JOLLS: Journal of Language and Literature Studies
Website: https://journal-center.litpam.com/index.php/jolls/index
Email: jolls@litpam.com
DOI: https://doi.org/10.36312/jolls.v3i2.1343

November 2023 Vol. 3, No. 2
e-ISSN: 2808-1099
pp. 135-147

The Efficacy of Process-Tracing Technologies for Supporting Academic Writing Instruction: A Lesson Learned from Vietnam

[1*]Huang Yan Wang, [2]Sammy Q. Dolba, [3]Alex Zamorano

[1]English Department Program, Can Tho University, Vietnam
[2]Faculty of Social Science, Philippine Normal University, City of Manila, Philippines
[3]CLIL program, University of UC Leuven-Limburg, Belgium

*Corresponding Author e-mail: phyen_wang@ctu.edu.vn

Received: June 2023; Revised: August 2023; Published: November 2023

Abstract

Writing-process research has undergone a transformative shift from relying on methods that were impractical for classroom settings, such as direct or video-based observations and concurrent verbal reports, to adopting less-obtrusive techniques like keystroke logging and eye tracking. The latter methods have become increasingly feasible due to the resolution of software and cost-related concerns, making them more accessible for pedagogical applications. Therefore, this study aims to investigate the efficacy of process-tracing technology for supporting academic writing instruction at a middle school in Vietnam. To carry out the research process, the researchers applied qualitative study. The participants in this study comprise a group of learners attending a middle school in Vietnam. Their involvement in the research revolves around the meticulous tracing of their writing process as they engage in the production of argumentative texts, with a particular focus on the utilization of technology during this endeavor. Data collection involved the application of both interviews and observations to gather comprehensive insights into the phenomenon under investigation. The findings of the study showed that process-tracing technology is able to help teachers and learners to control their academic writing achievement. The conclusion showed that the integration of process-tracing technology, combining keystroke logging and eye tracking, has proven to be a highly effective and valuable tool for supporting academic writing.

Keywords: process-based approcah; technology; academic writing

How to Cite: Wang, H. Y., Dolba, A. Q., & Zamorano, A. (2023). The Efficacy of Process-Tracing Technologies for Supporting Academic Writing Instruction: A Lesson Learned from Vietnam. *Journal of Language and Literature Studies,* 3(2), 135-147. doi: https://doi.org/10.36312/jolls.v3i2.1343

https://doi.org/10.36312/jolls.v3i2.1343

INTRODUCTION

A comprehensive examination of the existing literature on the writing processes in English as a Foreign Language (EFL) reveals a diverse array of valuable insights that hold significant relevance for writing educators (Al Zumor, 2021; Alghasab, 2020). One noteworthy discovery is that EFL writers demonstrate a greater generation of superior ideas, achieved at a heightened pace when they engage in free-writing techniques as opposed to employing pre-task planning in the development of both argumentative essays (Abbas & Herdi, 2018; Labinaz & Sbisà, 2018) and descriptive essays (Erickson, 2022). Additionally, it has been observed that these writers allocate varying amounts of time to different cognitive processes, a practice influenced by their proficiency level. As their proficiency increases, the time dedicated to planning and revising shows a consistent upward trend.

Furthermore, EFL writers exhibit distinctive patterns in their text reexamination, notes review, and task prompt assessment, with these practices being contingent upon their personalized approaches to task completion (Al- Zyoud et al., 2017; Boggs, 2019). Another interesting observation is that when writing under time constraints, EFL writers tend to make lower-level revisions more frequently than higher-level revisions (Astiantih & Akfan, 2023; Bakla, 2020). These lower-level revisions primarily entail content additions rather than content substitutions or reordering. These findings collectively contribute to a deeper understanding of the EFL writing process and offer valuable guidance to educators seeking to enhance writing instruction in EFL contexts. By incorporating these insights into pedagogical practices, writing teachers can effectively support the growth and development of EFL students as proficient and effective writers.

The existence of definitive writing-process formulae that consistently lead to high-quality writing is brought into question by compelling research findings. Even in the early stages of advocating the process-writing approach, scholars acknowledged this reality. For instance, Fadli et al. (2022) emphasized that the diversity of writers, tasks, and contexts necessitates the adoption of various strategies, which educators must aid learners in developing. However, this task is complicated by the scarcity of information regarding how EFL learners actually undertake the writing process and produce the texts they submit for feedback and evaluation (Del Campo et al., 2015; Dwigustini et al., 2021). Specifically, many instructors possess limited knowledge concerning the types of planning, if any, employed by their learners and how such planning influences text production (Elola & Oskoz, 2016; Hadi et al., 2021; Lating, 2022). Furthermore, instructors are often in the dark regarding the amount of time learners dedicate to different writing processes and whether this engagement proves effective and efficient.

Another notable uncertainty is whether students thoroughly review their texts before submission. The dearth of data on learners' uptake of process-oriented instruction can lead to instructors becoming disheartened with process-writing approaches, potentially causing them to restrain their utilization of the abundant knowledge derived from the EFL writing-process literature (Bai & Wang, 2020; Rafida, 2017). To address this issue, it becomes imperative to conduct comprehensive research that delves into the actual practices and behaviors of EFL learners during the writing process. By gathering robust data on students' writing approaches and the efficacy of various strategies, instructors can gain a more profound understanding of how to tailor writing instruction to individual needs (Balgopal & Wallace, 2009; Barrot, 2016; Chapelle, 2012). Such informed pedagogical practices can revitalize process-writing approaches, empowering educators to fully harness the wealth of knowledge offered by the EFL writing-process literature and ultimately foster more effective and competent EFL writers.

