JPF | Volume 13 | Number 3 | 2025 | 572 -585

p - ISSN: 2302-8939
e - ISSN: 2527-4015

Jurnal Pendidikan Fisika

https://journal.unismuh.ac.id/index.php/jpf

DOI: 10.26618/tpnr8c83

Analyzing Asynchronous Online Discussions in Solid-State Physics: Interaction Patterns and Cognitive Presence Among Distance Learners

Widiasih[1)*], Arisona [2)], Dwikoranto [3)], Rahmawati[4)], Ismail[5)]

[1)]*Department of Physics Education, Universitas Terbuka, Tangerang Selatan, 15437, Indonesia*
[2]*Department of Geological Engineering, Universitas Halu Oleo, Kendari, 93232, Indonesia.*
[3)]*Department of Physics Education, Universitas Negeri Surabaya, Surabaya, 60213, Indonesia*
[4)]*Department of Physics Education, Universitas Muhammadiyah Makassar, Makassar, 90221 Indonesia*
[5)]*Department of Science Education, Universitas Pendidikan Indonesia, Bandung, 40154, Indonesia*

**Corresponding author: widiasih@ecampus.ut.ac.id*

Received: May 06, 2025; Accepted: August 13, 2025; Published: September 24, 2025

Abstract – *The increasing adoption of online learning in higher education has placed asynchronous discussion forums at the center of teaching and learning, particularly in open and distance learning contexts where student engagement and collaborative inquiry are crucial. In physics education, however, fostering deep conceptual understanding through asynchronous communication remains challenging, as participation often tends to be surface-level and tutor-centered. This study aimed to analyze participation patterns, levels of cognitive presence, and their relationship to student performance in a Solid-State Physics course at Universitas Terbuka, Indonesia. Employing a descriptive case study design, the research collected data from learning management system logs, forum transcripts, tutor feedback, and assignment scores. Cognitive presence was coded using the Community of Inquiry framework, intercoder reliability was established with Cohen's kappa (κ = 0.88), and interaction structures were visualized using social network analysis. The results revealed that students frequently viewed the forums but contributed relatively few postings, indicating widespread passive participation. Most contributions were concentrated at the triggering and exploration phases, with only about 15% reaching integration or resolution. Interaction maps confirmed a strongly tutor-centered pattern, with minimal peer-to-peer exchanges, while comparison of participation and assignment data showed that more active contributors achieved higher performance. These findings underscore the limited depth of engagement in asynchronous forums but also highlight their potential to support learning when students participate meaningfully. The novelty of this study lies in its triangulated methodology and its focus on physics education in an open and distance learning context. The study contributes empirical evidence for improving asynchronous forum design and facilitation to foster higher-order engagement in physics learning.*

Keywords: *asynchronous online discussion; cognitive presence; open and distance learning; physics education; social network analysis*

I. INTRODUCTION

The global landscape of education has undergone unprecedented changes in the past two decades, with digital technology reshaping how knowledge is produced, accessed, and disseminated. The COVID-19 pandemic accelerated this transformation, forcing institutions worldwide to adopt online and blended learning models almost overnight (Bao, 2020; Hodges et al., 2020). This abrupt shift highlighted both the opportunities and the challenges of remote learning, particularly in fields such as physics, where conceptual understanding often depends on laboratory experiences and direct observation of phenomena (Rajab et al., 2020). In this context, teachers and students alike encountered difficulties in adapting traditional teaching materials and methods to online platforms, revealing significant gaps in preparedness and infrastructure (Albrahim, 2020; Fatmawati, 2019).

At the same time, educational theorists emphasize that the integration of digital tools in teaching should not be seen merely as a stopgap solution to crises such as the pandemic. Rather, it reflects a broader paradigm shift in education towards more flexible, interactive, and student-centered models (Lederman, 2020). Online and blended learning environments, when designed effectively, can enhance access, foster engagement, and provide new opportunities for collaboration across distances (Pratama & Yusro, 2016; Prayuda & Malik, 2021). Nevertheless, these environments also demand new pedagogical competencies from teachers and greater self-regulated learning skills from students, underscoring the complexity of teaching and learning in digital spaces (Rasheed et al., 2020).

The primary challenge in this transformation lies in ensuring that digital and remote learning can provide equivalent quality to traditional face-to-face instruction. Studies have shown that many students feel disconnected in online environments, citing difficulties with motivation, interaction, and maintaining focus (Singh & Thurman, 2019; Toquero, 2020). Similarly, teachers struggle to monitor student engagement and adapt materials that were originally designed for physical classrooms (Wu et al., 2011). These challenges are especially pronounced in science and technology disciplines, where abstract concepts and experimental practices require more than passive content delivery (Simanullang & Rajagukguk, 2020).

