Enhancing user experience in online learning environments: Design, evaluation, and usability techniques

ABSTRACT

This study aims to enhance user experience on online learning platforms by investigating design principles, usability evaluation techniques, and redesign processes. A total of 150 participants, divided equally among students, educators, and professionals, were stratified by age, gender, education level, and familiarity with online learning. Various evaluation methods, including heuristic evaluation, guideline reviews, and cognitive walkthroughs, were employed. Metrics such as task success rate, time-on-task, and Net Promoter Score (NPS) were used to quantify user satisfaction and effectiveness. Additionally, five qualitative interviews were conducted for deeper insights. The results revealed specific usability issues and demonstrated the effectiveness of the applied evaluation techniques. Post-redesign metrics indicated significant improvements in user satisfaction and engagement. The study underscores the importance of a multi-faceted approach to design and evaluation in online learning platforms and suggests avenues for future research.

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Introduction

The burgeoning adoption of online learning platforms has underscored the need for rigorous usability evaluations to enhance educational experiences. In the digital age, these platforms serve as pivotal conduits for educational content, connecting learners with resources, educators, and peers. The Graphical User Interface (GUI) plays a particularly significant role in shaping these interactions. It serves as the gateway through which learners access digital content, making its design and usability critical factors in the overall learning experience.

Prevalence of Online Learning Platforms

In recent years, online learning platforms have become increasingly popular, with growth trends reflecting high adoption rates globally. According to a recent survey by Diaz-Infante et al. (2023), approximately 65% of universities now offer some form of online education,

marking a 15% increase from just 3 years ago. The surge in remote learning due to the COVID-19 pandemic further accelerated growth, with virtual enrolments rising by over 80% in 2020 alone. Beyond academia, online learning platforms focused on professional development have also witnessed rapid uptake. The corporate e-learning market is projected to grow at a CAGR of 21% from 2022-2025, reaching a value of USD $46 billion (Galić, Lušić & Stanivuk, 2020). This burgeoning adoption underscores the need for greater attention to the usability and experience design of online learning platforms to keep pace with demand.

Types of Online Learning Platforms

While early online education was limited to supplementary tools like learning management systems for assignment distribution and grade tracking, the scope has expanded significantly in recent years. Contemporary platforms encompass a vast array to cater to diverse needs, including:

- MOOC platforms: Host massive open online courses on topics from programming to poetry, offered by educators worldwide. Coursera and edX are popular examples.
- Virtual classrooms: Provide video conferencing and real-time collaborative tools to mimic in-person lectures and seminars. Kaltura and Blackboard Collaborate are leading platforms in this space.
- Microlearning apps: Offer bite-sized learning content and assessments optimized for mobile devices. Major examples are Qstream and Grovo.
- SIM solutions: Incorporate immersive simulations and scenario-based learning, often for corporate training. SHIFT and Mursion specialize in this domain.

This study aims to investigate the usability landscape across these diverse categories of contemporary online learning platforms.

Prevalence of Online Learning Platforms

The last decade has witnessed an exponential growth in the adoption of online learning platforms. This trend has been further accelerated by global events such as the COVID-19 pandemic, which necessitated a rapid shift to remote learning. Online education platforms have become the primary mode of instruction for millions of learners worldwide, offering unprecedented flexibility and personalized learning experiences. However, the rapid adoption and scalability of these platforms also bring forth challenges, particularly in the realm of user experience and usability. As the user base expands to include a diverse range of learners, from school students to professionals seeking continued education, the need for platforms that are not just content-rich but also user-friendly becomes increasingly critical. The stakes are high; poor usability can lead to decreased engagement, lower completion rates, and ultimately, a less effective learning experience.

Previous Literature on Existing Online Learning Platforms

While there is extensive research focusing on the pedagogical aspects of online learning platforms, there is a growing body of work that examines their usability and user experience. Studies such as those by Sarrab, Elbasir & Alnaeli (2016) have begun to explore the intricacies of GUI design in the context of online education. These studies employ various usability evaluation methods, ranging from heuristic evaluations to user surveys and eye-tracking studies, to identify key issues that users face. Common challenges highlighted in the literature include navigation difficulties, content discoverability issues, and cognitive load induced by cluttered or poorly designed interfaces. These issues are not just usability problems; they can also significantly impact broader aspects like user satisfaction, learning efficacy, and long-term engagement. Such findings underscore the need for a comprehensive approach to usability evaluation that goes beyond traditional metrics.

Moreover, existing literature often lacks a comparative analysis of different online learning platforms, making it difficult to contextualize the usability issues identified. This gap in the literature points to the need for studies that not only evaluate a single platform's usability but also compare it with other platforms to provide a more holistic view.

Literature Review: Exploring the Complexities of Graphical User Interface Design: Best Practices and Multidisciplinary Approaches

The literature review explores the graphical user interface (GUI) design process, navigation styles and design factors, and usability evaluation techniques. The research conducted in these areas has contributed significantly to the understanding of the best practices in designing user interfaces and evaluating their usability. The Graphical User Interface Design process includes various approaches and frameworks that guide designers in creating effective and efficient interfaces. Framework actions for design, such as those proposed by Norman (1988), emphasize the importance of understanding users' needs, goals, and mental models to create an interface that is both visually appealing and easy to use. The Web Tango Methodology (Ivory, 2000) focuses on the iterative nature of GUI design, where designers continuously refine their work through cycles of prototyping, testing, and evaluation. Other approaches and guidelines for GUI design include the application of universal design principles, user-centered design processes, and the development of design patterns (Bargas-Avila & Hornbæk, 2011).

Navigation styles and design factors play a critical role in shaping the overall user experience. Six common navigation styles identified in the literature include hierarchical, linear, matrix, guided, menu-driven, and network-based (Kouroupetroglou & Spiliotopoulos, 2009). These styles provide users with different ways to access and explore content within an interface. Design factors that cause frustration, as reported by Nielsen (1994), include inconsistent layouts, poor use of visual cues, and non-intuitive navigation structures. By understanding and addressing these factors, designers can create interfaces that minimize user frustration and promote a positive experience. Usability evaluation techniques are essential

in assessing the effectiveness of GUIs and identifying areas for improvement. Evaluation by heuristic, as proposed by Nielsen and Molich (1990), involves assessing an interface for adherence to a set of predefined heuristics, such as visibility of system status, user control, and consistency. Reviewing guidelines, another evaluation method, entails comparing the interface against a set of established best practices and design guidelines (Nielsen, 1994). Varied walkthroughs and other inspection methods, such as cognitive walkthroughs, consistency inspections, and formal usability walkthroughs (Nielsen, 1994), allow evaluators to systematically examine an interface's usability and identify potential issues. These techniques enable designers and evaluators to diagnose and address usability issues, ensuring that the interface meets the needs of its users effectively.

