Building Upon What Is Already There: The Role of Prior Knowledge, Background Information, and Scaffolding in Inquiry Learning

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Abstract: Prior knowledge is one of the most important factors for learning. During the iterative cycles of inquiry learning, learners’ prior domain knowledge is modified, refined, and further developed, provided that learners act upon self-assessments of their understanding and that they can actually think of appropriate hypotheses. Furthermore, knowledge about inquiry strategies influences the quality of the learners’ inquiry activities, and the lack thereof requires compensatory support. This symposium brings together recent work about the role of prior knowledge for inquiry learning and ways to compensate for the lack of it. The four papers focus on the role of learners’ self-assessment of their current understanding for their subsequent inquiry activities, on the gradual refinement of their knowledge on the basis of reflection, and on prior presentation of theoretical background information and concurrent presentation of inquiry strategies as ways to compensate for lack of prior theoretical knowledge and strategy knowledge, respectively.

One of the most powerful factors that influence learning is what learners already know (Dochy, Segers & Buehl, 1999). This rather general finding applies to inquiry learning as well (see, e.g., Gijlers & de Jong, 2005). This symposium brings together recent work about the ways prior knowledge influences inquiry learning and ways to compensate for the lack of it.

Inquiry learning has been characterized as an iterative process in which knowledge is modified, refined, and thereby further developed (e.g., White & Frederiksen, 1998). Students generate knowledge by asking questions and stating hypotheses, conducting experiments, and drawing conclusions, and each of these cycles is informed by the knowledge the learners have acquired during the previous ones. In this line of reasoning, student learning in subsequent cycles can benefit from accurate metacognitive judgments about the appropriateness of their current knowledge. In fact, interventions that target learners’ self-assessment of their understanding can foster knowledge about the domain content (White & Frederiksen, 1998).

Within the framework of Scientific Discovery as Dual Search (SDDS, Klahr & Dunbar, 1988; van Joolingen & de Jong, 1997), learners’ knowledge can be characterized by attributes of hypotheses within the so-called hypothesis space. This space contains all possible hypotheses about a given class of phenomena. A learner’s knowledge is constituted by the information for each hypothesis he or she can think of whether it is considered worthwhile testing, has or has not been tested so far, and if it has been tested, whether it has been rejected or retained for further consideration (cf. van Joolingen & de Jong, 1997; Gijlers & de Jong, 2005). The set of hypotheses a learner can think of, i.e. the so-called learner hypothesis space, is determined by the learners’ knowledge of variables and relations (van Joolingen & de Jong, 1997) and constitutes an important limiting factor during iteratively progressing inquiry learning because learners cannot discover the right hypothesis if it is not within their search space. If learners’ hypothesis spaces are too limited, remedial intervention such as providing background information is required.
Another kind of knowledge that is relevant during the cycles of inquiry learning is knowledge about inquiry strategies. While generating hypotheses, designing and conducting experiments, making observations and recording data, and drawing conclusions are activities that operate upon the content of the domain, they are part of inquiry strategies. Accordingly, learners with better knowledge about inquiry strategies are more likely to be successful during their inquiry activities and therefore should acquire more domain knowledge. Conversely, learners lacking sufficient levels of knowledge about inquiry strategies need to be scaffolded appropriately in order to be able to conduct fruitful inquiry activities and learn successfully about the domain.

The papers in this symposium cover this array of aspects of the role of prior knowledge during inquiry learning. Jennifer Chiu investigated the effects of learners’ self-assessments of their understanding during a WISE unit about chemical reactions. Cheryl Madeira and Jim Slotta followed the recommendation to apply the iterative character of inquiry learning to teacher training (White & Frederiksen, 1998) and investigated the iterative refinement of teachers’ pedagogical content knowledge under the conditions of practical enactment and peer exchange. Alexander Rachel, Christof Wecker, Eva Heran-Dörr, Hartmut Wiesner and Frank Fischer investigated ways to compensate for elementary school students’ limited hypothesis spaces that do not contain assumptions about theoretical entities related to magnetism. Yvonne Mulder, Ard Lazonder and Ton de Jong focused on scaffolding that may compensate for lacking knowledge about inquiry strategies. They studied the effects of heuristic worked examples demonstrating how to gradually develop an equation that specifies a relationship among a set of variables.