To address these concerns, scholars propose that digital learning environments must be designed to foster presence, interactivity, and collaborative learning. Alzahrani (2017) and Garrison et al. (2000) highlighted the importance of the "Community of Inquiry" (CoI) framework, which emphasizes cognitive, social, and teaching presence as essential dimensions for effective online education. Ensuring these presences in a virtual environment requires the use of rich media, structured interactions, and meaningful assessment strategies. Teachers must also

adopt innovative instructional designs that blend synchronous and asynchronous components to balance flexibility with real-time interaction (Azizah et al., 2018; Barman et al., 2019). Despite these recommendations, however, many digital classrooms remain limited to static content delivery, lacking interactivity and opportunities for deeper engagement (Breivik, 2020).

One promising line of research emphasizes the role of digital instructional materials tailored specifically for online learning. Studies show that well-designed digital content can support conceptual understanding, encourage active participation, and scaffold students' independent learning processes (Bunyamin et al., 2019; Chai et al., 2020). For example, the incorporation of interactive simulations, multimedia resources, and collaborative tools can enhance both cognitive and affective engagement, making abstract concepts more tangible and accessible (van der Dennen, 2002; Anderson et al., 2003). Martin et al. (2018) demonstrated that instructional design, which integrates interactive features and clear communication channels, contributes significantly to students' satisfaction and learning outcomes in online settings. Moreover, Mehall (2020) stressed that the relational dimension of digital materials, such as their ability to facilitate meaningful teacher-student and peer-to-peer interaction, is equally critical. These findings suggest that the problem lies not only in access to digital tools but in the pedagogical and design principles guiding their use.

Despite these advances, gaps remain in our understanding of how digital instructional materials function in diverse contexts. Cho and Tobias (2016) argued that online learning effectiveness depends heavily on how instructional resources are integrated into the broader learning environment, yet few studies examine this integration systematically. Similarly, Gosmire et al. (2009) found that professional development for teachers in digital pedagogy remains limited, constraining their ability to design or adapt high-quality instructional materials. Sun and Chen (2016) further noted that most research on online learning focuses on higher education, while secondary school contexts—where students may lack the maturity or self-regulation needed for autonomous learning—are understudied. Alhazmi et al. (2021) also reported that digital inequities, including differences in internet access and technological literacy, compound these challenges, especially in developing regions. These gaps suggest that more research is needed not only on the technical aspects of digital materials but also on their pedagogical effectiveness, contextual relevance, and alignment with teachers' practices.

This present study aims to analyze the role and challenges of digital instructional materials in contemporary physics education, with particular attention to their application in magnetism teaching. Unlike much of the existing literature that focuses on either technological affordances or student outcomes in isolation, this study triangulates between teacher perspectives, instructional resources, and classroom challenges. Its novelty lies in situating the discussion of

digital instructional materials within the realities of science teaching, where abstract and spatially complex concepts such as magnetism demand innovative pedagogical approaches. By focusing on how teachers perceive students' difficulties and how digital tools can be leveraged to address them, this study contributes to both the theoretical understanding of digital pedagogy and the practical development of more effective instructional strategies. The findings are expected to inform the design of learning environments that not only transfer knowledge but also foster critical thinking, visualization, and problem-solving skills among students in physics education.

II. METHODS

This study employed a descriptive case study design to investigate asynchronous online discussions in the Solid-State Physics course at Universitas Terbuka, Indonesia. A case study design was chosen because it allows researchers to analyze authentic learning activities in depth and to uncover both the processes and outcomes of student engagement in online learning environments. The focus was on exploring how students participated in asynchronous forums, the levels of cognitive presence they achieved, and how these interactions related to their academic performance.

The distinct nature of Universitas Terbuka shaped the research context. This large, open, and distance learning institution relies primarily on digital platforms to serve students scattered across the country. The Solid-State Physics course was delivered fully online, using the institution's learning management system (LMS). Within this LMS, asynchronous discussion forums were a central learning component, designed to encourage students to engage in dialogue with peers and tutors. The use of asynchronous forums was particularly important in this setting, as it allowed students with diverse schedules and varied access to technology to participate in discussions at their own pace while maintaining opportunities for reflection and collaborative knowledge building.

The participants of this study were undergraduate students enrolled in the Solid-State Physics course during the semester of investigation. For structured interaction, the students were divided into eight asynchronous discussion groups. Each group was facilitated by a tutor who was responsible for initiating weekly prompts, encouraging participation, and providing clarifications or feedback to guide the discussion. While tutors played a crucial role in sustaining dialogue, the study also emphasized the role of peer contributions, as collaborative meaning-making among students is considered an essential component of higher-order learning. Thus, the participants represented a distributed community of learners interacting asynchronously, with the tutor serving as both a facilitator and a resource.