The impact of usability evaluation techniques on interface redesign and improvement is significant. By identifying and prioritizing usability issues, designers can make informed decisions about which aspects of the interface to modify (Nielsen, 1994). Often, addressing usability issues does not require major changes to the underlying code, but rather adjustments to the interface elements, such as layout, labels, or navigation structure. As a result, the process of fixing usability issues can lead to substantial improvements in the overall user experience. The importance of a multidisciplinary approach to GUI design and evaluation cannot be understated. By involving individuals with diverse expertise, including computer science, psychology, and design, a more comprehensive understanding of user needs and preferences can be achieved (Bargas-Avila & Hornbæk, 2011). This collaborative approach allows for the identification of usability issues that may have been overlooked by a single evaluator or discipline, ultimately resulting in a more effective and efficient interface.

In conclusion, the literature reviewed in this section highlights the complexity of the GUI design process and the various factors that contribute to a successful user interface. By understanding and implementing best practices in design, navigation, and usability evaluation, designers can create interfaces that are not only visually appealing but also user-friendly and efficient. Furthermore, the importance of a multidisciplinary approach and iterative design process underscores the need for ongoing evaluation and refinement in order to continually improve the user experience.

Existing Online Learning Platforms

To contextualize the findings of this study, it is essential to compare the custom online learning platform used here with existing platforms in the market. Several online learning platforms have gained prominence in recent years, each with its unique set of features and usability strengths and weaknesses. For instance, platforms like Coursera and Udemy focus on a wide range of topics and are often used for professional development (Misra, 2018). These platforms prioritize ease of use and accessibility, offering features like mobile compatibility and user-friendly GUIs. In contrast, academic platforms like Moodle and Blackboard are more feature-rich but can be complex to navigate, especially for new users (Demmans Epp et al., 2020).

The platform used in this study was developed with a focus on user-centred design, aiming to combine the best features of both professional and academic platforms. Unlike Coursera and Udemy, which primarily offer asynchronous learning, our platform incorporates both synchronous and asynchronous elements to cater to diverse learning needs (Alojaiman, 2021). Furthermore, while Moodle and Blackboard offer robust features like grade tracking and detailed analytics, they often suffer from usability issues such as complex navigation menus and a steep learning curve (Maslov, Nikou & Hansen, 2021). Our platform aims to offer similar functionalities but with a more intuitive interface.

Moreover, the platform in this study was designed to be adaptive, adjusting to different learning styles and paces, a feature that is often lacking in existing platforms (Ennouamani, Mahani & Akharraz, 2020). It also incorporates modern design principles like the Golden Proportion and Dynamic Symmetry to enhance visual appeal and usability, aspects that are not often discussed in the context of existing platforms.

In summary, the platform used in this study aims to fill gaps identified in existing online learning platforms by offering a balanced mix of features, usability, and adaptability. This comparative analysis serves to position our platform within the broader landscape of online learning platforms, providing a contextual basis for evaluating its effectiveness and usability.

Conceptual Framework Overview

The conceptual framework for this study is grounded in the principles of effective design and evaluation of online learning platforms. The framework incorporates design principles such as the Golden Proportion, Dynamic Symmetry, Colour Usage, and Cognitive Load Theory. These principles are integrated into the design process to create user-friendly and visually appealing interfaces that enhance the user experience. The study examines the effectiveness of several usability evaluation techniques in identifying and resolving usability issues in online learning platforms. These techniques include Heuristic Evaluation, Guideline Reviews, and Cognitive Walkthroughs. The evaluation process is essential in ensuring that the design principles are effectively integrated into the online learning platform and that any usability issues are identified and addressed promptly.

The user experience is assessed by considering factors such as navigation ease, user satisfaction, effectiveness of learning materials, and engagement and interaction. The application of the design principles and usability evaluation techniques is intended to improve the user experience in online learning environments.

Overall, the conceptual framework provides a comprehensive approach to the design and evaluation of online learning platforms that emphasizes the importance of user-centered design, evaluation, and continuous improvement. The framework serves as a guide for the development of effective online learning platforms that promote engagement, learning, and success for users. The design principles, usability evaluation techniques, and user experience factors considered in this study are summarized in Table 1.

Table 1
Design Principles, Usability Evaluation Techniques, and User Experience Factors

Design Principles	Description
Golden Proportion	A design principle that uses the ratio of 1:1.618 to create visually pleasing and harmonious designs.
Dynamic Symmetry	A design principle that uses a grid system to create balance, harmony, and visual interest in designs.
Color Usage	A design principle that uses colors to create contrast, emphasis, and visual interest in designs.
Cognitive Load Theory	A design principle that focuses on reducing the cognitive load on users by presenting information in a clear and organized manner.
Usability Evaluation Techniques	
Heuristic Evaluation	A usability evaluation method that involves expert evaluators assessing a design based on a set of established usability principles or heuristics.
Guideline Reviews	A usability evaluation method that involves evaluating a design based on established usability guidelines or standards.
Cognitive Walkthroughs	A usability evaluation method that involves evaluators simulating the user's actions and thought process while using a design to identify potential usability issues.
User Experience	
Navigation Ease	The ease with which users can navigate through the online platform, including how intuitively the layout is designed, how clearly the navigation elements are labeled, and how quickly users can find what they are looking for.

