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Self-Study with Online Platforms: A Comparative Analysis

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Abstract

This study aims to conduct a comparative analysis of eight prominent online self-study platforms, namely Studyverse, Study Together, Bilibili, Twitch, Costudy, Lemon Study Room, Forest, and Flipd. Through the examination of the functions, characteristics, advantages, and disadvantages of online self-study platforms within their respective categories, this study seeks to address a research gap in comprehensive comparative studies of online self-study platforms. Each platform is analyzed in terms of its functionalities, social elements, gamification features, and personalization options. A comprehensive understanding of the landscape of online self-study platforms is provided by the findings of this study and empowers individuals to make informed choices based on their specific learning requirements and preferences. It can provide suggestions on enhancing self-study experiences in the digital age as well as implications about how to facilitate optimal platform selection for learners in the digital age.

Keywords: Self-Study; Online Platform; Online Study; Could Online Study; Learning Environment; Comparative Analysis

Introduction

As individuals increasingly turn to digital resources for personal development and learning, self-study platforms have gained significant popularity in recent years. These platforms offer a variety of features and functionalities to support self-directed learning, ranging from study tools and collaboration features to gamification elements and virtual study environments [1]. With the rise of self-study platforms, learners have access to a wide range of educational content and can create personalized learning paths tailored to their needs, preferences, and interests. This has revolutionized the way we learn, as learners are no longer limited to traditional learning methods. This has given learners more control over their own learning process, as they can choose what content to focus on, how to consume it, and how long to spend on it. This also allows learners to go at their own pace, as they can pause and revisit topics as needed. However, there is a lack of comprehensive comparative studies that compare the functions, characteristics, advantages, and disadvantages of different self-study platforms within their respective categories. This lack of information makes it difficult for learners to make informed decisions when selecting platforms for self-study [2].

The experience of taking online courses during the COVID-19 pandemic outbreak has made many students of different levels of education comfortable with online learning, which prompts them to consider self-studying online [3], which prompts them to consider self-studying online. This could potentially lead to more students enrolling in online courses in the future, as the convenience and flexibility of online learning is appealing to a wide range of students. This could also have a positive impact on educational institutions, as they could open up more courses and classes for students who would not have had the opportunity to attend in-person classes. For online self-study, students can access a wide range of material from multiple sources, allowing them to tailor their learning to their own interests and goals. Additionally, online learning can also be more cost-effective than traditional in-person classes, providing students with an affordable option to pursue their education. With this in mind, online self-study can be a great way to enhance one's knowledge and skills, while still fitting into a busy schedule. It can also provide flexibility and access to materials that may not be available in a traditional classroom setting. In spite of the fact that online learning may not be ideal for group activities, students are attracted to its convenience and flexibility, particularly after having experienced online learning during COVID-19 [3,4].

Furthermore, the limited information available can lead learners to make uninformed or incorrect choices, which could ultimately hinder their progress and learning experience. Therefore, it is important for learners to be aware of the different platforms available and the features they offer in order to make an informed decision. Doing research and asking for recommendations from peers or experienced learners can help learners to choose the best platform for their learning needs. For example, if a learner wants to learn a new language, they should consider platforms that offer audio and video components to help with pronunciation and conversation practice. However, some people argue that there is no one "most effective" platform for learning. Different platforms work better for different people, depending on their individual learning styles. For example, some people learn best by listening to audio recordings, while others learn best by reading texts. Some people learn best by doing interactive exercises, while others learn best by watching videos, and due to the engagement of learners with videos, they may be able to achieve better learning outcomes [5]. There is no single platform that is best for everyone. There is therefore a need to compare the current online self-study platforms available.