The series of the four paper presentations will be complemented by the presentation of a discussant. This role has been taken over by Peter Reimann who is an eminent scholar in the learning sciences and has conducted and published research about inquiry learning himself. He will identify the major achievements and unresolved issues of the four papers. This will provide the basis for an open discussion with the audience.

Paper 1: Student Self-Assessment of Knowledge Integration in a Technology-Enhanced Chemistry Lesson
Jennifer L. Chiu

Supporting self-assessment can help students learn across many domains (e.g., Scardamalia & Bereiter, 1991). Self-assessment skills such as questioning or judging one’s own understanding and making decisions based on those assessments are especially important for inquiry science learning in technology-enhanced environments (Quintana, Zhang & Krajcik, 2005; White & Frederiksen, 1998). Although students benefit from accurate self-assessment, research demonstrates that students have difficulty evaluating their own performance (Dunning, Heath & Suls, 2004). Many factors contribute to learners overestimating or underestimating their understanding, such as the nature of the assessment task, subject-matter knowledge, the learning environment, and motivation. Students may be able to assess their understanding of facts or simple recall items accurately, but overestimate their understanding on open-ended or explanation items (Zoller, Fastow, Lubezky & Tsaparlis, 1999). Even if students can accurately assess themselves, they may or may not go back to improve their understanding.

This study explored how high school chemistry students assessed their own understanding in inquiry settings using criteria based on the knowledge integration (KI) framework. The KI perspective calls for conscientious, intentional learning and focuses on the connections among scientific ideas (Linn & Eylon, 2006). Engaging in knowledge integration encourages students to elicit prior knowledge, add new, normative ideas to these existing frameworks, develop criteria to examine new ideas and links that they have formed to their prior knowledge, and evaluate their understanding to sort and distinguish more productive and relevant ideas from less productive ideas. Traditional instruction tends to focus on eliciting and adding ideas, often leaving out critical processes of supporting students to examine, evaluate and refine their understanding (Linn & Eylon, 2011).

The KI perspective can particularly help chemistry learners because many students struggle to make connections among concepts at molecular, observable, and symbolic levels. For example, students view equations of chemical reactions, such as $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$ as problems to solve instead of a process of breaking and forming bonds among atoms (Krajcik, 1991). Prior research demonstrates that curricula designed with a knowledge integration approach benefit chemistry learners (Linn et al., 2006). This study used the chemical reactions curriculum unit within the Web-based Inquiry Science Environment (WISE), a computer-based environment that scaffolds inquiry science projects (Slotta & Linn, 2009). WISE projects provide various tools to support knowledge integration and scientific inquiry, such as visualizations, concept maps, idea managers, embedded assessments and online discussions. In addition to scaffolding inquiry, WISE provides detailed log reports of how students progress through projects, including where and when they click on particular steps or interact with certain tools, and if and how they revise answers to embedded assessment steps. The WISE chemical reactions unit guides students through a one-week investigation of how chemical reactions relates to climate change using dynamic molecular visualizations. Prior research with this unit demonstrated that students often overestimate their understanding when using dynamic molecular visualizations, and prompting...
explanations helped students identify gaps in their knowledge (Chiu & Linn, 2008). Building upon this research, this study explored: (1) if students could accurately assess their explanations using explicit knowledge integration criteria; (2) if evaluating explanations encouraged students to revisit and/or revise their explanations, and (3) if students’ ability to assess their explanation had any impact on overall learning of the unit.

**Method**

High school chemistry students (n = 93) from the same teacher completed *chemical reactions* as part of normal class instruction. After students’ first interactions with visualizations, they explained what they learned. The next step provided a rubric for students to evaluate their explanation based on the scientific ideas and connections within the explanation. Students rated their explanation and provided a justification for their evaluation. Students’ KI ratings were compared to researcher ratings of the same explanations. Log data were analyzed to determine if students revisited or revised their explanations. Pretest and posttest assessments that contained both conceptual and self-assessment items were used to determine overall impact on self-assessment ability and learning.

