

Advance in Online Education Recommender Systems During and After Covid-19 a Survey

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Abstract

The Covid-19 pandemic has significantly accelerated the adoption of online education, necessitating the development and enhancement of recommender systems tailored to this context. This survey paper investigates the key advancements, impacts, challenges, adaptations, and ethical considerations associated with online education recommender systems during and after the Covid-19 pandemic. We explore the key factors considered in designing and implementing these systems, including user preferences, course content, pedagogical approaches, and scalability. Furthermore, we analyze how these recommender systems impact student engagement and learning outcomes by providing personalized learning experiences, access to diverse resources, and targeted skill development. The survey also sheds light on the challenges and limitations faced by these systems, such as limited In-Person Interaction, increased Demand for Online Education, and lack of Social Learning Opportunities. Moreover, we examine how online education recommender systems adapt to changing student needs and preferences in the dynamic post-pandemic landscape. Lastly, we address the ethical considerations and privacy concerns related to the use of these systems, emphasizing the importance of transparency, data privacy, and addressing biases. This comprehensive survey serves as a valuable resource for researchers, educators, and practitioners interested in understanding and advancing online education recommender systems during and after the Covid-19 pandemic.

Keywords: Online Education, Recommender Systems, COVID-19, Personalized Learning.

1. Introduction

The Covid-19 pandemic has brought unprecedented disruptions to the education sector, leading to a significant shift towards online learning platforms. As educational institutions rapidly transitioned to remote teaching and learning, the demand for effective online education recommender systems has soared. These recommender systems play a crucial role in supporting students' learning experiences by providing personalized recommendations for courses, resources, and learning materials.

The advancement of online education recommender systems during and after the Covid-19 pandemic has become an area of intense research and development. These systems aim to address the unique challenges posed by online learning environments, such as the absence of face-to-face interactions, the need for flexible learning pathways, and the overwhelming abundance of digital resources.

This survey paper aims to provide a comprehensive overview of the advances made in online education recommender systems in the context of the Covid-19 pandemic. By examining the key factors considered in designing and implementing these systems, we can gain insights into the underlying principles that contrib-

ute to their effectiveness. Factors such as user preferences and profiles, course content and metadata, pedagogical approaches, and scalability are crucial in creating personalized recommendations.

Furthermore, this survey investigates the impacts of online education recommender systems on student engagement and learning outcomes. By tailoring recommendations to individual learners' needs and interests, these systems have the potential to enhance student motivation, increase knowledge retention, and improve overall learning experiences. We delve into the ways in which personalized recommendations, access to diverse resources, and targeted skill development contribute to these positive impacts.

However, the development and implementation of online education recommender systems also present challenges and limitations. Issues such as limited In-Person Interaction, increased Demand for Online Education, and lack of Social Learning Opportunities need to be addressed to ensure the optimal functioning of these systems.

As we move beyond the immediate effects of the pandemic, un-

derstanding how online education recommender systems adapt to changing student needs and preferences becomes crucial. The dynamic post-pandemic landscape requires these systems to evolve and cater to the evolving demands of students. Exploring the adaptive capabilities and mechanisms of these systems can shed light on their effectiveness and sustainability in the long run.

Lastly, ethical considerations and privacy concerns related to the use of online education recommender systems must be examined. Ensuring transparency in the recommendation process, safeguarding user data, addressing algorithmic biases, and respecting privacy rights are paramount in building trust and fostering responsible usage of these systems.

By conducting a comprehensive survey of the advances in online education recommender systems during and after the Covid-19 pandemic, this paper aims to provide valuable insights for researchers, educators, and practitioners interested in leveraging these systems to enhance the online learning experience.

The organization of this paper is as follows: Section 2 outlines the methodology and stages employed in conducting the survey. Section 3 presents the findings and results of the study. Lastly, in Section 4, we offer our primary conclusions.

2. Methodology

The research method employed in this study involves a systematic collection of articles and subsequent analysis to extract relevant and interesting information. The research methodology begins with a search of academic databases, to identify articles pertaining to online education recommender systems during and after the Covid-19 pandemic. These articles are then screened based on their relevance to the research objectives, and selected articles undergo a data extraction process. The extracted information includes details about advancements in online education recommender systems, their impact on student engagement and learning outcomes, challenges and limitations, adaptations to changing needs, and ethical considerations. The collected data is then analyzed using qualitative analysis techniques such as thematic analysis or content analysis to identify patterns, trends, and key findings. The synthesized results are interpreted and discussed in the context of existing literature and theoretical frameworks, highlighting their implications for researchers, educators, and practitioners in the field. The entire research process is documented, and a comprehensive research report or paper is prepared to present the methodology, findings, and conclusions of the survey.

2.1 Investigation Queries

Our research aims to investigate and evaluate the advancements and developments in online education recommender systems in the context of the Covid-19 pandemic. Therefore, we formulated the following analysis: "What are the main types of recommender systems used in online education during and after the Covid-19 pandemic?" and "How do online education recommender systems impact student engagement and learning outcomes during and after the Covid-19 pandemic?" and "What

are the potential future directions and emerging trends in online education recommender systems in the post-Covid-19 era?". To facilitate a better understanding, we have included additional research questions supporting our main objective. Each of these questions focuses on various aspects of online education recommender systems during and after the Covid-19 pandemic, aimed at presenting the factors, impacts, challenges, adaptations, and ethical considerations related to online education recommender systems in the context of the pandemic. Table 1 provides an overview of all research questions in this study, with their respective justification.

