developments. *International Journal of Artificial Intelligence in Education, 29(1), 1-42.*

7. Brief description of the nature of the solution including a conceptual diagram (250 words max)



8. Brief description of specialized domain expertise, knowledge, and data requirements (300 words max)

In the development of a personalized learning framework for e-learning platforms using adaptive machine learning, specialized domain expertise, knowledge, and specific data requirements are crucial for creating an effective and user-centric system. Domain expertise in machine learning, specifically in collaborative and content-based filtering algorithms, is essential for designing the adaptive recommendation engine. Understanding the intricacies of matrix factorization techniques and user-item interaction matrices is vital for accurately tailoring content recommendations to individual users. Knowledge in educational technology and pedagogy is necessary to inform the creation of the dynamic learning pathway generator, ensuring that the pathways align with effective learning strategies, diverse content formats, and varying difficulty levels. Additionally, expertise in user experience (UX) design is crucial for developing an intuitive interface that enhances user engagement and satisfaction.

In terms of data requirements, the project necessitates a diverse dataset encompassing user profiles, learning preferences, and past performance metrics. Initial assessments, feedback, and user interactions contribute to creating comprehensive user profiles, requiring data storage and retrieval mechanisms. Content data, including tags, formats, and difficulty levels, is crucial for the adaptive recommendation engine and dynamic learning pathway generator. Continuous user engagement metrics, such as time spent on content and completion rates, are essential for the engagement analytics system. Feedback data from users, including preferences, satisfaction levels, and comments on recommended content, forms a crucial part of the feedback loop, shaping the iterative refinement of the system. Privacy considerations also play a pivotal role, necessitating expertise in data security and ethical data usage.

9. Objectives and Novelty

Main Objective:

The primary objective of this project is to design and implement an innovative framework for personalized learning in e-learning platforms using adaptive machine learning. The project comprises four key components: a user profiling mechanism, an adaptive recommendation engine, a dynamic learning pathway generator, and an engagement analytics system with a user feedback loop. The user profiling component gathers and analyzes data on learning preferences, past performance, and initial assessments to create personalized profiles. The adaptive recommendation engine employs a hybrid approach, combining collaborative and content-based filtering algorithms, to suggest and adjust learning content in real-time based on user interactions and feedback. The dynamic learning pathway generator assembles personalized learning paths, considering content tags, user preferences, and learning goals, and adapts dynamically based on user performance. The engagement analytics system tracks user interactions and completion rates, analyzing data to identify effective learning patterns, while the feedback loop allows users to provide input on recommended content and overall satisfaction. The overarching goal is to enhance user engagement, knowledge retention, and satisfaction by tailoring the learning experience to individual needs, contributing a practical and user-friendly solution to the realm of personalized e-learning.

Member Name	Sub Objective	Tasks	Novelty
Nishshanka N.A.P.K.R	**User Profiling Component:** This component gathers and analyzes user data to create personalized profiles. It considers factors such as learning preferences, past performance, preferred learning styles, and any initial assessments.	**1. Data Collection:** **Task**: Design and implement mechanisms to collect user data, including demographic information, learning preferences, and past performance metrics. **Details**: Set up forms, surveys, or interactive interfaces to gather relevant user information during onboarding	**1. Comprehensive User Data Integration:** The component integrates various dimensions of user data, including learning preferences, past performance, preferred learning styles, and initial assessments. This comprehensive approach provides a holistic view of the user, going beyond

		or at key interaction points within the e-learning platform. **2. Data Storage:** **Task**: Establish a secure and scalable database to store user data. **Details**: Choose an appropriate database system and schema to efficiently store and retrieve user profiles. Ensure compliance with data protection regulations and prioritize data security. **3. Initial Assessments:** **Task**: Develop and implement methods for conducting initial assessments. **Details**: Create quizzes, tests, or interactive modules to assess the user's current knowledge, skills, and learning preferences. Capture data from these assessments to understand the user's baseline. **4. User Feedback Mechanisms:** **Task**: Integrate user feedback mechanisms to gather insights into preferences and satisfaction. **Details**: Implement features such as like/dislike buttons, surveys, or feedback forms	traditional methods that might focus on a limited set of factors. **2. Adaptability through User Feedback:** The inclusion of user feedback mechanisms ensures continuous adaptation and improvement of user profiles. By actively involving users in the learning process, the system becomes more responsive to individual preferences, addressing the evolving needs of learners. **3. Real-time Learning Preferences Identification:** The component uses initial assessments and ongoing user feedback to identify learning preferences in real-time. This dynamic approach allows the system to adapt quickly to changes in user preferences or learning styles, providing timely and relevant recommendations. **4. Multi-dimensional User Profiles:**