**Results**

Compared to researcher ratings, almost half (48%) of the students accurately assessed their explanations. Students also overestimated (32%) and underestimated (20%) their scores. When asked to justify their self-evaluations, around 30% of students explicitly used KI terms of scientific ideas and/or connections (i.e., “We should get a three because we only made one scientific connection in our explanation and our explanation was not very complex.”) Most students made general statements about their understanding, such as, “I [sic] chose two because in some of the questions I only gave half an answer because some parts I didn’t get that much, but I explained what I did know.”

Log data results reveal that only 42% of students went back to either their explanation or the associated visualization step immediately after the self-assessment step. If students went back to their explanation, they were likely to revise their explanation for a higher KI score ($\chi^2 (1, 93) = 14.4, p < .001$). Student scores significantly increased from pretest to posttest, replicating earlier results that the *Chemical Reactions* unit helps students make connections among representations in chemistry ($t(92) = 15.08, p < .01, ES g = 1.08$).

Regression analysis with pretest score, accuracy of explanation self-evaluation, and revisits to explanations as explanatory variables and posttest score as the dependent variable indicated that neither accuracy of the self-assessment nor revisiting the explanation significantly impacted posttest score. Controlling for pretest ability, explanation evaluation accuracy, and revisiting, students’ average self-ratings residuals tended to decrease from pretest to posttest, indicating less inflated self-ratings on the posttest ($R^2 = .2, F(4, 88) = 5.50, p < .001; \beta = .44, t = 4.55, p < .001$).

**Conclusion**

Results show that many students could use explicit knowledge integration criteria to assess their open-ended embedded explanations and encouraging students to go back can help them refine their explanations. Results suggest that encouraging students to assess their understanding helped students become more critical of their understanding from pretest to posttest. Since many students did not give KI-based justifications of their scores or go back to revise their explanation after giving themselves a less-than perfect score, students’ self-assessments may need to be accompanied by external feedback or support to encourage students to act upon their judgments.

**Paper 2: Iterative Design Enhances Inquiry-Based Teaching**

Cheryl Madeira, James D. Slotta

Teacher professional development can be realistically said to translate directly into more effective student learning (Davis & Varma, 2008; Gerard et al., 2011; Krajcik & Blumenfeld, 2006). Teachers need to understand their topic domain, make effective choices of instructional strategy, and assess student learning in ways that inform their pedagogical approach. Substantial literature has addressed teacher knowledge and professional development (e.g., Borko et al., 1997), including the different kinds of knowledge held by teachers, such as general instructional strategies for a specific content domain called Pedagogical Content Knowledge (PCK). This type of teacher knowledge depends on experience and builds on prior knowledge. Teacher learning can be very difficult to measure, as it is often implicit and embedded within the teachers’ practice (Davis & Varma, 2008). How can a professional development model help capture and promote teacher learning?

This paper presents data from a three-year design-based study that examined teacher learning in relationship to design and enactment of an inquiry-based science lesson. We investigated the impact of two interventions – reflection and peer-exchange – across three stages: (1) lesson planning, (2) enactment, and (3) revision of lesson, with the three stages repeated two or three times, iteratively, by teachers. We describe how
teachers developed understandings within the context of these activities, contributing to our understanding of situated collaborative learning and teacher professional development.

**Method**

This study used a design-based methodology to investigate the development of pedagogical content knowledge of nine science teachers \(N = 9\) in relation to their instructional practices (e.g., lesson design, preparations, classroom interactions, assessment and feedback), and student understanding. These teachers, who volunteered to participate in this study, entered with a range of experience (between 3 and 30 years) and disciplinary expertise (i.e., physics, biology, chemistry, or general science). The teachers came from 5 different schools located in a large urban city in North America and had a wide variety of technology experience and access. For confidentiality, all participants were given pseudonyms. Data sources include teacher surveys, interview questions, lesson plans, reflections (captured in a wiki), videotaped classroom enactments, field notes, student artifacts and responses, peer exchanges (on wiki, and in group meetings).

This paper reports on 3 iterations of the study, which gradually introduced the conditions of the intervention. Iteration 1 of the study included four teachers \((n = 4)\) who worked individually with the researcher-mentor to co-design, enact and reflect the inquiry-based science lesson. Iteration 2 added five more science teachers and improved the reflective prompts by connecting them directly to lesson planning and enactment, while adding community elements (face-to-face and online). In iteration 3, we continued to refine the reflections and community exchange, connecting teacher activities of lesson planning and enactment to topics of student prior knowledge, project-based learning and technology implementation.