The data analyzed in this study came from multiple sources provided by the LMS and course documentation. These included log data capturing student access and viewing behaviors, transcripts of postings in asynchronous discussion forums, written feedback from tutors, participation reports, and student assignment scores. By combining these sources, the study was able to analyze participation both quantitatively, through frequency of access and postings, and qualitatively, through the depth of discourse reflected in the contributions. The sequence of data collection and analysis is summarized in Figure 1, illustrating the process from data extraction to coding and comparing participation with student performance.

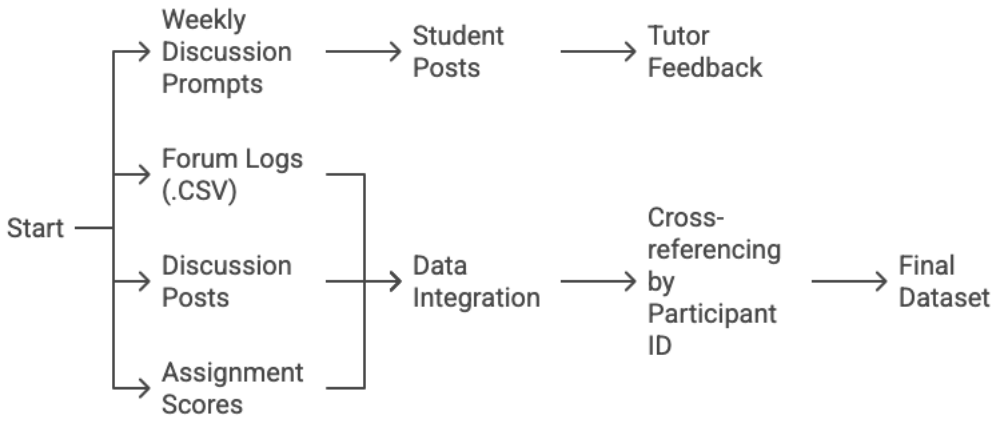

Figure 1. Research procedure for data collection and analysis

The analysis of student contributions in the discussion forums was carried out using the CoI framework. According to Garrison et al. (2000), cognitive presence is the extent to which learners can construct and confirm meaning through sustained reflection and discourse. In this study, each student posting was coded according to the four phases of cognitive presence: triggering events, exploration, integration, and resolution (Shea & Bidjerano, 2009). This framework provided a lens to assess whether students' contributions remained at a surface level of inquiry or progressed toward deeper integration and resolution of ideas.

To ensure rigor in the coding process, two independent raters analyzed the discussion transcripts using the CoI framework. Intercoder reliability was then measured using Cohen's kappa, which yielded a coefficient of $\kappa = 0.88$. According to Landis and Koch (1977), kappa values above 0.80 represent almost perfect agreement. This high level of reliability confirmed that the coding process was consistent and credible, thereby strengthening the validity of the findings regarding levels of cognitive presence achieved by the students.

In addition to content analysis, interaction mapping was employed to visualize patterns of participation within the discussion forums. Social Network Analysis (SNA) was applied, representing each participant as a node and each reply or posting directed to another participant as an edge connecting those nodes. This method enabled the researchers to identify structural

features of interaction, such as whether discussions were dominated by tutors or whether meaningful peer-to-peer communication emerged. Dawson (2008) emphasized that SNA provides powerful tools for diagnosing the structure of online learning communities, while noted that network visualizations can reveal participation patterns not readily apparent through textual analysis alone. By applying SNA, the study was able to highlight whether forums fostered collaborative engagement or remained primarily tutor centered.

Finally, student assignment scores were examined alongside participation measures to determine whether engagement in asynchronous forums contributed to academic achievement. Participation was assessed not only by the frequency of student postings but also by the cognitive depth demonstrated in their contributions, as captured by the CoI coding. Comparing these indicators with assignment scores allowed the researchers to evaluate the pedagogical value of asynchronous discussions in supporting physics learning outcomes.

III. RESULTS AND DISCUSSION

The analysis of asynchronous discussion activities indicated substantial disparities between students' viewing and posting behaviors. As presented in Table 1, students accessed the forums frequently, yet their active contributions through postings were limited. The number of views was considerably higher than the number of posts, underscoring the prevalence of passive engagement. Tutors consistently generated postings to sustain the flow of discussion, initiating prompts and responding to student messages. This pattern revealed that while the forums were widely accessed, active contributions were concentrated among a smaller subset of participants, and much of the activity was sustained by tutors rather than by peer interaction.