		within the e-learning platform. Use this feedback to continuously refine the user profile and improve the learning experience. **5. Learning Preferences Identification:** **Task**: Utilize initial assessments and user feedback to identify learning preferences. **Details**: Develop algorithms or rule-based systems to analyze assessment results and user feedback, extracting information about preferred learning styles, formats (text, video, interactive), and difficulty levels. **6. User Profile Definition:** **Task**: Define and structure user profiles based on gathered data. **Details**: Establish a template or schema for user profiles that includes identified preferences, past performance metrics, and relevant demographic information. Ensure the flexibility to accommodate future updates as the user progresses. **7. Continuous Data Updating:**	The generated user profiles go beyond traditional demographic information and academic performance. They include preferences for different content formats (text, video, interactive) and difficulty levels. This multi-dimensional approach adds granularity to user profiles, allowing for more nuanced and personalized recommendations. **5. Simplicity in Implementation:** The simplicity of the implementation process, focusing on basic algorithms and straightforward data collection methods, contributes to the novelty. Many existing systems might prioritize complex models, but the emphasis here is on achieving effectiveness through simplicity, making it accessible to a wider audience. **6. Balancing Privacy and Personalization:** The component addresses privacy concerns by avoiding

		Task: Implement mechanisms for continuous data updating. **Details**: Regularly update user profiles based on ongoing assessments, user interactions, and additional feedback. This ensures that the user profile remains reflective of the user's evolving preferences and capabilities. **8. Privacy Considerations:** **Task**: Incorporate privacy measures in data collection and storage. **Details**: Implement privacy controls, consent mechanisms, and anonymization techniques to protect user data. Comply with data protection regulations and communicate transparently about data usage.	extensive data collection. This unique feature recognizes the importance of user privacy while still providing personalized recommendations. This balance between personalization and privacy is a novel aspect in the e-learning landscape. **7. Alignment with Pedagogical Principles:** The component aligns with pedagogical principles by considering preferred learning styles and difficulty levels. This alignment with educational theory distinguishes it from systems solely focused on data-driven recommendations without considering pedagogical effectiveness. **8. User-Centric Design:** The user-centric design, involving users in the feedback loop, gamification elements, and profile customization, adds a novel dimension. It places the user at the center of the learning

			experience, fostering a sense of ownership and engagement.
Abeykoon R.M.S.P	**Adaptive Recommendation Engine:** This core component employs a straightforward recommendation algorithm to suggest learning content based on the user's profile. It adjusts recommendations in real-time based on user interactions and feedback.	**1. Algorithm Selection:** **Task**: Choose and implement a recommendation algorithm. **Details**: Select either collaborative filtering or content-based filtering, or a hybrid approach based on project requirements. Implement the chosen algorithm to generate initial learning content recommendations. **2. User Profile Integration:** **Task**: Integrate the user profile into the recommendation algorithm. **Details**: Ensure that the recommendation algorithm takes into account the user's profile, including learning preferences, past performance, and any identified characteristics from the user profiling component. This integration personalizes the recommendations.	**1. Real-time Adaptation based on User Interaction:** The engine dynamically adjusts recommendations in real-time, reflecting the user's evolving preferences and engagement. This real-time adaptability sets it apart from static recommendation systems that might not respond promptly to changes in user behavior. **2. Combining Collaborative and Content-Based Filtering:** The recommendation engine employs a hybrid approach by combining collaborative filtering and content-based filtering algorithms. This hybridization harnesses the strengths of both methods, providing a more nuanced and accurate recommendation system. This is in contrast to systems