Over time, writing-process research has undergone a transformative shift from relying on methods that were impractical for classroom settings, such as direct or video-based observations and concurrent verbal reports (de Kleine & Lawton, 2018; Fan & Xu, 2020), to adopting less-obtrusive techniques like keystroke logging and eye tracking. The latter methods have become increasingly feasible due to the resolution of software and cost-related concerns, making them more accessible for pedagogical applications. As part of a recent project, we delved into the potential benefits of leveraging these technologies to enhance EFL writing instruction, a comprehensive account of which is presented in this article. To guide our investigation, a central research question framed the study, focusing on how teachers effectively implement process-traced technology to support academic writing. This question aimed to shed light on the practical implementation of these cutting-edge tools in real educational settings and explore their role in enhancing the writing process and outcomes for EFL learners. By closely examining the experiences and

strategies of teachers utilizing process-traced technology, we sought to uncover valuable insights into the integration of these innovative approaches within the realm of EFL writing instruction. The findings from this study hold the potential to inform and enrich writing pedagogy by harnessing the unique affordances of advanced technologies for the benefit of both teachers and students alike.

RESEARCH METHOD

In order to ascertain the efficacy of the process-tracing technology in the context of supporting learners' academic writing practices, it becomes imperative to employ a rigorous and appropriate research design. In this regard, researchers made a deliberate choice to adopt an essentially qualitative case-study research design, recognizing that such an approach would offer the opportunity for in-depth exploration and a fine-grained analysis of a relatively small dataset (Cohen et al., 2018). This methodological decision aimed to delve deeply into the complexities and nuances of the process-tracing technology's impact on learners' writing behaviors, allowing for a comprehensive understanding of the underlying dynamics at play. Moreover, the utilization of a qualitative case-study design also served the purpose of providing valuable insights that could be directly applicable to teachers contemplating the integration of process-tracing technology in their instructional practices (Cohen et al., 2018; Miles et al., 2016).

By examining the technology's influence on learners' writing practices through a qualitative lens, the analysis generated rich and context-specific information that could be of practical value to educators seeking to optimize their students' writing experiences. The dataset selected for this investigation was thoughtfully curated to encompass a diverse range of perspectives on the writing activities facilitated by teachers. This inclusive approach to data collection aimed to capture a comprehensive portrayal of how the process-tracing technology interacted with various pedagogical strategies and learner characteristics. As a result, the study's findings were not only robust and relevant but also capable of offering valuable recommendations for teachers seeking to leverage process-tracing technology effectively to enhance their students' academic writing abilities.

The participants in this study comprise a group of learners attending a middle school in Vietnam. Their involvement in the research revolves around the meticulous tracing of their writing process as they engage in the production of argumentative texts, with a particular focus on the utilization of technology during this endeavor. Through this investigation, the researchers aim to gain valuable insights into the intricate dynamics and strategies employed by these learners as they harness technology to craft persuasive written compositions. The decision to center the study on learners at the middle school level is deliberate, as this developmental stage marks a crucial period of academic growth and cognitive development. Middle school learners are at a stage where they are gradually honing their writing skills and adapting to an increasingly technology-driven learning environment. As such, understanding how they navigate and utilize technology to construct argumentative texts is of utmost importance, as it may shed light on the evolving nature of writing practices in contemporary educational settings.

In this research study, data collection involved the application of both interviews and observations to gather comprehensive insights into the phenomenon under investigation. The researchers adopted a purposive sampling technique to select participants deliberately, ensuring that individuals with relevant experiences and perspectives related to the research objectives were included in the study. The data collected through interviews and observations were analyzed using qualitative methods, particularly an open-ended approach, which allowed for the exploration of diverse viewpoints and the in-depth examination of participants' responses. During the interview

phase, the researchers employed open-ended questions, formulated to elicit comprehensive and detailed responses from the participants. These questions were intentionally broad, aiming to encourage participants to freely express their thoughts, experiences, and attitudes related to the topic.

The researchers carefully considered and probed further into the information provided by participants, seeking to uncover underlying themes and patterns that could offer deeper insights into the phenomenon being studied. In addition to interviews, the researchers also employed observations to complement the data collection process. Through direct observation of participants' behaviors and interactions, the researchers sought to capture nuanced aspects of their experiences and actions that might not be fully articulated in interviews. Observation allowed the researchers to gain a holistic understanding of the participants' behaviors and the context in which they operated, enriching the data and adding contextual depth to the analysis. Upon collecting the data, the researchers engaged in a qualitative analysis, which involved a systematic examination of the information supplied by participants. By carefully reviewing the interview transcripts and observational notes, the researchers identified recurrent themes, patterns, and emerging concepts. This iterative process of data analysis allowed for the refinement and development of a comprehensive analysis that addressed the research questions and objectives.

