教育傳播與科技研究141期（2026年8月）
Research of Educational Communications and Technology No. 141, pp. 51-82 (August, 2026)
DOI: 10.6137/RECT.202608_(141).0003

Theory-Guided Learner-Centered Error-Correction Learning System Enhancement: Preliminary Evaluation of Its Educational Potential

Yu, Fu-Yun[1]

Abstract: Considering the numerous benefits of error correction for learning, this study developed a learner-centered error correction system aligned with the principles of sustainable learning. To further improve the system, three features based on previous research leveraging the affordances of digital technology were incorporated: (1) shared information on participants' work progress, (2) the ability to choose a help provider, and (3) identity concealment. Empirical evidence regarding these three features remains limited because previous studies have mainly involved adolescents or older participants with small sample sizes in short study durations and have resided mostly in media communication or interpersonal relationship fields. Thus, a 10-week study involving four purposively sampled sixth-grade classes (N = 104) was conducted to examine students' preferences for different feature arrangements and the reasons underlying those preferences. Several notable findings were obtained. Firstly, chi-square tests revealed that a significantly high proportion of participants supported (1) access to peers' work progress and (2) the ability to choose a help provider. However, this pattern was not observed for the enhanced design of identity concealment. Secondly, quantitative and qualitative findings regarding the participants' revealed preferences indicated strong social influence from high-achieving peers and friendship ties. Thirdly, in situations involving anonymity, nearly one-fourth of the participants changed their selections across the three examined conditions, indicating that the participants' preferences regarding anonymity were situation-contingent. Finally, the participants' explanations for preferring a particular arrangement highlighted the distinct, enabling effects of the three enhanced features in supporting purposive follow-up actions and reducing emotional discomfort to uphold meaningful learning and successful task completion. This study provides suggestions for system design and instructional implementation to create a supportive online learning environment that enhances productive error correction activities. The limitations of this study and recommendations for future research are also discussed.

Keywords: anonymity, group awareness, learner-centered error correction, self-choice, technology-enhanced learning systems

投稿日期：2025 年 11 月 3 日；通過日期：2026 年 5 月 25 日。
本論文感謝兩位匿名評審的修正意見，文中言論由作者自行負責。
1 國立成功大學教育研究所特聘教授
* 通訊作者：于富雲，E-mail: fuyun.ncku@gmail.com

理論引導學習者中心訂正學習系統之精進工程：教育潛能初探性評估

于富雲[1]

摘要：有鑑於錯題訂正對學習的眾多效益，研究者甫成功建置一個符合永續學習概念的「學習者中心錯題訂正學習系統」。為進一步精進系統功能，本研究鎖定具理論基礎，惟尚待實證研究強化的三項設計（參與者學習進度資訊公開、求救對象選擇以及線上個人身分隱藏），進行教育潛能之初探性實證研究。研究邀集一所國小六年級四個班級學生（$N = 104$），配合其社會科進行10週教學，以評估學生對三項精進設計是否有顯著偏好差異，並瞭解個人偏好的考量點。主要結果為：一、卡方檢定結果顯示，大多數參與者支持成員學習進度資訊公開與能對求救對象進行選擇的精進設計；然而，對於隱藏成員身分之設計則有顯著較多參與者持反對立場。二、姓名顯示方式質性與量化分析結果凸顯社會因素對個人行為的影響力，並指出學業成就與朋友情誼為社會影響力的重要來源。三、本研究有近四分之一參與者在不同情境間會改變個人對匿名性之偏好立場，顯示學生立場的情境依賴性。最後，學生的詮釋揭示本研究三項精進設計能提供具行動指引性的有意義訊息內容與無助於任務完成的情緒負擔，進而對學習與任務完成有促進作用。文末，在提出有關系統設計與教學實施之建議，以營造更具效能、友善的錯題訂正線上學習環境與活動之後，說明本研究限制及具學術潛能的未來研發方向。

關鍵字：匿名性、群體覺察、學習者為中心的錯題訂正、自主選擇、科技增強學習系統

Introduction

The multiple benefits of error correction for learning are well recognized (Narciss & Alemdag, 2024). They include reducing the repetition of making the same mistakes (Pineda Hoyos, 2018), promoting a deeper understanding of the study content (Chee & Abdullah, 2021; Metcalfe et al., 2024), and cultivating deep thinking (e.g., reflective thinking, critical thinking) (Balderas & Cuamatzi, 2018; Sompong, 2013). Currently, error correction is often regarded as the teacher's responsibility, with the work being directed mainly by the teacher (Hoth et al., 2022). However, according to information processing and metacognition theories, it may not be optimal in terms of cognitive and metacognitive gains under the traditional teacher-directed error-correction mode, compared to the student self-directed error-correction mode.

Briefly, information processing theorists suggest that, for learners to retain information in long-term memory, they must engage in specific cognitive strategies, such as rehearsal, elaboration, and organization (Gagne et al., 1993). For researchers who value the role of metacognition strategies (e.g., planning, monitoring, revision, and evaluation), the importance of these executive and regulatory

skills for attaining task goals is accentuated (Flavell, 1979; Schraw et al., 2006). To elaborate, when it is the teacher in charge of correcting the erroneous work of students, students mainly play the role of message receivers and copy down explanations and justifications given by the teacher without the need to think hard about the mistakes, nor to devote extra time or effort to the use of learning strategies. Alternatively, when learners are responsible for correcting their own errors, various types of cognitive and metacognitive strategies can be activated at a higher intensity and frequency compared to the teacher-directed error-correction approach. Explicitly, to accomplish the error-correction task, which entails providing the correct answer, analyzing and externalizing the reason for the mistake made, explaining why the correct answer is correct, and summarizing essential knowledge related to the wrongly answered question, among others (Khansir & Pakdel, 2018; Metcalfe et al., 2024; Rushton, 2018), students would need to review the study material (i.e., the use of rehearsal strategy). Additionally, they would need to induct, compile, reorganize, summarize the main points (i.e., the use of elaboration and organization), engage in a series of reflective, metacognitive thinking and behaviors, such as determining what is misunderstood and checking to see if they now understand the tested content correctly (i.e., the use of monitoring), planning what needs to be done to rectify mistakes or areas of misunderstanding (e.g., plans to take or strategies to be adjusted for misconception clarification) (i.e., the use of planning and revision), and analyzing and assessing how the mistakes were made (i.e., the use of evaluation), among others. Through these processes, learners mobilize various cognitive and metacognitive strategies and, accordingly, become skilled at error correction, leading to improved learning outcomes.

Besides being counterbalanced to what information processing and metacognition theorists would suggest for the benefit of deeper learning, from the viewpoint of classroom management and logistics, it is impractical to expect the teacher to correct and explain all students' errors (Pitukwong, 2024). Furthermore, research has found that when students are entrusted with the task of correcting errors in their work, they generally engage in superficial error-correction behaviors (i.e., rectifying inaccurate answers to the correct ones without analyzing the underlying misconception) (Zhang, 2025) due to their general lack of sufficient knowledge and strategies on productive error correction (Steuer et al., 2025). Subsequently, the learning effects from error correction are suboptimal (Keshavarz & Marzban, 2016).

To address these implementation challenges and better align with the constructivist educational paradigm, a theory-guided system centered on "learning by student-centered error correction" was developed (Yu, 2024). Based on the literature review on error correction (e.g., Khansir &

Pakdel, 2018; Rushton, 2018) and feedback (e.g., Kulhavy & Stock, 1989; Mason & Bruning, 2001), an error-correction framework consisting of seven core tasks was compiled and purposefully incorporated in the system as technological scaffolding to support productive learner-centered error correction. Additionally, in light of Meyer's (1993) concept of scaffolded instruction and Puntambekar and Kolodner's (1998) distributed scaffolding theory, a social interaction space that enables students to observe peer error-corrected work and send out requests for help to the online learning community was successfully constructed as a social scaffolding mechanism (Yu, 2024, 2025).

While evaluative studies conducted provided empirical data on the supportive effects of the technological scaffolding of the six structured error-correction tasks and social scaffolding mechanism embedded in the system (Yu, 2025, 2026), informal observations and student feedback point to promising areas for further system enhancement, specifically, three areas leveraging the affordances of technologies are targeted– shared information on work progress, a choice of the help provider, and identity concealment (i.e., anonymity) of the interacting parties.

In the following sections, the theoretical grounding of each of the enhanced areas is reviewed, with the current research gaps identified for the three research questions of the evaluation study before proceeding to the description of the main online learning spaces associated with enhanced design features and the design of the study.

Theoretical Foundations of Shared Information on Work Progress

The value of technology in providing adequately grouped information in online spaces to promote work efficiency and effectiveness is increasingly emphasized in computer-supported collaborative learning research (Schnaubert & Bodemer, 2022). This line of work on group awareness (GA) tools suggests that being informed about the group and its individual members' activities, knowledge, emotions, and social aspects of collaboration facilitates cognitive development, behavioral participation, and social emotion (Chen et al., 2024; Li et al., 2025). Recent GA research further provides empirical evidence confirming that shared information about other members in the group and their updated process states provides essential information to make relevant learning decisions (Schnaubert & Bodemer, 2022), which in turn result in increased peer participation, better performance in online collaborative learning environments (Lin et al., 2023), and heightened attitudes towards collaborative learning experiences (Yilmaz & Yilmaz, 2020). In light of the benefits brought about by GA tools, in the enhanced system, information on participants' performance and progress status at the error-correction task is displayed, aiming at helping students make informed decisions regarding the target(s) to observe and the help

to seek from (see the section on the online space for details).

Theoretical Foundations of the Choice of the Help-provider

"Choice" is pinpointed as one of the eight affordances of technologies (The National Academies of Sciences, Engineering, and Medicine, 2018). Motivational theories further provide theoretical foundations in support of granting students a choice in their undertaking. Specifically, in their proposed self-determination theory (SDT), Ryan and Deci (2000) emphasized that people have fundamental psychological needs for autonomy, competence, and relatedness. When social contexts provide opportunities and space for satisfying these basic psychological needs, engagement, motivation, performance, and development are likely to be optimal (Chiu, 2022). Among the three needs, autonomy pertains to students' discretion and power to decide matters relevant to their own; thus, it reflects the concept and value of choice. Alternatively, Malone and Lepper (1987) proposed a conceptual framework on intrinsic motivation that highlights control, challenge, curiosity, and fantasy as essential components and determining factors/sources for an individual to calculate the intrinsic value of an activity. Among these, control is akin to "choice" as both constructs acknowledge the pivotal role of student agency. Given the overall prevailing value of having a choice in one's undertaking, in the enhanced system version, students can choose to whom to send requests for help (as opposed to the original version, where requests are sent to all) during the error-correction process (see the online space section for details).