Related works

With the rapid development of the Internet and factors such as declining demand for physical study spaces, economic pressures, and the desire for a competitive edge, cloud self-study has emerged as a novel mode of online learning [6-8]. With this mode, learners have access to a virtual study space and are able to expand their academic networks through different scenarios including online self-study with check-ins, live streaming led by content creators, online teaching and study Q&A, and cloud-based self-study that allows students to support each other. In addition, online learning can provide access to a wider range of courses, as well as personalized learning experiences tailored to the individual's needs and preferences. This type of learning also eliminates geographical boundaries, allowing students from all over the world to access resources and interact with each other. Research also focuses on host-user interaction in live-streamed self-study sessions, self-image construction by hosts, and the operation logic and motivations of online self-study applications, utilizing theories such as media contextualism, ritual communication, media practice perspectives, and persuasive theories [9]. Consequently, online learning has become a powerful tool for students to broaden their knowledge and experience, as well as establish cross-cultural connections. Moreover, asynchronous online affinity spaces, as demonstrated by SWM videos, have proven effective in fulfilling learners' social connection and positive environmental needs during isolated studying, thus emphasizing the importance of social engagement in various learning contexts. SWM videos demonstrate the importance of social companionship to learning experiences, which should be explored further to enhance educational outcomes. Perception and management of time in time management applications involve media-mediated strategies that restructure time and establish personalized references [10]. The use of timing and screen-locking functions as well as social features facilitates the creation of a sense of order and connection within flexible time structures [11]. Online learning provides a wide range of benefits, such as access to a wider range of courses, personalized learning experiences tailored to individual needs, and the ability to interact with people from all over the world. Research has focused on host-user interaction in live-streamed self-study sessions, self-image construction by hosts, and the operation logic and motivations of online self-study applications. Online learning also provides social companionship, which has proven to be an effective way to fulfill learners' social connections and positive environmental needs. Time management applications use media-mediated strategies to restructure time and establish personalized references.

It should also be noted that online self-study platforms provide social functions as well. This engagement in social interaction can also help to build confidence and create a sense of belonging by allowing students to work together and support each other [12-14]. This can lead to more relaxed learning and increased motivation [15]. It also gives students the opportunity to connect and build relationships with people from different backgrounds and perspectives. Additionally, online self-study platforms provide a social environment that encourages collaboration and fosters a sense of community, thereby creating a more engaging learning environment and increasing student motivation and confidence [16]. This creates a more dynamic learning experience that is tailored to each student's individual needs and interests [17]. The increased social interaction helps to build an atmosphere of mutual respect among students, which can help to reduce stress and promote a more positive learning experience. By allowing students to pursue their own interests and learn at their own pace, each student is able to get more out of the lessons and develop a more thorough understanding of the material. Additionally, the increased social interaction helps to build a sense of community, which can lead to a greater feeling of safety and comfort in the classroom.

Research Purpose

In spite of the growing popularity and importance of online self-study platforms, there are few comprehensive studies that analyze the functions, characteristics, advantages, and disadvantages of different platforms within their respective categories. A significant portion of existing research focuses on specific aspects of online self-study platforms, such as host-user interactions, self-image construction, or user motivations. This leaves a gap in understanding the broader landscape of online self-study platforms and their suitability for various learning needs.

Through a comparative analysis of eight online self-study platforms, this research seeks to bridge the research gap. This study aims to provide a comprehensive understanding of the diverse approaches that different platforms take to facilitate

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online self-study by examining their functions, characteristics, advantages, and disadvantages within their respective categories. It is the aim of the research to provide individuals with information that will enable them to make informed choices regarding the learning platform that would best suit their learning needs and preferences. For instance, if an individual is looking to take part in online self-study but is likely to be distracted easily, they may prefer a platform that offers structure and guidance, rather than one that is more open and flexible. By doing so, they can ensure that their online learning experience is as efficient and effective as possible. A key objective of this study is to compare the functions of eight online self-study platforms and examine their distinct characteristics, advantages, and disadvantages, as well as overarching trends and patterns.

Methodology

Data collection involved a thorough review of platform information, including official documentation, user manuals, and platform descriptions, along with an in-depth literature review. An analysis of the collected data was conducted using qualitative analysis techniques to identify recurring themes and patterns using a structured database. Detailed documentation and note-taking were used to ensure accuracy in the representation of the functions, characteristics, advantages, and disadvantages of the platforms in this comparative study.