Table 1. Descriptive statistics of discussion activities across eight groups

Discussion	User	Posting	View	Discussion
		Teacher	Student	
1	17	17	17	1
2	18	15	18	2
3	18	1	19	3
4	19	1	17	4
5	17	3	16	5
6	16	15	17	6
7	17	4	17	7
8	17	15	17	8

Further analysis was conducted to examine the quality of student contributions in terms of cognitive presence, based on the Community of Inquiry framework. Figure 2 illustrates the distribution of postings across the four phases of cognitive presence: triggering events, exploration, integration, and resolution. The results show that most contributions were concentrated at the lower levels of triggering and exploration. Only a small proportion of contributions reached integration, and very few demonstrated resolution, with overall higher-order engagement accounting for approximately 15% of postings. These findings indicate that while students participated in the discussions, the depth of cognitive engagement remained limited.

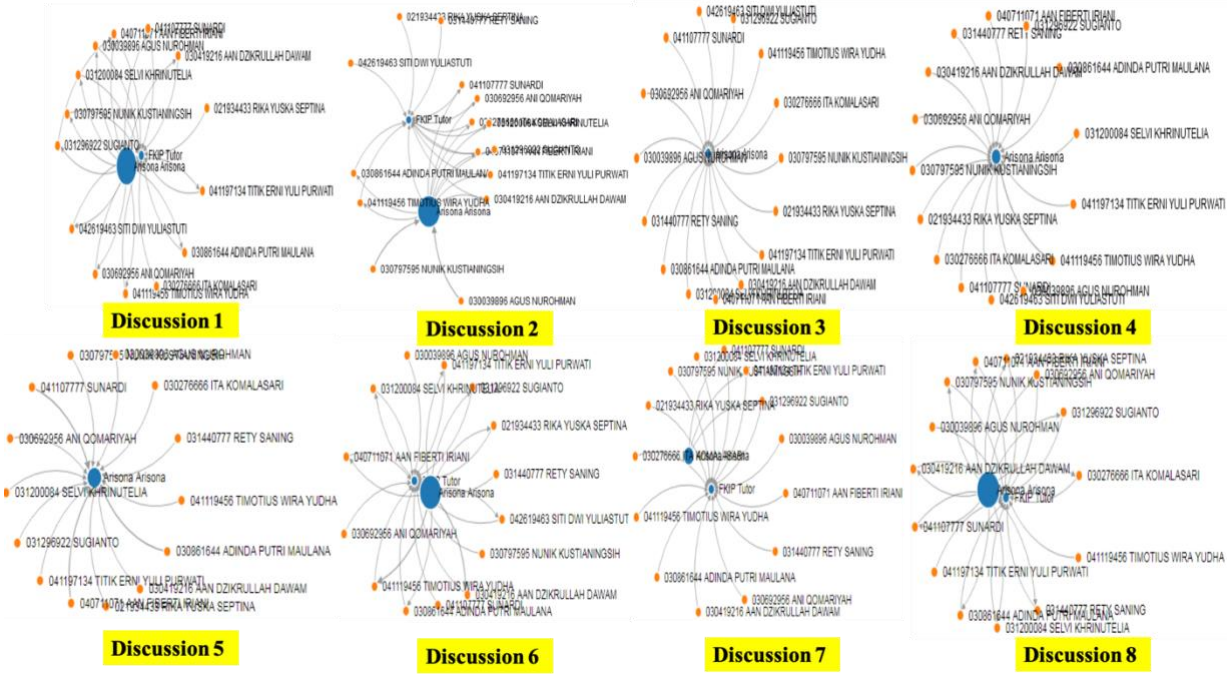

Figure 2. Distribution of contributions across cognitive presence phases

Interaction mapping was conducted to further examine the structural characteristics of participation. Figure 2 displays the network of interactions in one representative group. Tutors emerged as central nodes in the network, receiving the majority of messages and responding to students, while peer-to-peer interactions were scarce. The tutor-centered structure suggests that students tended to rely on tutor prompts and feedback rather than developing sustained dialogue with their peers.