Theoretical Foundations of Identity Concealment

Anonymity is considered a prominent feature that can be easily achieved by networked technologies (Velamazán et al., 2023) and has become a common form of information exchange in online communities (e.g., social media platforms) (Lee et al., 2014). On the grounds of relevant theories such as social impact theory (Latané, 1981) and the Social Identity Model of Deindividuation Effects (SIDE Model) (Postmes et al., 2001; Spears & Lea, 1992), research in the fields of computer-mediated communication (CMC) and organizational behavior has identified anonymity as an important factor influencing online knowledge sharing behavior, privacy, and discussion quality (e.g., rationality and civility) on online websites (Cooper et al., 1998; Jaidka et al., 2023; Mickeler et al., 2023). By reducing social risks associated with identity disclosure (Lee et al., 2014), self-validation and evaluation anxiety become less of a concern and threat to involving participants in anonymous situations (Hsieh et al., 2023). Several studies on online group communication have further provided evidence on the effects of anonymity on interaction processing and outcomes (Clark-Gordon et al., 2019; Pan et al.,

2023). For instance, one of the first empirical studies on the effects of anonymity, conducted by Gergen et al. (1973), provided evidence on the promotion of intimacy, affection, and playfulness among interacting parties. Yu and Liu (2009) found that concealing the identity of the participants helps create a psychologically safe interaction space for collaborating peers. Lee et al. (2014) also examined its effects from a psychological perspective and found that anonymity in online communities positively influences self-discrepancy, leading to improved information sharing. Based on these theoretical grounds coupled with evidence on anonymity's positive effects on facilitating more open, fluid online communication, in the enhanced version, the names of all participants can be set as anonymous when (1) accessing peers' error-corrected work, (2) seeking help from peers, and (3) responding to peers' requests for help during the error-correction process in the system (see the section on the online space for details).

The Significance and Research Questions of this Study

As explained, the three focal enhanced designs of the learner-centered error-correction system (i.e., sharing information on work progress, a choice of help providers, and identity concealment) are supported by adequate theoretical grounding. However, currently, empirical evidence on GA is at the burgeoning stage (Schnaubert & Bodemer, 2022), with existing studies primarily involving college students with small sample sizes (i.e., ranging from 40 to 80 participants) and a short research period (i.e., mainly concentrated within 0-1 month) (Li et al., 2025). As to the issue of granting learners control over their learning space, this concept is seldom actualized with associated functionalities made available to learners in online learning systems, owing to instructional designers' concern about the work involved in including choice options in single tasks and possible elevated cognitive load for students; thus, its educational potential is rarely empirically investigated in classroom settings (Velamazán et al., 2023). Finally, for the sake of anonymity, studies have mainly been examined in media communication or interpersonal relationship fields involving adolescents and beyond (Yu & Sung, 2022). Issues regarding how students involved in regular learning-related tasks in authentic educational settings respond to these designs should have educational importance in terms of online system design and instructional implementation strategies.

Hence, three research questions are proposed and examined in this study:

RQ1: Do primary students hold different preferences concerning having access to their classmates work progress on the error-correction task or not (RQ1-1)? What are their reasons for preferring a specific arrangement (RQ1-2)?

RQ2: Do primary students exhibit differential preferences to being given a choice

of the help provider or not (RQ2-1)? What are their reasons for the revealed preferences (RQ2-2) and the determining factors when deciding whom to send to (RQ2-3)?

RQ3: Do primary students have preferences for the identity revelation modes (i.e., revealed versus concealed) of their interacting parties when (1) accessing peers' error-corrected work (RQ3-1a), (2) sending out requests for help (RQ3-1b), and (3) responding to peers' requests for help (RQ3-1c)? What are their reasons for favoring a particular mode under a specific interaction situation (RQ3-2a, RQ3-2b, and RQ3-2c for the respective situations– accessing peers' error-corrected work, sending out requests for help, and responding to peers' requests for help)?

The Main Online Learning Spaces with Enhanced Design Features

The focal learner-centered error-correction system was built to extend and augment the computer-based assessment component of an online learning system pivoting on student-generated questions (Yu, 2009). Upon completing online drill-and-practice activities, students are taken directly to the main page of the error-correction system. For this study, the main page and social interaction spaces are described below.

The Main Page

On the main page, information on student performance at the individual question item level and the test as a whole for the drill-and-practice activity is displayed, as would typically be provided by computer-based assessment systems (see Figure 1). To proceed to the error-correction activity, one clicks on the error-correction proceed button (i.e., ) placed beside any wrongly answered question to be directed to the respective step-by-step error-correction pages. After completing all steps, one is taken back to the main page. Here, one can continue with the error-correction task for the remaining wrongly answered questions (by scrolling down the screen to reveal the rest of the practice items), or access any peer's completed error-corrected work for observation. By clicking on the view button (i.e., ) or any numbered box with a hyperlink, the peer's completed corrected steps are unveiled via a pop-up window for close examination (see the bottom of Figure 1 for any targeted step or all steps as a whole).

To assist students in making informed decisions regarding who or which step/task to target for observation, in the enhanced version, all participants' error-correction completion states are shown (see Figure 1). As advised by GA researchers, the design of GA tools should be theory-guided (Schnaubert et al., 2020). Hence, a color scheme is devised, based on Mayer's (2020) signaling principle in multimedia learning, to assist participating members in noting and differentiating the various completion states of each error-correction step or task. Explicitly, when the GA function is activated, the

error-correction steps/tasks are displayed in the corresponding color reflecting their correction state. Namely, the white-colored box represents a task/step that has not yet been attended to. The light green-colored box indicates that this task/step has been completed without the learner requesting online help from others. The dark green-colored box indicates that this task/step is completed after help is received from the online community (in response to their request for help), whereas the green-colored box shows that this task/step is completed before online help is received. The red-colored box is indicative that a request for help has been sent, but no response has yet been received from the online community. The orange box indicates that the teacher or peers have responded to the help request, but the help-seeker has not yet addressed this task/step.

In contrast, as demonstrated in Figure 2, the participants' identity can be obscured from view with the newly incorporated anonymity functionality without sharing the peer's error-correction states/progress (see Figure 2).

Figure 1

The Main Page under Identity Revelation (i.e., Real-name, the Original Version) and Group Awareness Settings (i.e., the Enhanced Version)

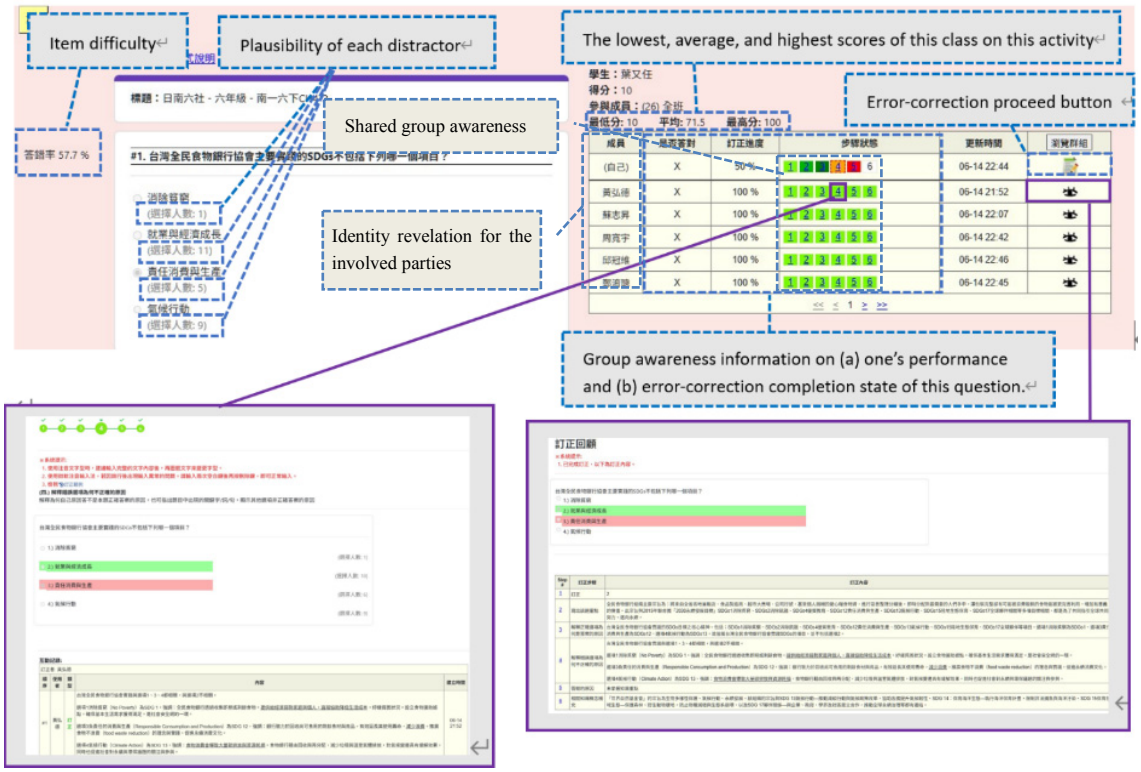
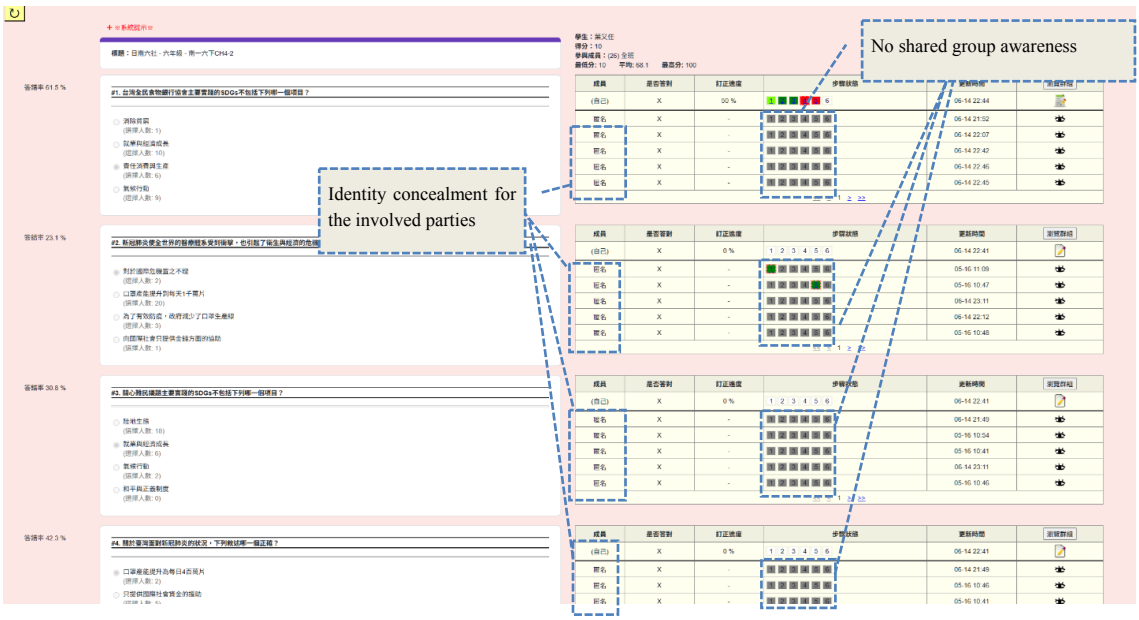