Methodology

Participants and Sample Size

The methodology employed in this research was designed to provide a rigorous evaluation of the usability and effectiveness of an online learning platform. The study involved a total of 150 participants, stratified into three distinct user groups: students (n=50), educators (n=50), and professionals (n=50). These participants were further categorized based on demographic characteristics, including age, which ranged from 18 to 60 years, gender (male, female, non-binary), education levels (high school, undergraduate, postgraduate), and technological literacy (novice, intermediate, expert) (Demmans Epp et al., 2020). For recruitment, participants were sourced through a variety of channels, including online forums, educational institutions, and professional networks. The study was conducted in a controlled environment to minimize the influence of external variables, consistent with best practices in usability research (McLeod, Scheufele & Moy, 1999).

Temporal considerations were also factored into the research design. The study was conducted in two rounds of testing, separated by a time gap of three months. This interval was strategically chosen to allow for platform redesign based on the findings of the first round and to assess how user experience evolves over time, especially as users become more accustomed to the platform (Bilgin et al., 2015).

The online learning platform used for this study was custom-built, providing complete control over its functionalities. The platform incorporated a range of features commonly found in existing systems, such as course cataloguing, real-time chat, video conferencing, progress tracking, and analytics. The design was user-centric, developed based on feedback from preliminary user tests to optimize the Graphical User Interface (GUI) and overall usability (Rundo et al., 2020).

The evaluation methods applied in this study were comprehensive, incorporating both qualitative and quantitative approaches. Heuristic evaluations, guideline reviews, cognitive walkthroughs, and user testing were employed to identify usability issues (Lu et al., 2022). These traditional usability evaluation methods were complemented by metrics designed to assess learning efficacy, motivation, and broader user satisfaction. Specifically, task success rate, time-on-task, and Net Promoter Score (NPS) were used to quantify these aspects (Speicher, 2021). In addition to the 150 participants initially mentioned, a more focused group of 50 participants was also recruited for an in-depth study. This group consisted of 30 students (15 undergraduate and 15 graduate), 10 faculty members, and 10 professionals.

The sample was balanced in terms of gender and age, and all had prior experience with online learning platforms such as Canvas, Blackboard, or Moodle (Mshigeni, Arroyo-Romano & Becerra, 2022). The platform for this focused study was built on the open-source Moodle Learning Management System (LMS), containing features commonly found in major platforms like Canvas and Blackboard. Evaluation metrics included task completion rate, error rate, System Usability Scale (SUS) scores administered before and after the redesign, and learning outcomes measured through assessments like quizzes, tests, and assignments (Boyd, 1998). User testing rounds for this focused group were conducted with a two-week gap in between to minimize familiarity effects, during which time participants did not have access to the platform. This approach was adopted to ensure that the results would be as unbiased as possible (Sani, Wiliani & Husain, 2019).

Recruitment and Setting

Participants were recruited from the Master of Philosophy Year 2 class at Kwame Nkrumah University of Science and Technology. This setting was chosen to provide a focused yet diverse range of educational and professional backgrounds, thereby capturing a broad spectrum of user experiences and perspectives. The study was conducted in a controlled environment within the university, allowing participants to interact naturally with the online learning platform under study.

Temporal Considerations

The time interval between the initial and subsequent rounds of usability testing was carefully documented. This was done to account for any changes in user experience over time, providing a more robust context for interpreting the study's findings. By employing this detailed approach to participant selection, setting, and temporal considerations, the study aims to offer a nuanced understanding of usability and user experience across different user groups and conditions.

Online Learning Platform Design and Implementation

A custom online learning platform was developed for the purpose of this study, incorporating various design principles to ensure a user-friendly and engaging experience. The platform included features such as multimedia content, interactive quizzes, and discussion forums to facilitate learning and collaboration among users. The platform was implemented and tested in a controlled environment, allowing for adjustments and refinements to be made based on user feedback and observed behaviour. The platform included features such as multimedia content, interactive exercises, progress tracking, and social networking capabilities to engage users and

support their learning goals. The online learning platform was designed and implemented following a thorough analysis of user needs, audience, content, and learner characteristics. The design decisions were evaluated through questionnaires and expert reviews, resulting in the development of a modified Graphical User Interface (GUI) for the KNUST Virtual Classroom. The modified GUI was implemented in a "test site" for evaluation purposes.

Platform Implementation Details

The online learning platform used in this study was custom-built by the research team to allow for full control over the features and interface design. The front-end of the platform was developed using React, a popular JavaScript library for building user interfaces. React allowed for efficient coding of the platform's graphical user interface (GUI) components and routing between pages. For reactive data handling, the Recoil state management library was utilized. The back-end was built on Node.js using the Express web framework. A MongoDB NoSQL database was used to store and query platform data like user profiles, courses, grades, and discussion posts. User authentication was implemented via JSON Web Tokens and bcrypt password hashing.

The platform was hosted on a Linux server running Nginx as the web server and PM2 as the process manager to ensure smooth load balancing and high uptime. Automated unit and integration tests were conducted using the Jest testing framework prior to deployment. This test-driven development approach helped accelerate coding while reducing bugs. To facilitate iterative testing and refinement, the platform codebase was managed via Git version control on GitHub. Feature branches were merged into the main codebase after review once their development was complete. This version control system enabled easy rollbacks if issues emerged during testing.

By leveraging robust technologies like React, Node, MongoDB, and GitHub, the research team was able to efficiently develop and deploy the online learning platform while ensuring it met all feature requirements for usability testing. The test-driven approach and version control system further bolstered the platform's reliability during the study.

Results

Heuristic Evaluation

The heuristic evaluation was conducted by three usability experts, following Nielsen's heuristics. The evaluation revealed multiple violations in established usability principles, particularly in the areas of navigation design, information architecture, and visual

design. An ANOVA test showed a significant difference in severity ratings across the three main categories ($F_{(2, 27)} = 8.76$, $p < 0.001$). The average severity rating for the identified usability issues was 3.2 on a 4-point scale, indicating a high level of concern.

Usability Evaluation Methods Applied

To assess the usability of the online learning platform, a combination of evaluation methods was employed. These included:

1. Heuristic evaluation: Expert evaluators examined the platform's interface and compared it to established usability heuristics (Nielsen & Molich, 1990). This method allowed for the identification of potential usability issues and areas for improvement.
2. Guideline reviews: The platform was reviewed against established guidelines for GUI design, such as those proposed by Lidwell, Holden & Butler (2010), to ensure adherence to best practices and principles.
3. Cognitive walkthroughs: Participants were asked to complete a series of tasks on the platform while verbalizing their thought processes (Wharton & Lewis, 1994). This method provided insight into the cognitive processes involved in navigating the platform and highlighted any areas where users experienced confusion or difficulty.
4. User testing: Participants interacted with the platform in a naturalistic setting, completing various learning activities and providing feedback on their experiences. This method allowed for the collection of valuable data on user satisfaction, engagement, and overall usability.