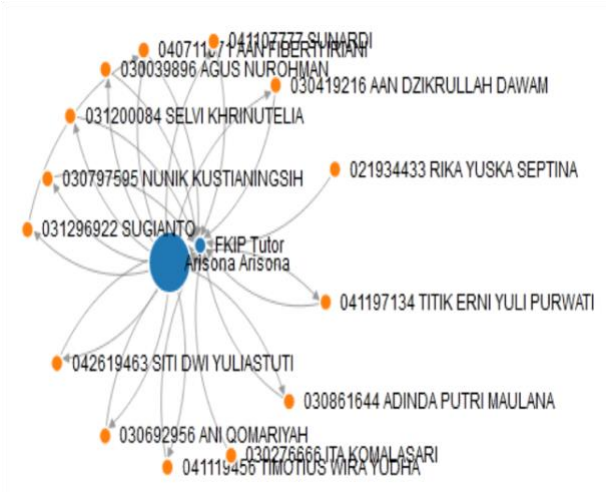

Figure 3. Interaction map of a representative discussion group

The relationship between student participation in discussions and their assignment performance was also examined. As presented in Table 3, students who actively participated in the forums and whose contributions reached higher levels of cognitive presence tended to achieve higher assignment scores. Conversely, students who posted infrequently or whose postings remained at lower cognitive levels generally obtained lower assignment results. Although causality cannot be definitively inferred, this pattern suggests that active and higher-order engagement in asynchronous discussions may be positively associated with learning outcomes in physics assignments.

Table 2. Comparison of discussion scores and assignment performance

Student	D1	D2	D3	D4	D5	D6	D7	D8	Discussion average score	T1	T2	T3	Average assignment
TWY	95	100	100	100	100	100	100	95	99	90	100	100	97
AFI	95	100	100	100	90	95	100	100	98	90	95	100	95
ANR	90	100	100	100	100	90	100	100	98	90	90	90	90
TYP	95	100	90	95	100	100	95	100	97	90	90	95	92
ADD	95	95	100	100	100	85	100	100	97	85	95	90	90
SNR	95	100	100	100	100	95	90	90	96	85	90	80	85
NKN	95	100	100	95	95	95	90	95	96	85	90	90	88
RYS	95	100	100	95	95	95	95	85	95	90	90	95	92
AQR	95	100	90	100	100	90	90	85	94	85	95	95	92
SKT	95	100	100	90	95	90	90	90	94	75	-	90	55
APM	90	100	90	95	90	90	90	95	93	85	90	90	88
SGT	90	90	100	90	90	90	90	100	93	75	95	90	87
IKS	90	100	100	95	100	-	100	95	85	80	95	100	92
RSG	-	90	95	90	100	100	90	85	81	80	90	90	87
SDY	100	100	100	100	-	60	-	-	58	90	90	-	60
ADT	-	-	-	-	-	-	-	-	-	80	-	-	27
LMD	-	-	-	-	-	-	-	-	-	-	85	-	28
SRT	-	-	-	-	-	-	-	-	-	-	-	-	-
MIL	-	-	-	-	-	-	-	-	-	-	-	-	-

The findings of this study revealed that while students frequently accessed asynchronous forums, their active contributions through postings were limited, resulting in a prevalence of passive participation or lurking. Beaudoin (2002) characterized lurkers as students who learn by observing but rarely contribute, a behavior that has been consistently observed in online education. Similarly, Lee and Choi (2011) emphasized that many learners read messages without responding, thereby restricting dialogic exchanges that sustain collaborative knowledge construction. In the present study, the disparity between the high number of views and relatively few postings, as reported in Table 1, illustrates this phenomenon. Such passive engagement undermines the development of community, which Rovai (2000) argued is critical for persistence and satisfaction in online learning.

The cognitive presence analysis provides deeper insight into the quality of participation. As shown in Figure 2, the majority of postings were concentrated at the triggering and exploration phases, with only a small percentage advancing to integration and resolution. According to Garrison et al. (2000), these latter phases are essential for higher-order learning, as they involve synthesizing information and applying knowledge to resolve problems. However, reaching these levels remains a challenge in asynchronous environments. Shea and Bidjerano (2009) confirmed that while online discussions are effective for initiating inquiry, they often fall short in fostering deeper integration. Akyol and Garrison (2011) similarly observed that cognitive presence typically develops only partially in online learning settings, suggesting that structured interventions are needed to support students' progression. In the context of physics education, where conceptual understanding requires integration of abstract ideas, the predominance of lower-level contributions suggests that the forums functioned primarily as platforms for information exchange rather than deeper cognitive engagement.

The structure of participation also shaped these outcomes. As depicted in Figure 3, tutors emerged as the central nodes in interaction networks, with most messages directed to them rather than among students. Dawson (2008) argued that networks with low density and reciprocity limit opportunities for building a genuine community of learners. Further demonstrated that SNA often reveals centralization in online discussions, with instructors functioning as hubs while peer-to-peer interactions remain minimal. In this study, the tutor-centered patterns confirmed that while teaching presence was strong, social presence among peers was weak, thereby constraining the development of higher cognitive presence. Anderson et al. (2003) highlighted that effective online learning requires a balance between teaching, social, and cognitive presence; when social presence is underdeveloped, collaborative inquiry is difficult to sustain.