Figure 2

The Main Page under Identity Concealment (i.e., the Enhanced Version) and Without Group Awareness (i.e., the original Version)



The Social Interaction Space

As briefly mentioned, in light of related literature (e.g., Meyer's (1993) concept of scaffolded instruction and Puntambekar and Kolodner's distributed scaffolding theory), a social interaction space is created within the original system to support help-seeking and provision among online community members. As illustrated in Figure 3, on the respective error-correction step/task page, right beneath (a) the wrongly answered question and (b) error-correction spaces is the social interaction space consisting of (c) request-for-help key-in space and (d) social interaction record space.

By default, the request-for-help message is sent to all participants when the help button is pressed, and the names of both the help seeker and the help provider, along with their message, are displayed and listed chronologically in the social interaction record space (see Figure 3). Alternatively, when anonymity and help-provider choice functionalities are activated, an additional helper selection button is made available. Once this button is pressed, as illustrated in Figure 4, the identity of their peers is concealed in the pop-up window; nonetheless, their performance on the question (i.e., answer correctly ○, or incorrectly ✕) and the test is provided to assist informed decisions regarding whom to send a request for help can be better made.

Figure 3

The Social Interaction Space without Identity Concealment and Choice of the Help-provider Functionalities Activated (i.e., the Original Version)

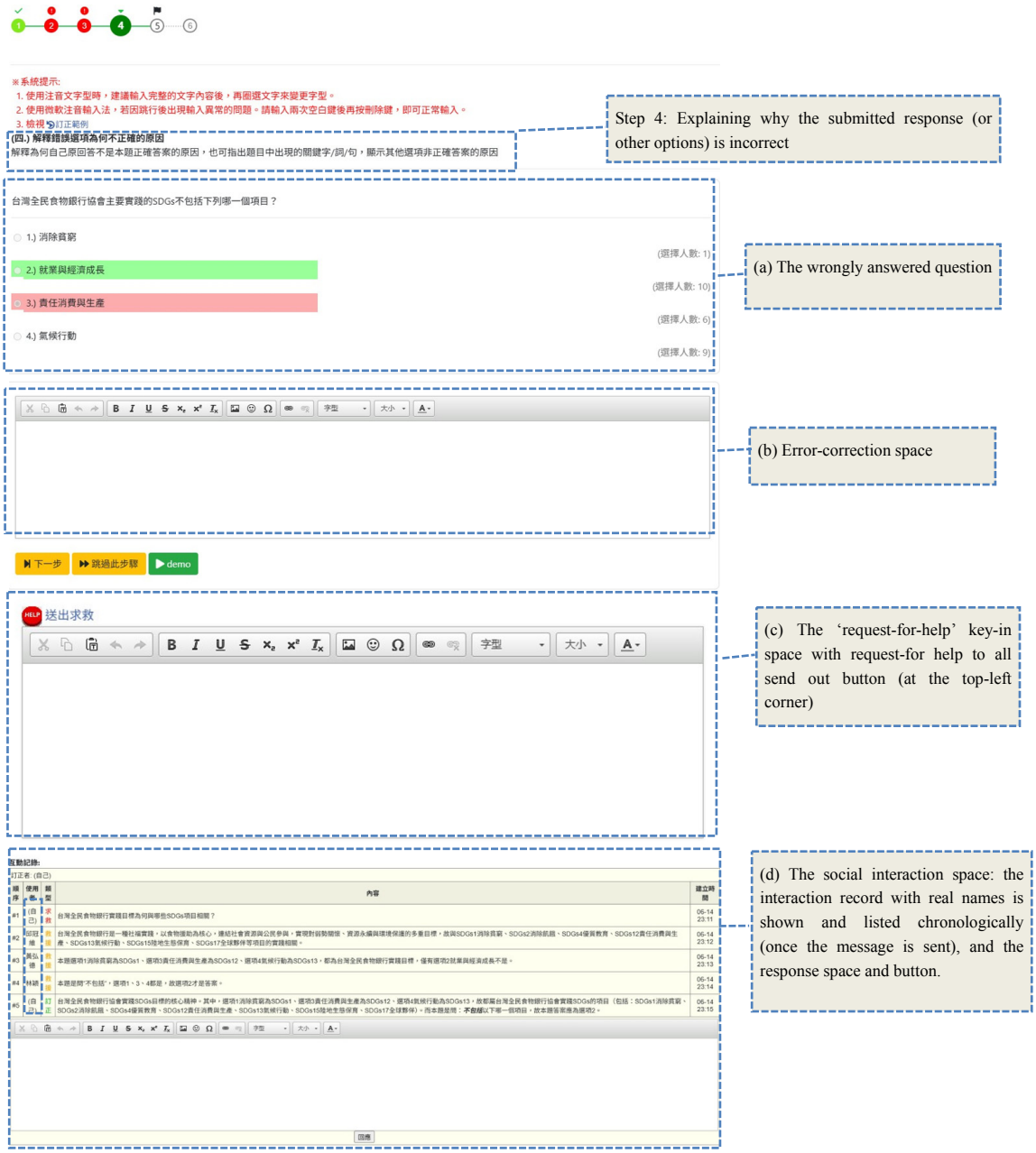
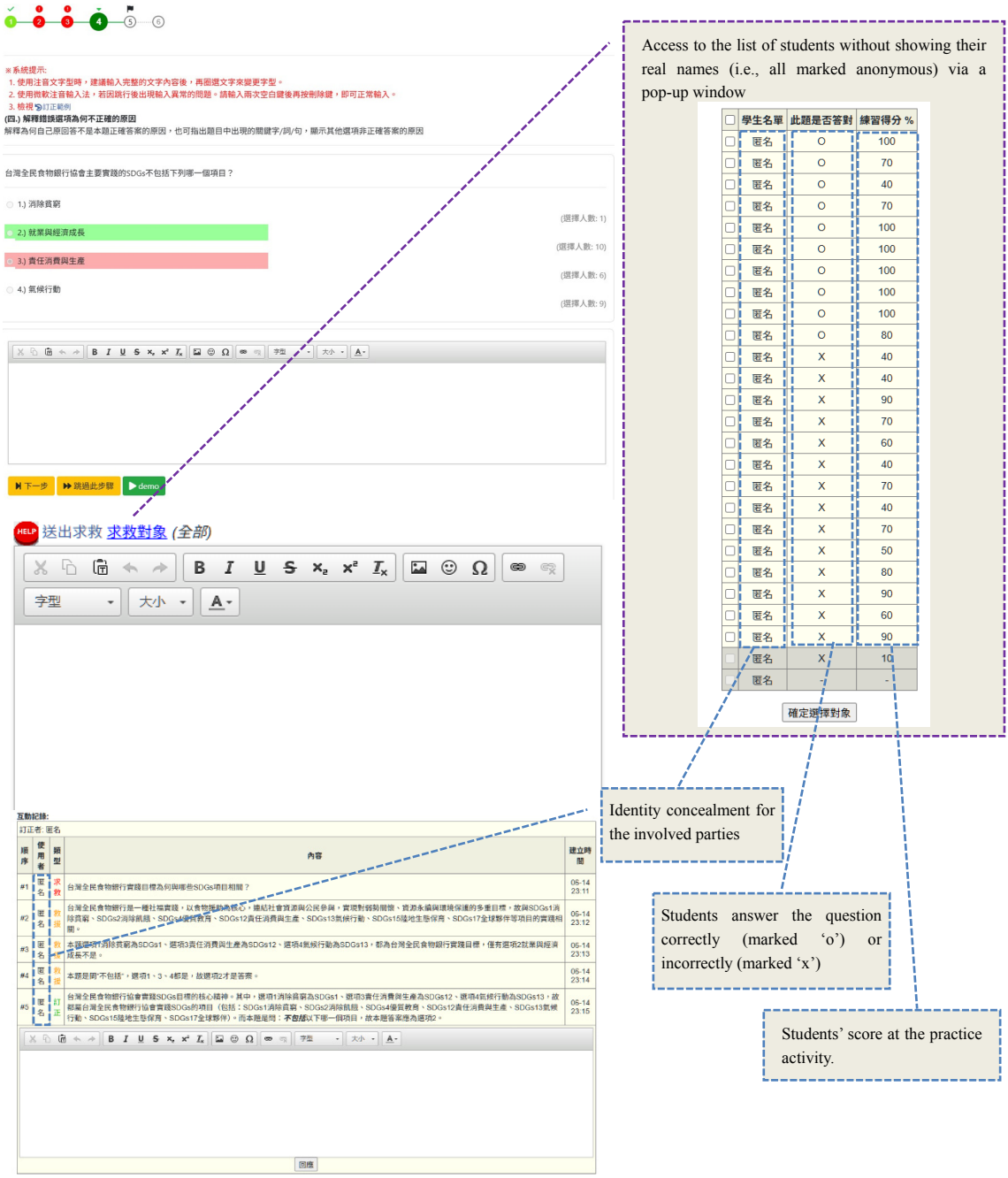


Figure 4

The Social Interaction Space with Anonymity and Choice of the Help-provider Functionalities Activated (i.e., the Enhanced Version)



The Design and Implementation of the Evaluation Study

To collect students' revealed preferences for the three focal design features of the enhanced version of the developed system, a study adopting a one-group posttest-only research design was conducted. To bridge the current gap in the investigated research topic (e.g., existing empirical evidence on GA was limited and mostly involved college students with a short research period and smaller sample sizes, studies on anonymity involved mainly adolescents and beyond), several premises were set for participant recruitment. For one, the primary school level was targeted. Secondly, it would deal with main subjects (i.e., Chinese, English, math, science, social studies) because routine practice activities followed by error correction would more likely be in place. Finally, subjects taught by the same teacher were purposefully targeted for securing a larger sample size. With these, four classes of sixth-grade primary school students (N = 102) taught by one social studies teacher were successfully recruited for participation in a 10-week activity. During this period, online learner-centered error-correction activities were integrated into the weekly routine of drill-and-practice activities to support teaching and learning.