RESULTS AND DISCUSSION

This research project took place within the context of an English as a Foreign Language (EFL) writing program at a middle school in Vietnam. The program comprised two sequenced courses, each with distinct objectives. The lower-level course focused on developing skills in crafting shorter essays and emphasized the process of writing, while the higher-level course involved more extended papers and placed a significant emphasis on genre-specific writing conventions. In order to facilitate the integration of technology into writing instruction, one class session per week was conducted in a computer lab, providing students with access to essential digital resources and tools to support their writing endeavors. The majority of students enrolled in these courses were native Vietnamese speakers, while the second-most common first languages represented among the learners were Filipino (Philippines) and Arabic. In accordance with ethical guidelines and considerations, the researchers were unable to directly implement their project within the ongoing courses. Instead, they recruited learners from these courses and offered compensation for their voluntary participation in additional writing tasks outside of regular class hours.

These supplementary writing tasks were designed to simulate the format and requirements of an individual writing conference, offering learners a more personalized and targeted writing experience (Cordeiro et al., 2018; Curwood et al., 2017). The selected participants were assigned a series of four argumentative writing tasks, each consisting of 400 words. The choice of argumentative writing tasks was deliberate, as previous research had suggested that this genre elicited more complex combinations of cognitive processes compared to narratives. By utilizing this task structure, the researchers aimed to observe and analyze a wide range of cognitive strategies and decision-making processes employed by the learners during the writing task, with the ultimate goal of gaining valuable insights into their writing practices and the integration of technology (Alkhataba et al., 2018; Daniel & Christopher, 2018). The decision to focus on argumentative writing tasks aligned with the broader objectives of the research project, which aimed to explore the impact of technology integration on learners' writing processes and outcomes. Through the careful selection of writing tasks and the recruitment of learners from the existing courses, the

researchers were able to construct a controlled and meaningful study design that yielded valuable findings on the interplay between technology integration and the cognitive processes involved in argumentative writing tasks in an EFL context.

The writing and process tracing components of this study were executed using the CyWrite system, a web-based tool specifically developed by the authors for this research. CyWrite offered participants a user-friendly text editor that closely resembled conventional word-processing software, facilitating a familiar writing experience (Azis & Husnawadi, 2020; Curwood et al., 2017). However, what set CyWrite apart was its capability to simultaneously capture the writing process through a combination of Keystroke Logging and Eye Tracking technologies. As participants responded to the writing tasks, the CyWrite editor adeptly recorded detailed logs of their keystrokes, text modifications, and eye fixations in a time-aligned manner. The collection of millisecond-level keystroke timings was achieved programmatically using event handlers within the JavaScript code that executed in the user's web browser. This enabled the precise tracking of writing actions and the temporal sequences in which they occurred, providing a rich dataset for subsequent analysis. To integrate Eye Tracking (ET) into the process tracing, the researchers employed a GazePoint GP3, a consumer-grade eye-tracking device available at a reasonable cost of approximately $700 USD.

The eye tracker was thoughtfully positioned beneath the computer screen, allowing participants to maintain a natural writing posture while their eye movements were monitored during the writing process (Fatiani et al., 2021; Fauzan & Ngabut, 2018). The real-time feed of eye-fixation coordinates generated by the eye tracker was seamlessly interfaced with the CyWrite editor, enabling the concurrent tracking of eye movements and writing actions in an unobtrusive manner. The use of the CyWrite system, with its integrated Keystroke Logging and Eye Tracking functionalities, offered a comprehensive and detailed understanding of participants' writing processes. This unique combination of technologies provided researchers with an extensive dataset, enabling them to examine the intricate interplay between cognitive writing processes and eye movements in real-time (Haerazi et al., 2020; Naghdipour, 2022). By leveraging the capabilities of the CyWrite system and the GazePoint GP3 eye tracker, this study advanced the field of process-oriented writing research, offering novel insights into the writing process in a technologically mediated environment. Moreover, the use of a consumer-grade eye tracker demonstrated the feasibility and affordability of incorporating Eye Tracking technology into writing process research, making it more accessible for future investigations in diverse educational and academic settings.

The first and most essential affordance of this technology was that it allowed individual students' engagement in processes to be observed in great detail and problems with that engagement to be diagnosed (Sharma, 2022; Shintani, 2016; Shintani & Ellis, 2013). The integration of the process graph and playback functionalities in the CyWrite system proved to be invaluable for instructors, as it provided them with unique insights into the actual writing process followed by students when producing their submissions for evaluation. By encouraging students to perform all their planning work, such as brainstorming and outlining, within the CyWrite editor, the system was able to trace and capture all the major stages of the writing process. These process traces were then transformed into web-based, interactive visualizations (Roderick, 2019; Troyan, 2016), enabling instructors to comprehensively review and assess students' writing practices. For illustrative purposes, Figure 1 presents a process graph showcasing the writing process of a lower-level student, identified as "Wang," during his completion of the first writing task. This particular essay was produced in a single session spanning approximately 90 minutes.

The process graph revealed that the initial 12 minutes of Wang's writing session were dedicated to intensive reading and rereading of the writing prompt, represented by a dense yellow area in the graph. Subsequently, the playback feature provided a dynamic representation of Wang's actions during the writing process. Upon analyzing the playback, it became evident that Wang commenced formulating his response immediately after the initial reading phase, without relying on an external plan or organizational structure. This style of writing was characteristic of what could be described as a "knowledge-telling" approach, as demonstrated by the video excerpt from the playback (Wu et al., 2020; Xianwei et al., 2016). These observations shed light on Adam's initial engagement with the writing task and his preference for spontaneous composition over a systematic planning process. The availability of such detailed process graphs and playbacks not only offers a deeper understanding of individual students' writing strategies but also presents an opportunity for instructors to identify strengths and weaknesses in their writing practices. By visualizing the writing process in this manner, instructors can provide more targeted feedback and guidance to students, aiding in the development of more effective writing skills and approaches.