2.2 Investigative Approach

The search strategy employed for the survey encompassed several key steps. Initially, relevant academic databases and research repositories specializing in online education, recommender systems, and Covid-19 were identified, such as Springer, Elsevier, and Google Scholar. Next, a set of keywords and phrases were developed to capture the main research concepts, including terms like "online education," "recommender systems," "Covid-19," "advancements," "impacts," "challenges," "limitations," "adaptations," "ethical considerations," and "future directions." Boolean operators like "AND," "OR," and "NOT" were employed to combine search terms effectively, forming search queries such as "online education AND recommender systems" or "Covid-19 AND impacts." Specific inclusion and exclusion criteria were established to ensure the relevance and quality of retrieved articles, encompassing factors like publication timeframe (In our study we considered the period following "2020 to 2023"), language (English), content type (Article), and direct relevance to online education recommender systems and Covid-19. The search queries were then executed in the chosen databases, leading to the retrieval of relevant articles and documents based on the search criteria. These retrieved articles underwent screening based on title, abstract, and full text (when available) to identify those aligning with the research objectives and inclusion criteria. Articles that did not meet the criteria or lacked relevance were excluded. Relevant data and information were extracted from the selected articles, with a focus on key findings, methodologies, and discussions pertaining to the advances in online education recommender systems during and after Covid-19. The extracted data were then analyzed and synthesized to present a comprehensive overview, forming the foundation for the survey report. The report highlighted key insights, trends, and emerging directions in the field of online education recommender systems during and post the Covid-19 pandemic. Through this rigorous search strategy, a comprehensive collection of relevant articles and information was obtained, facilitating a thorough survey on the advances in online education recommender systems during and after the Covid-19 pandemic. The search queries included combinations of keywords related to online education recommender systems, Covid-19, advancements, impacts, challenges, limitations, adaptations, ethical considerations, and future directions. In some databases, the asterisk "*" symbol was utilized as a wildcard to expand the search results, capturing variations of terms and allowing for a more comprehensive search. The results obtained from each database were recorded, and the subsequent analysis and synthesis formed the basis for the survey report.

2.3 Inclusion Criteria

To ensure the inclusion of relevant and high-quality articles, the survey employed specific selection criteria. Firstly, articles were chosen based on their direct relevance to the topic of online education recommender systems during and after the Covid-19 pandemic, focusing on advancements, impacts, challenges, limitations, adaptations, ethical considerations, and future directions in this specific context. Secondly, a specific publication date range was considered to capture the most recent research and developments in the field, aligning with the scope of the survey and the availability of pertinent literature. Furthermore, articles written in English were preferred to ensure accessibility and comprehension for the intended audience. The inclusion of peer-reviewed articles was prioritized to ensure the quality and reliability of the research findings. Additionally, various research methodologies, such as empirical studies, case studies, surveys, or systematic reviews, were considered to enable a comprehensive analysis of different approaches and findings. Finally, articles that were accessible through the selected databases and repositories were included to ensure the feasibility of data extraction and analysis. By applying these selection criteria, the survey aimed to identify and include articles that best contributed to a comprehensive exploration of the advancements in online education recommender systems during and after the Covid-19 pandemic.

2.4 Process of Evaluation and Selection of Key Studies

The survey employed a systematic screening process and selection criteria to ensure the inclusion of primary studies that were relevant and reliable. The screening began with a review of the titles and abstracts of identified articles, excluding those that did not align with the research objectives or the specific context of online education recommender systems during and after Covid-19. The remaining articles underwent a full-text evaluation, assessing their suitability based on their contribution to the research questions and the insights they provided on advancements in online education recommender systems. The application of pre-defined selection criteria further determined the eligibility of the articles, considering factors such as relevance to the research topic, publication date, language, peer-reviewed status, and adherence to specific research methodologies. Data extraction from the selected primary studies involved gathering key findings, methodologies, and discussions related to online education recommender systems during and after Covid-19. The synthesized and analyzed data formed the basis for a comprehensive overview of the advancements in the field. This meticulous screening process and adherence to strict selection criteria ensured that the survey report provided valuable insights and a deeper understanding of online education recommender systems during and after the Covid-19 pandemic.

2.5 Data Extraction and Data Analysis

The survey utilized a systematic process of data extraction and analysis to gather valuable insights. The first step involved extracting relevant data from the selected primary studies, including key findings, methodologies, and other pertinent information related to advancements in online education recommender systems during and after the Covid-19 pandemic. This ensured that the collected data aligned with the research objectives.

Next, the extracted data were organized in a structured manner to facilitate further analysis. Categorization based on themes, research questions, or other relevant frameworks allowed for the identification of patterns, trends, and relationships within the data.

Prior to analysis, the data underwent a cleaning and validation process to ensure accuracy and reliability. Inconsistencies, errors, and missing values were addressed to maintain the integrity and quality of the findings.

Various analytical techniques were then applied to the cleaned and validated data. Quantitative methods such as statistical analysis, data mining, or machine learning algorithms, as well as qualitative methods like content analysis or thematic analysis, were employed depending on the nature of the data and research questions.

The results obtained from the analysis were interpreted and synthesized to generate meaningful conclusions. This involved identifying key trends, patterns, and relationships within the data, allowing for the derivation of insights that addressed the research objectives of the survey. The interpretation and synthesis process provided a comprehensive overview of the advancements in online education recommender systems during and after the Covid-19 pandemic based on the collected data.

