Sharing Learning Log while maintaining privacy over blockchain: Heuristic Evaluation of BOLL

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Abstract: The Blockchain of Learning Logs (BOLL) system is a blockchain-based platform for connecting learners' educational records from multiple schools. The BOLL system creates a permanent record of learners' lifelong learning as immutable hashes on the blockchain, which can be analyzed to inform teaching and learning. This paper presents a usability analysis of the BOLL system using the 10 Jakob Nielsen Heuristics, with two user groups: students and teachers. The study evaluates the usability of various features, including the ability to view learner data from multiple schools, manage permissions, visualize analytics derived from connected learning logs, and provide access to learning materials used at various schools. Our findings highlight the successes of the BOLL system, including strong performance in areas such as consistency, real-world relevance, and user control. However, limitations were identified in error handling and the availability of comprehensive help and documentation. We conclude by emphasizing the need for future work to address these limitations and suggests potential avenues for improvement. Overall, this research contributes to the development of a user-friendly and privacy-conscious platform that can facilitate lifelong learning and enhance educational data sharing and analysis.
Keywords: BOLL, Blockchain, Learning Logs, Usability, Heuristic, Evaluation, Education

1. Introduction

The increase in the adoption of technology in teaching and learning has resulted in the need for a secure and efficient system to connect learners' educational records across multiple schools. The Blockchain of Learning Logs (BOLL) system offers a promising solution based on blockchain technology to create a permanent and tamper-proof record of learners' lifelong learning experiences (Ocheja, Flanagan, Ueda & Ogata, 2019). By maintaining privacy while enabling data sharing, BOLL has the potential to revolutionize the educational landscape. BOLL provides various features, interfaces and infrastructure to support access and usage of education data across different schools attended by learners including: learner profile, engagement analysis, cohort distribution, and access to learning contents as presented in (Ocheja, Flanagan, Majumdar, & Ogata, 2021; Ocheja, Flanagan, & Ogata, 2022a).
The architecture and key components of the BOLL system distinguish it from other blockchain-based solutions. This decentralized platform utilizes a network of distributed nodes to validate and record learners' educational activities. Consequently, BOLL ensures the integrity and security of the data, giving learners control over their educational records without compromising on trustworthiness and reliability. Understanding the usability of the BOLL system is crucial for its successful adoption and integration into educational environments. In light of this, we conducted a comprehensive usability analysis using the 10 Jakob Nielsen Heuristics (Nielsen, 1994). By evaluating the user experience from the perspectives of students and teachers, who engage with the system to access, share, and analyze educational records, we aim to identify strengths, weaknesses, and areas for improvement in the design and functionality of the BOLL system.

This research not only provides valuable insights into the usability of the BOLL system but also contributes to the broader field of blockchain-based educational systems. With a specific research focus on the usability of the BOLL system in maintaining privacy while securely sharing and analyzing educational records, we aim to address the research question of
　　① What is the usability of the Blockchain of Learning Logs (BOLL) system?

2.　　Related work
The increase in the adoption of technology in teaching and learning has resulted in the need for a secure and efficient system to connect learners' educational records across multiple schools. The Blockchain of Learning Logs (BOLL) system offers a promising solution based on blockchain technology to create a permanent and tamper-proof record of learners' lifelong learning experiences (Ocheja, Flanagan, Ueda & Ogata, 2019). By maintaining privacy while enabling data sharing, BOLL has the potential to revolutionize the educational landscape. BOLL provides various features, interfaces and infrastructure to support access and usage of education data across different schools attended by learners including: learner profile, engagement analysis, cohort distribution, and access to learning contents as presented in (Ocheja, Flanagan, Majumdar, & Ogata, 2021; Ocheja, Flanagan, & Ogata, 2022a).