Throughout Wang's writing process, there were sporadic instances of formulation, interspersed with certain periods of inactivity referred to as "flatlining," where no formulation or other writing-related activity was detected (e.g., observed between the 40- and 45-minute marks). The data analysis further revealed several points at which Wang temporarily left the text editor, as evidenced by gaps in the colored lines representing his writing process. Video playback confirmed that these interruptions were primarily attributed to dictionary and translation-tool consultations (Haerazi & Irawan, 2019, 2020; Yundayani, 2018), indicating Wang's recourse to external references to aid in his writing. Wang's formulation efforts persisted until the 76-minute mark, at which juncture he scrolled back up to the top of the file to revisit the writing prompt and instructions. A subsequent interruption occurred as the eye-tracker required recalibration. However, once recalibration was complete, Wang resumed his formulation and rereading of the writing prompt. During this phase, a noteworthy revision episode surfaced as the only distinct revisionary action undertaken during the entire writing session.

This revision involved Wang introducing a second headword to form a compound noun phrase and replacing the term "sad" with "disappointed" in the second sentence (refer to the video excerpt for visual clarity). Curiously, no explicit indication of Wang rereading the entire text was evident in the process graph and video playback, suggesting a lack of comprehensive self-review throughout the writing session. The findings from this meticulous examination of Wang's writing process provide valuable insights into his cognitive strategies and the specific moments when he engaged in formulation, revision, and external reference consultations. Such a detailed understanding of an individual writer's approach can contribute to more targeted and effective writing instruction (Wu et al., 2020; Yoon & Kim, 2022; Zabihi, 2018), as well as guide the development of pedagogical interventions tailored to the writer's specific needs and challenges. Additionally, these findings underscore the potential of process tracing and eye-tracking methodologies in illuminating the intricacies of the writing process and its underlying cognitive dynamics, thereby enriching the field of writing research and pedagogy.

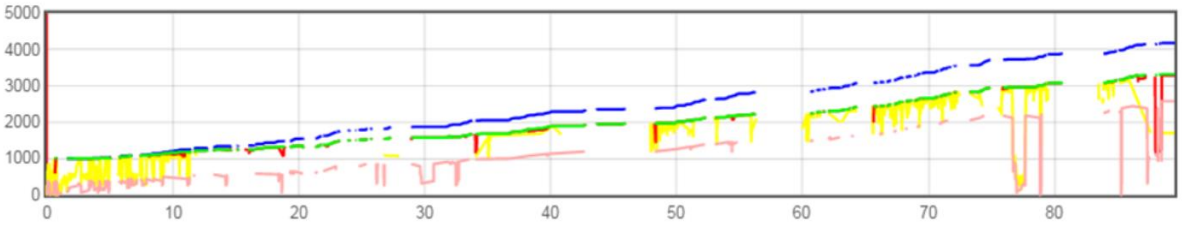

Figure 1. Wang's process graph for the first writing task, comprising a single session evidencing no external planning and minimal revision

Another lower-level student, identified as Mey, also completed the first writing task within a single session, dedicating approximately 80 minutes to the formulation process after initially spending about 10 minutes reading and rereading the writing prompt. Like Wang, Mey did not engage in any external planning, indicating a preference for spontaneous composition over structured pre-writing activities. However, Mey exhibited a distinct pattern of behavior in comparison to Wang during the writing session. Upon closer analysis of the process graph and video playback, it was evident that Mey allocated an additional 30 minutes to the revision phase towards the end of the writing session, as indicated by the presence of red and yellow areas below the green segment. The playback of this revision episode revealed that Mey's revisions predominantly involved word- and phrase-level changes (Rahmawati et al., 2018; Sampson et al., 2013; Wahid & Sudirman, 2023). While the nature of the revisions was relatively small-scale, many of them demonstrated improvements that notably enhanced the overall quality of the final written product. Despite the similarity in their writing stages, Mey's approach differed from Wang's in terms of her willingness to engage in revision and make constructive changes to her work. This key distinction signifies that Mey's writing development had progressed further along the continuum compared to Wang, who predominantly exhibited knowledge-telling characteristics in his writing process.

Notably, Mey's writing process suggests that she may be in the proximity of the knowledge-telling stage of writing development. However, her propensity for engaging in revision and demonstrating an understanding of how to refine her writing indicates that she occupies a more advanced position along the developmental continuum compared to Wang. The findings from Mey's writing session contribute to a deeper understanding of the diverse writing behaviors and developmental stages exhibited by lower-level students. By analyzing the specific cognitive strategies employed during the formulation and revision stages, educators can gain valuable insights into the individualized approaches to writing exhibited by different learners (Yundayani, 2018; Zabihi, 2018; Zhang et al., 2021). These insights, in turn, can inform pedagogical practices and interventions, providing targeted support to students based on their unique needs and stages of writing development. Additionally, this investigation further highlights the efficacy of process tracing and video playback in shedding light on the intricacies of the writing process and the dynamic nature of individual writing development, contributing to the advancement of writing research and instruction.