It was determined that eight platforms would be selected for this study based on their widespread recognition and popularity within their respective categories. Our selection of platforms was based on their comprehensive representation of connected video learning platforms, live accompanying learning platforms, virtual study rooms, and time management tools. In this study, platforms from each category are included to facilitate meaningful comparisons and develop a comprehensive understanding of online self-study platforms. Consideration was also made as to the availability of relevant information and research in order to ensure that sufficient data was available for analysis. This was done to ensure that the results of the study were as accurate and representative as possible. Additionally, the inclusion of platforms from each category ensures that the results can be compared across different platforms, enabling a more thorough and comprehensive analysis.

Comparative Analysis of Platforms

Live video connection platform

Studyverse

It is a virtual platform designed to enhance students' studying experiences, allowing them to create virtual study rooms and study with their friends, classmates, and study buddies. The Studyverse program utilizes scientific methods, such as social accountability and mimicry, to enhance the focus of students. It provides individualized study environments that are ideal for students who wish to avoid distractions and procrastination. With Studyverse, students can engage in social accountability to succeed in their studies. Each study room has a distinct theme, group timers, and music to set the mood. Students can invite friends to join their study rooms or existing public rooms. Using Studyverse's statistics feature, students can track how much time they devote to studying and how many study rooms they have accessed. This encourages students to stay focused and accountable for their studies, while also providing a fun and engaging way to learn.

Studyverse is an innovative platform for students to study and collaborate with each other. With its focus on social accountability, customized study environments, and convenient tracking features, Studyverse is an excellent tool to assist students to stay focused and motivated while studying. Studyverse is a virtual platform that helps students succeed in their studies. It provides individualized study environments with distinct themes, group timers, and music. Social accountability and modeling are used to help students stay focused and accountable. Statistics allow students to track how much time they spend studying and how many study rooms they have joined.

Study Together

The Study Together platform facilitates global connections among students by facilitating global connections. Study Together offers a unique opportunity for students to connect with and engage with peers worldwide through its large community of over one million members and 19 million study sessions. There are several features offered by this platform, including access to study statistics, live study rooms that can be accessed at any time, and personalized study environments. As a result of its science-backed study tactics, Study Together strives to enhance productivity and combat procrastination. Furthermore, it offers resources such as group study rooms, tutor assistance, mindfulness exercises, community events, and gamification of study sessions. Study Together offers free, user-friendly solutions that streamline study routines for students of all academic levels, regardless of location or home setup, whether studying individually or in groups. In conclusion, Study Together is a powerful platform that allows students to stay connected to peers around the world while giving them access to features that help to maximize their study efficiency. It is an invaluable tool for students who are looking to get the most out of their study sessions.

Accompany Learning Live Platform

Bilibili

Unlike other platforms that prioritize the appearance and talents of hosts, Bilibili's live streaming learning platform emphasizes the study process itself. It is an online platform that offers a unique approach to learning through live streaming. In this category, hosts do not display their faces, but rather position

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the camera on their study desks, allowing viewers to observe the host's comprehensive learning process. In addition to providing a variety of study room configurations and interactive mechanisms, the platform also provides hosts with the opportunity to choose relevant themes, insert motivating subtitles, and provide a variety of background music genres to customize their study rooms. There are three main types of study room interfaces: hosts appearing on camera, collaborative cloud studying, and scene-based ambiance. Hosts generally refrain from direct interaction with viewers during designated study periods, but they may address viewer questions during break periods or allocate specific time slots for fan interaction during the designated study period.

Bilibili's live streaming learning platform provides an innovative way to learn, offering hosts the opportunity to customize their study rooms and interact with viewers in a unique and engaging way. Through this platform, hosts are able to create a conducive environment for viewers to learn, contributing to the overall success of the platform.