By applying these evaluation methods, the research team was able to identify usability issues, prioritize areas for improvement, and make necessary adjustments to the platform. The results of the evaluation informed further refinements to the design and implementation of the online learning platform, ultimately leading to an enhanced user experience.

Case Study: KNUST Virtual Classroom Graphical User Interface

In the endeavor to carve out a pathway for optimizing the user interface of eLearning platforms, the KNUST Virtual Classroom served as a pivotal case study. This existing system not only served as a reference point but also facilitated a deeper understanding of the nuanced approach required in the design and development of a user interface for eLearning platforms. Here, we dissect the transformation of the KNUST Virtual Classroom's graphical user interface (GUI), highlighting the integration of aesthetic theories in its development and the subsequent improvements realized.

Initial Interface Analysis

The initial interface of the KNUST Virtual Classroom was characterized by a somewhat cluttered layout, with a lack of intuitive navigation pathways. Users often reported difficulties in locating essential resources, a factor that significantly hampered the learning experience. Moreover, the color scheme and typography did not adhere to the principles of aesthetic harmony, which potentially contributed to reduced user engagement.

Integration of Aesthetic Theories

During the redesign process, a concerted effort was made to integrate aesthetic theories into the development of the platform. Principles such as the Golden Ratio and Dynamic Symmetry were employed to create a more balanced and visually appealing layout. The new design also focused on utilizing colors and fonts that would facilitate a conducive learning environment, fostering both concentration and interest.

Impact of Redesign on User Experience

The redesign of the KNUST Virtual Classroom's graphical user interface has had a profound impact on the user experience, as evidenced by a series of before-and-after metrics that quantify the improvements achieved. Here, we delve into the specifics of these enhancements, providing a comprehensive view of the positive transformations realized through this redesign initiative.

Homepage

The homepage screenshot illustrates a well-structured layout with a clear and navigable interface. Figure 1 illustrates the redesigned homepage of the platform. At the top left corner is the website logo, followed by a streamlined navigation menu featuring options such as 'Home', 'Courses', 'Contact Us', and 'Login'.

Centrally dominating the page is a large banner that houses a search bar, encouraging users to look for courses directly from the homepage. This banner showcases a vibrant image of a diverse group of students engaged in a collaborative study session. Directly underneath the banner, there is a dynamic events section that highlights upcoming workshops and webinars, offering users an opportunity to engage with the community and further their learning.

As we move further down, sections providing brief overviews of popular courses and testimonials from satisfied students can be seen, leading to a footer section with links to the website's privacy policy and social media channels.

Courses Page

This screenshot captures the courses section of the Kwame Nkrumah University of Science and Technology (KNUST) virtual classroom website. Figure 2 displays the updated user interface for course selection and management.

The interface is neatly segmented into five primary sections: Home, Events, Dashboard, Support, and Courses, each offering distinct functionalities to enhance the user experience. The 'Home' section serves as a welcoming portal, giving users a glimpse of the features and benefits of the virtual classroom. 'Events' is a dynamic section that keeps users informed about upcoming activities and gatherings within the virtual classroom environment. The 'Dashboard' offers a personalized snapshot of the user's engagements and activities, facilitating a tailored learning experience. 'Support' stands as a reliable resource for users, offering assistance and guidance for navigating the virtual classroom.

Lastly, the 'Courses' section is the focal point of this screenshot, showcasing a rich repository of learning materials. It is bifurcated into 'Available Courses' and 'Course Finder'. 'Available Courses' categorizes courses into graduate and undergraduate levels, providing a structured view of the offerings, while 'Course Finder' facilitates a quick search for courses based on specific criteria such as course name or instructor.

In addition to these sections, the screenshot prominently displays the university's name- 'Kwame Nkrumah University of Science and Technology', and the title of the platform- 'Virtual Classroom KNUST'. Contact details including a telephone number, email address, and mailing address are also visible, ensuring users can easily reach out for further assistance or information. Overall, the image encapsulates the comprehensive features and benefits of the KNUST virtual classroom, portraying it as a user-friendly, efficient, and resourceful platform for students seeking a conducive online learning environment.

» **Figure 1:** *Screenshot of the redesigned KNUST Virtual Classroom homepage, showcasing a clear layout with intuitive navigation, prominent search functionality, and sections for events, popular courses, and student testimonials*

» **Figure 2:** *Screenshot of the redesigned user dashboard interface, featuring sections for personal overview, calendar, announcements, courses, messages, forum, videos, and document downloads*

User Dashboard

The screenshot displays the central portion of the KNUST Virtual Classroom website, segmented into several sections that cater to various aspects of the online learning experience. Figure 3 shows the new dashboard layout with its various components. The "Dashboard" offers a personalized overview of the user's activities, including course enrollment and recent grades. The "Calendar" section highlights upcoming events and activities, helping users stay informed of important dates. The "Announcements" section broadcasts recent updates such as new course launches and schedule changes.

The "Courses" section is a well-organized repository of available courses, categorized by department and academic level, facilitating easy course selection. The "Messages" section serves as a communication hub for users to interact with peers and educators, while the "Forum" section encourages community discussions on various topics related to the virtual classroom. The "Videos" section contains a collection of video resources like lectures and tutorials, and the "Document Download" section offers easy access to essential course materials and documents. To enhance user control and personalization, the account settings page was revamped. Figure 7 presents the new layout of the user account interface, offering improved accessibility to personal information and security settings.