Model-writer data can also be used to demonstrate the processes of evaluation and revision, which researchers found to be particularly problematic for learners (Chapelle et al., 2015; Plakans et al., 2019). The video excerpt presented shows a writing session of more than 50 minutes that is entirely given over to these processes. The first and major

stage is devoted to addressing higher-level issues of content and discourse. The second, shorter session is spent dealing with local issues of grammar and expression. This example is also useful for showing how the text becomes shorter (reflected in the downward movement of the green product line) as evaluation and revision progress, as ideas are expressed more succinctly, and as unnecessary material is edited out. Some students found this particularly revelatory because their own revisions were restricted to adding, substituting, or, occasionally, repositioning material.

The process-writing approach to learning has a discernible impact on students' writing production, particularly concerning the quality and organization of their written products (Fadli et al., 2022; Fatiani et al., 2021; Haerazi & Kazemian, 2021). When students are afforded sufficient time to engage in the writing process, they have a valuable opportunity to thoughtfully structure and arrange their ideas before commencing the actual writing phase. The process-writing approach emphasizes the importance of pre-writing activities, such as brainstorming, outlining, and planning, to facilitate a comprehensive and coherent written composition (Dari et al., 2022; Kazemian et al., 2021). By allocating ample time for these preparatory stages, students can systematically develop their thoughts and arguments, resulting in well-organized and logically structured written work. Moreover, the process-writing approach encourages iterative writing practices, where students engage in multiple drafts and revisions to refine their ideas and arguments continuously.

With sufficient time at their disposal, students can revise and polish their work, addressing any areas of weakness or ambiguity, and enhancing the overall clarity and persuasiveness of their writing. Incorporating time for reflection and revision within the writing process enables students to internalize feedback and make informed decisions about content, style, and expression (Hadi & Karyadi, 2023; Sumarsono & Permana, 2023; Susilawati, 2023). This iterative approach fosters critical thinking skills and nurtures students' ability to self-assess and improve their writing, promoting a growth mindset towards writing. Furthermore, providing students with adequate time for the writing process helps mitigate the negative effects of writing under time pressure. When students are rushed and constrained by tight deadlines, they may sacrifice the opportunity to develop their ideas fully and resort to hurried writing, potentially resulting in less coherent and less sophisticated written products (Rachmaida & Mutiarani, 2022; Wismanto et al., 2022). In conclusion, the process-writing approach emphasizes the significance of time and the iterative nature of the writing process. Allowing students sufficient time to engage in pre-writing activities, multiple drafts, and revisions fosters the development of more organized, well-structured, and refined written compositions. By incorporating such time-sensitive practices into writing instruction, educators can empower students to become more effective and confident writers, capable of producing high-quality written work that reflects thoughtful content and compelling arguments.

CONCLUSION

In conclusion, the integration of process-tracing technology, combining keystroke logging and eye tracking, has proven to be a highly effective and valuable tool for supporting academic writing. Through the seamless capture and analysis of students' writing processes, this technology offers a unique and in-depth perspective into the intricate cognitive dynamics involved in the writing task. The detailed process graphs and video playbacks provided by the technology afford instructors an unprecedented opportunity to observe how students produce their written products and gain invaluable insights into their individual writing strategies. The use of keystroke logging allows for the precise tracking of writing actions, including keystrokes, text changes, and pauses,

providing a granular view of the writing process. Simultaneously, eye tracking complements this information by capturing students' eye movements, shedding light on their visual attention and cognitive focus during the writing task. The combination of these technologies offers a comprehensive understanding of how students engage with the writing prompt, plan their compositions, and make revisions, leading to a more holistic assessment of their writing proficiency.

The interactive visualizations generated by the process-tracing technology facilitate a dynamic and engaging review of students' writing processes. Instructors can explore the data in real-time, allowing for immediate feedback and targeted interventions to address specific writing challenges. This formative approach to assessment empowers students to actively participate in their writing development and fosters a growth mindset towards writing improvement. The application of process-tracing technology has also demonstrated its value in the identification of specific writing behaviors and tendencies, such as knowledge-telling or knowledge-transforming approaches. This valuable insight into students' cognitive strategies informs personalized instructional strategies tailored to their unique needs, fostering a more effective and adaptive approach to writing instruction. Overall, the efficacy of process-tracing technology for supporting academic writing is evident in its ability to enhance writing instruction, empower students to become more reflective and deliberate writers, and provide instructors with a comprehensive view of their students' writing processes.

RECOMMENDATION

The incorporation of process-tracing technology, encompassing both keystroke logging and eye tracking, holds immense promise as a transformative tool for supporting academic writing in educational settings. Based on the valuable insights gained from its implementation, we strongly recommend its widespread adoption in writing instruction. The real-time, in-depth analysis of students' writing processes provided by this technology offers instructors a novel and comprehensive perspective into their students' cognitive strategies, enabling personalized and targeted feedback that fosters continuous writing improvement. By encouraging students to engage in pre-writing activities within the process-tracing technology, educators can nurture a more deliberate and reflective approach to writing, instilling crucial skills of planning and revision. Moreover, the interactive visualizations generated by the technology enhance students' agency and engagement in the writing process, promoting a growth mindset towards writing proficiency. The identification of specific writing behaviors, such as knowledge-telling or knowledge-transforming approaches, facilitates a nuanced understanding of students' writing development, leading to tailored instructional strategies that address individual needs.