The first session was allocated for orientation and training, where the purposes and basic knowledge and skills of productive error correction were introduced. Essentially, the value of learning from errors is accentuated (e.g., avoiding repeating the same mistakes, opportunities for mastering the tested concept, promoting deeper learning) (Chee & Abdullah, 2021; Metcalfe et al., 2024; Pineda Hoyos, 2018). In addition, noting that students generally engage in superficial error-correction behaviors (Zhang, 2025) and thus may not benefit fully from error-correction activities (Keshavarz & Marzban, 2016), knowledge and strategies on productive error correction, including identifying the main idea of the tested question, justifying why the correct answer is correct, and explaining why the previously submitted response is incorrect, was explained and demonstrated during the orientation and training session. Next, the operational procedures for navigating the main learning spaces, which included drill-and-practice and learner-centered error-correction systems and their associated functionalities (e.g., accessing peer-corrected work in the main page, requesting and responding to help within social interaction spaces), were described before students engaged in individual hands-on practice. For the remaining weeks, during each online learning activity, students first answered a set of questions on the currently covered social studies content and then self-corrected their incorrectly answered questions. As for those who achieved a perfect score on practice worksheets or finished correcting all misanswered questions before the end of the designated error correction time, they were

directed to target whichever questions they felt were more difficult, misanswered more often by their classmates (by referring to the statistics shown on the system, see Figure 2), or got the question right by guessing for error correction. The instruction was based on the ideology and concept of error-based learning and self-regulated learning— essentially, areas of uncertain or fragile understanding may more effectively prompt productive regulation than those that focus exclusively on correctness (Hadwin et al., 2018; Metcalfe et al., 2024).

While informal observations confirmed that generally participants were capable of completing the correction tasks by following the structured correction steps prescribed by the system, the teacher played a pivotal role in helping students get the most out of the engaged activity. Explicitly, additional pedagogical mechanisms designed by the teacher as support for student-centered error correction include, but not limited to: selecting and setting up a context-appropriate, domain-specific step-by-step error-correction process with exemplars and prompts as a technological scaffold (e.g., main ideas of the present unit), responding to students' online requests for help as social scaffold, providing whole-class feedback (on both exemplar error-correction work and inadequate handling of the task from peers) while clarifying misconceptions and explaining why a particular option is correct or incorrect to promote a deep understanding of the knowledge tested in the question (i.e., content knowledge), and providing a student manual delineating the main procedural steps for individual student's reference, among others. Furthermore, besides requesting online assistance via the system designs, students can choose to raise their hands to signal assistance directly from the teacher as they used to in the traditional way.

To enable students to make meaningful comparisons based on personal concrete experiences and facilitate focused explorations, rather than activating all functionalities at the beginning of the study, students were exposed to different setting arrangements. Namely, shared information on work progress activated (i.e., the enhanced version; see Figure 1) and deactivated (see Figure 2), the choice of the help-provider not activated (see Figure 3) or activated (i.e., the enhanced version; see Figure 4), and anonymity not activated (see Figure 1) and activated (i.e., the enhanced version; see Figure 2) were purposefully arranged by the teacher on several occasions throughout the 10-week study. Every time a different setting was introduced, a brief description of the specific functionality was given, with any associated procedural steps highlighted when the situation called for it (e.g., the meaning of different colors denoting different work progress/state of each error-correction task/step, sending out requests for help to all versus a subset of participants).

With this study design guided by the three research questions, three instruments were developed to collect data on students' revealed preferences for different arrangements after

their exposure to the respective targeted functionalities/features. Most questions in the instruments are selection-type, with a follow-up component for explanations of their selections. The first instrument has one question and asks students' preference for being shown information on participants' work progress (i.e., whether it is shared publicly or not) and their justifications. The second instrument consists of two questions. Q1 asks students about their preference for being given a choice of a help provider or not, and their considerations. Q2 inquiries factors students consider when selecting targets to send out requests for help (check all that apply): students with high academic performance, circle of friends, others (elaborate). The third instrument consists of three questions, all targeting the "identity" design feature in three situations: accessing peers' error-corrected work (for Q1), sending out requests for help (for Q2), and responding to peers' requests for help (for Q3). For example, Q1 is worded as: "*Which identity arrangement do you prefer better when accessing peers' error-corrected work: real-name or anonymity (i.e., the identity of the interacting parties not shown)? Please explain your reasons.*"

Descriptive statistics (i.e., *f* and %) and chi-square tests were used to analyze quantitative data collected. The constant comparative method developed by Glaser and Strauss (1967) was adopted for processing descriptive data, which employs induction analysis by the steps suggested by Lincoln and Guba (1985) (i.e., unitizing and categorizing) and involves a simultaneous comparison of all explanatory responses for a specific selection of any developed conceptual categories and relationships among them. Plainly, students' open-ended responses were first read repeatedly to gain familiarity with the data. Initial codes were then generated to capture recurring ideas. Similar codes were grouped into broader themes, which were reviewed and refined to ensure they accurately represented students' perspectives. Representative responses were selected to illustrate each theme.

Results and Discussion of the Evaluation Study

In the following sections, results on each of the three RQs on students' preferences with their supporting reasons for the two versions (i.e., original and enhanced) of the three focal design features are presented in 4.1-4.3, respectively. Under each section, as a general rule, results on students' responses to the selection questions are presented first (i.e., RQ1-1, RQ2-1, RQ3-1a, RQ3-1b, RQ3-1c) before the representation of the results on the supporting explanatory data (i.e., RQ1-2, RQ2-2, RQ3-2a, RQ3-2b, RQ3-2c) and the discussion section in 4.4. For discussion, it basically follows the sequence of RQ1 to RQ3, except that the findings on RQ1-1, RQ2-1, RQ3-1a, RQ3-1b, RQ3-1c are presented integratively at the beginning before the discussion of the qualitative data for each of the RQs.

Results on the Provision of Shared Information on Work Progress (RQ1)

For RQ1-1, as shown in Table 1, more than 70% of the participants (specifically, 72.73%) preferred the enhanced version, while only slightly over one-fourth (27.27%) supported the original version (i.e., not publicly sharing information on group members' work progress). The chi-square test further confirmed its statistical significance at the 0.001 level, with a value of $X^2 = 20.45$.

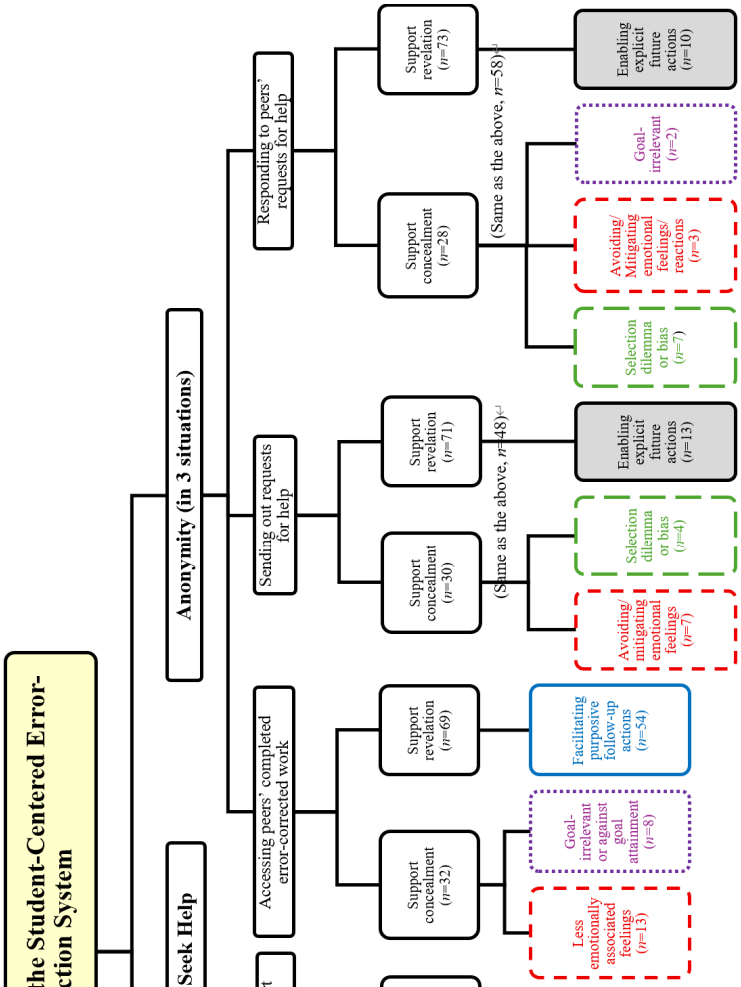
Table 1
Statistics on Students' Preferences for the three Enhanced Design Features

	Yes (enhanced version) *f* (%)	No (original version) *f* (%)	X^2
Instrument 1: shared information on participants' work progress	72 (72.73%)	27 (27.27%)	20.45
Instrument 2: being given the choice of the help provider	71 (71.72%)	28 (28.28%)	18.68
Instrument 3: identity concealment Q1. When accessing peers' error-corrected work	32 (31.68%)	69 (68.32%)	13.55
Q2. When sending out requests for help	30 (29.70%)	71 (70.30%)	16.64
Q3. When responding to peers' requests for help	28 (27.72%)	73 (72.28%)	20.05

As to their reasons for leaning toward their chosen arrangement (RQ1-2), quite a few of this group in favor of the enhanced version simply stressed the beneficial aspect of the GA function– allowing them to know/note the work progress of their peers and vice versa (e.g., "*This way, I can see the correction progress of the whole class, and others can also see my correction progress*") (*n* = 39, 54.17%). Nonetheless, some students provided meaningful explanations of its definite effect and pointed to the salient theme– "supporting purposive follow-up actions" (*n* = 23). For this, some students appreciated this additional piece of information enabled by the GA tool for facilitating worthwhile help-seeking (e.g., "*This way, I can see how far others have progressed, so I will know whether I should ask them for help*.") and/or help-provision behaviors (e.g., "*When it is displayed, I can see how far the other person has gotten with their corrections so that I can help them with it*.") (*n* = 14). Others highlighted its use for targeted observation (e.g., "*Since I can see my classmates' corrections, I can take a look if I do not understand something, or discuss the questions I find difficult with them, avoiding bothering others who have not yet completed the step/task*") (*n* = 8).