In order to analyze the various data from Wiki contributions, interviews and field notes, two coding schemas were developed – one for lesson planning and one for enactment – that included elements to measure teacher knowledge, following Grossman’s (1990) taxonomy: pedagogical content knowledge (PCK), content knowledge (CK), pedagogical knowledge (PK), technology pedagogical content knowledge (TPCK), contextual knowledge (CXK). Each code was ranked for quality with a value from 1 to 3, where 1 represented fragmented evidence of that knowledge, and 3 represented a highly coherent instance of the knowledge, and 2 was anything in between. In addition to these codes, we employed the characteristics of project-based learning as measures of inquiry-based lessons (e.g., student-driven questions, collaborative activities). Thus, if the lesson incorporated more inquiry-based approaches, the lesson plan itself scored higher. These coding schemes allowed us to capture improvements in teachers’ plans and enactments between iterations of our study, reflecting the added benefits of our improved intervention. They also allowed us to correlate those improvements to specific features of teacher knowledge and inquiry-based teaching. Only the lesson planning data will be presented in this paper, in relation to teachers’ prior knowledge. The elements in the coding schema reflected teachers’ understanding of student learning (i.e., PCK), including how teachers would respond to student ideas in their lesson revisions and subsequent enactments. The coding schema for Lesson Planning had high intercoder reliability (Kappa = .80).

**Results**

We hypothesized that when teachers revise lessons based on their reflections about the enactment, they would improve the quality of those lesson plans. This proved true for five of the six participants who completed two iterations, with the exception of Bill (teacher), whose lesson plan included less student collaboration and interactions in Iteration 2 than it did in Iteration 1 (based on results from analysis of lesson planning coding schema). The correlations provide evidence of a link between the quality of teachers’ reflections and the quality of their designed lessons. Teachers who were able to reflect in detail and link their lesson objectives to student learning were able to improve their lessons in the following iteration. Teachers who used the tools and followed the rules of reflection consistently showed improvements in their overall lesson planning score from the first to the second iteration.

**Conclusion**

Presumably, these improvements were due to teachers’ reflections about the strengths and liabilities of their lesson in the previous enactment. The teachers were able to ‘see’ what worked and didn’t work with the lesson plan, reflect on this in a concrete way, and then improve on their design and approach for the next iteration. Thus, scaffolded reflection throughout the course of these two planning and enactment cycles appears to play a productive role in helping teachers’ inquiry into their own practice, resulting in improved lesson designs and improved teacher knowledge of lesson planning.
The idea behind inquiry learning is that learners discover knowledge about scientific phenomena independently (de Jong, 2006). As most learners struggle with the activities required for this purpose, it has been suggested to provide scaffolding for them (de Jong & van Joolingen, 1998).

A more far-reaching goal of science education, however, is to acquire knowledge on the theory level that goes beyond observable phenomena. For example, in phenomena related to magnetism, theoretically assumed molecular magnets cannot be observed directly. A problem during inquiry learning might be that theories that assume such unobservable entities cannot easily be discovered because the learners’ hypothesis spaces (Klahr & Dunbar, 1988; van Joolingen & de Jong, 1997) will hardly contain assumptions about these entities. In a prior study we found that secondary school students can acquire more knowledge on the theory level if they receive a presentation of theoretical background information prior to investigating the phenomena themselves, whereas subsequent presentation of theoretical background information after an inquiry phase had no lasting effect (Rachel et al., 2010).

The current study focused on the question whether primary school children can likewise acquire knowledge on the theory level and knowledge on the level of phenomena during inquiry activities if supported accordingly. In particular, we investigated the short- and longer-term effects of prior presentation of theoretical background information, subsequent presentation of theoretical background information and specific scaffolding during inquiry learning activities on knowledge on the level of phenomena and knowledge on the theory level.

