A Student Learning Style Auto-Detection Model in a Learning Management System

Amirah Binti Rashid
Department of Information Technology and Communication, Balik Pulau Polytechnic, Malaysia
amirah.rashid@pbu.edu.my

Raja Rina Raja Ikram
Fakulti Teknologi Maklumat dan Komunikasi, Universiti Teknikal Malaysia Melaka, Malaysia
raja.rina@utem.edu.my (corresponding author)

Yarshini Thamilarasan
Protech Digital Sdn Bhd, Malaysia
yarshinithamilarasan@gmail.com

Lizawati Salahuddin
Fakulti Teknologi Maklumat dan Komunikasi, Universiti Teknikal Malaysia Melaka, Malaysia
lizawati@utem.edu.my

Noor Fazilla Abd Yusof
Fakulti Teknologi Maklumat dan Komunikasi, Universiti Teknikal Malaysia Melaka, Malaysia
elle@utem.edu.my

Zakiah Rashid
Department of Science, Penang Matriculation College, Malaysia
zakiahzsm@gmail.com

Received: 3 February 2023 | Revised: 14 April 2023 | Accepted: 22 April 2023

 DOI: https://doi.org/10.48084/etasr.5751

ABSTRACT

Learning style plays an important role in enabling students to have an efficient learning process. This paper proposes an auto-detection model of student learning styles in learning management systems based on student learning activities. A literature review was conducted to investigate the components of online learning activities. The search terms used were "online learning activities", "learning management systems", and "Felder-Silverman Learning Style Model (FSLSM)." A combination of the search terms above was also executed to enhance the search process. Based on the results of the review, eleven classes of online learning activities were identified, namely forum, chat, mail, reading materials, exam delivery time, exercises, access to examples, answer changes, learning materials, exam results, and information access. The online learning activities identified were then mapped to the Felder-Silverman model based on four model dimensions: processing, perception, input, and understanding. The proposed model shows the attributes of the online learning activities based on the dimensions in the FSLSM. The proposed model can assist educators to improve learning content according to the suitability of students and recommend appropriate learning materials to students based on their characteristics and preferences. Future studies include the use of machine learning algorithms such as decision trees to auto-detect student learning styles in learning management systems.

Keywords-auto detection; student learning style; Felder-Silverman learning management system

I. INTRODUCTION

The ways that we teach and learn have changed as technology has advanced. The quick advancement of information and communication technologies has transformed conventional classrooms into cutting-edge learning spaces [1]. For instance, the ability to study whenever and wherever you want has been made possible through the internet sharing of educational information [2]. Online attendance marking systems have also significantly decreased the amount of time spent by teachers verifying students' attendance, increasing the amount of time spent teaching and learning. Additionally, tests or assignments can be given online along with the necessary guidance and criticism to encourage learning outside the scheduled classes [3]. There are numerous more typical amalgamations of teaching methods that are enabled or made easier by contemporary technologies. Due to the growing number of smart learning elements accessible, managing these characteristics is essential for efficient and well-organized instructional processes. Educational institutions now frequently run their own Learning Management Systems (LMSs) and offer a variety of online smart learning capabilities for a wide range of students [4]. An LMS is a web-based system with a wide selection of instructional and course management capabilities. LMS can facilitate group conversations, debates, document sharing, assignment submission, quizzes, grading, and course evaluations through these educational technologies. An LMS also has the potential to serve students from a variety of backgrounds, including those related to culture, age, or gender.

Identification of student learning style categorizes students according to the way they view and respond to information during the teaching process [5]. There are various types of learning styles that can be adopted by students depending on the suitability of the learning environment. A study conducted between the medical students of Isfahan University showed that learning style may be influenced by student gender [6]. Male students are more inclined to kinesthetic learning style while female students are more inclined to aural learning style. On the other hand, there are contradicting research results stating that gender is not a key aspect in determining student learning style [7]. BizzApps software was used to study whether learning styles affect student achievement [8]. The results of the study show that learning style can contribute to the students' success if the learning process is tailored towards it. In addition, 25% of students prefer various learning styles applied during the teaching process as this encourages them to actively contribute to the classroom. Identification of learning styles can assist educators to improve the learning content according to the suitability of students and recommend appropriate learning materials based on their characteristics and preferences [9].