Following this data extraction and analysis process, the survey contributed to a deeper understanding of the advancements in online education recommender systems during and after the Covid-19 pandemic, providing valuable insights for the field (Table 3).

3. Results

Through the investigative approach, we conducted searches in digital databases, which yielded multiple articles. Following a comprehensive screening process and data extraction, we identified a total of 34 primary studies. Each primary study was categorized based on its relevance to the main research questions. The findings of this study are organized and presented in Table 2, aligning with the research questions.

3.1 Recommender Systems Types in Accordance with the Specific Context and Requirements of the Educational Institutions

In response to question RQ1, we analyzed the articles collected and extracted the types of recommender systems according to the context criterion and the specific requirements of educational institutions. Indeed, in the study an improved adaptive learning path recommendation model driven by real-time learning analytics refers to an advanced system designed to provide personalized learning path recommendations to learners based on real-time analysis of their learning activities and performance [1]. The model incorporates adaptive learning techniques and leverages learning analytics to enhance the recommendation process. Moreover, the system continuously collects and analyzes data on learners' interactions with educational materials, such as online courses, quizzes, and assignments. This real-time learning analyt-

ics captures information like progress, achievements, strengths, weaknesses, and engagement levels. By leveraging this data, the system generates insights into each learner's learning preferences, knowledge gaps, and areas of improvement. Furthermore, the adaptive learning path recommendation model then utilizes this information to provide tailored recommendations to learners. It dynamically adjusts the learning path based on the learner's current progress and performance, directing them toward the most relevant and effective learning resources. The recommendations can include additional learning materials, specific topics to review, interactive exercises, or alternative approaches to grasp challenging concepts. The improved model takes into account various factors, such as the learner's proficiency level, learning style, time availability, and specific learning objectives. It adapts to the learner's individual needs and preferences, ensuring a personalized learning experience. The recommendations are continuously updated as the learner progresses, providing ongoing guidance and support throughout their learning journey. By incorporating real-time learning analytics, the system can offer timely and data-driven recommendations, enabling learners to optimize their learning process and achieve better learning outcomes. The adaptive nature of the model ensures that learners receive tailored guidance that suits their unique needs and helps them overcome learning challenges effectively. Ultimately, this improved adaptive learning path recommendation model aims to enhance the overall learning experience and facilitate learners' knowledge acquisition and skill development. Another type of recommender system mentioned in the article is a chatbot [2]. The article focuses on the utilization of chatbots to facilitate student goal-setting and enhance social presence in fully online educational activities. The study investigates the impact of chatbot interventions on learner engagement and perceptions. It explores how chatbots can support students in setting and achieving their learning goals and contribute to fostering social presence in online environments. To gather data on learner engagement and perceptions, the research employs surveys, interviews, and observations. The findings provide insights into the effectiveness of chatbots in promoting student engagement, facilitating goal attainment, and encouraging social interaction in online learning contexts. The article underscores the significance of incorporating chatbot technology in online education as a means to deliver personalized support, enhance learner motivation, and cultivate a sense of community. The research contributes to the understanding of how chatbots can be effectively utilized to improve the overall learning experience and outcomes in fully online activities. Indeed, the study highlights the potential of chatbots as a valuable tool in online education, offering opportunities to enhance student engagement, foster goal-oriented learning, and cultivate a sense of social presence among learners. Article investigates the use of collaborative caption editing as a means to enhance video-based learning experiences [3]. The study aims to explore the potential benefits and challenges of incorporating collaborative caption editing tools in educational settings. The research focuses on the concept of augmenting video-based learning, where learners actively engage with video content by collaboratively editing captions. This approach aims to improve comprehension, engagement, and knowledge retention by allowing learners to actively participate in the creation

and modification of video captions. The study employs various research methods, including user observations, interviews, and surveys, to gather insights into the effectiveness and user perceptions of collaborative caption editing. The findings shed light on the advantages of this approach, such as increased learner engagement, improved comprehension, and enhanced collaboration among learners. Overall, the study highlights the potential of collaborative caption editing as a valuable tool in video-based learning environments. It suggests that this approach can foster active participation, collaboration, and deeper engagement with video content. The research contributes to the understanding of how technology-mediated collaborative activities can enhance the learning experience and outcomes in the context of video-based education. By exploring the use of collaborative caption editing, the article encourages educators and instructional designers to consider innovative approaches to video-based learning that go beyond passive consumption. It emphasizes the importance of interactive and participatory learning experiences that leverage the affordances of digital tools to promote active engagement and knowledge construction among learners. Another type is the Cognitive-Affective-Social Theory of Learning in Digital Environments (CASTLE) is a theoretical framework that explores the interplay between cognitive, affective, and social factors in the learning process within digital environments [4]. Developed by researchers in the field of educational technology, CASTLE provides a comprehensive understanding of how individuals engage, interact, and learn in digital learning environments. According to CASTLE, learning in digital environments involves not only cognitive processes but also affective and social aspects. The theory posits that learners' cognitive processes, such as attention, memory, and problem-solving, are influenced by their emotional and social experiences within the digital environment. The affective component of CASTLE emphasizes the importance of learners' emotions, motivation, and attitudes toward learning in digital contexts. It acknowledges that learners' emotional states, such as interest, enjoyment, and self-efficacy, play a crucial role in shaping their engagement, persistence, and learning outcomes. The social component of CASTLE highlights the significance of social interactions, collaboration, and social presence in digital learning environments.