**Method**

Three to four intact 4th grade classes from German primary schools were randomly assigned to each condition of a 2x2x2-factorial design with scaffolding (unspecific/specific), prior presentation of theoretical background information (without/with) and subsequent presentation of theoretical background information (without/with) as independent variables. The 612 participants from 31 classes were on average $M = 9.25$ ($SD = 0.52$) years old; 305 of them were girls, 307 were boys.

The students first completed a 20 minute pretest. Then they worked on an inquiry unit about magnetism for 120 minutes in which they conducted hands-on experiments in dyads at up to eleven learning stations. Finally they completed a 25-minute posttest. Two months later they completed a 25 minute delayed posttest in their classrooms.

Dyads in the conditions with unspecific scaffolding received general prompts to engage in the three inquiry activities of predicting, describing and explaining. Dyads in the condition with specific scaffolding received content- and task-specific prompts for these inquiry activities. In the conditions with prior presentation of theoretical background information, initially a 30-minute introduction to the theoretical background of magnetism was provided by a teacher. No such introduction was given in the conditions without prior presentation of theoretical background information. In the conditions with subsequent presentation of theoretical background information a 30-minute teacher-led wrap-up phase about the same topics as in prior presentation of theoretical background information took place at the end of the learning phase, while there was no such phase in the conditions without subsequent presentation of theoretical background information.

Identical knowledge tests were used in the immediate and delayed posttests. They consisted of ten groups of tasks with several subtasks with multiple-choice, true-false and an open answering format that required the learners to insert labels into line drawings. The subtasks were coded as correct or incorrect on separate coding variables. The scale for knowledge on the level of phenomena comprised 15 coding variables and had sufficient reliability (immediate posttest Cronbach’s $\alpha = .60$; delayed posttest Cronbach’s $\alpha = .61$). The scale for knowledge on the theory level comprised 15 coding variables too and had satisfactory reliability (immediate posttest Cronbach’s $\alpha = .81$; delayed posttest Cronbach’s $\alpha = .82$). A subset of tasks from the parts of the test that captured knowledge on the level of phenomena was used for the pretest (9 coding variables, Cronbach’s $\alpha = .61$).

**Results**

The main results were the following: With respect to knowledge on the level of phenomena, in the immediate posttest no significant main or interaction effects of the independent variables were found. In the delayed posttest a small main effect in favour of the conditions with prior presentation of theoretical background information was detected, $F(1; 22.13) = 5.51; p = .03$; partial $\eta^2 = .20$.

With respect to knowledge on the theory level, in the immediate posttest a significant main effect in favour of the conditions with unspecific scaffolding, $F(1; 22.12) = 8.29; p = .01$; partial $\eta^2 = .04$, and an
interaction effect between prior presentation of theoretical background information and subsequent presentation of theoretical background information, $F(1; 22.12) = 4.46; p < .05$; partial $\eta^2 = .02$, were found. In particular, in the presence of prior presentation of theoretical background information or subsequent presentation of theoretical background information, learners acquired more knowledge on the theory level than without both of them. In the delayed posttest, however, this interaction effect disappeared. Instead, there was a significant main effect in favour of the conditions with prior presentation of theoretical background information, $F(1; 22.10) = 7.55; p = .01$; partial $\eta^2 = .03$.

**Discussion**

The results indicate a superiority of unspecific scaffolding during inquiry activities with respect to knowledge on the theory level. With general prompts for inquiry, the learners have to set sub-goals for inquiry themselves. As a consequence, the function of each current activity for the overall goal of investigating the theoretical assumptions might be more transparent to the learners than with highly specific questions. Furthermore, prior presentation of theoretical background information appeared beneficial for knowledge on the level of phenomena and knowledge on the theory level. While immediately after the learning phase a summary in the context of subsequent presentation of theoretical background information might be at least a functional equivalent to prior presentation of theoretical background information (as evidenced by the interaction of prior and subsequent presentation of theoretical background information), in the long run prior presentation of theoretical background information seems to be superior. This effect might be explained by the opportunity provided by prior presentation of theoretical background information to apply the theory to be learned during inquiry activities, thereby yielding higher levels of knowledge on the theory level. In sum, this study demonstrates that primary school children can learn about challenging topics involving scientific theories that cannot readily be discovered, provided that they are supported appropriately.