Figure 5

Emerging Themes Underlying Students' Support vs. Opposition of the Three Enhanced Design Features



Alternatively, for those supporting the original version (i.e., no GA tools), while the majority "*saw no use* or *felt no differences"* in it (n = 16), four students explicitly indicated unwanted "emotional burdens" that come along with publicly shared work progress information (e.g., "*I do not want others to see my progress, in case someone makes fun of me for being slow;" "This way, there will not be any pressure.*"). Figure 5 summarizes the salient theme that emerged from the participants' responses.

Results on Being Given a Choice of the Help Provider (RQ2)

The quantitative results, which involved being given a choice of whom to send requests for help (as opposed to the original send-to-all version) (RQ2-1), reflected a similar pattern to those of RQ1-1 (i.e., access to the group's work progress). Explicitly, more than 70% of the participants (71.72%) supported the enhanced version, with an obviously lesser proportion of the participants (28.28%) leaning toward the original version (i.e., not being given the choice to whom to send requests for help) (see Table 1). The chi-square test also found that the different proportions reached statistical significance at the 0.001 level, $X^2 = 18.68$.

Explanatory comments provided by the participants in support of being given the choice revealed two salient themes (RQ2-2; see Figure 5). The first theme reflected an "approach mindset" (n = 35). With the choice functionality, while some students focused on peers' academic performance (e.g., who "*got a perfect score on the test*," "*got the question right*," or "*are high-achievers*"), others depended their decision on the help seeker on personal relationships (e.g., "*whom they are acquainted with*," or "*are friends*"), or focused on personality (being "*thrust-worthy*" or "*friendlier*") to accomplish the error-correction task in a more effective and/or efficient way. The second theme that emerged from this group's responses reflected an "avoidance mindset" (n = 27). As some students put it, "*This way, I will not end up talking to someone I am not familiar with*;" "*Because I do not like asking girls questions;*" *"It would feel awkward to send it to the whole class;*" "*Because if we do not choose who to ask, what if the person we ask is not good at social studies and gives the wrong answer?*"

As for those in opposition to being given the choice, the most salient theme is "increasing the chances of being helped" (n = 16) since whoever is "*available*," "*willing*," or "*capable*" can jump in anytime to help (see Figure 5).

Finally, regarding the second follow-up question on the factors that influence their decisions on whom to send requests for help (RQ2-3), 60.20% of the respondents selected the "students with high academic performance" option, and 42.86% selected the "circle of friends" option. A few others pointed to other characteristics (e.g., "*Whoever got the question right or was quick to respond to peers' requests,*" "*Classmates with a pleasant*

personality to interact with") as determining factors.

Results on the Provision of Identity Concealment (i.e., anonymity) (RQ3)

Contrary to the researchers' expectation, the results showed that more participants preferred the original identity revelation mode over the enhanced identity concealment mode in all three situations– accessing peers' completed error-corrected work (RQ3-1a), sending out requests for help (RQ3-1b), and responding to peers' requests for help (RQ3-1c). Further chi-square tests found that the results under all three situations reached statistical significance at the 0.001 level, with the values ranging from 13.55 to 20.05 (see Table 1 for details).

The constant comparison method, conducted on the reasons provided by respondents in support of identity concealment when accessing peers' completed error-corrected work under the GA mode (n = 32) (RQ3-2a) revealed two salient themes. As shown in Figure 5, the first one is "less emotionally associated feelings (e.g., stress, pressure, embarrassment)" (n = 13). As shared by the participants, "*Because this way, no one else can see it, and if your corrections are not done well, others will not laugh at you;*" "*Seeing other people's names makes me feel a bit pressured;*" "*This way, it will not be awkward*." The second theme is "goal-irrelevant or against goal attainment" (n = 8). As two students shared it, "*There is no need to see who got the question wrong. Just referring to the corrected answers is enough;*" "*This can prevent people with bad intentions from copying the answers of those with good grades, and I think this functionality (i.e., identity revelation) should be shut down.*" Alternatively, the main theme that emerged from the comments provided by those in favor of identity revelation reflected that of GA– "supporting purposive follow-up actions to take" (n = 54) (see Figure 5). Under this theme, many students similarly accentuated this functionality for facilitating meaningful help-seeking (e.g., "*This way, I can see who got the question right and who got it wrong, so I can go to the person who got it right and ask them to teach me;*" "*This way, I can ask my best friends for help—if they know I am having trouble, they will help me.*") (n = 38). Additionally, quite a few others similarly highlighted its facilitating use for targeted observation (e.g., "*This way, I can choose which classmate's work to look at– I can choose someone I trust;*" *"I can refer to the corrections made by people who did well*.") (n = 16).

Regarding the reasons for supporting a specific identity mode under the help-seeking condition (RQ3-2b), regardless of the position one held, a handful of students wrote "*same as the above*" (n = 48). For those that provided additional descriptive comments, while a few did not lead to insightful, meaningful comments (e.g., "*I think this way is better;*" "*This way, I can see other people's names*.") (n

= 11), those who supported the concealed identity mode, one theme that emerged from the data analysis reflected the same theme as that in the GA situations– "avoiding/mitigating emotional feelings" (n = 7). Moreover, another theme highlighted the potential problem of a "selection dilemma or bias" (n = 4) (see Figure 5). As some students mentioned, "*This way, one will not be put in situations where they need to choose who to send out help;*" "*Because if someone sees a classmate's name, they might not want to help that classmate*." On the other hand, others that supported the revealed identity mode highlighted its value for "enabling explicit future actions" (e.g., "*expressing appreciation to those lending a helping hand*;" "*facilitating future mutual assistance in return*") (n = 13) (see Figure 5).

Finally, regarding their reasons for supporting the identity revelation or concealment arrangement in the help-provision situation (RQ3-2c), many students again responded with "*same as the above*" (n = 58). Furthermore, regardless of which side they were on, for those that provided additional descriptive comments, quite a few, again, yielded limited insightful comments (e.g., "*This way is better;" "This way, classmates will know who helped them;*" "*I do not think it is necessary to see other people's names*."). The constant comparative method done on the rest of explanations revealed similar sentiments as those under the other two situations– "enabling explicit future actions" (n = 10) (e.g., "*Because I want to see who helped me so that I can help them in return later*"), without "selection dilemma or bias" (n = 7) (e.g., "*If it is anonymous, there will not be situations like I am closer to you so leading to always helping only you*"), "avoiding/mitigating emotional feelings/reactions" (n = 3) (e.g., "*If I go to help them and they know who I am, it would be awkward, and I do not want to make them feel pressured*"), and goal-irrelevant (n = 2) (e.g., "*Even without names, we can still work together to solve the problems we do not understand*") (see Figure 5).

Discussion

Based on the results, several salient trends are observed. First and foremost, as reflected in students' responses to the selection questions to answer RQ1-1, RQ2-1, RQ3-1a, RQ3-1b, and RQ3-1c, a predominant percentage of participants exhibited specific preferences for a particular setting – visibility of peers' work progress, choice of help providers, and identity revelation of the interaction group across multiple situations. All significant chi-square analyses (p < .001) results confirmed that participants are not indifferent to interactional design features in technology-mediated learning contexts. Instead, they held clear and definite positions on how computer-supported collaborative learning environments should be configured. The pronounced differential preferences are meaningful as they signal that learners are sensitive to online interface designs, rather than treating system configuration as a neutral accessory to learning.

Secondly, while the majority of the participants supported two of the three enhanced versions– showing participants' work progress and being given a choice of the help provider, substantially more participants preferred the original version for identity revelation (i.e., no identity concealment) for all three online interaction situations (RQ3-1a, RQ3-1b, and RQ3-1c). A closer examination of student selections further revealed that about one-fourth of the participants (23.76%) shifted their selections among the three examined situations. In other words, when dealing with anonymity, students' stands are not across-the-board but situation-contingent, depending on their role and the learning tasks to be undertaken.

Thirdly, the reasons emphasized by those in support of showing participants' work progress (i.e., RQ1-2) reflect the concept of collective consciousness and its associated effects as highlighted by sociologist Émile Durkheim (Smith, 2014). Broadly defined, collective consciousness, also known as shared or common consciousness, refers to a shared understanding of what is meaningful, acceptable, and valued within a community or society (e.g., norms, codes, and practices). It extends beyond individual members and acts as a force to help individuals bond experiences, guide intentional behavior, and maintain social cohesion. As voiced by many of the participants, it was through the shared information made readily available by the GA tools purposefully incorporated into the enhanced version of the system that helped guide and make such intentional actions (e.g., help provision, targeted observation) feasibly attainable. This finding not only reinforced that process transparency (in the form of completion and progress status) is a valued feature in online environments by acting as an informational reference frame and source to support sense-making and enable action planning for profitable next steps (Jivet et al., 2020) but also aligns with recent GA research, which confirms that access to information about group members' updated process states supports awareness of their knowledge and expertise (Chen et al., 2022) and is essential for decision-making on the part of the interacting parties (Schnaubert & Bodemer, 2022).

