

that 94% of the activities in the process model could be correctly recognized by the algorithm of the inductive miner in the ProM Framework.

IV. CONCLUSION

This study has successfully identified a dominant student in the WhatsApp group based on hub and authority values. Besides, a free-rider was also spotted. The presence of the dominant student and free-rider has made collaboration and students' performance on social networks are weak. Student performance on e-learning has been analyzed, in which students' activities, namely, the course module viewed and course viewed, showed higher frequency than other activities. It revealed that activity log on social network and e-learning divide valuable information about the activities of the student. This information can be used to improve students' collaboration and to enhance students' activity in e-learning.

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REFERENCES

- [1] PISA. (2015) Programme for International Student Assessment, "Pisa Results in Focus," PISA. [Online]. Available: <https://www.oecd.org/pisa/pisa-2015-results-in-focus.pdf>.
- [2] A. Mueen, B. Zafar, dan U. Manzoor, "Modeling and Predicting Students' Academic Performance Using Data Mining Techniques," *Int. J. Mod. Educ. Comput. Sci.*, vol. 8, no. 11, pp. 36–42, Nov. 2016.
- [3] M. Ciolacu, A. F. Tehrani, R. Beer, dan H. Popp, "Education 4.0—Fostering student's performance with machine learning methods," in *2017 IEEE 23rd International Symposium for Design and Technology in Electronic Packaging (SIITME)*, 2017, pp. 438–443.
- [4] Y. Kim, "The Framework of Cloud e-Learning System for Strengthening ICT Competence of Teachers in Nicaragua," *Int. J. Adv. Sci. Eng. Inf. Technol.*, vol. 8, pp. 62–67, Feb. 2018.
- [5] F. H. Wang, "An exploration of online behaviour engagement and achievement in flipped classroom supported by learning management system," *Comput. Educ.*, vol. 114, no.1 pp. 79–91, 2017.
- [6] A. Krouska, C. Troussas, dan M. Virvou, "SN - Learning: An exploratory study beyond e - learning and evaluation of its applications using EV - SNL framework," *J Comput Assist Learn*, vol. 35, no.1 pp. 168–177, Oct. 2018.
- [7] A. Singh, "Mining of Social Media data of University students," *Educ. Inf. Technol.*, vol. 22, no. 4, pp. 1515–1526, 2017.
- [8] J.-H. Lam dan W. W. K. Ma, "When and how does learning satisfy? Working collaboratively online with a clear purpose," *Int. J. Innov. Learn.*, vol. 23, no. 4, pp. 400–415, 2018.
- [9] A. E. E. Sobaih, M. A. Moustafa, P. Ghandforoush, dan M. Khan, "To use or not to use? Social media in higher education in developing countries," *Comput. Human Behav.*, vol. 58, pp. 296–305, 2016.
- [10] A. Bogarin, R. Cerezo, dan C. Romero, "Discovering learning processes using Inductive Miner: A case study with Learning Management Systems (LMSs)," *Psicothema*, vol. 30, no. 3, pp. 322–329, 2018.
- [11] N. F. Kolan, N. Jailani, M. Abu Bakar, dan R. Latih, "Trust Model Based on Islamic Business Ethics and Social Network Analysis," *Int. J. Adv. Sci. Eng. Inf. Technol.*, vol. 8, no. 6, pp. 2323, 2018.
- [12] P. M. T. Crespo, "Social networks exploration for educational data mining," Instituto Superior Técnico, Lisboa (PT), 2013.
- [13] F. Elghibari, R. Elouahbi, dan F. El Khoukhi, "Data Mining for Detecting E-learning Courses Anomalies: An Application of Decision Tree Algorithm," *Int. J. Adv. Sci. Eng. Inf. Technol.*, vol. 8, no. 3, pp. 980, 2018.
- [14] I. Yurek, D. Birant, dan K. U. Birant, "Interactive process miner: a new approach for process mining," *Turk J Elec Eng Comp Sci*, vol. 26, pp. 1314–1328, 2018.
- [15] J. G. Rigby, "Principals' conceptions of instructional leadership and their informal social networks: An exploration of the mechanisms of the mesolevel," *Am. J. Educ.*, vol. 122, no. 3, pp. 433–464, 2016.
- [16] S. Ahajjam, M. El Haddad, dan H. Badir, "A new scalable leader-community detection approach for community detection in social networks," *Soc. Networks*, vol. 54, hal. 41–49, 2018.
- [17] E. Rojas, J. Munoz-Gama, M. Sepúlveda, dan D. Capurro, "Process mining in healthcare: A literature review.," *J. Biomed. Inform.*, vol. 61, pp. 224–36, 2016.
- [18] A. Bogarín, R. Cerezo, dan C. Romero, "Discovering learning processes using inductive miner: A case study with learning management systems (LMSs)," *Psicothema*, vol. 30, no. 3, pp. 322–329, 2018.
- [19] J. Munoz-gama, *Conformance Checking and Diagnosis in Process Mining, Comparing Observed and Modeled Processes*, 1 ed. Chile: Springer, 2016.
- [20] K. L. Vogt, "Measuring Student Engagement Using Learning Management Systems," University of Toronto, Toronto (CA), 2016.
- [21] A. Brodsky, G. Shao, M. Krishnamoorthy, A. Narayanan, D. Menascé, dan R. Ak, "Analysis and optimization based on reusable knowledge base of process performance models," *Int. J. Adv. Manuf. Technol.*, vol. 88, no. 1–4, pp. 337–357, 2016.
- [22] J. Hagerty, "2017 Planning Guide for Data and Analytics," *Gartner*, 2016. [Online]. Available: https://www.gartner.com/binaries/content/assets/events/keywords/cat_alyst/catus8/2017_planning_guide_for_data_analytics.pdf.
- [23] R. Jugulum, "Importance of Data Quality for Analytics," in *Quality in the 21st Century*, Springer, 2016, pp. 23–31.
- [24] D. C. Corrales, A. Ledezma, dan J. C. Corrales, "From Theory to Practice: A Data Quality Framework for Classification Tasks," *Symmetry (Basel)*, vol. 10, pp. 1–29, 2018.
- [25] S.-H. Cheong dan Y.-W. Si, "Accelerating the Kamada-Kawai algorithm for boundary detection in a mobile ad hoc network," *ACM Trans. Sens. Networks*, vol. 13, no. 1, pp. 3, 2017.
- [26] R. Conforti, M. Dumas, L. García-Bañuelos, dan M. La Rosa, "BPMN miner: automated discovery of BPMN process models with hierarchical structure," *Inf. Syst.*, vol. 56, pp. 284–303, 2016.
- [27] W. M. P. Van der Aalst, *Process mining: data science in action*, 2 ed. London: Springer, 2016.
- [28] B. Van Dongen, J. Carmona, dan T. Chatain, "A Unified Approach for Measuring Precision and Generalization Based on Anti-alignments," in *14th International Conference on Business Process Management (BPM'16)*, 2016, pp. 39–56.
- [29] A. Burattin, F. M. Maggi, dan A. Sperduti, "Conformance checking based on multi-perspective declarative process models," *Expert Syst. Appl.*, vol. 65, pp. 194–211, 2016.
- [30] J. Siles-González dan C. Solano-Ruiz, "Self-assessment, reflection on practice and critical thinking in nursing students," *Nurse Educ. Today*, vol. 45, pp. 132–137, 2016.