3.　　Methodology
The evaluation in this study is conducted through a heuristic approach, which involves experts systematically examining the BOLL system against the established usability heuristics (Nielsen, 1994). This approach allows us to identify potential usability issues and provide recommendations for enhancing the system's usability and user experience. In this evaluation, we define the following user goals to be carried out while evaluating the usability of the BOLL system.
Students:
- View learning data at different schools to support current learning activities.
- Grant and revoke permissions to view data at previous school to teacher at current school.
- Access digital contents such as textbooks and lecture slides as revision materials.

Teachers:
- View profile of students on prerequisite courses to support their current learning goal.
- View the engagement distribution of students in a prerequisite course towards recommending appropriate revision across cohorts.
- Compare the engagement of students across different times or courses to detect consistent behaviour or at-risk tendencies.
- Access digital contents used by students in a prerequisite course to understand the depth of learning or assessment.

3.1　*Participants*
A diverse group of participants was selected to represent the target user groups of the BOLL system: students and teachers. To minimize bias, participants were recruited from various educational institutions that could potentially use the BOLL system. Efforts were made to ensure a varied representation in terms of teaching and learning experience, as well as familiarity with blockchain technology and learning management systems. In total, 4 teachers and 7 students participated in this evaluation.

3.2　*BOLL Features*
To provide participants with a hands-on experience of the BOLL system, specific features and functionalities that support the user goals were demonstrated. These features included the ability to view learner data from multiple schools, manage permissions for data access, visualize analytics derived from connected learning logs, and provide access to learning

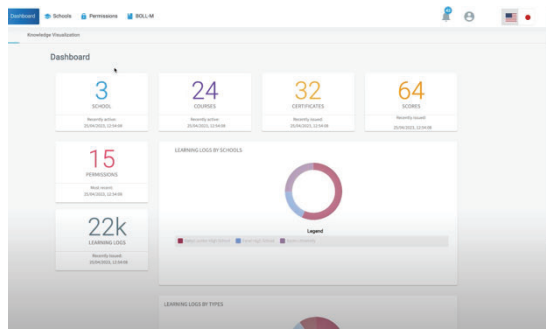materials used across various educational institutions.
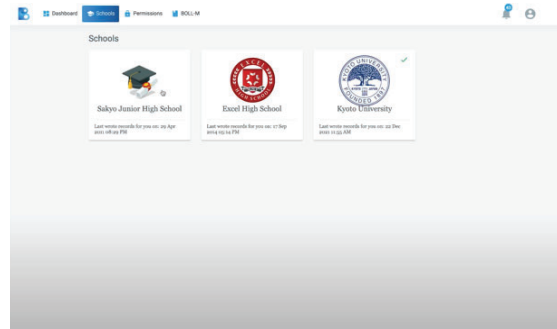

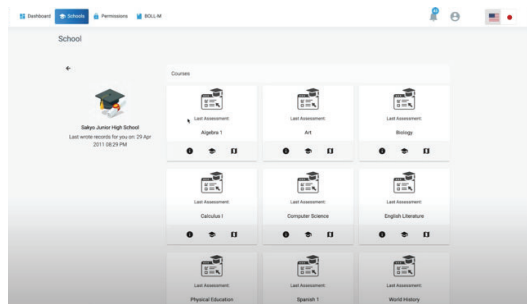*Figure 1.* Dashboard view [student]

Figure 2. Schools view [student]

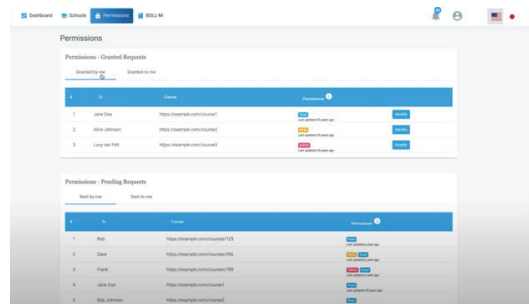*Figure 3.* Courses view [student]

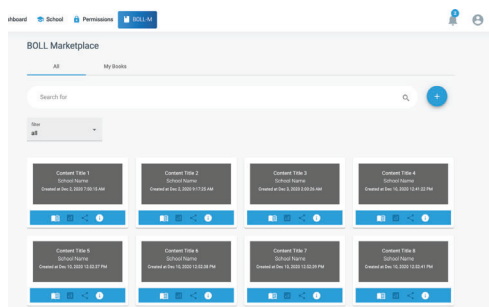*Figure 4.* Permissions view [student]