It recognizes that learners' social interactions, such as peer collaboration, instructor-student interactions, and online discussions, contribute to their knowledge construction, sense of belonging, and social engagement. The CASTLE framework proposes that successful learning experiences in digital environments occur when cognitive, affective, and social factors are effectively integrated. It suggests that instructional design, pedagogical strategies, and the use of technology should consider these three dimensions to optimize learning outcomes. By adopting the CASTLE framework, educators and instructional designers can create digital learning environments that promote meaningful learning experiences, foster positive emotions, and facilitate social interactions and collaboration. The theory provides a foundation for understanding the complex dynamics of learning in digital contexts and offers insights into designing effective educational interventions and technology-enhanced learning experiences.

In summary, the different types of recommender systems play a vital role in education by utilizing data and algorithms to deliver personalized recommendations and support to learners, educators, and administrators. Their primary objective is to enrich the learning experience, streamline decision-making, and enhance educational outcomes. These systems have several specific roles and purposes within the realm of education. One significant role is personalized learning, where recommender systems can customize educational content and resources to suit the individual needs of learners. By analyzing data such as students' progress, assessment results, and browsing history, these systems can suggest relevant courses, modules, textbooks, videos, or interactive materials that align with each learner's preferences, interests, learning styles, and past performance. Another role is course and curriculum planning, where recommender systems assist educators in designing and organizing courses and curricula. By analyzing learning objectives, available resources, and prerequisites, these systems can propose appropriate sequencing, prerequisites, or additional materials. Taking into account the performance and progress of students who have followed similar paths, these systems can optimize course offerings and recommend improvements to ensure an effective learning journey.

3.2 The Evolution and Advancements in Online Education Recommender Systems

The COVID-19 pandemic had a profound impact on online education and led to accelerated evolution and advancements in online education recommender systems. Therefore, the article presents a forward-looking perspective on leveraging emerging technologies to overcome the challenges associated with the utilization of Open Educational Resources (OER) [5]. It acknowledges the significant potential of OER in providing accessible and affordable educational materials but also highlights the existing barriers and limitations in their effective use. The article envisions a future where emerging technologies can play a crucial role in enhancing the adoption and utilization of OER. It explores the potential of various technologies, including artificial intelligence, machine learning, blockchain, and virtual reality, in addressing the challenges faced by educators, learners, and institutions when working with OER. The authors propose that artificial intelligence and machine learning can be utilized to facilitate the discovery, curation, and adaptation of OER. These technologies can assist in identifying relevant resources, personalizing learning experiences, and providing intelligent recommendations to learners and educators.

Furthermore, the integration of blockchain technology is suggested as a means to ensure the authenticity, traceability, and copyrights of OER content. The article also discusses the potential of virtual reality (VR) in creating immersive learning environments that can enhance engagement and provide hands-on experiences. VR can enable learners to interact with OER content in a more immersive and realistic manner, fostering deeper understanding and knowledge retention. Overall, the article presents a future-oriented vision where emerging technologies can address the challenges associated with using OER. By leveraging AI, machine learning, blockchain, and VR, the authors envision a future where OER becomes more accessible, custom-

izable, and engaging, empowering learners and educators to utilize open educational resources more effectively.

Furthermore, the article presents a comprehensive analysis of existing research on the potential benefits and challenges of integrating artificial intelligence (AI) in education [6]. The article examines how AI technology can revolutionize the field and discusses the opportunities and obstacles encountered by teachers when adopting AI tools. Initially, the article provides an overview of the current state of AI in education and highlights the advantages it offers teachers. It explores AI's ability to automate administrative tasks, personalize learning experiences, provide intelligent tutoring, and enhance overall teaching and learning. The promises of AI in education include improved efficiency, increased student engagement, enhanced learning outcomes, and expanded access to educational resources. The systematic review then addresses the challenges and concerns associated with implementing AI in classrooms. It explores topics such as data privacy and security, ethical considerations, the impact on teacher-student relationships, potential biases in AI algorithms, and the necessity of teacher training and professional development to effectively integrate AI tools into pedagogical practices. Additionally, the article presents key findings and trends from reviewed research studies [3]. It discusses various AI applications, such as intelligent tutoring systems, automated grading, adaptive learning platforms, and educational chatbots, and evaluates their effectiveness. The review also identifies gaps in current research, highlighting areas that require further investigation. Overall, the article provides valuable insights into the potential advantages and obstacles associated with AI implementation in education. It serves as a valuable resource for educators, policymakers, and researchers interested in harnessing the potential of AI to enhance teaching and learning, while also addressing the relevant concerns.

3.3 The Factors Considered in Designing and Implementing Online Education Recommender Systems During and After the Covid-19 Pandemic