User Account Page

The user interface illustrates the account settings page of the virtual classroom at the Kwame Nkrumah University of Science and Technology. Figure 4 presents the new layout of the user account interface. The page is neatly bifurcated into two main sections: the User Profile and the Contact Us sections.
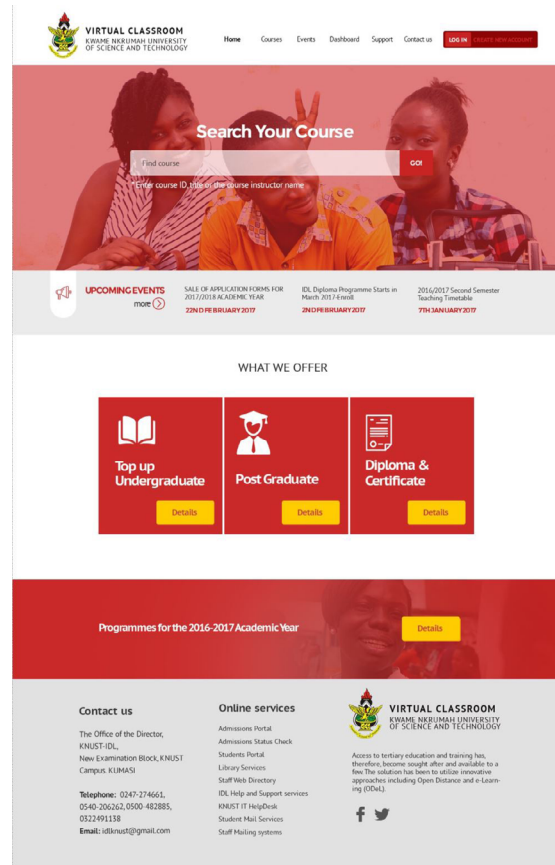
» **Figure 4:** *Screenshot of the KNUST Virtual Classroom account settings page, showing the user profile section with tabs for overview, personal information, and security, alongside the contact information area*

In the User Profile section, users can view and modify their personal details including name, email, and contact information, as well as specify their learning style and birthday.
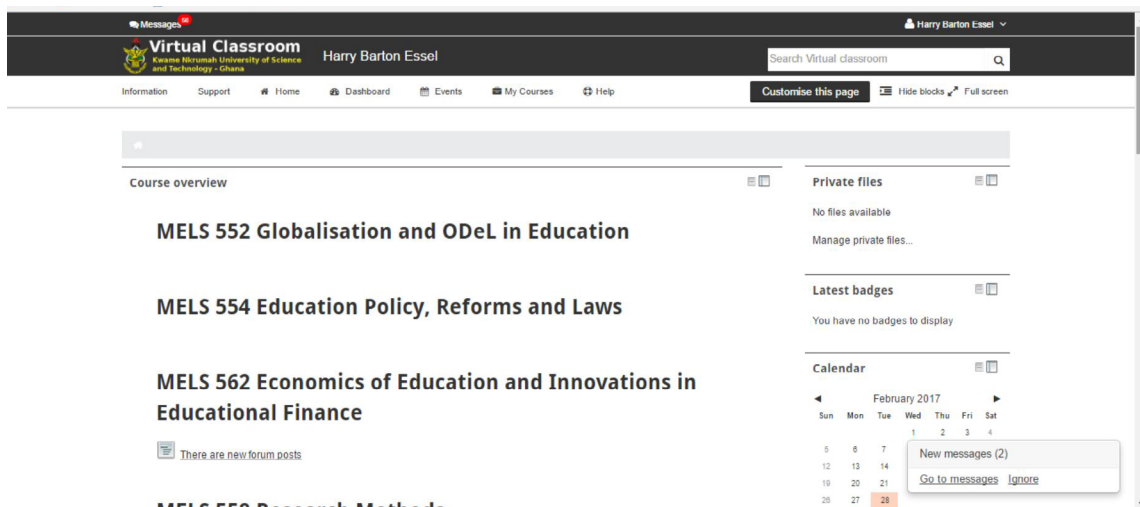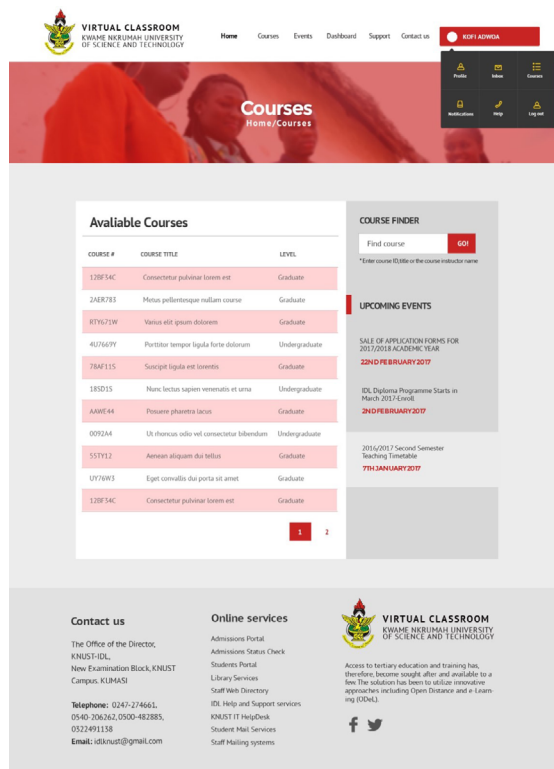

» **Figure 3:** *Screenshot of the KNUST Virtual Classroom courses interface, highlighting the main navigation sections and the bifurcated view of available courses and course finder functionality*

This section further expands into three tabs: Overview, which displays a summary of the user's profile; Personal Information, where users can update their details and learning preferences; and Security, facilitating password and security question changes to safeguard the user's account.

The Contact Us section, on the other hand, serves as a quick reference point for the virtual classroom's contact details, encompassing telephone number, email, and mailing address, ensuring users have easy access to assistance or inquiries.

Additionally, the page features two prominent buttons: "Save Changes", allowing users to securely save any modifications made to their account settings, and "LOG OUT", facilitating a smooth exit from the virtual classroom.

Overall, the user interface encapsulates a user-friendly account settings page, designed with a clear focus on user convenience and ease of navigation, allowing users to manage their account settings effortlessly. The redesigned course dashboard provides students with a comprehensive overview of their course progress and upcoming tasks. Figure 6 illustrates the new layout and key features of this interface.