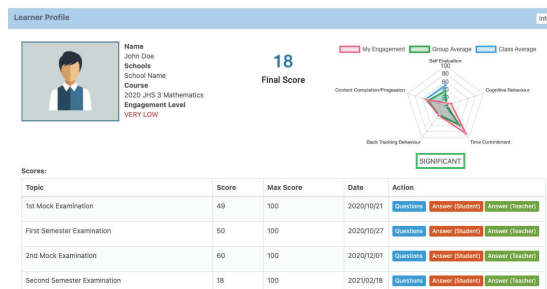*Figure 5.* Learning contents view [student]

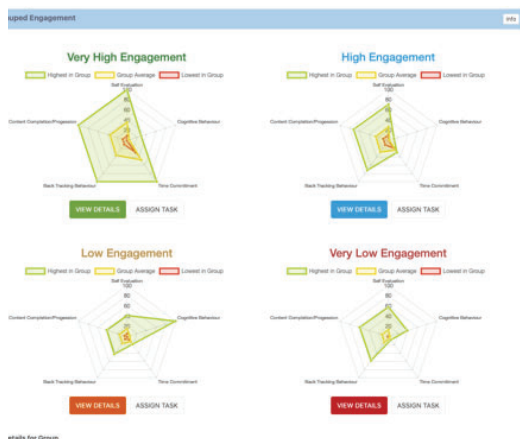*Figure 6.* Learner profile view [teacher]
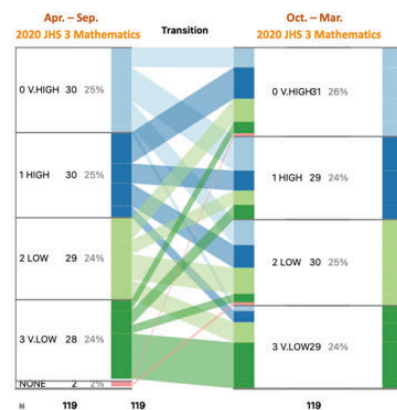

Figure 7. Prior engagement view [teacher]

Figure 8. Compare engagement view [teacher]