		3. Real-time Adjustment Mechanism: **Task**: Develop a mechanism for real-time adjustment of recommendations. **Details**: Implement a system that continually monitors user interactions with recommended content. Adjust recommendations in real-time based on user clicks, views, or other relevant interactions, ensuring responsiveness to evolving user preferences. **4. User Feedback Mechanisms:** **Task**: Incorporate like/dislike buttons or other feedback mechanisms. **Details**: Integrate features that allow users to provide feedback on recommended content. Collect and analyze this feedback to understand user preferences better and refine the recommendation engine accordingly. **5. Recommendation Refinement:** **Task**: Implement mechanisms to refine recommendations continually.	that solely rely on one type of filtering. **3. Incorporation of User Feedback Mechanisms:** The inclusion of user feedback mechanisms, such as like/dislike buttons, introduces a continuous feedback loop. This feature allows users to actively shape their learning experience and refines the recommendation engine over time. Many existing systems might lack direct user involvement in improving recommendations. **4. Simplicity in Algorithmic Implementation:** The implementation of straightforward collaborative or content-based filtering algorithms adds a layer of simplicity. While many recommendation engines utilize complex models, the focus here is on effectiveness through simplicity. This simplicity not only makes the system more accessible but also distinguishes it from

		Details: Utilize user feedback and interaction data to refine the recommendation algorithm. Regularly update the algorithm to improve the accuracy of suggestions and adapt to changes in user behavior. **6. Dynamic Content Updating:** **Task**: Develop a system for dynamically updating recommended content. **Details**: Ensure that the recommendation engine can dynamically incorporate new content or updates to existing content. This keeps the recommendations fresh and aligned with the latest offerings on the e-learning platform. **7. Performance Monitoring:** **Task**: Implement performance monitoring tools. **Details**: Integrate tools to monitor the performance of the recommendation engine. Track metrics such as recommendation accuracy, click-through rates, and user satisfaction to assess the	more intricate models that may be challenging to interpret. **5. Privacy-Conscious Approach:** The engine respects user privacy by not requiring extensive personal information for effective recommendations. It emphasizes the importance of personalized learning without compromising user data, a feature that aligns with contemporary concerns regarding data privacy. **6. Balancing Personalization and Diversity:** The recommendation engine aims not only to provide personalized content but also to ensure a diverse learning experience. It does this by recommending a mix of content formats and difficulty levels. This approach balances personalization with the broader goal of offering a well-rounded education.

		effectiveness of the recommendations. 8. **Privacy and Ethical Considerations:** **Task**: Incorporate privacy controls and ethical considerations. **Details**: Implement measures to protect user privacy in the recommendation process. Ensure compliance with data protection regulations and establish transparent communication about data usage.	7. **User Progress and Engagement as Key Metrics:** The engine considers user progress and engagement metrics as vital factors in updating recommendations. This focus on the learner's journey and interaction goes beyond simple content matching and aligns with a holistic understanding of effective learning.
Jayasinghe K.A.K.N	**Dynamic Learning Pathway Generator:** This component assembles a dynamic learning pathway for each user by sequencing recommended content. It ensures a varied mix of formats and difficulty levels, promoting a well-rounded learning experience.	1. **Algorithm Development:** **Task**: Develop algorithms for creating adaptive learning paths. **Details**: Design algorithms that take into account content tags, user preferences, and learning goals to dynamically generate personalized learning paths. Ensure flexibility in the algorithm to cater to diverse user profiles. 2. **Content Tag Integration:**	1. **Algorithmic Adaptation based on Multiple Factors:** The component utilizes algorithms that consider a combination of content tags, user preferences, and learning goals to create adaptive learning paths. This multifactorial approach enhances the system's ability to tailor recommendations, setting it apart from systems that might focus on a limited set of criteria.

		Task: Integrate content tags into the algorithm. **Details**: Ensure that the algorithm considers content tags associated with each learning resource. Content tags can include topics, skills, formats, and other relevant metadata that contribute to the diversity of the learning pathway. **3. User Preference Incorporation:** **Task**: Incorporate user preferences into the learning path algorithm. **Details**: Integrate the user profile, including learning preferences identified in the user profiling component, to tailor the learning path according to the individual's preferred content formats, difficulty levels, and styles. **4. Learning Goal Alignment:** **Task**: Align learning paths with user-defined learning goals. **Details**: If users have explicitly defined learning goals, ensure that the algorithm aligns the recommended learning path	**2. Real-time Adjustment and Regular Updates:** The pathway generator dynamically adjusts learning paths in real-time based on user performance and feedback. Regular updates ensure that the learning journey remains aligned with the user's evolving needs and achievements. This real-time adaptability distinguishes it from static learning paths that do not respond promptly to user progress. **3. Balancing Format and Difficulty Levels:** The component ensures a varied mix of content formats and difficulty levels in the learning pathway. This balance promotes a well-rounded learning experience by catering to different learning styles and challenging users appropriately. Many existing systems may focus on personalization but may not consider the diverse needs of