ACKNOWLEDGMENT

We extend our sincere appreciation and acknowledgement to researchers who have contributed to the development and advancement of process-tracing technology, integrating keystroke logging and eye tracking, for its invaluable support in academic writing. Their pioneering efforts have opened new avenues of exploration and understanding in the field of writing research and pedagogy. The seamless integration of keystroke logging and eye tracking has enabled us to gain unprecedented insights into the cognitive processes underlying students' writing behaviors, enriching our understanding of how they engage with writing tasks and make critical decisions during the writing process. We also extend our gratitude to the funding agencies and institutions that have supported and invested in the research and development of this technology.

REFERENCES

Abbas, M. F. F., & Herdi, H. (2018). Solving the Students' Problems in Writing Argumentative Essay Through Collaborative Writing Strategy. *English Review: Journal of English Education*, *7*(1), 105. https://doi.org/10.25134/erjee.v7i1.1499

Al Zumor, A. Q. (2021). Stance in Advanced Academic Writing by Saudi EFL Postgraduates: A Corpus-Based Study of Critique Writing. *Journal of Languages and Language Teaching*, *9*(4), 371. https://doi.org/10.33394/jollt.v9i4.4288

Al- Zyoud, A., Al Jamal, D., & Baniabdelrahman, A. (2017). Mind Mapping and Students' Writing Performance. *Arab World English Journal*, *8*(4), 280–291. https://doi.org/10.24093/awej/vol8no4.19

Alghasab, M. B. (2020). Flipping the Writing Classroom: Focusing on the Pedagogical Benefits and EFL Learners' Perceptions. *English Language Teaching*, *13*(4), 28. https://doi.org/10.5539/elt.v13n4p28

Alkhataba, E. H. A., Abdul-Hamid, S., & Ibrahim, B. (2018). Technology-Supported Online Writing: An Overview of Six Major Web 2.0 Tools for Collaborative-Online Writing. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3151131

Astiantih, S., & Akfan, S. S. (2023). Utilizing Concept Maps to Enhance Students' Writing Skills. *Journal of Languages and Language Teaching*, *11*(3), 433. https://doi.org/10.33394/jollt.v11i3.7993

Azis, Y. A., & Husnawadi, H. (2020). Collaborative Digital Storytelling-based Task for EFL Writing Instruction: Outcomes and Perceptions. *The Journal of AsiaTEFL*, *17*(2), 562–579. https://doi.org/10.18823/asiatefl.2020.17.2.16.562

Bai, B., & Wang, J. (2020). Conceptualizing self-regulated reading-to-write in ESL/EFL writing and investigating its relationships to motivation and writing competence. *Language Teaching Research*, 136216882097174. https://doi.org/10.1177/1362168820971740

Bakla, A. (2020). A mixed-methods study of feedback modes in EFL writing. *Language Learning*, *24*(1), 107–128. https://doi.org/10125/44712

Balgopal, M. M., & Wallace, A. M. (2009). Decisions and Dilemmas: Using Writing to Learn Activities to Increase Ecological Literacy. *The Journal of Environmental Education*, *40*(3), 13–26. https://doi.org/10.3200/JOEE.40.3.13-26

Barrot, J. S. (2016). Using Facebook-based e-portfolio in ESL writing classrooms: Impact and challenges. *Language, Culture and Curriculum*, *29*(3), 286–301. https://doi.org/10.1080/07908318.2016.1143481

Boggs, J. A. (2019). Effects of teacher-scaffolded and self-scaffolded corrective feedback compared to direct corrective feedback on grammatical accuracy in English L2 writing. *Journal of Second Language Writing*, *46*, 100671. https://doi.org/10.1016/j.jslw.2019.100671

Chapelle, C. A. (Ed.). (2012). Mobile-Assisted Language Learning. *The Encyclopedia of Applied Linguistics, Oxford: Wiley-Blackwell*. https://onlinelibrary.wiley.com/doi/10.1002/9781405198431.wbeal0768.pub2

Chapelle, C. A., Cotos, E., & Lee, J. (2015). Validity arguments for diagnostic assessment using automated writing evaluation. *Language Testing*, *32*(3), 385–405. https://doi.org/10.1177/0265532214565386

Cohen, L., Manion, L., & Morrison, K. (2018). *Research Methods in Education (8th Edition)*. New York: Routledge.

Cordeiro, C., Castro, S. L., & Limpo, T. (2018). Examining Potential Sources of Gender Differences in Writing: The Role of Handwriting Fluency and Self-Efficacy Beliefs.

Written Communication, *35*(4), 448–473. https://doi.org/10.1177/0741088318788843

Curwood, J. S., Lammers, J. C., & Magnifico, A. M. (2017). From Research to Practice: Writing, Technology, and English Teacher Education. In H. L. Hallman (Ed.), *Advances in Research on Teaching* (Vol. 27, pp. 121–141). Emerald Group Publishing Limited. https://doi.org/10.1108/S1479-368720170000027007

Daniel, R. B., & Christopher, J. (2018). The Effects of Online Collaborative Writing and TOEIC Writing Test- Preparation on L2 Writing Performance. *The Journal of AsiaTEFL*, *15*(2), 383–397. https://doi.org/10.18823/asiatefl.2018.15.2.8.383