3.3 *Questionnaire Design*

For each user group, a set of questionnaires were developed based on the 10 Jakob Nielsen Heuristics for usability evaluation. These heuristics served as a set of guidelines for assessing the usability of interactive systems. Each heuristic was adapted to the context of the BOLL system, and specific questions were formulated to evaluate the system's performance against each criterion. Furthermore, the questionnaires aimed to gather both quantitative and qualitative feedback from participants regarding their experience and perception of the BOLL system's usability. To mitigate biases in this study, we developed clear and unbiased questionnaires with expert input and pilot-testing. Although the study had a limited sample size which affects generalizability, the results still offer valuable insights into the BOLL system's usability.
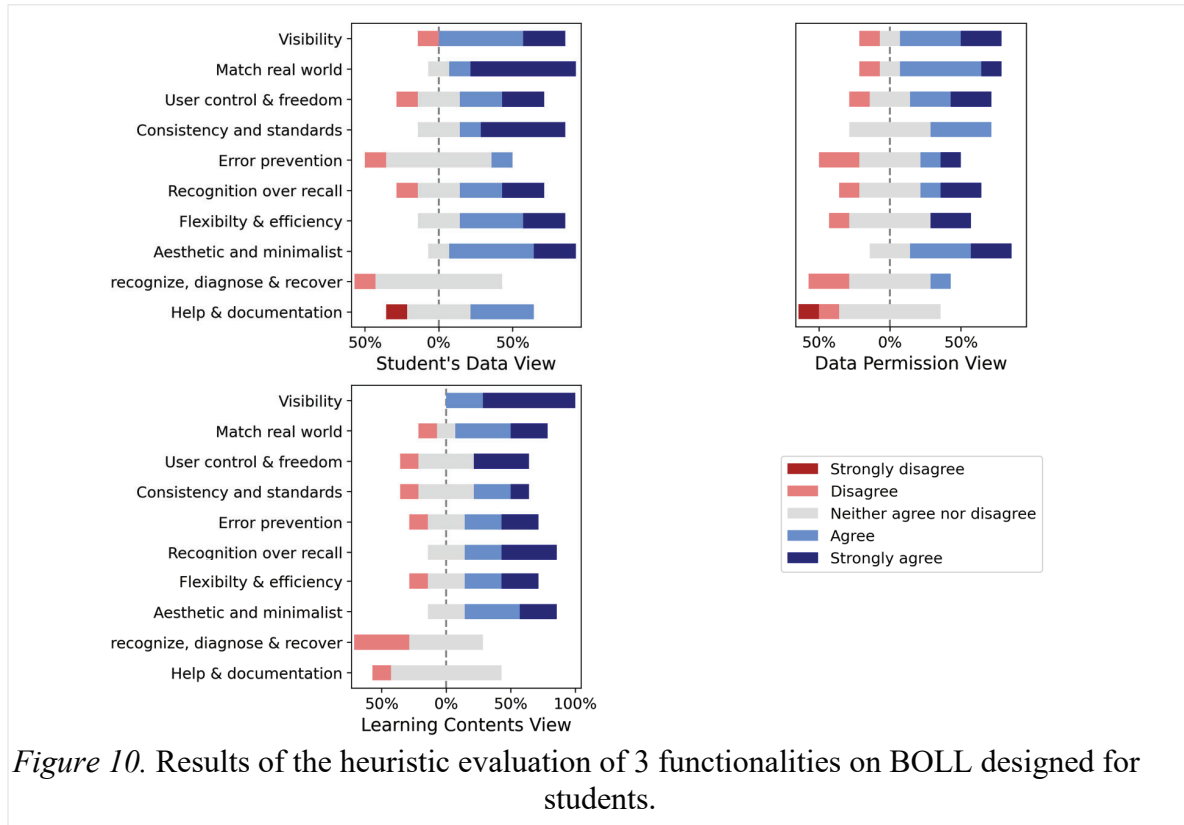
4. Results

The data collected from the questionnaires were analyzed to assess the usability of the BOLL system. Figures 9 and 10 show the results of the analysis of the quantitative data retrieved on a 5-scale Likert for each of the system features for each user group.