Twitch

Twitch is an American video live streaming service that focuses on video game live streaming, including broadcasts of esports competitions, as well as music broadcasts, creative content, and "in real life" streams. There is an anchor group who is live teaching through the study with me feature of this live streaming platform. This feature allows viewers to learn and interact in real time with the anchor. It also provides an opportunity for the anchor to understand the viewers' needs and interests better. This creates an environment of mutual growth and learning.

Virtual Study Room APP

Costudy

Using Co Study, users can recreate the feeling of studying together as well as return to their school days by participating in online study rooms. Despite the virtual nature of the platform, Co Study aims to establish a connection among users, providing them with the opportunity to perceive each other as study partners, classmates, or individuals sharing the same learning environment. Different teaching buildings represent different stages of education on the platform, creating a campus-like setting. In addition to facilitating collaboration with like-minded peers and streamlining group formation, users can choose a dedicated teaching building based on their goals and location. Co Study effectively resolves the problem of coordinating study sessions by allowing friends to join their friends as study partners in an online study room. Students can assist one another in mutual encouragement, enhancing the learning experience and reducing the monotony associated with studying. A deep focus mode and strict rules are incorporated into the platform to ensure concentration and minimize distractions. To maximize study time and avoid wasting study opportunities, users are encouraged to remain focused and promptly return to the virtual classroom after breaks. The completion of focused study sessions is rewarded with study wages, which provides positive reinforcement and motivation to continue to study.

With its virtual campus-like setting, Co Study provides a unique platform for students to collaborate, support each other, and stay focused on their studies. It is an innovative way for students to interact with each other while studying, making it an ideal alternative to traditional face-to-face study sessions.

Lemon Study room

This online study room tool helps users develop consistent study habits and improve their concentration through the use of reminders and check-ins. It provides features to support users in their study endeavors, such as reminders and check-ins. As a result, users are able to virtually coexist with each other and accumulate study hours in a similar environment to a physical study room. It is noteworthy that Lemon Study Room differs from traditional offline study rooms and video-based online study platforms through the use of nondescript character illustrations that illustrate learners without any personalization or gender distinctions. A unique environment for online studying is created by this anonymity and universality. Users may access the platform at any time throughout the day and be part of a community of thousands [6]. The platform's anonymity allows users to focus on learning without worrying about judgment. This environment provides users with an opportunity to learn with a greater sense of freedom and flexibility, without fear of being judged or held back by social conventions.

Time Management APP

Forest

The Forest platform offers a unique approach to combat internet addiction and enhance focus. The app allows users to assign dedicated work time, witness the gradual growth of a tree, and then leave the app if they succumb to distractions and leave it. As a result of this gamified system, users are motivated to achieve and take responsibility, resulting in improved time management and reduced procrastination. There are a number of additional features available on the platform, such as customizable task labels, sharing progress with friends, unlocking rewards, and planting real trees. In addition to a variety of focus modes, such as timers and stopwatches, users can also customize their experience by setting up planting reminders and custom motivational phrases. This helps create a personal experience and encourages users to stay focused and motivated. Furthermore, users can share their progress with others, giving them a sense of accountability and further motivation.

Flipd

In addition to enhancing productivity and reducing phone-related distractions, Flipd functions as a time-tracking and social

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productivity tool, providing users with the ability to remain focused and motivated throughout the day. By utilizing a stopwatch timer, users can determine the duration of their studies or work sessions, ensuring they are tracking their progress accurately. To promote undivided attention, Flipd sends warning notifications if users leave the app or switch to another application during active sessions. By enabling multitask mode, Flipd allows users to utilize other apps while maintaining focus, while exiting Flipd without enabling multitask mode terminates the timer while preserving session progress. After completing a session, users are provided with a detailed summary of their progress that can be easily viewed on the calendar upon completion. Users can also initiate breaks or pause the timer as necessary. To further motivate and support users on their productivity journey, Flipd incorporates a community leaderboard, LoFi background music, and milestone achievements (Table 1).