II. LITERATURE REVIEW

There are several models that have been used to classify student learning styles. One popular model is the VARK model, which categorizes students into four learning styles: Visual, Auditory, Reading/writing, and Kinesthetic/tactile [10]. The VARK model has been used in various educational settings and has been found to be effective in helping students identify their preferred learning style and improving their study skills [10]. Another model that has been widely used is the Honey and Mumford model, which classifies learners into four categories: activist, reflector, theorist, and pragmatist [11]. This model emphasizes the importance of experiential learning and encourages students to engage in various learning activities that match their preferred learning style. Other notable models include the Kolb learning style inventory, which categorizes students into four learning styles: converging, diverging, assimilating, and accommodating [13], and the Dunn and Dunn model, which emphasizes the importance of environmental factors and categorizes students into five categories: environmental, emotional, sociological, physiological, and psychological [13]. While these models have been effective in helping students identify their preferred learning styles and improving their study skills, they have some limitations. For instance, they are often criticized for oversimplifying the complex process of learning and for not accounting for the multifaceted nature of learning styles. Additionally, some of these models may not be suitable for all students, as individual differences and cultural factors can play a significant role in determining learning style preferences [11].

The Felder-Silverman Learning Style Model (FSLSM) was defined by Felder and Silverman and is commonly used in engineering and computer science education studies [10–13]. FSLSM learning styles have four dimensions, with each dimension consisting of two types of learning styles. The four dimensions are preprocessing, perception, input and understanding [14]. Figure 1 shows the Felder-Silverman learning style model.

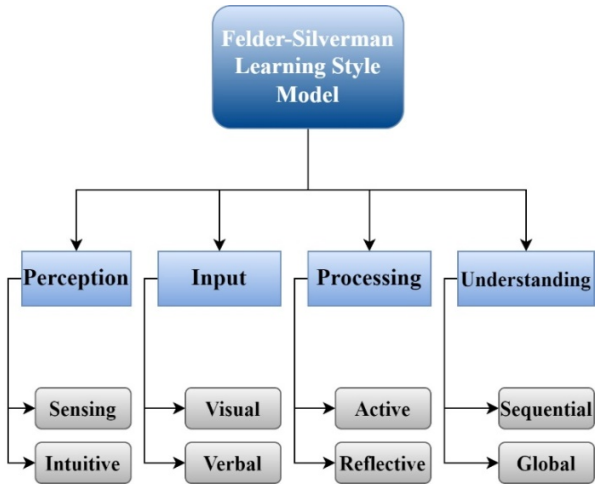

Fig. 1. The Felder-Silvermann Learning Style Model (FSLSM).

The processing dimension pertains to the way students process information, with active and reflective learners as subcategories. Active learners engage in discussions and group learning, while reflective learners prefer solitary learning but think deeply about the information. The perception dimension describes how students perceive information, with sensing learners focusing on facts and practical assignments and intuitive learners preferring to apply concepts in real-life

scenarios. The input dimension relates to the way students receive information, with visual learners understanding concepts through images and diagrams, and verbal learners preferring detailed explanations. Lastly, the understanding dimension pertains to the way students organize information, with sequential learners using linear step methods to understand and solve problems, while global learners understand information in a random, non-linear fashion.

The research gap in this area lies in the lack of automation in identifying student learning styles in an LMS. The existing models require manual input from the student or the teacher, which can be time-consuming and may not always be accurate. Therefore, there is a need for an automated system that can accurately identify student learning styles based on their behavior in the LMS, e.g. navigation patterns, content access, and interaction with the learning materials. The proposed model in this paper aims to fill this gap by using machine learning algorithms to automatically detect student learning styles in the LMS, which can improve the personalized learning experience and enhance student engagement and academic performance. The proposed model is based on the FSLSM.