Figure 9. Results of the heuristic evaluation of 4 functionalities on BOLL designed for teachers.
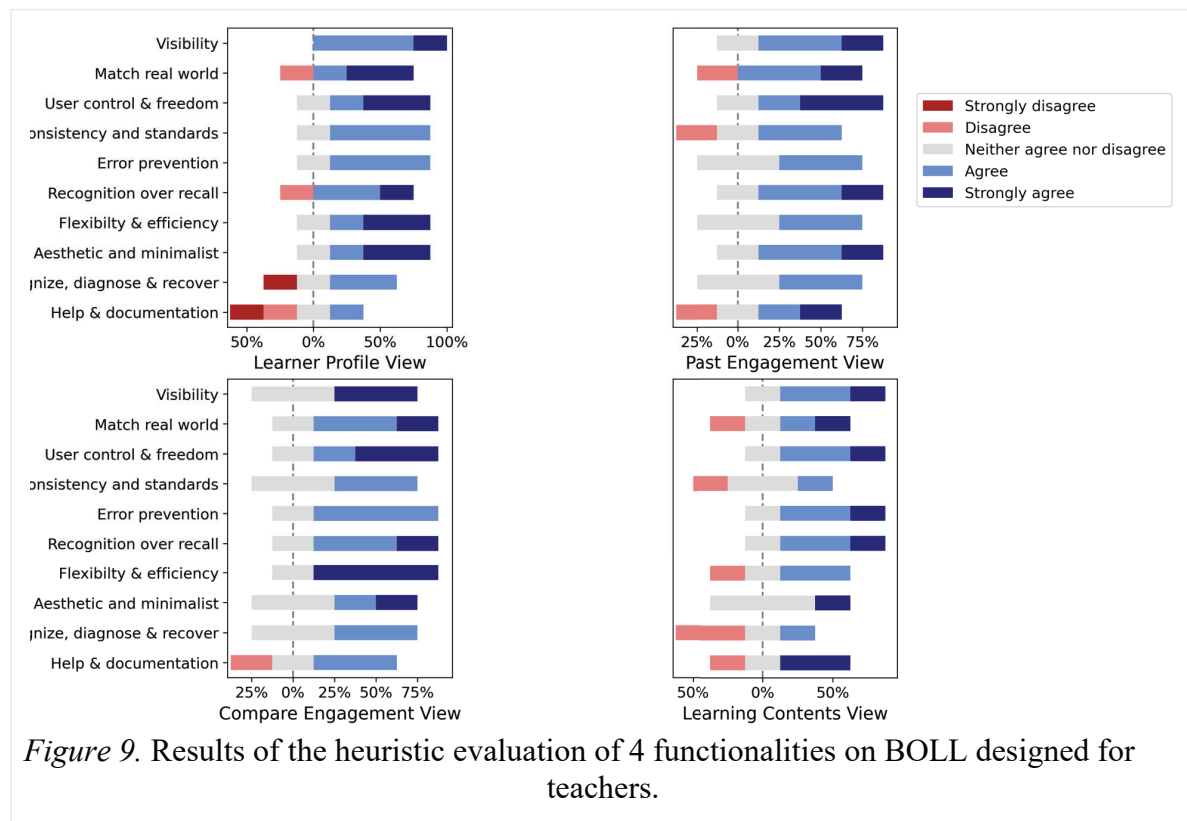
To interpret the results of the heuristic evaluation conducted on a 5-point Likert scale, we first calculate the mean of the scores given by the participants for each of the 10 Jakob Nielsen heuristic criteria. For each mean score, we assign a meaning as follows:

- *4.5 – 5.0, Excellent:* The Boll system performs exceptionally well on this criterion.
- *3.5 – 4.49, Good:* The BOLL system generally meets the heuristic guidelines and achieves a satisfactory level of usability for this criterion.
- *2.5 – 3.49, Fair:* The BOLL system shows some usability issues and room for improvement in meeting the heuristic guidelines for this criterion.
- 1.5 – 2.49, Poor: The BOLL system has significant usability issues and deviates considerably from the heuristic principles for this criterion.
- *– 1.49, Very Poor:* The BOLL system severely lacks usability and fails to address the heuristic guidelines for this criterion.

Figure 10. Results of the heuristic evaluation of 3 functionalities on BOLL designed for students.

We report the results of the evaluations of various features of BOLL by each user group below.

4.1 Teacher group

Overall, the heuristic evaluation conducted by the teacher group revealed a generally positive perception of the BOLL system in terms of usability. The learner profile view received positive ratings across most of the evaluated heuristics, indicating a good level of consistency, error prevention, recognition over recall, and match to the real-world context. The visibility, user control & freedom, flexibility & efficiency, and aesthetic and minimalist aspects of the interface were well-regarded, receiving ratings of 4.0 or higher. However, there is room for improvement in terms of help & documentation, which was rated as fair (m = 2.50). The evaluation of the past engagement view, compare engagement view, and learning contents view also showed generally positive results, with consistent ratings above 3.0 for most heuristics. Notably, the flexibility & efficiency heuristic scored high in the compare engagement view (m = 4.50), indicating its effectiveness. Overall, these findings suggest that the BOLL system demonstrates promising usability, with specific areas identified for potential enhancements, particularly in terms of providing better help and documentation resources for teachers.