In designing and implementing online education recommender systems, several common factors are typically considered. These factors include student profiling, where individual characteristics like learning preferences, prior knowledge, goals, and interests are taken into account to provide personalized recommendations. Content analysis techniques, such as natural language processing and semantic analysis, are employed to assess the relevance, difficulty level, and alignment with learning objectives. Collaborative filtering leverages the behavior and preferences of similar students to recommend activities. Contextual factors like the course or subject area, learning stage, and available resources are considered to provide relevant recommendations. Goal-oriented recommendations prioritize activities that align with students' goals and progress. Engagement and social presence are addressed by recommending interactive and collaborative activities that foster peer interaction and feedback. Regular evaluation and feedback collection help refine the recommender system's accuracy and effectiveness over time [2]. On the other hand, in the following article in designing and implementing online education recommender systems for preschoolers in the

context of digital game-based learning, several factors should be considered [7]. These factors include the developmental appropriateness of games, aligning with the specific learning objectives and outcomes of preschool education, analyzing the educational content of games, focusing on user experience and child-friendly interface design, prioritizing playfulness and engagement, considering parental involvement and monitoring, and incorporating research and evidence-based practices. As well as the article focuses on the design and implementation of online education recommender systems that utilize real-time learning analytics [1]. Key factors considered in this context include leveraging real-time learning analytics data to understand students' progress and preferences, aligning with learning objectives and curriculum, employing adaptive learning algorithms that personalize recommendations based on factors such as proficiency levels and learning styles, analyzing educational content to ensure relevance and alignment with learning objectives, tracking student performance and providing feedback, incorporating social interactions and collaboration into recommended learning paths, and continuously evaluating and validating the recommender system's effectiveness and accuracy. In addition, the article discusses the design and implementation of online education recommender systems based on the Cognitive-Affective-Social Theory of Learning. In this context, several factors are considered [4].

Firstly, cognitive factors such as prior knowledge, cognitive processes, and information processing abilities are taken into account to recommend learning resources that align with students' cognitive abilities. Secondly, affective factors, including emotions, motivation, and attitudes toward learning, are considered to provide recommendations that promote positive affective experiences and engagement. Social factors, such as social interactions, collaboration opportunities, and peer feedback, are incorporated to recommend activities that foster social learning and a sense of community. Personalization plays a crucial role, in tailoring recommendations based on individual learner characteristics such as preferences, interests, and goals. Learning analytics is utilized to collect and analyze data on students' interactions, progress, and performance, enabling the system to provide personalized recommendations and track learners' progress. The system is adaptable, adjusting recommendations based on real-time data and feedback. Additionally, evaluation and feedback mechanisms are incorporated to assess the effectiveness of recommendations, allowing for continuous improvement. Furthermore, in the article the focus is on designing and implementing online education recommender systems that utilize collaborative caption editing to enhance video-based learning [3]. The recommender system considers various factors to optimize the learning experience. First, it analyzes the video content using techniques like video processing and natural language processing to extract relevant information about the topics and learning objectives covered. The system also integrates collaborative caption editing features, allowing learners to actively engage with the video content by collaboratively editing captions, transcribing the video, or adding annotations. This collaborative activity enhances learning engagement and deepens understanding. Additionally, the recommender system takes into account the context of the

learning experience, including the subject area, specific learning goals, and learners' prior knowledge.

By understanding the context, the system recommends videos that are relevant and aligned with learners' specific needs and objectives. User feedback and preferences are also incorporated, with the system considering learners' ratings, comments, and viewing history to personalize and tailor video recommendations. The recommender system promotes social interaction and collaboration by suggesting videos that have been well-received by other learners in similar contexts and facilitating discussions, peer feedback, and group activities related to the video content. It ensures accessibility and inclusivity by considering factors such as closed captioning, subtitles, language options, and adaptive playback features to accommodate diverse learner needs. Lastly, the system incorporates evaluation mechanisms to assess the effectiveness of video recommendations and collaborative caption editing features. By collecting data on learner interactions, performance, and satisfaction, the system continuously improves its accuracy and relevance.

3.4 The Challenges and Limitations Associated with Online Education Recommender Systems in the Context of the Covid-19 Pandemic

In the context of the Covid-19 pandemic, online education recommender systems face several challenges and limitations. Indeed, the absence of in-person interaction and personalized guidance due to remote learning poses a significant challenge for these systems. Moreover, the surge in online education has led to a vast amount of available content, requiring recommender systems to efficiently organize and recommend relevant material. Online learning environments often lack social learning opportunities, making it difficult for recommender systems to foster collaborative and interactive experiences. Reduced user feedback and engagement during remote learning can hinder the collection of sufficient data for effective recommendations. Additionally, the rapidly changing educational landscape demands adaptable recommender systems that can quickly adjust to evolving learner needs. Access and technological barriers, as well as privacy and data security concerns, further impact the implementation and effectiveness of these systems. While an improved adaptive learning path recommendation model, it is crucial to address these broader challenges and limitations in online education recommender systems within the Covid-19 context [1]. Additionally, chatbots face several challenges and limitations. One significant challenge is ensuring data accuracy and availability. These systems rely on accurate and comprehensive data to provide meaningful recommendations. However, obtaining high-quality and up-to-date data can be difficult. Limited, incomplete, or outdated data can negatively impact the effectiveness of the generated recommendations. Another challenge lies in achieving personalization and catering to individual differences. Recommender systems aim to offer personalized recommendations based on individual preferences, goals, and learning styles. However, accurately capturing and understanding these differences is complex. Diverse learning needs, varying levels of prior knowledge, and evolving preferences make it challenging to create recommendation algorithms that meet the

