Supporting Meaningful Revision of Scientific Ideas in an Online Genetics Unit

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Abstract: This research investigates two ways to encourage revision of scientific essays an online genetics unit. Revising is difficult for students, due partly to lack of practice and guidance. We examine the effects of two activities designed to support gaining ideas from evidence by comparing an essay annotator activity that models the essay revision process (*text*) to an activity in which students annotate screenshots of interactive models from the unit (*model*). All students improved in their ability to revise, but low prior knowledge students benefited more from the *text* annotator condition.

Introduction

Complex scientific topics such as genetic inheritance are notoriously challenging for students; understanding inheritance requires integration of phenomena occurring at various levels, ranging from DNA, genes, and alleles to inheritance of chromosomes to phenotypic expression (Jacobson & Wilensky, 2006). Students especially struggle with revising explanations after encountering new evidence (Berland & Reiser, 2009). Typically, students' revisions include only surface-level or grammatical fixes rather than integration of new content (Crawford et al., 2008; Bridwell, 1980), resulting in a collection of disconnected ideas. We explore revision guidance in the form of a *text* annotator (Fig 1), designed to make the revision process more visible, and a *model* annotator, designed to reinforce interpretation of evidence from the output of genetics simulations and models.

We employ the knowledge integration (KI) framework for curriculum design and analysis of student work since it emphasizes eliciting and building on students' prior ideas, making it an ideal framework for promoting integrated revision (Linn & Eylon, 2011). Within the knowledge integration framework, revising ideas can help students integrate new concepts, and may especially help students who come in with low prior knowledge (LPK). Our goal in this work is to encourage revision to help students move beyond rote skills and towards purposeful and usable construction of knowledge. The genetics unit employed in this study was designed according to the knowledge integration framework to promote building on students' prior knowledge.

Methods

Six classes of 6th grade students (N=173) from one teacher participated in this study (94% non-white, 89% free/reduced lunch, 30% ELL). Students completed our 10-day Genetics and Simple Inheritance unit during class periods, working individually on the pretest and posttest, and working in pairs or groups of 3 on the unit itself. A revision question was also included on the pre/post test, asking students to revise their explanation after receiving new information about a pedigree. This question allowed us to assess students' ability to incorporate new knowledge in their scientific explanations before and after completing the unit. Two essay revision assessments that were embedded in the curriculum unit were analyzed as well (*Sibling* and *Punnett Square*). After answering each of these questions, student groups received one of the two types of experimental guidance (*text* or *model* annotation), and were then prompted to revise their initial response.

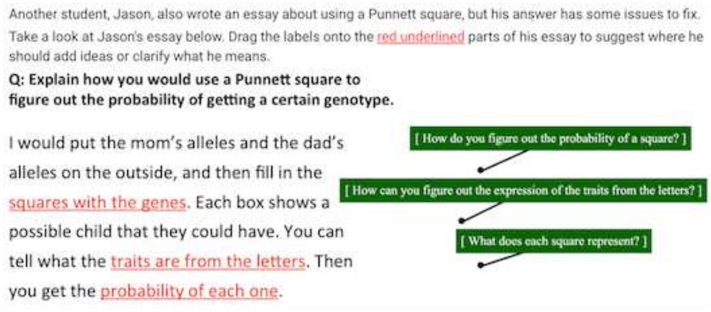

Figure 1. Example revision guidance activity for the *text* annotator condition.

All items were scored using a 5-point Knowledge Integration (KI) scale, which rewards making connections between scientific ideas. For each revision item (pre/post and embedded), KI scores were given to both the initial and revised essays and revision gain was calculated (revised score minus initial score). For some analyses, we categorized students that received a score of 1 or 2 on their pretest essay as “low prior knowledge” (LPK) and students that received a 3-5 as “high prior knowledge” (HPK). This cutoff was chosen because a KI score of 3 must include at least one normative scientific idea, while a score of a 2 does not. Qualitative revision codes were also given to the embedded essay revisions and pre/post revision item based on how a student revised. A code was given for whether students made connected (C) or disconnected (D) revisions. Another code was given for whether students added new (N) ideas in their revision or expanded existing (E) ideas that were already present in their initial response.

Results

All students improved in KI score from pretest (mean=1.89) to posttest (mean=2.61) [t(152)=9.66; p<0.001] and students’ revision gain score improved significantly from pre to posttest, regardless of condition [t(86)=4.40; p<0.001]. Students gained, on average, only 0.02 points from their revisions on the pretest, but gained 0.62 points from their revisions on the posttest. This shows the revision activities can improve students’ revision skills. Low prior knowledge students gained an average of 0.56 points more than high prior knowledge students from pretest to posttest [t(152)=2.17; p<0.05] across both conditions. We also found that LPK students revised by adding new ideas more often on the posttest than in their pretest revisions [t(143)=3.82, p<0.001].

For both embedded items, all students improved from initial to revised score (*Siblings:* [t(175)=4.19, p<0.001]; *Punnett Square:*[t(175)=5.90, p<0.001]), with an average gain of about 0.20 points on each. Students in the *text* annotator condition were more likely to revise by adding new ideas on the *Siblings* item, approximately 2.94 times as often as students in the *model* annotator condition [z(175)=2.40; p<0.05].

The *text* annotator provided the greatest advantage on the *Siblings* item for LPK students; they revised 2.64 times as often as those in the *model* condition [z(98)=1.99, p<0.05] and were 2.58 times as likely to revise by adding new ideas as compared to LPK students in the *model* condition [z(155)=1.97; p<0.05].

On the embedded *Siblings* item, high prior knowledge students were 4.54 times as likely to revise in a connected way as compared to LPK students [z(169)=2.53; p<0.05]. Similarly, on the *Punnett Square* question, high prior knowledge students were 3.43 times as likely to revise in a connected way [z(169)=2.13; p<0.05]. Our curriculum activities not only supported LPK students in adding ideas, but also helped HPK students successfully connect their prior knowledge to new science content.

Students who made any revisions at all on either embedded question achieved an average revision gain score of 0.33 points higher from pre to post than students who did not revise at all during the unit [t(118)=6.65; p<0.001]. In addition, making connected revisions on the embedded revision questions resulted in, on average, a pre to posttest gain of 0.44 points more than students who did not make connected revisions on the embedded assessment questions [t(152)=2.10; p<0.05]. This suggests that practice making connected revisions during the unit resulted in increased pre/post learning gains.

Significance

This study reveals that students can improve their understanding of genetics as well as their ability to revise their ideas after encountering new evidence by using curricular supports designed to help with revisions. Engaging in integrated revision during instruction is connected to significantly greater pre to post learning, supporting our KI perspective that making connections is a powerful learning strategy. In addition, our *text* annotator activity was more effective in supporting low prior knowledge students to add more new ideas to their revised explanations, and to revise more often. This reveals that students, especially LPK students, perhaps need less guidance directed toward helping them interpret model output and instead need help distinguishing which of their ideas are relevant for their explanations. This activity may help by making the revision process more visible.

References

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