4.2 Student group

The heuristic evaluation conducted with the student group demonstrated overall positive perceptions of the usability of the BOLL system. In the student's data view, the system received high ratings for consistency and standards (m = 4.29), match to the real-world context (m = 4.57), visibility (m = 4.00), and aesthetic and minimalist design (m = 4.14), indicating that students found these aspects well-designed and effective. The system also performed well in terms of user control and freedom (m = 3.71), recognition over recall (m = 3.71), and flexibility and efficiency (m = 4.00). However, there were areas identified for improvement, particularly in recognizing, diagnosing, and recovering from errors (m = 2.86) and providing comprehensive help and documentation (m = 3.14). Similarly, in the data permission view, the system exhibited strengths in consistency and standards (m = 3.43), user control and freedom (m = 3.71), visibility (m = 3.86), and aesthetic and minimalist design (m = 4.00). However,

there were opportunities for improvement in recognizing, diagnosing, and recovering from errors (m = 2.86) and providing comprehensive help and documentation (m = 2.57). In the learning contents view, the system received positive ratings for consistency and standards (m = 3.43), user control and freedom (m = 3.71), error prevention (m = 3.71), recognition over recall (m = 4.14), visibility (m = 4.71), and aesthetic and minimalist design (m = 4.00). However, improvements were needed in recognizing, diagnosing, and recovering from errors (m = 2.57) and providing comprehensive help and documentation (m = 2.86). Overall, the evaluation provided valuable insights, indicating that while the BOLL system demonstrated strengths in various usability aspects, there were specific areas, such as error handling and help/documentation, that required attention and improvement. These findings highlight the importance of addressing these concerns to enhance the overall user experience for students.

5.   Conclusion

In conclusion, this paper presented a heuristic evaluation of the Blockchain of Learning Logs (BOLL) system, focusing on its usability from the perspectives of both students and teachers. The evaluation revealed several successes of the BOLL system, including strong performance in areas such as consistency, real-world relevance, user control, and aesthetic design. These findings demonstrate the system's potential to effectively support lifelong learning and facilitate the sharing of educational records securely. However, limitations were identified, particularly in terms of error handling and the availability of comprehensive help and documentation resources. Future work should prioritize addressing these limitations to further enhance the system's usability. Additionally, the small sample size and potential biases in participant selection limits the generalizability of the findings in this study. However, the insights gained from this study, in conjunction with previous research and theoretical considerations, provide a valuable foundation for further explorations and refinements of the BOLL system's usability. Future studies with larger and more diverse samples would help validate and extend our findings.

Acknowledgements

References

Dyckhoff, A. L., Zielke, D., Bültmann, M., Chatti, M. A., & Schroeder, U. (2012). Design and implementation of a learning analytics toolkit for teachers. *Journal of Educational Technology & Society*, *15*(3), 58-76.

Nielsen, J. (1994, April). Enhancing the explanatory power of usability heuristics. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems* (pp. 152-158).

Ocheja, P., Agbo, F. J., Oyelere, S. S., Flanagan, B., & Ogata, H. (2022b). Blockchain in education: A systematic review and practical case studies. *IEEE Access*, *10*, 99525-99540.

Ocheja, P., Flanagan, B., & Ogata, H. (2022a). Assessment Results on the Blockchain: A Conceptual Framework. In *Artificial Intelligence in Education. Posters and Late Breaking Results, Workshops and Tutorials, Industry and Innovation Tracks, Practitioners' and Doctoral Consortium: 23rd International Conference, AIED 2022, Durham, UK, July 27–31, 2022, Proceedings, Part II* (pp. 306-310). Cham: Springer International Publishing.

Ocheja, P., Flanagan, B., Ueda, H., & Ogata, H. (2019). Managing lifelong learning records through blockchain. *Research and Practice in Technology Enhanced Learning*, *14*(1), 1-19.

Ocheja, P., Flanagan, B., Ueda, H., & Ogata, H. (2021). Investigating Relevance of Prior Learning Data Connected through the Blockchain. In *Proceedings of the Proceedings of the 29th International Conference on Computers in Education, Bangkok, Thailand* (pp. 279-284).