The relationship between participation and performance provides further evidence of the importance of active engagement. Table 2 showed that students who contributed more frequently

and at higher cognitive levels achieved stronger assignment scores. Hrastinski (2008) noted that active participation in online discussions enhances learning by supporting reflection and collaborative meaning-making. Similarly, Davies and Graff (2005) reported that higher participation in online discussions was positively associated with academic achievement. In this study, while causality cannot be assumed, the consistent trend across groups suggests that asynchronous forums have the potential to improve student outcomes when participation is meaningful.

The limited peer-to-peer interaction observed in this study may also be explained by contextual and pedagogical factors. Hu and Wu (2011) noted that unstructured asynchronous discussions often result in surface-level exchanges, as students lack guidance on how to build on peers' ideas. Darabi et al. (2011; 2013) demonstrated that structured prompts and scaffolding strategies can significantly enhance the depth of online discourse. In addition, cultural norms in educational settings where authority is concentrated on instructors may reinforce tutor-dominated exchanges, as suggested by Lee and Choi (2011), who identified both external and internal factors influencing persistence in online courses. Cho and Tobias (2016) and Sadaf and Olesova (2017) further highlighted the importance of instructor facilitation strategies, such as Socratic questioning, in encouraging peer-to-peer dialogue. In the case of Universitas Terbuka, infrastructural challenges and students' lack of confidence in expressing complex ideas likely contributed to the reliance on tutors, as indicated by the consistently tutor-centered networks.

These findings have important implications for the design and facilitation of asynchronous discussions in physics education. The limited presence of integration and resolution phases indicates the need for more purposeful prompts that require synthesis, critique, and application. Research has shown that problem-based and case-driven prompts can encourage higher-order thinking (Darabi et al., 2013). Tutor training is also essential to equip facilitators with strategies for weaving student contributions, redistributing attention, and encouraging peer engagement rather than serving as the sole source of feedback. Without such scaffolds, discussions risk remaining tutor-led and surface-level, as evidenced in this study.

At the same time, this study makes a methodological contribution by combining log data, content analysis of cognitive presence, and social network mapping to triangulate findings. Many studies of online learning rely primarily on self-reported surveys, which provide limited insight into actual behaviors. By integrating behavioral, discourse, and structural indicators, this study provides a more comprehensive picture of participation in asynchronous forums. Nevertheless, some limitations must be acknowledged. The study was limited to one course with a relatively small cohort, which may restrict the generalizability of results. Moreover, off-platform

interactions could not be captured by LMS logs, leaving open the possibility that some collaboration occurred outside the recorded environment.

IV. CONCLUSION AND SUGGESTION

The results of this study demonstrated that although students frequently accessed the asynchronous discussion forums, their active participation through postings was limited. Most contributions were concentrated at the lower levels of cognitive presence, with only a small proportion progressing to integration and resolution. Interaction mapping further revealed that discussions were predominantly tutor-centered, with minimal peer-to-peer exchanges. Despite these limitations, students who participated more actively and at higher cognitive levels tended to achieve stronger assignment scores, indicating a positive relationship between meaningful engagement in asynchronous discussions and academic performance in physics.

This study has several limitations. It was conducted in a single course with a relatively small cohort, which may limit the generalizability of the findings. Furthermore, off-platform interactions were not captured, leaving open the possibility that additional collaboration occurred outside the recorded environment. Future research should investigate larger and more diverse cohorts, employ experimental designs to test the effectiveness of specific facilitation strategies, and explore the integration of structured prompts and scaffolds to foster higher-order engagement. Despite its limitations, this study contributes to the field of physics education by providing empirical evidence from an open and distance learning context, highlighting both the challenges and opportunities of asynchronous discussions. By triangulating log data, cognitive presence analysis, and social network mapping, the study advances understanding of how online forums function in physics education and offers insights for improving the design and facilitation of asynchronous learning environments.

REFERENCES

Akyol, Z., & Garrison, D. R. (2011). Assessing metacognition in an online community of inquiry. *The Internet and Higher Education, 14*(3), 183–190. https://doi.org/10.1016/j.iheduc.2011.01.005

Albrahim, F. A. (2020). Online teaching skills and competencies. *Turkish Online Journal of Educational Technology, 19*(1), 9–20. https://eric.ed.gov/?id=EJ1239983

Alhazmi, L. S. S., Bawadood, M. A. A., Aljohani, A. M. S., Alzahrani, A. A. R., Moshref, L., Trabulsi, N., & Moshref, R. (2021). Pain management in breast cancer patients: A multidisciplinary approach. *Cureus Journal of Medical Science, 13*(6), 1-5. https://doi.org/10.7759/cureus.15994