Fourthly, students revealed reasons for being given a choice of the help provider or not' (RQ2-2) map closely onto autonomy as a basic psychological need in Ryan and Deci's (2000) SDT, as well as control as an essential element of Malone and Lepper's (1987) intrinsic motivation framework. As both theories posit, autonomy and agency-supporting conditions promote better motivation and engagement. With online conditions addressing learners' preferences, it is understandable that this incorporated design was affirmed as promoting error-correction tasks being completed in a more effective and/or efficient way (regardless of whether it involved choosing or avoiding a specific peer helper, or whether no help providers need to be specified). Being given the choice of a helper

also reduced futile invested effort and perceived social risk because students would weigh potential benefits against anticipated costs (e.g., embarrassment or threat to self-esteem) (Karabenick, 2003; Mahasneh et al., 2012; Ryan et al., 2001). As shared by those in support, peer helpers perceived to be supportive, competent (by those adopting an approach or avoidance mindset), or assessed to be unfit, undesirable (by those adopting an avoidance mindset) increased the likelihood that help can be successfully sought and created a sense of psychological safety on the part of the help-seeker.

Fifthly, while relevant theories guide the design and development of the three newly embedded functionalities in the system to serve explicit purposes, some functionalities complement each other nicely. Explicitly, as reflected in participants' descriptive responses to RQ1-2 and RQ2-2, GA tools work well with the help-seeking functionality by providing information on whom to target (e.g., those available and capable) for ensuring that the error-correction task can be more effectively and efficiently completed, compared to resorting to the help-seeking functionality alone. This finding, in essence, reflects what Ainsworth (2006) suggested about employing multiple (representational) tools to attain complementary function for educationally meaningful goals.

Sixthly, as revealed in students' responses as to the factors that affect students' decisions on whom to send out requests for help during target selection (i.e., RQ2-3), as shown by the obtained quantitative data, more than 60% and 40% of the respondents selected "students with high academic performance" and "circle of friends," respectively. This result is in general agreement with the "approach mindset" theme revealed by the participants' descriptive explanations. Additionally, these findings resonate with empirical evidence from the literature on social influence, which suggests that people's attitudes and behaviors are influenced by their peers in various situations (Laursen & Veenstra, 2021; Watts et al., 2024). For instance, the study by Yu and Sung (2019) found that students' online behaviors are influenced by contextual social cues such as friendship. Steenberghs et al. (2024) uncovered that academic achievement acted as a significant influencer affecting school-aged children's academic emotional engagement. In contrast, friendships influenced both peers' behavioral and emotional engagement and disengagement.

Finally, the finding that students expressed a distinct preference regarding identity revelation underscores that identity configuration is a high-impact design decision in peer-interaction systems. For those in support of the identity concealment arrangement for online communication (RQ3-2a, RQ3-2b, RQ3-2c), the reasons provided by the respondents, for the most part, are in accordance with what social psychologists highlighted as the distinct affordance of anonymity– reduced social risk

and lowered threat to self in interaction contexts, conducive to the alleviation of evaluation anxiety and self-validation (Hsieh et al., 2023; Moral-Toranzo et al., 2007); therefore, it helps create a psychological safety environment for learners (Lee et al., 2014; Yu & Liu, 2009). In contrast, for the majority of the participants rooting for the original version (i.e., revealing one's identity), the value of contextual social cues for facilitating purposive follow-up actions to be taken for the attainment of the task's ultimate goal (i.e., learning from error correction) was stressed. This piece of finding, in fact, restates the necessity and importance of replication studies in different contexts. As explained in the significance of this study (see Section 1.4), while studies on anonymity have found that identifiability may constrain expression and jeopardize psychological safety on the part of participants by introducing unproductive emotional discomfort (e.g., unnecessarily elevated evaluation anxiety), they primarily reside outside the educational arena– in the fields of media communication or interpersonal relationships (Yu & Sung, 2019). With the quality and quantity of participation as the primary concern of communication researchers, the inequality of participation caused by visible status cues or labels (e.g., age, gender, race, job title, or social popularity) naturally revealed in identifiable situations, where high-status individuals may dominate the conversation, leading to suboptimal interaction experiences and outcomes, would not be tolerated (Siegel et al., 1986; Weisband et al., 1995). In contrast to this study, which was conducted in an educational setting, as substantiated, students involved in learning tasks in authentic educational settings appear to have the timely, satisfactory completion of the engaged task for the promotion of deep learning at the forefront; accordingly, students may respond differently. Explicitly, students engaged in error correction for their wrongly answered questions exhibited a significant preference for the identity revelation mode over the concealment mode.

Conclusion

The world's first learner-centered error-correction system, which aims at engaging students in self-directed error-correction activities, as opposed to most computer-based assessment systems that accentuate the provision of instant, automatic, and personalized feedback to students' misanswered questions (Chen et al., 2023; Chevalère et al., 2025), was successfully constructed (Yu, 2024, 2025, 2026). In essence, the ideology of the developed system is in alignment with the value and concept of sustainable learning, which emphasizes future-focused skills and experiences to ensure life-long learning and continuous development (e.g., learning to learn, critical reflection) (Graham et al., 2015; Hays & Reinders, 2020). Further prompted by informal observations and students' feedback, and guided by relevant foundational theories in cognitive psychology, educational psychology, learning sciences,

communication, social psychology, and organizational behavior, including shared mental models, self-determination theory, intrinsic motivation theory, evaluation apprehension theory, social impact theory, and the SIDE model, this work highlighted three design features for system enhancements– shared information on participants' progress, a choice of the help provider, and anonymity of the interacting parties. Given that existing studies on the potential of GA and anonymity mostly involved adolescents or college students, had small sample sizes, and were conducted over a short period of time, and that the educational potential of granting students choice options in single tasks is rarely empirically investigated in classroom settings, the educational potential of the three enhanced designs was assessed with primary school students.

Contributions of this Study

This investigated work contributes to the research community in several significant ways. First, to address the current research gaps, both quantitative and qualitative data on revealed preferences for the three enhanced features as computer-supported collaborative tools were collected from a large group of primary school students ($n > 100$) partaking in routine learning tasks in an extended study period (i.e., 10 weeks). As confirmed, a significantly more proportion of the participants supported two of the newly embedded design features as efficacious system enhancements for learning (i.e., GA and being given a choice for their help provider); nonetheless, a significantly more proportion was against the enhanced design (i.e., anonymity) and expressed concerns under the three examined interaction contexts– accessing peers' completed error-corrected work, sending out requests for help, and responding to peers' requests for help with clear, legitimate reasons. In other words, the respective educational potential of the three enhanced design features for primary school students as learning devices was empirically assessed and understood.

Moreover, findings on (1) access to peers' work progress, (2) being given a choice of the help provider, and (3) a strong social influence from peers with high academic achievement and tied friendships are definite and decisive, and empirically confirmed by the participants at the primary school educational level, a less-examined target group in social psychology research (Li et al., 2025; Schnaubert & Bodemer, 2022).

Finally, the participants' strong support reasons are consistent with theories emphasizing the centrality of collective consciousness, autonomy, and social influence, making them critical considerations when designing peer-support affordances in learning systems. This finding attests to this study's relevance in bridging research, theory, and practice. As is evident, the targeted features of the enhanced system and anticipated effects (e.g., real-time updates and display of group members' work progress and completion states,

instant help-seeking and provision from the online community) would be hard to attain, if not unattainable, without the support of digital technologies. By leveraging the affordances of technologies, most of the system enhancements appear to be in better conformity with the majority of students' preferred learning situations.

Suggestions for System Design and Instructional Implementation

Based on the findings of this study, several suggestions are provided for system design and instructional implementation consideration. First, given that a noticeable percentage of students in the study exhibited strong, explicit preferences for being given information on (1) group progress and (2) being given a choice when deciding who to seek help, highlighting their facilitating effects for undertaking purposive actions and better attainment of work effectiveness and efficiency, system designers of learner-centered peer-support environments are advised to incorporate these two features into learning technologies as transparency and autonomy promoting features.

Second, although the results found that a significant percentage of participants supported a specific design feature, legitimate reasons were provided to support both camps of supporters and opponents. Given that creating multiple online spaces incurs few, if any, additional expenses for schools, as compared to physical classrooms, system developers and the teacher are advised to set up multiple virtual spaces. Further, system developers could consider including a student self-choice option in the management console space, rather than allowing teachers to have sole control over the settings of the incorporated features, so that student agency in their learning can be acknowledged. In other words, a learner-centered configuration rather than one-size-fits-all determined by the teacher is suggested.

Third, given that students' preferences for identity revelation and concealment are situation-dependent, system designers are advised to treat identity settings as configurable to address participants' fluid preferences in different situations. Similarly, teachers are advised to allow their students to self-select their preferred mode across situations to better satisfy students' differentiated needs. Doing so not only better accommodates students' preferences for different arrangements but, more importantly, it honors students' agency and autonomy, as increasingly advocated by educators (Darvishi et al., 2024; Godwin-Jones, 2024).

Finally, as shared by the participants, peers acted as strong influencers, consistent with literature on social impact theory– students are affected by those of a higher status (e.g., high academic achievers), or having better established relationships (e.g., close friends) (Latané, 1981). In view of this, teachers are advised to conceive and set up measures ahead of time (e.g., demanding students to externalize their reasoning with adequate backing when referring to and adopting or rejecting peers'

suggestions for error correction) to alleviate undesirable, unwanted influence from peers under the revealed identity mode.

Limitations of this Study and Suggestions for Future Work

This study involved sixth-grade students and examined students' revealed preferences for three focal system features of computer-supported collaborative tools for error correction as part of their social science learning activities– shared information, choice of the help-provider, and identity concealment. While several major findings were obtained, some limitations of this work should be noted. First, although informal observations confirmed that participants of this study were capable of completing the correction tasks by following the structured correction steps prescribed by the system, the external generalizability of this study to lower grade levels or those with restricted cognitive development warrants further validation.

Second, guided by the aim of this study, students were exposed to both original and enhanced modes under the teacher's arrangement on different occasions (rather than having students self-choose their preferred mode) so that data collection on students' subjective views can be based on concrete experiences. As such, data on students' actual use of different modes at their discretion were not possible with the current study design. Nonetheless, the (in)congruence of subjective perspectives and actual system use is a research area of great academic and practical relevance. Hence, researchers are advised to investigate this research topic in the future, when students' self-choice of different modes for each of the three focal functionalities (e.g., for identity revelation/concealment) is permissible. Furthermore, because learners' subjective preferences do not necessarily reflect their actual behavioral performance, future studies should analyze and examine learners' actual online use behaviors and collect their underlying choice considerations under different contexts via qualitative data collection methods, such as unstructured interviews. With this design, issues regarding whether, how, and why students actually use the functions they claim to like more can be rigorously examined. This line of future work could address this study's limitations of relying solely on participants' subjective perceptions collected by questionnaires, while underscoring the necessity of collecting objective behavioral metrics to evaluate the true efficacy of educational tools.