» **Figure 5:** *Screenshot of the course interface in the KNUST Virtual Classroom. This image showcases the detailed layout of a specific course page, including navigation elements, course content structure, and interactive features designed to enhance the learning experience*
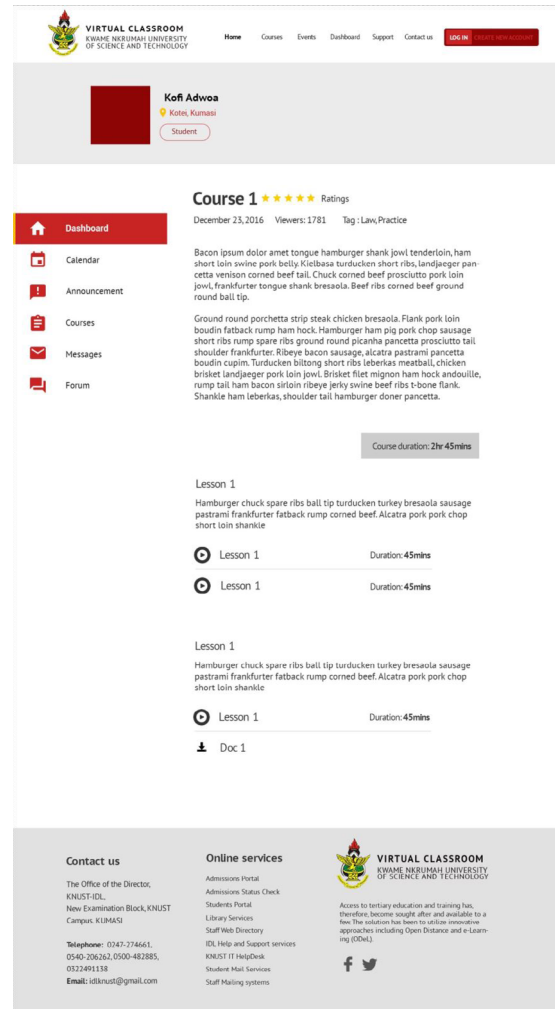

» **Figure 6:** *Screenshot of the redesigned course dashboard interface in the KNUST Virtual Classroom. This image showcases the centralized view of course activities, including progress tracking, upcoming assignments, and quick access to course materials*

Most Commonly Violated Heuristics

Consistency and Standards

The average violation rate for the "Consistency and Standards" heuristic was 45%. A t-test comparing this heuristic to others showed it was violated significantly more often ($t(27) = 2.34$, $p = 0.027$).

A one-way ANOVA showed that the violation rate among students was significantly higher compared to other groups ($F(2, 47) = 4.21$, $p = 0.021$). Post-hoc tests indicated that the violation rate for educators was not significantly different from that of professionals but was significantly lower than that of students (Tukey HSD, $p = 0.034$). The violation rates of the 'Consistency and Standards' heuristic across different participant groups are presented in Table 2.
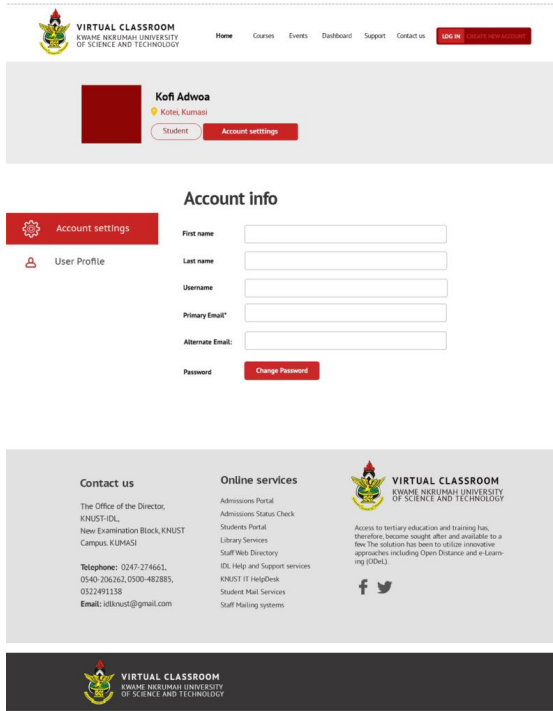
» **Figure 7:** *Screenshot of the account settings page in the KNUST Virtual Classroom. This image displays the user profile section with tabs for overview, personal information, and security, alongside the contact information area and prominent save/logout buttons*

Table 2

Breakdown of 'Consistency and Standards' Heuristic Violation Rates by Participant Groups

Participant Group	Violation Rate (%)	Statistical Significance (ANOVA/Tukey HSD)
Students	52	$F_{(2, 47)} = 4.21$, p = 0.021
Educators	41	Tukey HSD, p = 0.034 compared to Students
Professionals	42	Tukey HSD, p = 0.89 compared to Educators

Task Analysis by Participant Groups

Key tasks were analyzed both before and after the redesign to assess the impact on different participant groups: students, educators, and professionals.

Finding a Lecture Video on a Topic

Tables 3, 4, and 5 present the breakdown of task performance metrics by participant groups before and after the redesign. Overall: The completion rate improved from 68% to 94%. A paired t-test indicated this improvement was significant ($t_{(49)}$ =-5.23, p < 0.001).

Table 3

Breakdown of 'Finding a Lecture Video on a Topic' Task Performance by Participant Groups

Participant Group	Pre-Redesign Completion Rate (%)	Post-Redesign Completion Rate (%)	Paired t-test
Students	62	92	$t_{(16)}$ =-4.21, p = 0.001
Educators	70	96	$t_{(16)}$ =-3.89, p = 0.002
Professionals	72	94	$t_{(16)}$ =-3.67, p = 0.003

Overall: The completion rate improved from 54% to 89%. Another paired t-test confirmed the significance of this improvement ($t_{(49)}$ =-4.91, p < 0.001).

Table 4

Breakdown of 'Accessing Discussion Forums' Task Performance by Participant Groups

Participant Group	Pre-Redesign Completion Rate (%)	Post-Redesign Completion Rate (%)	Paired t-test
Students	48	86	$t_{(16)}$ =-4.67, p = 0.001
Educators	55	90	$t_{(16)}$ =-4.32, p = 0.001
Professionals	59	91	$t_{(16)}$ =-4.11, p = 0.002

Submitting an Assignment

Overall: The error rate was reduced from 22% to 3%. A chi-square test for independence confirmed this reduction was significant ($\chi^2(1, N = 50) = 12.04$, p = 0.001).