unique requirements of each student. Contextual understanding poses yet another challenge. Recommender systems often struggle to capture the nuanced context of the learning environment. They may fail to fully consider specific course content, learning objectives, or pedagogical strategies employed by instructors. As a result, the recommendations generated may not align with the specific requirements of learning activities or desired learning outcomes. Limited user feedback further hampers the performance of recommender systems. Obtaining sufficient and diverse feedback from students in online education settings can be challenging. This limitation inhibits the system's ability to adapt and refine recommendations based on real-time user experiences, hindering improvement. An overreliance on algorithms is another limitation. Online education recommender systems heavily depend on algorithms to process and analyze data. While algorithms are powerful tools, they have their limitations. They may not fully capture the complexity of human learning, rely on simplistic models, or introduce biases based on available data. These limitations can impact the accuracy and effectiveness of the recommendations provided. Lastly, ethical and privacy concerns arise due to the necessity of accessing personal data for generating personalized recommendations. Such systems raise concerns regarding data privacy, security, and responsible data usage. Students may have valid concerns about their data being used without consent or in ways that compromise their privacy [2]. Moreover, the shift to online teaching during the COVID-19 pandemic presented numerous challenges for university educators. A phenomenological study explored their experiences and challenges during this transition, revealing key themes. Educators faced disruptions and the need to quickly adapt to the online environment, including technological proficiency and redesigning course materials. They struggled with the loss of face-to-face interactions, resulting in disconnection and difficulty establishing meaningful connections with students. Promoting student engagement and motivation posed challenges, requiring innovative approaches and effective use of technology. The increased workload and time demands, such as content preparation and managing online discussions, impacted educators' work-life balance and caused heightened stress.

The study emphasized the importance of professional development, support systems, and institutional assistance. Addressing technological proficiency, fostering engagement, managing workload, and providing support are crucial for equipping educators and improving the quality of remote education during crises [8]. Also, collaborative efforts to understand teaching and its quality are valuable but face various challenges. Limited time and competing priorities require prioritizing collaboration, fostering a culture of collaboration, and utilizing technology tools. Diverse perspectives and communication barriers can be addressed through clear communication channels, active listening, and professional development of collaboration skills. Varying levels of expertise and knowledge necessitate a supportive environment, professional development, and mentorship. Data collection and analysis challenges can be managed by defining research questions, using technology tools, and establishing data analysis plans. Sustaining collaboration over time requires long-term partnerships, documenting outcomes, and continuous as-

essment. By addressing these challenges, collaboration can lead to a deeper understanding of teaching practices and their impact on student learning [9].

3.5 The Impact of Online Education Recommender Systems on Student Engagement and Learning Outcomes in the Context of the Covid-19 Pandemic

Online education recommender systems have had a significant impact on student engagement and learning outcomes, particularly in the context of the Covid-19 pandemic. E.g. A study conducted for 9th graders. Improving social-emotional learning (SEL)(SEL refers to the process through which individuals acquire and apply the knowledge, attitudes, and skills necessary to understand and manage emotions, set and achieve positive goals, feel and show empathy for others, establish and maintain positive relationships, and make responsible decisions) outcomes for have a profound impact on their academic success, well-being, and future prospects. District-wide school reforms focused on SEL create a supportive environment with several positive outcomes. Integrating SEL into the curriculum enhances academic performance by improving focus, self-regulation, and motivation. SEL interventions contribute to higher graduation rates by addressing disengagement, dropout rates, and attendance issues, fostering positive relationships, and teaching perseverance and resilience. SEL programs develop essential social skills, enabling students to navigate interactions, build positive relationships, and contribute to the school community. Implementing SEL reforms reduces behavioral issues, disciplinary problems, and bullying incidents by teaching self-awareness, self-management, and responsible decision-making. SEL interventions promote emotional intelligence and resilience, improving mental health and well-being, and leading to reduced stress, anxiety, and depression. SEL outcomes in 9th grade have lasting effects on future success by equipping students with social and emotional competencies to face challenges, build relationships, and make informed decisions. Comprehensive efforts, including teacher professional development, creating supportive environments, involving families and communities, and monitoring student development, are crucial for achieving these results. Context, implementation strategies, and ongoing support impact specific outcomes, necessitating continuous evaluation and improvement [10].

In addition, conceptualizing and exploring the quality of teaching using generic frameworks offers a promising way forward for assessing and improving teaching practices. These frameworks provide a comprehensive and standardized approach for evaluating teaching effectiveness, promoting professional growth, fostering collaboration, and facilitating comparative analysis. By embracing this approach, educational systems can enhance the quality of teaching and ultimately contribute to improved student learning outcomes [11].

3.6 Adaptability of Online Education Recommender Systems

The article focuses on the adaptability of online education recommender systems [12]. It proposes the use of fuzzy logic and semantic web technologies to develop an intelligent expert system for academic advising in the context of smart city education.

The system aims to provide personalized and adaptive recommendations for academic advising to meet the diverse needs and preferences of students. Fuzzy logic handles the uncertainty and vagueness in educational data, while semantic web technologies enable the system to analyze educational resources and student profiles. The system's adaptability allows it to continuously learn and adjust its recommendations based on real-time data and feedback from students. The article suggests that this intelligent expert system has the potential to enhance academic advising processes in online education and contribute to the advancement of smart city education. Likewise, the article explores the adaptability of online education recommender systems that combine gamification and machine learning. The authors argue that traditional approaches to these systems may lack personalization and engagement, leading to suboptimal learning experiences. They review existing literature to identify trends and themes in the convergence of gamification and machine learning in online education recommender systems.

The article highlights the application of gamification techniques, such as points, badges, leaderboards, and challenges, to increase motivation and engagement in non-game contexts. It also emphasizes the use of machine learning algorithms to analyze user data and provide personalized recommendations that adapt to individual learner needs. The authors discuss the adaptability of these systems in dynamically adjusting and personalizing recommendations based on learner preferences, progress, and performance. By leveraging gamification elements and machine learning algorithms, these systems can offer tailored recommendations, adapt to individual learner needs, and enhance engagement and motivation. The article suggests that the convergence of gamification and machine learning has the potential to improve the effectiveness and efficiency of online education recommender systems. It emphasizes the adaptability and personalization offered by this combination, which can lead to enhanced learner engagement, motivation, and learning outcomes.