III. METHODOLOGY

Literature review was conducted to identify the components of online learning activities used in LMSs. The literature was sourced from four databases: Ebsco Host, IEEE Explore, Proquest, and Google scholar. The search terms used were "online learning activities", "learning management systems", and "Felder-Silverman Learning Style Model (FSLSM)." A combination of the search terms above was also executed to enhance the searching process. A search was also conducted in Google to identify miscellaneous books, publications, and organization websites using the same terms. The purpose of the literature review was to identify online learning activities in LMSs and their integration with the FSLSM. The online learning components identified were then mapped to the FSLSM based on the four model dimensions. The purpose of this mapping was to match the suitable online learning components in LMSs with the appropriate learning dimensions. A model was then proposed from the integration of the online learning activities and the FSLSM. The attributes of the proposed model are defined to support the identification of learning style using LMSs.

IV. RESULTS

A. Online Learning Activities

Based on the review, eleven components were identified as activities in online learning that can be identified in LMSs. Basic component requirements are important when building online activity course learning. The first basic components are forums, chat, and mail [15]. These components are used to evaluate the students' active involvement in the on-line communication. The next components are related to a student's perception. They are reading materials, whether abstract or concrete, the time taken to submit quiz questions, tests, and exams, the time taken to perform reinforcement exercises, the access to examples, the frequency of changing answers during the exams, the number of attempted exercises [16, 17]. The learning materials component categorizes a student as a visual or verbal learner. In this component, learning materials are implemented into two categories, namely through diagrams and listening. After that, a quiz can be implemented based on the given input. The obtained score can assess student tendencies. The activities involved are reading materials in the form of videos, text, diagrams, and pictures [13]. The final component is accessing information and exam results [16]. This component describes how students receive the information provided and then sort it according to their understanding. Their level of understanding can be seen through the results of the examination based on the scales that have been set. Table I shows the mentioned components.

TABLE I. ONLINE LEARNING ACTIVITIES IN LMSs

Activities	Explanation	References
Forum	Involves forum posts, replies, and readings	[16]
Chat	Participates, listens, no participation	[16]
Mail	Use, does not use	[16]
Reading materials	Concrete, abstract	[16, 17]
Exam delivery time	Time taken to submit the exam questions	[16, 17]
Exercises	The amount of exercises that had been done	[16, 17]
Access to examples	The number of access to examples attempted	[16, 17]
Answer changes	The numbers in the answer changes during exams	[16, 17]
Learning materials	Diagrams, pictures, videos, text, presentations	[17]
Exam results	High, moderate, low	[16]
Information access	Global, sequential	[16]

A. Integration of Felder-Silverman Learning Style Model and Online Learning Activities

Based on the results, the components of online learning activities are mapped to the dimensions of the FSLSM. Table II shows a summary of online LMSs activities based on the FSLSM according to the literature review. The main online activities in processing are related to forum, mail, and chat activities [16]. The main online activities for perception are related to exam revision, questions, exercises review, reading materials, and learning resource types [16, 17]. The main online activities related to input are video and visual materials, forum visits, questions, and right answers [17]. The main online activities related to understanding are information access, content visit, and exam results [16, 18].

V. THE PROPOSED MODEL

Figure 2 shows the proposed model to identify student learning styles in LMSs based on the Felder-Silverman approach. The identified attributes were mapped to the four main dimensions of the FSLSM and are included in the proposed model. A definition of the attributes and its related values are displayed in Table III.

TABLE II. SUMMARY OF ONLINE LEARNING ACTIVITIES BASED ON FSLSM

FSLSM	[17]	[18]	[16]	[19]	[20]
Processing	forum_post	content_visit	forum	format_activity	question_answer
	self_assesment	forum_post	mail	learning_resource_type	visit_learning_content
	forum_view	forum_stay	chat	interactivity_type	forum_visit
	text_materials	forum_visit		interactivity_level	
Perception	concrete_materials	question_graphic	exam_revision	format_activity	right_answer
	examples	question_text	exercises	learning_resource_type	revised_answer
	abstract_materials		exam_delivery_time		
	exercises_review		answer_changes		
			access_to_examples		
			reading_materials		
Input	visual_materials	forum_visit		format_activity	right_answer
	video_materials	question_graphic		learning_resource_type	forum_visit
	text_materials	question_text			
	forum_post				
Understanding	navigational_pattern	content_visit	information_access	structure_activity	option_solve_problem
	course_overview		exam_results		visit_learning_content

