An Online Drill-and-Practice System Anchoring the Cultivation of a Growth Mindset: Design Concepts, Core Components, and Preliminary Evaluation

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Abstract: Given the far-reaching effects of a growth mindset on cognitive, social-emotional, and professional development, this work aimed to construct the world's first online drill-and-practice learning system designed to cultivate a growth mindset. The central ideas valued by growth mindset advocates (e.g., viewing mistakes as opportunities for cognitive growth, focusing on learning processes over outcomes) were incorporated by designing, developing, and integrating an error-correction subsystem—consisting of six productive error-correction steps—into an existing drill-and-practice platform. This paper primarily explains the design concepts and core components that support the productive error-correction process. An evaluation study involving four classes of sixth-grade students (*n*=104) was conducted to provide preliminary data on the system's effectiveness in fostering a growth mindset.

Keywords: Drill-and-practice activity, growth mindset, learning from errors, online learning system design and development, practice with feedback

1. Introduction

Numerous researchers (e.g., Dweck, 2007; Sousa et al., 2024) emphasized the significance of cultivating a growth mindset for human personal and professional development. Additionally, studies have substantiated the educational value of a growth mindset for promoting academic improvement, mental health (Burnette et al., 2023), and social-emotional development (Jiang et al., 2023). While explicit strategies, interventions, and tips for fostering the development of a growth mindset have been proposed (e.g., embracing mistakes as opportunities for learning and growth, focusing on effort and learning processes over outcomes, encouraging self-reflection) (Burnette et al., 2022), how to integrate these into routine classroom activities remains insufficiently addressed.

Given that practice on pre-determined learning objectives with feedback is an essential instructional component, yet explanatory feedback on students' performance is predominantly provided by the system or the teacher, this work focuses on developing a student-centered error-correction subsystem to augment online drill-and-practice activities. Since engaging students in error correction aligns with the principles of a growth mindset, this subsystem was designed to promote active learner involvement in the process.

2. Design Concepts and Core Components to Guide the Development of a Productive Error-Correction Process

As several researchers have urged, to maximize learning, students and teachers should focus on more than simply correcting errors, ensuring that other important aspects of the error-correction process are not neglected. For instance, Byrne (1988) and Cogie et al. (1999) encouraged students to think about what types of errors are made, besides providing the

correct answer. Arias (2004) suggested that reasons for errors should be highlighted, and the correct use should be explained. Iseni (2011) similarly suggested that students explain their errors and attend to the types and frequency of errors made during error correction. Khansir and Pakdel (2018) pointed out that error correction involves not only the analysis of the source and location of errors but also the provision of explanations for misconception clarification.

Researchers in feedback and problem analysis have also highlighted other crucial areas for consideration. Kulhavy and Stock (1989) proposed four types of task-specific elaboration messages in response to question-answering, among which the 'instruction-based elaboration'—concerning information covered in the curriculum—is most pertinent. Mason and Bruning (2001) distinguished four types of elaborated feedback. Of these, three are worth considering: 'topic-contingent' messages provide definitive, basic information on the study topic; 'bug-related' messages supply error-specific information; and 'response-contingent' messages offer explanations for the correct answer. To help learning through problems, Pelley and Dalley (1997) proposed explicit steps for problem analysis and emphasized the importance of identifying the topic(s) of the problem and understanding why the correct answers are correct and the incorrect answers are incorrect.

Drawing on the above literature, we proposed six core components and subsequently incorporated them into our system to guide students in productive error correction. They are: (1) correcting mistakes, (2) pinpointing the main ideas tested in the question, (3) explaining why the submitted answer is incorrect, (4) justifying why the correct answer is correct, (5) identifying the sources of the errors, and (6) retrieving and interlinking pertinent knowledge pieces to the question. These highlighted error-correction processes embody the core values of a growth mindset and are expected to foster such a mindset in learners.

3. Preliminary evaluation of the Effects of an Online Error-Correction System on the Cultivation of a Growth Mindset

Four sixth-grade classes (n=104) participated in this study over ten weeks. In the first week, students filled out a scale to assess their beliefs on fixed and growth mindsets, before the teacher gave a brief training session on the aim of the newly integrated error-correction activity (i.e., promoting a deeper understanding of the study topic and elaborative knowledge construction) and system use. Starting from the second week, as a routine in each week, students received two 40-minute instructional sessions on social science delivered by the teacher. Afterwards, in another 40-minute instructional session, the teacher gave brief whole-class feedback on students' performance from the previous week, highlighting model student work and clarifying common misconceptions. Then, students completed a 10-item online multiple-choice quiz on the social science topic covered during the current week. Upon completion, they proceeded to the online error-correction task, in which they worked through each of the six components for any questions they had answered incorrectly, following the step-by-step procedures provided in the system. Finally, students completed the same scale again at the end of the 10th week. Jiăng's scale, with established validity and reliability, was adapted to ensure contextual fitness.

The results based on pair-sample t-tests did not substantiate that students engaged in online drill-and-practice with error-correction activities led to a significantly lower score on a fixed mindset, t=0.17, $p > 0.05$, nor a significantly higher score on a growth mindset, t=-1.49, $p > 0.05$. Several factors may account for the unexpectedly unconfirmed findings. First, it appears that the training session centered more on the technical (i.e., completing the task in the system) rather than the conceptual (i.e., the meaningfulness and usefulness of each error-correction component) and motivational aspects (i.e., positive climate management) of the integrated activity. Second, an instructional implementation consisting of 15 minutes of student-centered error correction for nine weeks (i.e., 135 minutes) may not be sufficient to produce substantial results. As mindset researchers have suggested, several contextual factors (e.g., differences in implementation procedures) influence which growth mindset interventions are effective, for whom, and under what conditions (Burnette et al., 2023). Third, having students engaged in online drill-and-practice with error-correction activities on social

science (i.e., one specific domain) may not be impactful enough to affect students' general beliefs in their intelligence and aptitudes, given that people could possess different mindsets and beliefs about themselves in different areas (Dweck & Master, 2009).

4. Conclusion

An online system to extend a drill-and-practice system for the cultivation of a growth mindset is the aim of this work. Given the unconfirmed findings and the implementation procedures used in this study, future research should include a training session that explicitly conveys the value of each error-correction component—potentially through persuasive messages that tap into students' valuation system (Falk, 2025)—and extend the intervention period to support online drill-and-practice activities across multiple subject areas. Incorporating qualitative methods, such as in-depth unstructured interviews exploring students' perceptions of each component's role in fostering a growth mindset, would also help validate and refine the proposed error-correction framework.

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