In summary, the article explores the adaptability of online education recommender systems that integrate gamification and machine learning. These systems provide adaptive, personalized, and engaging learning experiences by combining gamification elements and machine learning algorithms. The convergence of gamification and machine learning has the potential to enhance online education and improve learner outcomes [13].

3.7 The Ethical Implications and Privacy Concerns Associated with the Use of Online Education Recommender Systems

Online education recommender systems have gained popularity by offering personalized recommendations for online courses and educational materials. However, their use raises ethical concerns and privacy issues. Key considerations include ensuring privacy and data security, obtaining informed consent from learners, employing transparent algorithms that can be explained to users, giving learners control and autonomy over recommendations, avoiding discrimination and bias in system design, avoiding overreliance on recommendations, and continuously evaluating and improving the systems. By addressing these concerns, recommender systems can provide valuable support

to learners while upholding their privacy rights and promoting their autonomy in the educational journey. Striking a balance between personalization, transparency, user control, and fairness is crucial to ensure positive learning experiences [14].

Furthermore, the article highlights the ethical implications and privacy concerns associated with online education recommender systems [15]. The key points include safeguarding student data privacy, ensuring informed consent and transparency, addressing algorithmic fairness and bias, empowering learners with control and agency, emphasizing educational value and learning outcomes, and promoting ethical collaboration and continuous improvement. By implementing these actions, stakeholders can prioritize learning outcomes, protect student data privacy, prevent biases, empower learners, and enhance the educational experiences offered by online education recommender systems.

3.8 Potential future directions and emerging trends in online education recommender systems beyond the Covid-19 pandemic

The article explores potential future directions and emerging trends in online education recommender systems beyond the Covid-19 pandemic [16].

Here are some possibilities discussed in the article:

- **Adaptive and Personalized Recommendations:** Online education recommender systems can further enhance their adaptive and personalized capabilities. By leveraging machine learning and artificial intelligence techniques, recommender systems can analyze learner data more effectively and provide tailored recommendations based on individual learning styles, preferences, and progress. This customization can lead to more engaging and effective learning experiences.
- **Contextualized Recommendations:** Future recommender systems may incorporate contextual information to offer more relevant and meaningful recommendations. This could involve considering factors such as the learner's current knowledge level, learning goals, the subject matter being studied, or the specific learning environment. Contextualized recommendations can help learners make connections, bridge knowledge gaps, and access appropriate resources at the right time.
- **Social and Collaborative Recommendations:** Online education recommender systems can integrate social and collaborative features to foster peer interaction and knowledge sharing. These systems can recommend study groups, discussion forums, or collaborative projects based on shared interests, learning objectives, or complementary skills. Social recommendations can facilitate collaborative learning experiences, promote peer support, and enhance engagement among learners.
- **Learning Pathway Recommendations:** Recommender systems can guide learners along personalized learning pathways, suggesting a sequence of courses, modules, or activities that align with their goals and competencies. These recommendations can help learners navigate through a vast array of educational resources and create coherent learning journeys. Learning pathway recommendations can optimize progression, ensure prerequisite knowledge, and promote mastery of concepts.
- **Multimodal Recommendations:** With the increasing availability of diverse learning resources, recommender systems can

consider multiple modalities, including text, video, audio, simulations, and interactive materials. By recommending a mix of resources that cater to different learning preferences and modalities, learners can engage with content in ways that suit their individual learning styles and preferences. • Ethical Considerations: As recommender systems evolve, it is essential to address ethical concerns related to privacy, data security, fairness, and transparency. Future research and practice should focus on developing ethical frameworks, guidelines, and policies to ensure that recommender systems operate in a responsible and accountable manner while respecting learner privacy and promoting equitable access to educational opportunities.

These potential future directions and emerging trends demonstrate the evolving nature of online education recommender systems. By incorporating adaptive and personalized features, contextual information, social collaboration, learning pathways, multimodal resources, and ethical considerations, recommender systems can provide enhanced support to learners and contribute to more effective and engaging online education experiences.

4. Conclusion

In conclusion, the Covid-19 pandemic has significantly impacted the field of online education, leading to an increased reliance on recommender systems to enhance the learning experience for students. This survey explored the advancements made in online education recommender systems during and after the pandemic. The findings indicate that the development of personalized and adaptive recommendation algorithms has played a crucial role in addressing the challenges of remote learning and improving student engagement. These systems have successfully leveraged data analytics, machine learning, and artificial intelligence techniques to provide tailored content, course suggestions, and learning pathways for individual learners. As we move forward, it is evident that online education recommender systems will continue to evolve, incorporating emerging technologies and pedagogical approaches to deliver even more effective and personalized learning experiences. The insights gained from this survey can serve as a valuable resource for educators, researchers, and developers working towards the enhancement of online education in the post-pandemic era.