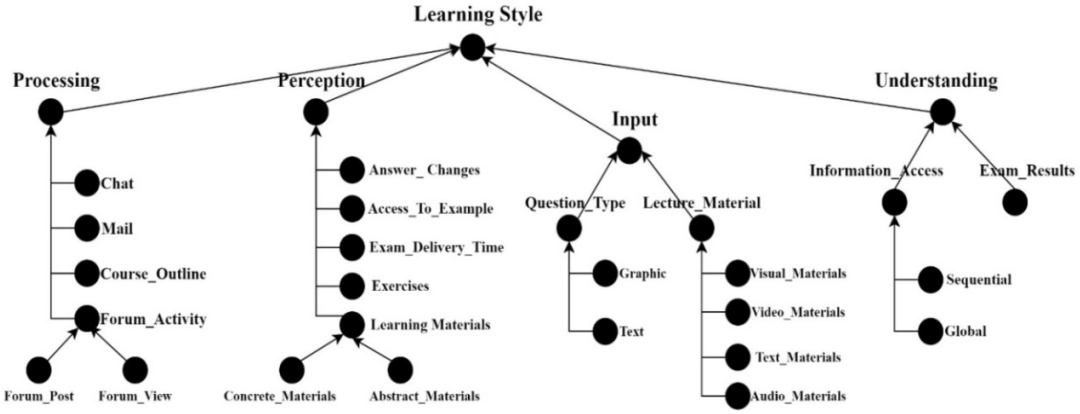

Fig. 2. The proposed model.

TABLE III. PROPOSED ATTRIBUTES AND VALUES FOR THE LEARNING STYLE DIMENSIONS IN THE PROPOSED MODEL

Dimension in FSLSM	Learning style	Attribute_Name	Attribute_Value	Percentage of attribute_value	Ref.
Processing	**Active**	- Forum_Post - Mail - Chat - Course_outline	- No of posting in forum - Use or do not use - Participate or not participate - No of visited courses outline	- More than 75% - More than 75% - More than 75% - Between 25% - 75%, none	[16, 21]
	Reflective	- Forum_View - Mail - Chat - Course_outline	- No of view post in forum - Use or do not use - Participate or not participate - No of visited courses outline	- More than 75% - Between 25% - 75%, none - Between 25% - 75%, none - More than 75%	[12, 20]
Perception	**Sensing**	- Concrete_Materials - Exercises - Exam_Delivery_Time - Access_To_Examples - Answer_Changes	- No of visits - No of visits - Submission time in exam - No of visits - No of attempted answer change	- More than 75% - More than 75% - More than 75% - More than 75% - Between 20% - 50%, none	[16, 21]
	Intuitive	- Abstract_Materials - Exercises - Exam_Delivery_Time - Access_To_Example - Answer_Changes	- No of visits - No of visits - Submission time in exam - No of visits - No of attempted answer changes	- More than 75% - Between 25% - 75%, none - Between 50% - 75%, none - Between 25% - 75%, none - More than 50%	[16, 21]
Input	**Visual**	- Visual_materials - Video_materials - Graphic_Question_Type	- No of visits - No of visit - No of correct answers	- More than 75% - More than 75% - More than 75%	[19]
	Verbal	- Text_materials - Audio_materials - Text_Question_Type - Forum_Post	- No of visits - No of visits - No of correct answers - No of forum posts	- More than 75% - More than 75% - More than 75% - More than 75%	[17, 20]
Understanding	**Sequential**	- Sequential_Information_Access - Exam_Results	- No of visits - Right answers on process questions	- More than 75% - Way more than 70%	[16, 20]

Table III shows the proposed attribute and values of online learning activities mapped to the FSLSM dimensions. Table III describes in detail the mapping of each learning activity and the involvement of students in each activity. The learning style of students can be identified more accurately based on the involvement of students in each online learning activity. The attribute value for each learning style is based on previous study studies. Active and reflective learning style is dependent on the number of forum posts, usage of mail, chat, and course outline visits. Sensing and intuitive learning styles depend on the number of visits to course materials, exercises, exam delivery time, and number of answer changes. Visual and verbal learning styles depend on the number of visits towards video, visual, text, and audio material. Sequential and global learning styles depend on exam results and the number of visits. The proposed attributes and values of online learning activities mapped to the dimensions in the FSLSM, as presented in Table III, provide a comprehensive guide for educators to identify students' learning styles based on their engagement with online learning activities. This approach has the potential to improve the effectiveness of online learning by enabling educators to tailor their teaching methods to the specific learning styles of their students. The proposed approach of mapping online learning activities to the dimensions of the FSLSM is a novel way of identifying students' learning styles in online learning environment. This approach allows educators to use data from the LMS to gain insight into the way their students engage with online activities and customize their teaching methods accordingly. For example, by analyzing a student's forum participation and email usage, educators can identify whether the student has an active or reflective learning style. Similarly, by analyzing a student's usage of video and visual materials, educators can identify whether the student has a visual or verbal learning style.