With the same constraints, data on quantitative indicators of students' academic learning and performance were not collected and analyzed. Issues regarding whether there is a correlation between the incorporated functions and learning outcomes for students with different statuses and social ties (e.g., academic performance and friendships) represent a promising direction for future studies. Given the increasing attention given to differentiated instruction and its significance,

and a recent study confirmed that students with higher and lower academic achievement show significantly different patterns in terms of levels of quality learning-from-errors processes (Zhang, 2025), researchers are advised to investigate if, how, and why individual differences affect students' preferences and actual use of different functionalities. Also, given the current finding that students' need for anonymity may differ when switching between roles, from the perspectives of social impact theory and the SIDE model, researchers can investigate whether any cross-influence between role identity and function preference exists under different assumed roles and situations (i.e., requesting help versus providing help in anonymous and identified online spaces) and whether it has effects on learning outcomes of educational importance (e.g., motivation, anxiety, satisfaction with the learning experience and peer relationships).

Third, while several technological and social designs have been incorporated into the system, and while, as in any classrooms equipped with a theory-guided, empirically affirmed, technologically efficacious learning system, the teacher played a pivotal role in helping ensure that students benefited from the arranged activity (e.g., the setup of an educationally sound, step-by-step error-correction process; the design and implementation of a training session on productive error correction and the main functionalities of the system; and the preparation of a user manual for individual reference), the system can be further enhanced with AI technologies. Explicitly, pedagogical agents to act as additional online support for auto-hints or question prompts/templates can be designed and included.

Following on the previous point, currently, the system relies on teachers and/or peers as social scaffolds. While the teacher provided weekly whole-class feedback to address students' inadequate error-corrected performance/work, AI technologies can be leveraged and incorporated in the system as a personalized, tailored error feedback handling mechanism.

Finally, as explicated, the three main functionalities were intentionally introduced at specific points (rather than all activated at the beginning of this study for students' use at their discretion) for focused exploration. In other words, participants were exposed to each of the enhanced functionalities for a couple of instances throughout the 10-week study. Hence, the novelty effect cannot be effectively ruled out and analyzed with the current study design. Considering that novelty is a key factor that will affect/mediate the effect of a technological intervention on learning (Lee et al., 2025; Rodrigues et al., 2022), which may produce a tentative emotional effect (e.g., learning interest, motivation), researchers are suggested to look deeper into students' usage patterns through a longer implementation period in the future. Furthermore, by mapping a time-series trend chart of functionality usage against revealed preferences or learning outcomes of educational relevance (e.g., learning interest, motivation, satisfaction toward the learning

experience), the long-term educational potential of the functionalities can be assessed.

Acknowledgement

This study was supported by the Ministry of Science and Technology, Taiwan (MOST 111-2410-H-006-023-MY3).

References

Ainsworth, S. (2006). DeFT: A conceptual framework for considering learning with multiple representations. *Learning and Instruction, 16*(3), 183-198. https://doi.org/10.1016/j.learninstruc.2006.03.001

Balderas, I. R., & Cuamatzi, P. M. G. (2018). Self and peer correction to improve college students' writing skills. *Profile: Issues in Teachers' Professional Development, 20*(2), 179-194. https://doi.org/10.15446/profile.v20n2.67095

Chee, S. M., & Abdullah, M. N. L. Y. (2021). The effectiveness of self-correction strategy in improving primary school students' mathematics achievement. *MOJES: Malaysian Online Journal of Educational Sciences, 9*(4), 41-52.

Chen, D., Jeng, A., Sun, S., & Kaptur, B. (2023). Use of technology-based assessments: A systematic review covering over 30 countries. *Assessment in Education: Principles, Policy & Practice, 30*(5-6), 396-428. https://doi.org/10.1080/0969594X.2023.2270181

Chen, D.-K., Zhang, Y., Luo, H., Zhu, Z.-F., Ma, J.-S., & Lin, Y.-R. (2024). Effects of group awareness support in CSCL on students' learning performance: A three-level meta-analysis. *International Journal of Computer-Supported Collaborative Learning, 19*(1), 97-129. https://doi.org/10.1007/s11412-024-09418-3

Chen, D.-K., Zhang, Y., & Lin, Y.-Y. (2022, July 19-22). *Group awareness and group awareness tools in computer-supported collaborative learning: A literature review* [Paper presentation]. International Symposium on Educational Technology, Hong Kong, China. https://doi.org/10.1109/ISET55194.2022.00013

Chevalère, J., Berthon, M., Rocher, N., Pailler, D., Mazenod, V., & Huguet, P. (2025). A digital safe space for learning: How computer-assisted instruction supports students with lower academic self-concept. *Education and Information Technologies, 30*, 15413-15440. https://doi.org/10.1007/s10639-025-13424-9

Chiu, T. K. F. (2022). Applying the self-determination theory (SDT) to explain student engagement in online learning during the COVID-19 pandemic. *Journal of Research on Technology in Education, 54*, S14-S30. https://doi.org/10.1080/15391523.2021.1891998

Clark-Gordon, C. V., Bowman, N. D., Goodboy, A. K., & Wright, A. (2019). Anonymity and online self-disclosure: A meta-analysis. *Communication Reports, 32*(2), 98-111. https://doi.org/10.1080/08934215.2019.1607516

Cooper, W. H., Gallupe, R. B., Pollard, S., & Cadsby, J. (1998). Some liberating effects of anonymous electronic brainstorming. *Small Group Research, 29*, 147-178. https://doi.org/10.1177/1046496498292001

Darvishi, A., Khosravi, H., Sadiq, S., Gašević, D., & Siemens, G. (2024). Impact of AI assistance on student agency. *Computers & Education, 210*, 104967. https://doi.org/10.1016/j.compedu.2023.104967

Flavell, J. (1979). Metacognition and cognitive monitoring: A new area of cognitive-

developmental inquiry. *American Psychologist, 34*(10), 906-911. https://doi.org/10.1037/0003-066X.34.10.906

Gagne, E., Yekovich, C. W., & Yekovich, F. R. (1993). *The cognitive psychology of school learning*. Harper Collins College Publishers.

Gergen, K. J., Gergen, M. M., & Barton, W. N. (1973). Deviance in the dark. *Psychology Today, 7*, 129-130.

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Aldine Transaction.

Godwin-Jones, R. (2024). Distributed agency in language learning and teaching through generative AI. *Language Learning & Technology, 28*(2), 5-30. https://doi.org/10.64152/10125/73570

Graham, L., Berman, J., & Bellert. A. (2015). *Sustainable learning: Inclusive practices for 21st century classrooms.* Cambridge University Press.

Hadwin, A., Järvelä, S., & Miller, M. (2018). Self-regulation, co-regulation, and shared regulation in collaborative learning environments. In D. H. Schunk & J. A. Greene (Eds.), *Handbook of self-regulation of learning and performance* (2nd ed., pp. 83-106). Routledge/Taylor & Francis Group. https://doi.org/10.4324/9781315697048-6

Hays, J., & Reinders, H. (2020). Sustainable learning and education: A curriculum for the future. *International Review of Education, 66*, 29-52. https://doi.org/10.1007/s11159-020-09820-7

Hoth, J., Larrain, M., & Kaiser, G. (2022). Identifying and dealing with student errors in the mathematics classroom: Cognitive and motivational requirements. *Frontier in Psychology, 13*. https://doi.org/10.3389/fpsyg.2022.1057730

Hsieh, A. Y., Lo, S. K., Chiu, Y. P., & Hwang, Y. (2023). Social anxiety and online media choice: Visual anonymity as a key. *International Journal of Human-Computer Interaction, 40*(23), 7908-7914. https://doi.org/10.1080/10447318.2023.2278303

Jaidka, K., Mukerjee, S., & Lelkes, Y. (2023). Silenced on social media: The gatekeeping functions of shadowbans in the American Twitterverse. *Journal of Communication, 73*(2), 163-178, https://doi.org/10.1093/joc/jqac050

Jivet, I., Scheffel, M., Schmitz, M., Robbers, S., Specht, M., & Drachsler, H. (2020). From students with love: An empirical study on learner goals, self-regulated learning and sense-making of learning analytics in higher education. *The Internet and Higher Education, 47*, 100758. https://doi.org/10.1016/j.iheduc.2020.100758

Karabenick, S. A. (2003). Seeking help in large college classes: A person-centered approach, *Contemporary Educational Psychology, 28*(1), 37-58. https://doi.org/10.1016/S0361-476X(02)00012-7

Keshavarz, R., & Marzban, A. (2016). A comparison of efficiency in teacher correction strategies in Iranian EFL learners' speaking improvement. *International Journal of English Linguistics, 6*(6), 183-194. https://doi.org/10.5539/ijel.v6n6p183

Khansir, A., & Pakdel, F. (2018). Place of error correction in English language teaching. *Educational Process: International Journal, 7*(3), 189-199. http://dx.doi.org/ 10.22521/edupij.2018.73.3

Kulhavy, R. W., & Stock, W. A. (1989). Feedback in written instruction: The place of response certitude. *Educational Psychology Review, 1*(4), 279-308. https://doi.org/10.1007/BF01320096

Latané, B. (1981). The psychology of social impact. *American Psychologist, 36*(4),

343-356. https://doi.org/10.1037/0003-066X.36.4.343

Laursen, B., & Veenstra, R. (2021). Toward understanding the functions of peer influence: A summary and synthesis of recent empirical research. *Journal of Research on Adolescence, 31*(4), 889-907. https://doi.org/10.1111/jora.12606

Lee, H., Choi, J., Kim, K. K., & Lee, A. R. (2014). Impact of anonymity on information sharing through internal psychological processes: A case of South Korean online communities. *Journal of Global Information Management, 22*(3), 57-77. https://doi.org/10.4018/jgim.2014070103

Lee, J., Chen, C. C., & Basu, A. (2025). From novelty to knowledge: A longitudinal investigation of the novelty effect on learning outcomes in virtual reality. *IEEE Transactions on Visualization and Computer Graphics, 31*(5), 3204-3212. https://doi.org/10.1109/TVCG.2025.3549897

Li, H.-H., Xu, Y.-P., Li, Y.-Y., Wang, J.-Y., Tang, X.-R., & Yin, X. H. (2025, April 18-20). *The impact of group awareness tools on students' learning engagement from the perspective of CSCL– A systematic literature review based on empirical research (2000-2024)* [Paper presentation]. 2025 7th International Conference on Computer Science and Technologies in Education (CSTE), Wuhan, China. https://doi.org/10.1109/CSTE64638.2025.11092098

Lin, J. W., Huang, H. H., & Chen, H. R. (2023). Team-based learning with group awareness: Impact on students with different self-regulated learning levels. *Interactive Learning Environments, 32*(8), 4009-4019. https://doi.org/10.1080/10494820.2023.2194334

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage.