Dari, R. W., Rahmawati, E., & Akhiriyah, S. (2022). An Analysis of Writing Strategies Used by Students of English Language Department. *Journal of Languages and Language Teaching*, *10*(3), 414. https://doi.org/10.33394/jollt.v10i3.5413

de Kleine, C., & Lawton, R. (2018). An analysis of grammatical patterns in generation 1.5, L1 and L2 students' writings: A replication study. *Journal of Second Language Writing*, *42*, 12–24. https://doi.org/10.1016/j.jslw.2018.10.003

Del Campo, R., Buchanan, W. R., Abbott, R. D., & Berninger, V. W. (2015). Levels of phonology related to reading and writing in middle childhood. *Reading and Writing*, *28*(2), 183–198. https://doi.org/10.1007/s11145-014-9520-5

Dwigustini, R., Sari, N., Susilawati, S., & Nisa, B. (2021). Fostering Students' Writing Skill by the Integration of Mall Application. *Journal of Languages and Language Teaching*, *9*(1), 34. https://doi.org/10.33394/jollt.v9i1.3264

Elola, I., & Oskoz, A. (2016). Supporting Second Language Writing Using Multimodal Feedback. *Foreign Language Annals*, *49*(1), 58–74. https://doi.org/10.1111/flan.12183

Erickson, E. (2022). An Analysis of Writers' Errors in Producing Descriptive Texts; Intercultural Studies. *Journal of Languages and Language Teaching*, *10*(3), 444. https://doi.org/10.33394/jollt.v10i3.5389

Fadli, K., Irawan, L. A., & Haerazi, H. (2022). English Teachers' Feedback on Students' Writing Work in the New Normal Era: Teachers' Feedback; Writing Skills. *Journal of Language and Literature Studies*, *1*(2), 83–92. https://doi.org/10.36312/jolls.v1i2.624

Fan, Y., & Xu, J. (2020). Exploring student engagement with peer feedback on L2 writing. *Journal of Second Language Writing*, *50*, 100775. https://doi.org/10.1016/j.jslw.2020.100775

Fatiani, T. A., Rahman, A., & Jupri, J. (2021). Practicing Cooperative Learning Model Using Picture Cube and Story Marker to Improve Writing Skills. *Journal of Language and Literature Studies*, *1*(1), 29–40. https://doi.org/10.36312/jolls.v1i1.500

Fauzan, A., & Ngabut, M. N. (2018). EFL Students' Perception on Flipped Learning in Writing Class. *Journal on English as a Foreign Language*, *8*(2), 115. https://doi.org/10.23971/jefl.v8i2.792

Hadi, M. S., Izzah, L., & Putra, A. D. (2021). Analysis of the Use of Banksy Image in Improving Students' Writing Skill. *Journal of Languages and Language Teaching*, *9*(4), 519. https://doi.org/10.33394/jollt.v9i4.4005

Hadi, M. S., & Karyadi, A. N. (2023). Can Social Media-Style Fanfiction Stories Enrich Students' Narrative Writing Mastery? *Journal of Languages and Language Teaching*, *11*(1), 123. https://doi.org/10.33394/jollt.v11i1.5814

Haerazi, H., & Irawan, L. A. (2019). Practicing Genre-Based Language Teaching Model to Improve Students' Achievement of Writing Skills. *IJELTAL (Indonesian Journal*

of English Language Teaching and Applied Linguistics), *4*(1), 9. https://doi.org/10.21093/ijeltal.v4i1.246

Haerazi, H., & Irawan, L. A. (2020). Developing Intercultural Language Learning (ILL) model to teach writing skills at Indonesian private universities. *EduLite: Journal of English Education, Literature and Culture*, *5*(1), 43. https://doi.org/10.30659/e.5.1.43-54

Haerazi, H., & Kazemian, M. (2021). *Self-Regulated Writing Strategy as a Moderator of Metacognitive Control in Improving Prospective Teachers' Writing Skills*. *1*(1), 1–14. https://doi.org/10.36312/ejolls.v1i1.498

Haerazi, H., Utama, I. M. P., & Hidayatullah, H. (2020). Mobile Applications to Improve English Writing Skills Viewed from Critical Thinking Ability for Pre-Service Teachers. *International Journal of Interactive Mobile Technologies (IJIM)*, *14*(07), 58. https://doi.org/10.3991/ijim.v14i07.11900

Kazemian, M., Irawan, L. A., & Haerazi, H. (2021). Developing Metacognitive Writing Strategy to Enhance Writing Skills Viewed from Prospective Teachers' Critical Thinking Skills. *Journal of Language and Literature Studies*, *1*(1), 14.

Labinaz, P., & Sbisà, M. (2018). Argumentation as a dimension of discourse: The case of news articles. *Pragmatics & Cognition*, *25*(3), 602–630. https://doi.org/10.1075/pc.18024.lab

Lating, A. Z. Y. (2022). The Improvement of the Students' Ability in Writing Procedure Text Using Video Recipe. *Journal of Languages and Language Teaching*, *10*(3), 461. https://doi.org/10.33394/jollt.v10i3.5328

Miles, M. B., Huberman, A. M., & Saldana, J. (2016). *Quantitative Data Analysis: A Methods Sourcebook (Third)*. Los Angeles: Sage Publication.