Overall, the mapping of online learning activities to the dimensions of the FSLSM is a valuable contribution to the field of online education. This approach provides a practical and data-driven method for identifying students' learning style in online learning environments and has the potential to improve the quality and effectiveness of online education.

VI. CONCLUSION

Knowledge of the learning style is an important element in ensuring that the teaching and learning process is well implemented. The proposed model defines the learning style attributes which can help identify the respective learning style. Understanding student learning styles can help teachers to improve the learning content according to the suitability of students, recommend appropriate learning material, and improve the communication and interaction skills between humans and computers through features in the learning management system [21]. Since most interactions between students and instructors occur in learning management systems, the system should be developed to cater the student specific requirements during the teaching process for a successful learning experience. Furthermore, incorporating these learning style attributes into the design of learning management systems can enhance the overall learning experience. Such features can include adaptive learning technologies, personalized learning pathways, and customized feedback mechanisms. By leveraging the power of technology to support and complement traditional teaching methods, educators can create a more dynamic and interactive learning environment that meets the needs of diverse learners.

ACKNOWLEDGMENT

This study is supported by the Fakulti Teknologi Maklumat dan Komunikasi, Universiti Teknikal Malaysia Melaka.

REFERENCES

[1] S. S. T. Alatawi *et al.*, "A New Model for Enhancing Student Portal Usage in Saudi Arabia Universities," *Engineering, Technology & Applied Science Research*, vol. 11, no. 3, pp. 7158–7171, Jun. 2021, https://doi.org/10.48084/etasr.4132.

[2] M. A. Al-Shargabi, "An Integrated Decision Support Model For Enhancing Continuous Improvement Of Academic Programs," *Engineering, Technology & Applied Science Research*, vol. 9, no. 5, pp. 4835–4841, Oct. 2019, https://doi.org/10.48084/etasr.3079.

[3] M. Alsuwaiket, A. H. Blasi, and R. A. Al-Msie'deen, "Formulating Module Assessment for Improved Academic Performance Predictability in Higher Education," *Engineering, Technology & Applied Science Research*, vol. 9, no. 3, pp. 4287–4291, Jun. 2019, https://doi.org/10.48084/etasr.2794.

[4] Y. Thamilarasan and R. R. R. Ikram, "MyMUET: A Design of a Mobile based Crowdsourced Assessment for Malaysia University English Test with Non-Synchronous Participant Interaction," *International Journal of Innovative Technology and Exploring Engineering*, vol. 8, no. 11, pp. 2971–2977, https://doi.org/10.35940/ijitee.K2277.0981119.

[5] N. A. Kamarudin, R. R. R. Ikram, F. N. Azman, L. Salahuddin, and H. T. Jaya, "A design of gamification Artificial Intelligence coding activities to improve cognitive skills among primary students," in *Proceedings of Mechanical Engineering Research Day 2022*, Aug. 2022, pp. 191–192.

[6] A. Sarabi-Asiabar *et al.*, "The Relationship Between Learning Style Preferences and Gender, Educational Major and Status in First Year Medical Students: A Survey Study From Iran," *Iranian Red Crescent Medical Journal*, vol. 17, no. 1, Dec. 2014, Art. no. e18250, https://doi.org/10.5812/ircmj.18250.

[7] M. Shuib and S. N. Azizan, "Learning Style Preferences among Male and Female ESL Students in Universiti-Sains Malaysia," *Journal of Educators Online*, vol. 12, no. 2, pp. 103–141, Jul. 2015, doi: 10.9743/jeo.2015.2.3.