Mahasneh, R. A., Sowan, A. K., & Nassar, Y. H. (2012). Academic help-seeking in online and face-to-face learning environments. *E-Learning and Digital Media, 9*(2), 196-210. https://doi.org/10.2304/elea.2012.9.2.196

Malone, T. W., & Lepper, M. R. (1987). Making learning fun: A taxonomy of intrinsic motivations for learning. In R. E. Snow & M. J. Farr (Eds.), *Aptitude, learning, and instruction*: *Cognitive and affective process analyses* (pp. 222-253). Erlbaum.

Mason, B., & Bruning, R. (2001). *Providing feedback in computer-based instruction: What the research tells us*. Unpublished.

Mayer, R. E. (2020). *Multimedia learning* (3rd ed). Cambridge University Press. https://doi.org/10.1017/9781316941355

Metcalfe, J., Xu, J., Vuorre, M., Siegler, R., Wiliam, D., & Bjork, R. A. (2024). Learning from errors versus explicit instruction in preparation for a test that counts. *British Journal of Educational Psychology, 95*(1), 11-25. https://doi.org/10.1111/bjep.12651

Meyer, D. K. (1993). What is scaffolded instruction? Definitions, distinguishing features, and misnomers. In D. J. Leu & C. K. Kinzer (Eds.), *Examining central issues in literacy research, theory, and practice* (pp. 41-53). National Reading Conference.

Mickeler, M., Khashabi, P., Kleine, M., & Kretschmer, T. (2023). Knowledge seeking and anonymity in digital work settings. *Strategic Management Journal, 44*(10), 2413-2442. https://doi.org/10.1002/smj.3504

Moral-Toranzo, F., Canto-Ortiz, J., & Gómez-Jacinto, L. (2007). Anonymity effects in computer-mediated communication in the case of minority influence. *Computers in*

Human Behavior, 23(3), 1660-1674. https://doi.org/10.1016/j.chb.2005.09.002

Narciss, S., & Alemdag, E. (2024). Learning from errors and failure in educational contexts: New insights and future directions for research and practice. *British Journal of Educational Psychology, 95*(1), 197-218. https://doi.org/10.1111/bjep.12716

Pan, X. Y., Hou, Y. B., & Wang, Q. (2023). Are we braver in cyberspace? Social media anonymity enhances moral courage. *Computers in Human Behavior, 148*, 107880. https://doi.org/10.1016/j.chb.2023.107880

Pineda Hoyos, J. E. (2018). Error correction and repair moves in synchronous learning activities. *International Journal of Educational Technology in Higher Education, 15*, Article 23. https://doi.org/10.1186/s41239-018-0105-2

Pitukwong, K. (2024). Investigating effective error correction strategies employed by teachers in enhancing students' writing skills at the higher education level. *Journal of Business Administration and Languages, 12*(1), 16-30.

Postmes, T., Spears, R., Sakhel, K., & de Groot, D. (2001). Social influence in computer-mediated communication: The effects of anonymity on group behavior. *Personality and Social Psychology Bulletin, 27*(10), 1243-1254. https://doi.org/10.1177/0146167201271001

Puntambekar, S., & Kolodner, J. L. (1998). Distributed scaffolding: Helping students learn in a "learning by design" environment. In A. S. Bruckman, M. Guzdial, J. L. Kolodner, & A. Ram (Eds.), *Proceedings of the third international conference of the learning sciences* (*ICLS'98*) (pp. 35-41). Association for the Advancement of Computing Education

Rodrigues, L., Pereira, F. D., Toda, A. M., Palomino, P. T., Pessoa, M., Carvalho, L. S. G., Fernandes, D., Oliveira, E. H. T., Cristea, A. I., & Isotani, S. (2022). Gamification suffers from the novelty effect but benefits from the familiarization effect: Findings from a longitudinal study. *International Journal of Educational Technology in Higher Education, 19*(1). https://doi.org/10.1186/s41239-021-00314-6

Rushton, S. J. (2018). Teaching and learning mathematics through error analysis. *Fields Mathematics Education Journal, 3*, 1-12. https://doi.org/10.1186/s40928-018-0009-y

Ryan, A. M., Pintrich, P. R., & Midgley, C. (2001). Avoiding seeking help in the classroom: Who and why? *Educational Psychology Review, 13*, 93-114. https://doi.org/10.1023/A:1009013420053

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*, 68-78. https://doi.org/10.1037/0003-066X.55.1.68

Schnaubert, L., & Bodemer, D. (2022). Group awareness and regulation in computer-supported collaborative learning. *International Journal of Computer-Supported Collaborative Learning, 17*, 11-38. https://doi.org/10.1007/s11412-022-09361-1

Schnaubert, L., Harbarth, L., & Bodemer, D. (2020). A psychological perspective on data processing in cognitive group awareness tools. In M. Gresalfi & I. S. Horn (Eds.), *The interdisciplinarity of the learning sciences, 14th international conference of the learning sciences (ICLS) 2020* (2nd ed., pp. 951-958). International Society of the Learning Sciences. https://repository.isls.org//handle/1/6839

Schraw, G., Crippen, K., & Hartley, K. (2006). Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. *Research in Science Education, 36*(1), 111-139. https://doi.org/10.1007/s11165-005-3917-8

Siegel, J., Dubrovsky, V., Kiesler, S., & McGuire, T. W. (1986). Group processes in computer-mediated communication. *Organizational Behavior and Human Decision Processes, 37*(2), 157-187. https://doi.org/10.1016/0749-5978(86)90050-6

Smith, K. (2014). *Émile Durkheim and the collective consciousness of society: A study in criminology*. Anthem Press.

Sompong, M. (2013). Error analysis. *Thammasat Review, 16*(2), 109-127.

Spears, R., & Lea, M. (1992). Social influence and the influence of the "social" in computer-mediated communication. In M. Lea (Ed.), *Contexts of computer-mediated communication* (pp. 30-65). Harvester-Wheatsheaf.

Steenberghs, N., Lavrijsen, J., Kiuru, N., & Verschueren, K. (2024). Peer influences on (dis)engagement in early adolescence: The role of friendship, social status, and academic status. *Journal of Youth and Adolescence, 53*(4), 940-954. https://doi.org/10.1007/s10964-023-01895-3

Steuer, G., Tulis, M., & Peterson, E. R. (2025). Learning from errors and failure in educational contexts. *British Journal of Educational Psychology, 95*, 1-10. https://doi.org/10.1111/bjep.12723

The National Academies of Sciences, Engineering, and Medicine. (2018). *How people learn: Learners, contexts and cultures* (2nd ed.). National Academies Press. https://doi.org/10.17226/24783

Velamazán, M., Santos, P., Hernández-Leo, D., & Vicent, L. (2023). User anonymity versus identification in computer-supported collaborative learning: Comparing learners' preferences and behaviors. *Computers & Education, 203*, 104848. https://doi.org/10.1016/j.compedu.2023.104848

Watts, L. L., Hamza, E. A., Bedewy, D. A., & Moustafa, A. A. (2024). A meta-analysis study on peer influence and adolescent substance use. *Current Psychology, 43*, 3866-3881. https://doi.org/10.1007/s12144-023-04944-z

Weisband, S. P., Schneider, S. K., & Connolly, T. (1995). Computer-mediated communication and social information: Status salience and status differences. *Academy of Management Journal, 38*(4), 1124-1151. https://doi.org/10.5465/256623

Yilmaz, R., & Yilmaz, F. G. (2020). Examination of the effectiveness of the task and group awareness support system used for computer-supported collaborative learning. *Educational Technology Research and Development, 68*, 1355-1380. https://doi.org/10.1007/s11423-020-09741-0

Yu, F. Y., & Sung, S. (2022). Factors influencing peer referencing behavior during an online learning activity. *Journal of Social and Personal Relationships, 39*(12), 3853-3878. https://doi.org/10.1177/02654075221114288

Yu, F. Y. (2009). Scaffolding student-generated questions: Design and development of a customizable online learning system. *Computers in Human Behavior, 25*(5), 1129-1138. https://doi.org/10.1016/j.chb.2009.05.002

Yu, F. Y. (2024). Theory-driven design for the development of a student-centered error-correction online learning system. In A. Kashihara, B. Jiang, M. M. Rodrigo, & J. O. Sugay (Eds.), *Proceedings of the 32nd international conference on computers in*

education (Vol. 1, pp. 806-808). Asia Pacific Society of Computers in Education.

Yu, F. Y. (2025). The desirability of peer-assisted learning spaces for online student-centered error correction: A preliminary evaluation. In B. Jiang, Y. Song, M. M. Rodrigo, & J. Warriem (Eds.), *Proceedings of the 33rd international conference on computers in education* (Vol. 1, pp. 295-297). Asia Pacific Society of Computers in Education.

Yu, F. Y. (2026, April 8-12). *Computer-based assessment in support of productive learner-centered error-correction: What it entails and its educational potential* [Paper presentation]. American Educational Research Association Annual Meeting, Los Angeles, CA, USA.

Yu, F. Y., & Liu, Y. H. (2009). Creating a psychologically safe online space for a student-generated questions learning activity via different identity revelation modes. *British Journal of Educational Technology, 40*(6), 1109-1123. https://doi.org/10.1111/j.1467-8535.2008.00905.x

Yu, F. Y., & Sung, H. S. (2019). Online targeting behavior of peer-assessors under identity-revealed, created, and concealed modes. *Educational Technology and Society, 22*(1), 15-27.

Zhang, E. (2025). Unravelling the quality of processes of learning from errors: Insights from students' written error reflections in factoring tasks. *Learning and Instruction, 100*, 102199. https://doi.org/10.1016/j.learninstruc.2025.102199