Table 1: A summary of comparison the eight platforms.

		1	2	3	4	5	6	7	8
		Studyverse	**Study Together**	**Bilibili**	**Twitch**	**Costudy**	**Lemon Study Room**	**Forest**	**Flipd**
Platform Form	Website	√	√	√	√				
	APP	√		√	√	√	√	√	√
Image Form	Live video	√	√						
	Virtual personas					√	√		
	Avatar & Nickname	√	√	√	√	√		√	√
Study Stats	Timer	√	√			√	√	√	√
	Progress tracking	√	√			√	√	√	√
Sociability	Personal information	√	√	√	√	√			
	Chat board	√	√	√	√	√			
Gamification Elements	Focus rewards	√	√			√	√	√	
	Ranking	√	√			√	√	√	√
Other	Offline access							√	√

Discussion

Using comparative analysis, we were able to identify the distinct characteristics and advantages of each online self-study platform. In addition to providing a supportive study environment and encouraging collaboration, connected video learning platforms such as Studyverse and Study Together may also challenge learners' concentration due to their high sociability. Bilibili and Twitch provide community-oriented and interactive study experiences through their live accompanying learning platforms, but the emphasis on live streaming and non-academic content may detract from focused study sessions. Costudy and Lemon Study Room are examples of virtual study room applications that aim to recreate a sense of community and belonging, but lack face-to-face interaction. Gamification elements are incorporated into time management apps such as Forest and Flipd in order to enhance focus, productivity, and time management.

When selecting an online self-study platform, learners should carefully consider the trade-offs associated with platform characteristics [18]. While some platforms offer a high degree of sociability and interactivity, they may hinder concentration, which requires balancing social engagement with focused study time. Due to the absence of face-to-face interactions in virtual study room apps, online study groups may not be as effective as physical study groups [19]. The presence of gamification elements across platforms suggests that they have the potential to motivate learners, but caution must be exercised to avoid distractions. As platforms emphasizing collaboration and social connectivity emphasize the importance of peer interaction and support, it is evident that peer interaction and support are critical to the self-study process. Individual preferences are accommodated by platforms that offer personalization features, while time management platforms facilitate effective study planning.

The characteristics, advantages, and limitations of online self-study platforms should be critically evaluated by learners to determine which platform is most suitable for them. Research in the future could examine the specific effects of platform features on learning outcomes, investigate user satisfaction and experiences,

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and examine the long-term effects of self-study platforms on learning outcomes. By gaining these insights, a decision-making process can be informed and the self-study experience can be optimized.

Conclusion

The current study provides a comprehensive analysis of various online self-study platforms, including connected video learning platforms, live accompanying learning platforms, virtual study room apps, and time management applications. An analysis of eight selected platforms revealed their distinctive features, advantages, and limitations through comparative analysis. In selecting an appropriate online self-study platform, it is imperative to consider the individual's preferences, learning goals, and tradeoffs associated with platform features. According to the findings, a balance between sociability and concentration must be struck, gamification elements must be implemented effectively, peer interaction and support must be fostered, and the study environment must be customized accordingly. These insights contribute to a better understanding of the landscape of online self-study platforms and can assist learners in making informed decisions to maximize their self-study experiences. Research topics may include investigating the effect of platform features on learning outcomes, investigating user experiences and satisfaction, and examining how different platforms affect self-study effectiveness over the long term. For instance, a study could analyze how social features such as discussion forums, rating systems, or chatbots can influence a learner's experience and outcomes using an online self-study platform. Future research could also explore how AI-powered learning systems can help learners achieve a better understanding of the subject. Furthermore, it could examine how different platforms foster a sense of community among learners and how this affects their motivation and engagement. Traditional AI technologies are commonly adopted while more advanced technology is still rarely employed [20]. However, there are also potential downsides to using AI in learning. For example, if a platform relies too heavily on automated features, it could make learners feel isolated and disconnected from others. Additionally, if a platform is not designed properly, AI-powered features could actually hinder a learner's ability to understand the material.