[8] N. D. A. Halim, A. Jusoh, M. Mokhtar, and A. H. Abdullah, "Effectiveness of Using BizzApss in Enhancing Students' Achievement with Different Learning Styles," in *RCEE Conference Proceedings*, 2016, vol. 1, pp. 260–264.

[9] A. Viloria, I. R. Petro Gonzalez, and O. B. Pineda Lezama, "Learning Style Preferences of College Students Using Big Data," *Procedia Computer Science*, vol. 160, pp. 461–466, Jan. 2019, https://doi.org/10.1016/j.procs.2019.11.064.

[10] A. Seyal, Y. Mey, M. Matusin, nor zainah Siau, and A. Rahman, "Understanding Students Learning Style and Their Performance in Computer Programming Course: Evidence from Bruneian Technical Institution of Higher Learning," *International Journal of Computer Theory and Engineering*, vol. 7, no. 3, pp. 241–247, Jun. 2015, https://doi.org/10.7763/IJCTE.2015.V7.964.

[11] P. Ramírez-Correa, J. Alfaro-Pérez, and M. Gallardo, "Identifying Engineering Undergraduates' Learning Style Profiles Using Machine Learning Techniques," *Applied Sciences*, vol. 11, no. 22, Jan. 2021, Art. no. 10505, https://doi.org/10.3390/app112210505.

[12] I. Katsaris and N. Vidakis, "Adaptive e-learning systems through learning styles: A review of the literature," *Advances in Mobile Learning Educational Research*, vol. 1, no. 2, pp. 124–145, Oct. 2021, https://doi.org/10.25082/AMLER.2021.02.007.

[13] R. Felder, "Learning and Teaching Styles in Engineering Education," *Journal of Engineering Education*, vol. 78, no. 7, pp. 674–681, Jan. 1988.

[14] A. Hidayat, K. Adi, and B. Surarso, "Determine Felder Silverman Learning Style Model using Literature Based and K-Means Clustering," in *2021 Sixth International Conference on Informatics and Computing (ICIC)*, Jakarta, Indonesia, Aug. 2021, pp. 1–6, https://doi.org/10.1109/ICIC54025.2021.9633010.

[15] P. García, A. Amandi, S. Schiaffino, and M. Campo, "Using Bayesian Networks to Detect Students' Learning Styles in a Web-based education system," *Proceedings of ASAI 2005, Argentine Symposium on Artificial Intelligence*, Jan. 2005.

[16] P. García, S. Schiaffino, and A. Amandi, "An enhanced Bayesian model to detect students' learning styles in Web-based courses," *Journal of Computer Assisted Learning*, vol. 24, no. 4, pp. 305–315, 2008, https://doi.org/10.1111/j.1365-2729.2007.00262.x.

[17] R. R. Maaliw III and M. A. Ballera, "Classification of Learning Styles in Virtual Learning Environment Using J48 Decision Tree," in *14th International Conference on Cognition and Exploratory Learning in Digital Age*, Oct. 2017, pp. 149–156.

[18] J. Bernard, T.-W. Chang, E. Popescu, and S. Graf, "Using Artificial Neural Networks to Identify Learning Styles," in *Artificial Intelligence in Education*, 2015, pp. 541–544, https://doi.org/10.1007/978-3-319-19773-9_57.

[19] L. Assis, A. C. Rodrigues, A. Vivas, C. G. Pitangui, C. M. Silva, and F. A. Dorça, "Relationship Between Learning Styles and Learning Objects: A Systematic Literature Review," *International Journal of Distance Education Technologies*, vol. 20, no. 1, pp. 1–18, 2022, https://doi.org/10.4018/IJDET.296698.

[20] J. Feldman, A. Monteserin, and A. Amandi, "Automatic detection of learning styles: state of the art," *Artificial Intelligence Review*, vol. 44, no. 2, pp. 157–186, Aug. 2015, https://doi.org/10.1007/s10462-014-9422-6.

[21] A. E. Labib, J. H. Canós, and M. C. Penadés, "On the way to learning style models integration: a Learner's Characteristics Ontology," *Computers in Human Behavior*, vol. 73, pp. 433–445, Aug. 2017, https://doi.org/10.1016/j.chb.2017.03.054.