Naghdipour, B. (2022). ICT-enabled informal learning in EFL writing. *Journal of Second Language Writing*, *56*, 100893. https://doi.org/10.1016/j.jslw.2022.100893

Plakans, L., Liao, J.-T., & Wang, F. (2019). "I should summarize this whole paragraph": Shared processes of reading and writing in iterative integrated assessment tasks. *Assessing Writing*, *40*, 14–26. https://doi.org/10.1016/j.asw.2019.03.003

Rachmaida, F., & Mutiarani, M. (2022). The Use of Spinning Wheel Games to Improve Students' Writing Procedural Texts. *Journal of Languages and Language Teaching*, *10*(4), 530. https://doi.org/10.33394/jollt.v10i4.5766

Rafida, T. (2017). The Integration of Vocabulary and Effective Sentence Mastery towards Students' Argumentative Writing Skills. *Register Journal*, *10*(1), 1. https://doi.org/10.18326/rgt.v10i1.1-11

Rahmawati, F. S., Cahyono, B. Y., & Anugerahwati, M. (2018). Effect of story maps on EFL students' achievement in writing narrative texts. *Journal on English as a Foreign Language*, *8*(2), 130. https://doi.org/10.23971/jefl.v8i2.877

Roderick, R. (2019). Self-Regulation and Rhetorical Problem Solving: How Graduate Students Adapt to an Unfamiliar Writing Project. *Written Communication*, *36*(3), 410–436. https://doi.org/10.1177/0741088319843511

Sampson, V., Enderle, P., Grooms, J., & Witte, S. (2013). Writing to Learn by Learning to Write During the School Science Laboratory: Helping Middle and High School Students Develop Argumentative Writing Skills as They Learn Core Ideas: Writing to Learn by Learning to Write in Science. *Science Education*, *97*(5), 643–670. https://doi.org/10.1002/sce.21069

Sharma, D. (2022). Making Meaningful Connections and Learning Workplace-Like Business Writing Through LinkedIn and Blogging. *Business and Professional*

Communication Quarterly, *85*(3), 298–318. https://doi.org/10.1177/23294906221109188

Shintani, N. (2016). The effects of computer-mediated synchronous and asynchronous direct corrective feedback on writing: A case study. *Computer Assisted Language Learning*, *29*(3), 517–538. https://doi.org/10.1080/09588221.2014.993400

Shintani, N., & Ellis, R. (2013). The comparative effect of direct written corrective feedback and metalinguistic explanation on learners' explicit and implicit knowledge of the English indefinite article. *Journal of Second Language Writing*, *22*(3), 286–306. https://doi.org/10.1016/j.jslw.2013.03.011

Sumarsono, D., & Permana, D. (2023). Contract Learning as Individualized Instructional Strategies in Improving Students' Performance in Academic Writing Courses. *Journal of Languages and Language Teaching*, *11*(1), 94. https://doi.org/10.33394/jollt.v11i1.6683

Susilawati, S. (2023). Integrating Content and Language to Teach ESP Writing Online with the Assistance of Google Docs. *Journal of Languages and Language Teaching*, *11*(1), 14. https://doi.org/10.33394/jollt.v11i1.6617

Troyan, F. J. (2016). Learning to Mean in Spanish Writing: A Case Study of a Genre-Based Pedagogy for Standards-Based Writing Instruction. *Foreign Language Annals*, *49*(2), 317–335. https://doi.org/10.1111/flan.12192

Wahid, J. H., & Sudirman, S. (2023). The Effect of Mind Mapping Technique on Students' Writing Skills. *Journal of Languages and Language Teaching*, *11*(1), 39. https://doi.org/10.33394/jollt.v11i1.6692

Wismanto, A., Suyoto, S., & Ulumuddin, A. (2022). Developing an Instruction Model for News Writing Based on the Cooperatif Type Group Investigation Strategy. *Journal of Languages and Language Teaching*, *10*(2), 174. https://doi.org/10.33394/jollt.v10i2.4956

Wu, W.-C. V., Yang, J. C., Scott Chen Hsieh, J., & Yamamoto, T. (2020). Free from Demotivation in EFL Writing: The Use of Online Flipped Writing Instruction. *Computer Assisted Language Learning*, *33*(4), 353–387. https://doi.org/10.1080/09588221.2019.1567556

Xianwei, G., Samuel, M., & Asmawi, A. (2016). *A Model Of Critical Peer Feedback To Facilitate Business English Writing Using Qzone Weblogs Among Chinese Undergraduates*. *4*, 17. https://doi.org/10.52380/mojet

Yoon, S. Y., & Kim, N.-Y. (2022). The Use of Metadiscourse Markers in Mobile-Assisted Flipped Learning in L2 Writing. *The Journal of AsiaTEFL*, *19*(1), 180–196. https://doi.org/10.18823/asiatefl.2022.19.1.11.180

Yundayani, A. (2018). Present Situation Analysis: Students' Early Characteristics in Writing for Academic Purposes. *English Review: Journal of English Education*, *6*(2), 119. https://doi.org/10.25134/erjee.v6i2.1262

Zabihi, R. (2018). The Role of Cognitive and Affective Factors in Measures of L2 Writing. *Written Communication*, *35*(1), 32–57. https://doi.org/10.1177/0741088317735836

Zhang, H., Southam, A., Fanguy, M., & Costley, J. (2021). Understanding how embedded peer comments affect student quiz scores, academic writing and lecture note-taking accuracy. *Interactive Technology and Smart Education*, *ahead-of-print*(ahead-of-print). https://doi.org/10.1108/ITSE-01-2021-0011