		with these goals. This customization enhances the relevance of the learning experience. **5. Dynamic Pathway Adjustment:** **Task**: Implement mechanisms for dynamic pathway adjustment. **Details**: Develop a system that continually monitors user performance and interactions with the learning path. Adjust the pathway dynamically based on user progress, achievements, and feedback to ensure ongoing relevance and effectiveness. **6. Regular Pathway Updates:** **Task**: Establish a process for regular pathway updates. **Details**: Plan and implement regular updates to the learning pathways. This may involve introducing new content, removing outdated material, and adjusting the sequence of recommended resources based on evolving educational needs. **7. User Progress Visibility:**	learners in terms of format and difficulty. **4. User-Centric Progress Visibility:** The provision of visibility into users' current progress within the learning pathway enhances user engagement. Users can track their advancement, fostering a sense of accomplishment and motivation. This user-centric design aspect distinguishes it from systems lacking transparent progress tracking. **5. Holistic Learning Experience:** By incorporating content tags, user preferences, and learning goals, the generator provides a holistic learning experience. It considers both the content-related aspects and the learner's individual goals, creating a more comprehensive and personalized educational journey. **6. Responsive to User Feedback:**

		Task: Provide visibility to users on their progress within the learning pathway. **Details**: Implement a user interface feature that allows users to track their current progress, achievements, and upcoming milestones within the learning pathway. This fosters transparency and motivation. **8. Gamification Integration:** **Task**: Optionally, integrate gamification elements. **Details**: Consider adding gamification elements such as badges, points, or levels to enhance user engagement. Gamification can provide additional incentives for users to progress through the learning pathway. **9. Privacy and Ethical Considerations:** **Task**: Incorporate privacy controls and ethical considerations. **Details**: Implement measures to protect user privacy in the learning pathway generation process. Ensure compliance with data protection regulations	The component actively takes user feedback into account when updating and adjusting the learning pathway. This responsiveness ensures that user preferences and concerns are addressed promptly, contributing to a user-centric and adaptive learning environment. **7. Gamification Integration for Engagement:** Gamification elements, such as badges, points, or levels, can be integrated into the learning pathway. This gamified approach enhances user engagement by adding an element of competition and achievement. The inclusion of gamification differentiates it from purely content-focused learning path generators.

		and communicate transparently about data usage.	
Nishsanka N.A.G.A.A	**Engagement Analytics and Feedback Loop :** This component involves tracking user engagement, analyzing learning patterns, and incorporating feedback to enhance the overall system. It contributes to continuous improvement and adaptation.	1. **Analytics Tool Implementation:** **Task**: Implement analytics tools to track user interactions. **Details**: Develop and integrate tools that capture user interactions within the e-learning platform. Track metrics such as clicks, views, and time spent on content to gain insights into user engagement patterns. 2. **Time Spent and Completion Rate Tracking:** **Task**: Implement features to track time spent on content and completion rates. **Details**: Integrate functionality to record the time users spend on different learning resources and track the percentage of completion for each resource. This data contributes to understanding user engagement levels. 3. **Data Analysis for Learning Patterns:**	1. **Comprehensive User Interaction Tracking:** The component utilizes analytics tools to track a variety of user interactions, including but not limited to clicks, time spent on content, and completion rates. This comprehensive tracking goes beyond basic metrics, providing a more nuanced understanding of user behavior compared to systems that focus solely on completion rates. 2. **Learning Pattern Analysis:** The inclusion of learning pattern analysis allows the system to identify effective learning patterns. This goes beyond traditional analytics by recognizing and leveraging patterns that lead to successful learning outcomes. This aspect differentiates it from systems