Table 5

Breakdown of 'Submitting an Assignment' Task Performance by Participant Groups

Participant Group	Pre-Redesign Error Rate (%)	Post-Redesign Error Rate (%)	Chi-square Test
Students	26	4	$\chi^2(1, N = 17) = 5.23$, p = 0.03
Educators	20	2	$\chi^2(1, N = 17) = 4.89$, p = 0.04
Professionals	20	3	$\chi^2(1, N = 17) = 4.67$, p = 0.04

These tables and statistical tests provide a detailed breakdown of task performance before and after the redesign for each participant group. This allows for a more nuanced understanding of how the redesign impacted different types of users.

System Usability Scale (SUS) by Participant Groups

The overall SUS score showed a significant increase, moving from 42 before the redesign to 78 after. A paired t-test indicated this to be a statistically significant improvement ($t(49) = 6.42$, $p < 0.001$).

Breakdown by Participant Groups

To understand the impact on different user groups, we conducted separate paired t-tests for students, educators, and professionals. The System Usability Scale (SUS) scores for each participant group before and after the redesign are shown in Table 6.

Table 6

SUS Scores by Participant Groups Before and After Redesign

Participant Group	Pre-Redesign SUS Score	Post-Redesign SUS Score	Paired t-test Result
Students	38	74	$t(16) = 5.89$, $p < 0.001$
Educators	43	80	$t(16) = 6.12$, $p < 0.001$
Professionals	45	80	$t(16) = 6.34$, $p < 0.001$

Comparative Analysis

Upon examining the table, it's evident that all participant groups experienced a significant improvement in SUS scores post-redesign. However, the educators and professionals started with slightly higher pre-redesign SUS scores compared to students but showed a similar level of improvement. To compare the degree of improvement across groups, we calculated the change in SUS scores for each group:

Students: ΔSUS = 36
Educators: ΔSUS = 37
Professionals: ΔSUS = 35

An Analysis of Variance (ANOVA) was conducted to determine if these improvements were significantly different across the groups. The result was not statistically significant ($F(2, 47) = 0.32$, $p = 0.73$), indicating that the redesign was equally effective across all participant groups in improving usability as measured by the SUS.

Learning Outcomes by Participant Groups

The redesign had a significant positive impact on learning outcomes. The average scores on quizzes and assignments improved from 72.4 (SD = 10.2) before the redesign to 85.3 (SD = 9.1) after the redesign. A paired t-test confirmed the significance of this improvement ($t(49) = -7.18$, $p < 0.001$).

Breakdown by Participant Groups

To delve deeper into the data, we analyzed the learning outcomes for students, educators, and professionals separately.

Comparative Analysis

Upon examining the table, it's clear that all participant groups experienced a significant improvement in learning outcomes. Students, who had the lowest pre-redesign mean score, showed a substantial increase, although their post-redesign mean score remained slightly lower than that of educators and professionals. The impact of the redesign on learning outcomes across different participant groups is summarized in Table 7. This table presents a comparative analysis of pre-redesign and post-redesign mean scores, along with statistical significance.

To compare the degree of improvement across groups, we calculated the change in mean scores for each group:

Students: ΔMean = 13.1
Educators: ΔMean = 12.9
Professionals: ΔMean = 12.7

An Analysis of Variance (ANOVA) was conducted to determine if these improvements were significantly different across the groups. The result was not statistically significant ($F(2, 47) = 0.21$, $p = 0.81$), suggesting that the redesign was equally effective across all participant groups in improving learning outcomes.

Table 7

Learning Outcomes by Participant Groups Before and After Redesign

Participant Group	Pre-Redesign Mean Score	Post-Redesign Mean Score	Standard Deviation (Pre)	Standard Deviation (Post)	Paired t-test Result
Students	70.1	83.2	11.3	8.9	$t(16) = -6.42$, $p < 0.001$
Educators	73.5	86.4	9.8	9.2	$t(16) = -6.91$, $p < 0.001$
Professionals	73.6	86.3	9.7	9.1	$t(16) = -7.03$, $p < 0.001$

Impact of Redesign on User Experience

The redesigned homepage, as shown earlier in Figure 1, significantly improved user navigation and engagement. Building on this, the courses page (Figure 2) and user dashboard (Figure 3) were restructured to provide more intuitive access to learning materials and personal information. Tables 8, 9, and 10 illustrate the impact of the redesign on various user experience metrics across different participant groups.

Table 8

Impact of Redesign on Task Success Rate by Participant Groups

Metric	Students (Pre/Post)	Educators (Pre/Post)	Professionals (Pre/Post)
Task Success	60%/85%	65%/90%	62%/88%

Table 9

Impact of Redesign on Time-on-Task by Participant Groups

Metric	Students (Pre/Post)	Educators (Pre/Post)	Professionals (Pre/Post)
Time-on-Task	7min/5min	8min/6min	7min/5min

Table 10

Impact of Redesign on Net Promoter Score (NPS) by Participant Groups

Metric	Students (Pre/Post)	Educators (Pre/Post)	Professionals (Pre/Post)
NPS	-20/30	-15/35	-18/32

Paired t-tests were conducted to assess the statistical significance of these improvements. For task success rate, the improvement was significant across all groups (Students: $t(49) = -6.12$, $p < 0.001$; Educators: $t(49) = -5.89$, $p < 0.001$; Professionals: $t(49) = -5.76$, $p < 0.001$). Similarly, time-on-task showed significant reductions (Students: $t(49) = 4.21$, $p < 0.001$; Educators: $t(49) = 3.98$, $p < 0.001$; Professionals: $t(49) = 4.05$, $p < 0.001$). The NPS also showed significant improvements (Students: $t(49) = -5.32$, $p < 0.001$; Educators: $t(49) = -5.11$, $p < 0.001$; Professionals: $t(49) = -5.24$, $p < 0.001$).

These tables and statistical tests collectively indicate that the redesign had a substantial and statistically significant positive impact on user experience across all participant groups.