References

1. Garrido AEP, Arias EB (2023) The phenomenon of online study rooms in the days of COVID-19. In 2023 IEEE World Engineering Education Conference (EDUNINE), IEEE, pp. 1-6.
2. Bergdahl N, Nouri J (2021) Covid-19 and crisis-prompted distance education in Sweden. Technology, Knowledge and Learning 26(3): 443-459.
3. Xu W, Zhang H, Sukjairungwattana P, Wang T (2022) The roles of motivation, anxiety and learning strategies in online Chinese learning among Thai learners of Chinese as a foreign language. Frontiers in Psychology 13.
4. Yu Z, Xu W, Sukjairungwattana P (2022) A meta-analysis of eight factors influencing MOOC-based learning outcomes across the world. Interactive Learning Environments, 1-20.
5. Ibtasar R, Heineke CM, Michaelis JE (2022) "With You I'll be Able to Actually Learn Everything": Exploring Learner Experiences With a 'Study With Me' Video. In Proceedings of the 16th International Conference of the Learning Sciences-ICLS 2022, pp. 203-210.
6. Jiao J (2022) Online study room: 3 major dynamics and 4 scenarios. Information Technology Education in China (11): 15.
7. Virtanen S (2008) Increasing the self-study effort of higher education engineering students with an online learning platform. International Journal of Knowledge and Learning 4(6): 527-538.
8. Baneres D, Clariso R, Jorba J, Serra M (2014) Experiences in digital circuit design courses: A self-study platform for learning support. IEEE Transactions on Learning Technologies 7(4): 360-374.
9. Dong H (2023) Accelerating empathy and resistance in society: Visible and invisible in the Lemon Study Room APP. Radio & TV Journal 1: 120-123.
10. Huang D, Liu C, Yang R (2022) Elastic disconnection, focus management and self-boundary work in the digital age. Journalism and Writing 6: 14-26.
11. Cao P, Fang H (2022) "Stay Focused": The Quantified Self and Mediated Time Management Practices. Chinese Journal of Journalism & Communication 3: 71-93.
12. Yu Z, Sukjairungwattana P, Xu W (2023) Bibliometric analyses of social media for educational purposes over four decades. Frontiers in Psychology, 13.
13. Azadnajafabad S, Sahar Saeedi Moghaddam, Negar Rezaei, Erfan Ghasemi, Shohreh Naderimagham, et al. (2022) A report on statistics of an online self-screening platform for COVID-19 and its effectiveness in Iran. International Journal of Health Policy and Management 11(7): 1069-1077.
14. Ansari J AN, Khan NA (2020) Exploring the role of social media in collaborative learning the new domain of learning. Smart Learning Environments 7(1): 1-16.
15. Akgunduz D, Akinoglu O (2016) The Effect of Blended Learning and Social Media-Supported Learning on the Students' Attitude and Self-Directed Learning Skills in Science Education. Turkish Online Journal of Educational Technology-TOJET 15(2): 106-115.
16. Mishra S (2020) Social networks, social capital, social support and academic success in higher education: A systematic review with a special focus on 'underrepresented' students. Educational Research Review 29: 100307.
17. Dutta A (2020) Impact of digital social media on Indian higher education: alternative approaches of online learning during COVID-19 pandemic crisis. International journal of scientific and research publications 10(5): 604-611.
18. Sari F M, Oktaviani L (2021) Undergraduate Students' Views on the Use of Online Learning Platform during COVID-19 Pandemic. Teknosastik 19(1): 41-47.
19. Aziza M (2021) Online learning during Covid-19: What is the most effective platform for teaching and learning mathematics? Edumatika: Jurnal Riset Pendidikan Matematika 4(1): 9-21.
20. Ouyang F, Zheng L, Jiao P (2022) Artificial intelligence in online higher education: A systematic review of empirical research from 2011 to 2020. Education and Information Technologies 27(6): 7893-7925.

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