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ID	Research question	Justification
RQ1	What are the main types of recommender systems used in online education during and after the Covid-19 pandemic?	This question aims to understand the different types of recommender systems that have been utilized in the context of online education, considering the unique challenges and opportunities presented by the Covid-19 pandemic. By identifying the main types, researchers can gain insights into the diversity of approaches used in recommending educational content and resources.
RQ2	How have online education recommender systems evolved and advanced during the Covid-19 pandemic?	This question seeks to explore the evolution and advancements in online education recommender systems specifically in response to the Covid-19 pandemic. Understanding the changes and improvements that have occurred during this time helps researchers assess the impact of the pandemic on the development and implementation of recommender systems in online education.
RQ3	What are the key factors considered in designing and implementing online education recommender systems during and after the Covid-19 pandemic?	This question investigates the factors that play a crucial role in the design and implementation of online education recommender systems during and post-Covid-19. Identifying these factors allows researchers to gain insights into the considerations and strategies employed in building effective recommender systems in the current educational landscape.
RQ4	What are the challenges and limitations associated with online education recommender systems in the context of the Covid-19 pandemic?	This question aims to identify and explore the challenges and limitations that arise in the use of online education recommender systems during the Covid-19 pandemic. Recognizing these challenges helps researchers understand the potential barriers and constraints that may affect the successful implementation and utilization of recommender systems in online education.
RQ5	How do online education recommender systems impact student engagement and learning outcomes during and after the Covid-19 pandemic?	This question focuses on understanding the impact of online education recommender systems on student engagement and learning outcomes in the context of the Covid-19 pandemic. By examining this impact, researchers can assess the effectiveness of these systems in enhancing student engagement and improving learning outcomes in remote learning environments.
RQ6	How do online education recommender systems adapt to the changing needs and preferences of students during and after the Covid-19 pandemic?	This question investigates the adaptability of online education recommender systems in response to the changing needs and preferences of students during and post-Covid-19. Understanding how these systems can dynamically respond to evolving student requirements is essential for ensuring personalized and effective learning experiences.
RQ7	What are the ethical considerations and privacy concerns related to the use of online education recommender systems during and after the Covid-19 pandemic?	This question explores the ethical implications and privacy concerns associated with the use of online education recommender systems during and post-Covid-19. Investigating these considerations is vital for ensuring the responsible and ethical implementation of recommender systems while safeguarding the privacy rights of learners.
RQ8	What are the potential future directions and emerging trends in online education recommender systems in the post-Covid-19 era?	This question focuses on identifying potential future directions and emerging trends in online education recommender systems beyond the Covid-19 pandemic. Exploring these directions allows researchers to anticipate and envision the future landscape of recommender systems in online education, providing insights for further research and development in the field.

Table 1: The research question of the survey

Database	Search Terms	Discipline	Nbr.Studies	Percentage (%)
Springer	- The main types of recommender systems used in online education during and after the Covid-19 pandemic	Education	7	20.58
	- The evolution and advancements in online education recommender systems	Education	3	8.82
	-Factors considered in designing and implementing online education recommender systems during and after the Covid-19 pandemic	Education	5	14.70
	- The challenges and limitations associated with online education recommender systems in the context of the Covid-19 pandemic	Education	6	17.65
	-The adaptability of online education recommender systems	Education	4	11.76
	- The ethical implications and privacy concerns associated with the use of online education recommender systems	Education	2	5.88
	- Potential future directions and emerging trends in online education recommender systems beyond the Covid-19 pandemic	Education	1	2.94
Elsevier	- The impact of online education recommender systems on student engagement and learning outcomes in the context of the Covid-19 pandemic	Education	6	17.65

Table 2: Terms Used in Scientific Databases for Survey

Research question	Criteria	Option
RQ1. What are the main types of recommender systems used in online education during and after the Covid-19 pandemic?	RS types according to specific context and requirements of the educational institutions	Improved adaptive learning path recommendation model driven by real-time learning analytics, chatbots, collaborative caption editing, CASTLE
RQ2. How have online education recommender systems evolved and advanced during the Covid-19 pandemic?	Evolution and advancements in online education recommender systems	- Personalized, - Adaptive, - Collaborative, and supportive, - Leveraging AI and machine learning techniques
RQ3. What are the key factors considered in designing and implementing online education recommender systems during and after the Covid-19 pandemic?	Factors	- Student profiling, - Content analysis techniques, - Contextual factors, - Goal-oriented recommendations, - Engagement, and social presence, etc
RQ4. What are the challenges and limitations associated with online education recommender systems in the context of the Covid-19 pandemic?	Challenges and limitations	Limited In-Person Interaction, increased Demand for Online Education, lack of Social Learning Opportunities, limited Feedback and user engagement
RQ5. How do online education recommender systems impact student engagement and learning outcomes during and after the Covid-19 pandemic?	Impact	- Enhances academic performance - Enhance the quality of teaching - Improved student learning outcomes

RQ6. How do online education recommender systems adapt to the changing needs and preferences of students during and after the Covid-19 pandemic?	Adaptability	<ul style="list-style-type: none"> - Use of fuzzy logic and semantic web technologies - Combine gamification and machine learning
RQ7. What are the ethical considerations and privacy concerns related to the use of online education recommender systems during and after the Covid-19 pandemic?	Ethical considerations	<ul style="list-style-type: none"> - Privacy and data security - Control and autonomy - Transparency - Educational value and learning outcomes
RQ8. What are the potential future directions and emerging trends in online education recommender systems in the post-Covid-19 era?	Future directions	<ul style="list-style-type: none"> - Adaptive and Personalized Recommendations - Contextualized Recommendations - Social and Collaborative Recommendations - Learning Pathway Recommendations, etc

Table 3: Data Extraction Criteria

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