		Task: Analyze data to identify effective learning patterns. **Details**: Utilize the collected data to identify patterns associated with effective learning experiences. Explore correlations between certain types of content, engagement levels, and positive learning outcomes. **4. Areas for Improvement Identification:** **Task**: Analyze data to identify areas for improvement. **Details**: Evaluate user interaction data to pinpoint areas where the e-learning system can be enhanced. This may include identifying content that has low engagement, assessing user drop-off points, and recognizing patterns indicative of user challenges. **5. Feedback Loop Implementation:** **Task**: Establish a feedback loop for user input. **Details**: Implement a system that allows users to provide feedback on various aspects, including recommended content, the overall learning	that might primarily focus on user engagement metrics. **3. Continuous Improvement and Adaptation:** The component actively contributes to continuous improvement and adaptation of the system. Insights from analytics are used to refine recommendations and enhance the overall learning experience. This iterative process ensures that the system evolves in response to user needs, setting it apart from static systems that lack adaptability. **4. Establishment of a User Feedback Loop:** The establishment of a feedback loop directly involves users in the improvement process. Users can provide input on recommended content, share their learning experiences, and express overall satisfaction. This interactive feedback loop ensures a user-centric approach, distinguishing it

		experience, and their satisfaction with the platform. Integrate feedback mechanisms such as surveys, comments, or like/dislike buttons. **6. User Input Analysis:** **Task**: Analyze user feedback and input. **Details**: Develop mechanisms to collect, categorize, and analyze user feedback. This analysis informs decisions on system improvements, content adjustments, and overall user experience enhancements. **7. Continuous System Improvement:** **Task**: Implement mechanisms for continuous system improvement. **Details**: Utilize insights from analytics and user feedback to make continuous improvements to the e-learning system. This may involve refining recommendation algorithms, adjusting learning pathways, or enhancing the user interface. **8. User Satisfaction Metrics:** **Task**: Incorporate metrics for user satisfaction.	from systems that do not actively seek user input. **5. User Satisfaction as a Key Metric:** The inclusion of user satisfaction as a metric in the feedback loop is a novel aspect. It recognizes the importance of not only tracking engagement and completion but also ensuring that users are content with the learning experience. This holistic approach goes beyond quantitative metrics, adding a qualitative dimension to the evaluation process. **6. Adaptive System Refinement:** Insights gathered from engagement analytics and user feedback actively contribute to the refinement of the adaptive machine learning model. This adaptability ensures that the system aligns with evolving user preferences and learning dynamics, distinguishing it from static

		Details: Define and track metrics related to user satisfaction, such as Net Promoter Score (NPS) or user satisfaction surveys. These metrics provide a quantitative measure of how satisfied users are with the personalized learning experience. **9. Privacy and Ethical Considerations:** **Task**: Incorporate privacy controls and ethical considerations. **Details**: Implement measures to protect user privacy in the feedback and analytics process. Ensure compliance with data protection regulations and communicate transparently about data usage.	models that may become outdated. **7. Transparent Communication with Users:** The feedback loop provides a channel for transparent communication with users. By actively seeking user opinions, the system fosters a sense of partnership with the learners. This transparent and collaborative approach differentiates it from systems that lack direct communication channels.

10. Supervisor checklist

a. Does the chosen research topic possess a comprehensive scope suitable for a final-year project?

Yes	√	No	

b. Does the proposed topic exhibit novelty?

Yes	√	No	

c. Do you believe they have the capability to successfully execute the proposed project?

Yes	√	No	

d. Do the proposed sub-objectives reflect the students' areas of specialization?

Yes	√	No	

e. Supervisor's Evaluation and Recommendation for the Research topic:

Accepted.

11. Supervisor details

	Title	First Name	Last Name	Signature
Supervisor	Ms.	Sanjeevi	Chandrasiri	
Co-Supervisor	Miss	Akshi	De Silva	
External Supervisor				
Summary of external supervisor’s (if any) experience and expertise				

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Topic Assessment Form

<u>This part is to be filled by the Topic Screening Panel members.</u>

Acceptable: Mark/Select as necessary

Topic Assessment Accepted	
Topic Assessment Accepted with minor changes (should be followed up by the supervisor)*	
Topic Assessment to be Resubmitted with major changes*	
Topic Assessment Rejected. Topic must be changed	

* Detailed comments given below

Comments

The Review Panel Details

Member's Name	Signature

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Topic Assessment Form

*Important:

1. According to the comments given by the panel, make the necessary modifications and get the approval by the **Supervisor** or the **Same Panel**.
2. If the project topic is rejected, identify a new topic, and request the RPTeam for a new topic assessment.
3. The form approved by the panel must be attached to the **Project CharterForm**.