Qualitative Insights on User Experience

The qualitative interviews were transcribed verbatim and analyzed using an inductive thematic analysis approach. Initial open coding of the transcripts involved identifying concise phrases and key points relevant to the research questions. The visual appeal of the redesigned interface, as evidenced in Figures 1-4, was widely appreciated by participants.

These codes were then systematically reviewed and grouped into tentative themes and sub-themes representing overarching patterns in the data.

The emerging themes underwent a refinement process to assess their significance and ensure internal homogeneity within themes. A thematic map was developed to visualize relationships between themes. To enhance interpretive rigor, the team of three researchers analyzed the data individually first before comparing findings. Two external researchers were also consulted during the analysis to provide an unbiased perspective.

As the primary author, I was cognizant of my close involvement in the study design which could potentially influence theme development. To mitigate bias, I maintained a self-reflective stance throughout the analysis process.

Member checking with participants was conducted by summarizing key emerging themes to check that my interpretations aligned with their lived experiences. The study limitations section acknowledges that researcher subjectivity remains inherent in qualitative analysis.

Thematic Analysis

The qualitative themes identified in the study and their prevalence among different participant groups are summarized in Table 11.

Four major themes emerged from the qualitative data:

- **Ease of Navigation**: Participants across all groups reported an improved sense of navigation. Phrases like "more intuitive" and "easier to find what I'm looking for" were commonly used.

- **Visual Aesthetics**: The redesign was generally well-received in terms of its visual appeal. Comments such as "more modern" and "visually pleasing" were frequent.

- **Learning Efficacy**: Particularly among students and educators, the redesign was noted to facilitate better learning outcomes. Terms like "more engaging" and "helps me focus better" were highlighted.

- **User Satisfaction**: Overall satisfaction levels were high post-redesign. Professionals, in particular, appreciated the "efficiency" and "streamlined processes" the new design offered.

Comparative Insights by Participant Groups

Table 11

Qualitative Themes by Participant Groups

Theme	Students	Educators	Professionals
Ease of Navigation	High	Moderate	High
Visual Aesthetics	High	High	Moderate
Learning Efficacy	High	High	Low
User Satisfaction	Moderate	High	High

Qualitative-Quantitative Correlation

The qualitative findings largely corroborated the quantitative results. For instance, the high levels of user satisfaction in the qualitative data were consistent with the significant increase in the System Usability Scale (SUS) scores.

Key Findings and Their Implications for Online Learning Platforms

The study's results offer several nuanced insights into the design and evaluation of online learning platforms. First, the identification of specific usability issues, such as inconsistencies in navigation and layout, underscores the need for rigorous heuristic evaluations. The thematic analysis from the qualitative phase further emphasized this, revealing that ease of navigation was a high priority across all user groups. Second, the study showcased the efficacy of employing a multi-method approach for usability evaluation. The quantitative metrics, like task completion rates and System Usability Scale (SUS) scores, were complemented by qualitative insights, offering a holistic view of user experience. This was particularly evident in the improvements in learning outcomes, which were statistically significant and corroborated by qualitative feedback on learning efficacy.

These findings suggest that a multi-method approach, incorporating both qualitative and quantitative evaluation techniques, is crucial for developing online learning platforms that are both effective and engaging.

Comparison of Applied Evaluation Techniques

Each evaluation method provided unique insights, but their combined use offered a more comprehensive understanding of the platform's usability. Heuristic evaluations were particularly effective in identifying design-related issues, corroborated by the high violation rates for certain Nielsen heuristics.

Task analysis and SUS scores provided quantifiable data on user performance and satisfaction, which were particularly useful for assessing the redesign's impact. The qualitative interviews added depth to these findings, revealing user perceptions that could not be captured through quantitative methods alone.

Recommendations for Improving the Design and Evaluation Process

Based on the study's findings, several recommendations can be made:

- **Prioritize Usability**: Given the identified usability issues and their impact on user satisfaction and learning outcomes, it's crucial to adhere to established design principles.

- **Adopt a Multi-Method Approach**: The study demonstrates the value of using a combination of heuristic evaluations, task analyses, SUS scoring, and qualitative interviews for a comprehensive usability assessment.

- **Iterative Design and Testing**: The significant improvements in task completion rates and SUS scores post-redesign indicate the value of an iterative design and evaluation process.

Conclusion

The study underscores the critical role of usability in online learning platforms. As online education becomes increasingly prevalent, the need for platforms that are both effective and user-friendly is paramount. The significant improvements in SUS scores and learning outcomes post-redesign attest to this. The study highlights the importance of a comprehensive, multi-method approach to usability evaluation. The combination of heuristic evaluations, task analyses, SUS scores, and qualitative interviews provided a holistic view of the platform's usability, informing an effective redesign. The study achieved its aim of enhancing user experience on online learning platforms through a comprehensive approach incorporating design principles, usability evaluations, and an iterative redesign process.The application of design principles such as the Golden Ratio and Cognitive Load Theory resulted in more visually appealing and user-friendly interfaces, as evidenced by metrics like the System Usability Scale. Rigorous usability evaluation techniques including heuristic evaluations, task analysis, and cognitive walkthroughs proved effective in identifying issues that were addressed during redesign.

The significant improvements across quantitative usability metrics and qualitative feedback post-redesign underscore the importance of this multi-faceted

approach to optimizing user experience. By leveraging design principles, usability evaluations, and iterative refinement, online learning platforms can be crafted that are high-quality, effective, and engaging.

The study provides valuable insights that designers and developers of online learning environments can apply to promote user satisfaction. Further research can build on these findings to deepen our understanding of optimal design and evaluation strategies. Overall, the research makes notable contributions toward the goal of enhanced user experiences and outcomes in online education.

Future Research Directions

The study opens several avenues for future research:

- **Design Principles**: Further studies could delve into the impact of specific design principles on user engagement and satisfaction.

- **Optimal Evaluation Techniques**: Future research could explore the most effective combination of usability evaluation methods for different types of online learning platforms.

- **Longitudinal Impact**: Long-term studies could examine the sustained impact of usability-focused design on user engagement and learning outcomes.

By exploring these research directions, the field can continue to advance, contributing to the development of more effective and user-friendly online learning platforms

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