Alzahrani, M. G. (2017). The effect of using online discussion forums on students' learning. *Turkish Online Journal of Educational Technology, 16*(1), 164–176. https://eric.ed.gov/?id=EJ1124930

Anderson, G., Barton, S., & Wahlberg, M. (2003). Reflections and experiences of further education research in practice. *Journal of Vocational Education and Training, 55*(4), 499–516. https://www.tandfonline.com/doi/abs/10.1080/13636820300200241

Azizah, E. C. I., Aryadita, H., & Herlambang, A. D. (2018). Evaluasi kualitas website forum diskusi online menggunakan metode Webqual 4.0 dan importance performance analysis (Studi Kasus Pada Website Dictio). *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer, 2*(8), 2549–2559. https://j-ptiik.ub.ac.id/index.php/j-ptiik/article/view/1850

Bao, W. (2020). COVID-19 and online teaching in higher education: A case study of Peking University. *Human Behavior and Emerging Technologies, 2*(2), 113–115. https://doi.org/10.1002/hbe2.191

Barman, L., Engquist, M., Jansson, M., & Enoksson, F. (2019). Interactions in online discussion forums – An underutilized resource for learning? In *2019 IEEE Frontiers in Education Conference (FIE)*, 1–5. https://doi.org/10.1109/FIE43999.2019.9028512

Beaudoin, M. F. (2002). Learning or lurking? Tracking the "invisible" online student. *The Internet and Higher Education, 5*(2), 147–155. https://doi.org/10.1016/S1096-7516(02)00086-6

Breivik, J. (2020). Argumentative patterns in students' online discussions in an introductory philosophy course. *Nordic Journal of Digital Literacy, 15*(1), 8–23. https://doi.org/10.18261/issn.1891-943x-2020-01-02

Bunyamin, A., Arwizet, K., Aziz, A., & Ambiyar. (2019). Penerapan metode belajar diskusi berbantuan Google Classroom untuk meningkatkan hasil belajar gambar teknik mesin siswa kelas X teknik pengelasan SMK Negeri 1 Kecamatan Guguak. *Ranah Research: Journal of Multidisciplinary Research and Development, 2*(1), 213-219. https://jurnal.ranahresearch.com/index.php/R2J/article/view/212

Chai, H., Liu, Z., Hu, T., & Li, Q. (2020). A new conceptual framework for measuring online listening in asynchronous discussion forums. In N. Pinkwart & S. Liu (Eds.), *Artificial intelligence supported educational technologies*, 7–70. Springer International Publishing. https://doi.org/10.1007/978-3-030-41099-5_4

Cho, M. H., & Tobias, S. (2016). Should instructors require discussion in online courses? Effects of online discussion on community of inquiry, learner time, satisfaction, and achievement. *The International Review of Research in Open and Distributed Learning, 17*(2), 123–140. https://doi.org/10.19173/irrodl.v17i2.2342

Darabi, A., Arrastia, M. C., Nelson, D. W., Cornille, T., & Liang, X. (2011). Cognitive presence in asynchronous online learning: A comparison of four discussion strategies. *Journal of Computer Assisted Learning, 27*(3), 216–227. https://doi.org/10.1111/j.1365-2729.2010.00392.x

Darabi, A., Liang, X., Suryavanshi, R., & Yurekli, H. (2013). Effectiveness of online discussion strategies: A meta-analysis. *American Journal of Distance Education, 27*(4), 228–241. https://doi.org/10.1080/08923647.2013.837651

Davies, J., & Graff, M. (2005). Performance in e-learning: Online participation and student grades. *British Journal of Educational Technology, 36*(4), 657–663. https://doi.org/10.1111/j.1467-8535.2005.00542.x

Dawson, G. (2008). Early behavioral intervention, brain plasticity, and the prevention of autism spectrum disorder. *Development and Psychopathology, 20*(3), 775–803. https://doi.org/10.1017/S0954579408000370

Fatmawati, S. (2019). Efektivitas forum diskusi pada e-learning berbasis Moodle. *Refleksi Edukatika: Jurnal Ilmiah Kependidikan, 9*(2), 210–216. https://doi.org/10.24176/re.v9i2.3379

Garrison, D. R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education, 2*(2–3), 87–105. https://doi.org/10.1016/S1096-7516(00)00016-6

Gosmire, D., Morrison, M., & Van Osdel, J. (2009). Perceptions of interactions in online courses . *Journal of Instructional Psychology, 5*(4), 609-617. https://www.researchgate.net/publication/242088057_Perceptions_of_Interactions_in_Online_Courses

Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020). The difference between emergency remote teaching and online learning. *Educause Review*. https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning

Hrastinski, S. (2008). Asynchronous and synchronous e-learning. *Educause Quarterly, 31*(4), 51–55. https://er.educause.edu/articles/2008/11/asynchronous-and-synchronous-elearning

Hu, H., & Wu, M. (2011). Important photon emission results reported by Michael Persinger's group. *Journal of Consciousness Exploration & Research, 2*(10), 1555–1556. https://jcer.com/index.php/jcj/article/view/192/209

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33*(1), 159–174. https://doi.org/10.2307/2529310

Lederman, D. (2020). Will shift to remote teaching be boon or bane for online learning? *Inside Higher Ed.* https://www.insidehighered.com/digital-learning/article/2020/03/18/most-teaching-going-remote-will-help-or-hurt-online-learning

Lee, Y., & Choi, Y. (2011). A review of online course dropout research: Implications for practice and future research. *Educational Technology Research and Development, 59*(5), 593–618. https://doi.org/10.1007/s11423-010-9177-y

Martin, F., Wang, C., & Sadaf, A. (2018). Student perception of helpfulness of facilitation strategies. *The Internet and Higher Education, 37,* 52–65. https://doi.org/10.1016/j.iheduc.2018.01.003

Mehall, S. (2020). Purposeful interpersonal interaction in online learning: What is it and how is it measured? *Online Learning, 24*(1), 182–204. https://doi.org/10.24059/olj.v24i1.2002

Pratama, H., & Yusro, A. C. (2016). Implementasi WhatsApp mobile learning untuk meningkatkan hasil belajar mahasiswa pokok bahasan pengenalan komponen elektronika.

Jurnal Pendidikan Fisika dan Keilmuan, 2(2), 65–69. https://doi.org/10.25273/jpfk.v2i2.696

Prayuda, J., & Malik, A. A. (2021). Efektivitas komunikasi terhadap proses belajar dalam pembelajaran online. *Da'wah and Communication Islamic Journal, 2*(1), 33-40. https://www.siducat.org/index.php/dawuh/article/view/205

Rajab, M. H., Gazal, A. M., & Alkattan, K. (2020). Challenges to online medical education during the COVID-19 pandemic. *Cureus, 12*(7), 1-8. https://doi.org/10.7759/cureus.8966

Rasheed, R. A., Kamsin, A., & Abdullah, N. A. (2020). Challenges in the online component of blended learning: A systematic review. *Computers & Education, 144,* 1-17. https://doi.org/10.1016/j.compedu.2019.103701

Rovai, A. P. (2000). Building and sustaining community in asynchronous learning networks. *The Internet and Higher Education, 3*(4), 285–297. https://doi.org/10.1016/S1096-7516(01)00037-9

Sadaf, A., & Olesova, L. (2017). Enhancing cognitive presence in online case discussions with questions based on the practical inquiry model. *American Journal of Distance Education, 31*(1), 56–69. https://doi.org/10.1080/08923647.2017.1267525

Shea, P., & Bidjerano, T. (2009). Community of inquiry as a theoretical framework to foster "epistemic engagement" and "cognitive presence" in online education. *Computers & Education, 52*(3), 543–553. https://doi.org/10.1016/j.compedu.2008.10.007

Simanullang, N. H. S., & Rajagukguk, J. (2020). LMS based on Moodle to improve students learning activity. *Journal of Physics: Conference Series, 1462*(1), 1-7. https://doi.org/10.1088/1742-6596/1462/1/012067

Singh, V., & Thurman, A. (2019). How many ways can we define online learning? A systematic literature review of definitions of online learning. *American Journal of Distance Education, 33*(4), 289–306. https://doi.org/10.1080/08923647.2019.1663082

Sun, A., & Chen, X. (2016). Online education and its effective practice: A research review. *Journal of Information Technology Education: Research, 15,* 157–190. https://doi.org/10.28945/3502

Toquero, C. M. (2020). Challenges and opportunities for higher education amid the COVID-19 pandemic: The Philippine context. *Pedagogical Research, 5*(4), 1-5. https://doi.org/10.29333/pr/7947

van der Dennen, J. M. (2002). (Evolutionary) Theories of warfare in preindustrial (foraging) societies. *Neuro Endocrinology Letters, 23*(Suppl 4), 55–65. https://www.researchgate.net/publication/10977857_Evolutionary_Theories_of_warfare_in_preindustrial_foraging_societies

Wu, S.-Y., Hwang, W.-Y., Hou, H.-T., & Liu, E. Z.-F. (2011). A case study of Seamless Online Learning Integrated Discussion. *2011 International Conference on Electrical and Control Engineering*, 6205–6208. https://doi.org/10.1109/ICECENG.2011.6056861