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Designing and testing an Adapted Primary Literature-based technology-enhanced environment for learning and instruction of scientific writing in high-school biology

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1. Abstract

Developing scientific communication skills has become a major educational goal in science education. Learning how to produce scientific texts is essential to developing an understanding of science and to learning science. However, many issues remain unclear regarding the learning goals and the suitable strategies for implementing writing practices in the science classroom. The main goal of this study is to design and examine a teaching and learning environment which is based on Adapted Primary Literature (APL), aimed at promoting scientific writing skills of high-school biology majors. The initial hypothesis was that APL can serve as an apprenticeship genre for high-school biology students' writing and along with the teachers' mediation and coaching could promote the socialization of high school biology students into the scientific community.

The methodological approach chosen for this research was Design-Based Research (DBR). The study consisted of four phases: In phase I, the students' difficulties and the teachers' challenges in the process of inquiry-based writing in high-school biology classes were identified and characterized; In phase II, the initial design principles (DP) were defined and the prototype of the learning and teaching environment was designed and developed. The environment was named "SWIM" which stands for – "Scientific Writing Interactive Model"; In phase III, three consecutive iterations were performed. In each iteration the SWIM technology-enhanced learning environment (TELE) was implemented in a growing scale (from 2 classes in the first iteration to 41 classes in the third iteration), evaluated and revised, to create the subsequent version; In phase IV a reflection of the design and implementation process was made in order to draw conclusions about learning and instruction of scientific writing in high-school biology classes, to produce the final DP and to outline recommendations for future research.

The findings from the first phase of the study indicated that high-school biology majors are lacking the genre knowledge required for writing an inquiry-project report, including specific scientific writing components students are struggling with, such as: raise criticism, justification of the inquiry, resources and citation, and scientific merit of the hypothesis. In addition, teachers experience difficulties instructing writing of an inquiry-project report, and usually implement an inefficient individual instruction. The results also suggest that reading an APL article (and pointing out the similarities to the inquiry-project report) is not sufficient for facilitating scientific writing skills of high-school biology majors, probably due to focusing on the content rather than on the genre. From the findings of the first phase, I concluded that there is a need for an instructional framework that will exploit the APL as an apprenticeship genre to assist the teachers in instructing the writing process of an inquiry-project report and to address specific scientific writing difficulties the students are experiencing during this writing process.

In the second phase of this DBR, the initial DP of the SWIM-TELE were defined and the prototype (SWIM 1.0) was developed accordingly. These DP are founded on the basis of genre-oriented pedagogy, and enabled the implementation of the SWIM environment according to the sociocognitive apprenticeship framework. The high-level conjecture about the SWIM-TELE was that inquiry-based writing in high-school biology requires genre knowledge that can be gained by using APL as an apprenticeship genre. This conjecture was embedded in the environment in different elements. These elements enable mediating

apprenticeship processes that may result in the improvement of students' scientific writing skills.

The findings from the three iterations in the third phase of the research indicate that following the implementation of the SWIM-TELE the students' scientific writing skills and writing strategies had improved. The students also gained appreciation for writing in science and self-efficacy for writing, as well as a better understanding of the biological concepts underlying their inquiry-project. Based on the results obtained in the first iteration, the SWIM-TELE was revised to integrate a process-oriented pedagogy that better linked the genre knowledge gained to the writing of the students' inquiry-project reports. The results also show that in classes in which the SWIM-TELE was implemented, the teachers applied the genre-process pedagogy by sociocognitive apprenticeship process using the APL-based elements and process-based features embedded in the environment for this process.

As the conjectures of the SWIM-TELE were verified, I argue that: a) the SWIM teaching and learning environment with its underlying genre (APL-based) and process elements together with the technological support, enabled the teachers to apprentice their students by modeling, coaching and fading, using APL as an apprenticeship genre, b) Eventually, these processes enabled students to develop scientific writing skills, including genre knowledge and writing strategies as well as gaining self-efficacy for writing in science and appreciation for the important roles writing holds in science.

This research shows for the first time that APL can be used for instructing scientific writing. By exploiting the APL as an apprenticeship genre, the teachers can advance their students awareness of the language of the discipline and thus facilitate the enculturation of their students into the scientific discourse community.

This research also shows that effective instruction of scientific writing of high-school biology students should be based on integrated genre-process pedagogy. In addition to the construction of genre knowledge by the students, the writing instruction process should also include the teaching of writing strategies and self-regulation procedures along with extensive and productive feedback and collaboration.

Taken together, a SWIM instructional model was designed to claim that knowledge and expertise are distributed and shared between the teacher, the students and the SWIM-TELE. This distribution enables the apprenticeship process and eventually the socialization of the students into ways of knowing and understanding within the discipline.