**Paper 4: Using Worked Examples to Scaffold Students’ Understanding of the Inquiry Learning Process**

Yvonne G. Mulder, Ard W. Lazonder, Ton de Jong

Technology-enhanced inquiry learning environments enable students to develop a deep understanding of science content and processes. Computer simulations have long been incorporated in these environments, and are increasingly being supplemented with opportunities for students to build computer models of the phenomena they are investigating via the simulation. Even though inquiry and modeling are potentially powerful ways of learning, students often lack the skills to take full advantage of these activities (e.g., de Jong & van Joolingen, 1998). A recent study showed that domain novices are quite capable of identifying relevant variables, but experience considerable difficulties in specifying the relations between these variables. Instead of gradually working toward a full-fledged scientific equation to specify a relationship, novices tried to induce and model these equations from scratch (Mulder, Lazonder, & de Jong, 2010).

Novice learners’ tendency to ‘jump the gun’ points to a lack of knowledge about inquiry strategies that can in principle be controlled by organizing the inquiry learning process in successive phases of increasing complexity (i.e., model progression: White & Frederiksen, 1990). Model progression indeed enhances inquiry and modeling performance (e.g., Mulder, Lazonder, & de Jong, 2011; Swaak, van Joolingen, & de Jong, 1998)—but not to a sufficient degree. It thus seems that students need additional support in order to better understand the activities in each model progression phase entail, and how they should be performed.

The present study examined the effectiveness of heuristic worked examples to deliver this support. Heuristic worked examples were proposed by Hilbert and colleagues (Hilbert & Renkl, 2009; Hilbert, Renkl, Kessler, & Reiss, 2008) as means to extend the application of worked examples from well-structured problem-solving tasks to more ill-structured, and hence more complex tasks. Unlike ‘traditional’ worked examples that provide students with a single algorithm to solve one particular type of problem, heuristic worked examples outline a series of problem solving strategies and demonstrate their usage in or across a range of related tasks. Heuristic worked examples have been successfully applied in, for instance, concept mapping and second language learning tasks (Renkl, Hilbert, & Schworm, 2009), and are expected to be beneficial to inquiry and modeling tasks as well.

The present study sought to validate this expectation by comparing the learning and performance of high-school students who worked in an inquiry learning environment with modeling facilities. All students were supported by model progression, but only students in the worked example condition received additional heuristic worked examples that exemplified the activities students should perform within each of three model progression phases. Students in this condition were accordingly expected to exhibit more proficient inquiry and modeling behavior and, as a result, perform better and learn more than students from the control condition who were not supported by heuristic worked examples.
Method
Eighty-two high-school students (aged 15-17) were randomly assigned to either the worked examples condition \((n = 46)\) or the control condition \((n = 36)\). Students in both conditions had to investigate a charging capacitor and create a computer model of its behavior. This task was divided into three model progression phases that asked students to first identify and sketch the model with its variables and relations, then specify all relations in qualitative terms (e.g., if resistance increases, then current decreases), and finally transform these qualitative specifications into physics equations (e.g., \(I = V / R\)).

Students in the worked examples condition could consult two heuristic worked examples for each phase. These examples came in the form of annotated videos that showed the inquiry respectively modeling activities of an anonymous person on a comparable task in a different domain. Students in the control condition did not receive these worked examples.

The study took place during four 50-min science lessons. In lesson 1, students were introduced to the learning environment and completed the knowledge pretest which addressed the meaning of key domain concepts (i.e., voltage source, resistance, capacitor, and capacitance) and the physics equations that govern the behavior of a charging capacitor. Lesson 2 and 3 were devoted to the inquiry and modeling task, and lesson 4 was used to administer the knowledge posttest. The posttest contained the same items as the pretest, although phrased in modeling terms to maximize resemblance with the learning task, plus six additional items about all qualitative relations in the simulation's underlying model.

Results
Main findings indicate that students in both conditions had comparable and low pretest scores, \(F(1, 80) = 0.03, p = .866\), needed quite the same amount of time on task, \(F(1, 80) = 0.70, p = .404\), but spent this time differently. As instructed by the worked examples, students in this condition did more experiments with the simulation, \(F(1, 80) = 12.57, p = .001\), and took more time to analyze and interpret the outcomes, \(F(1, 80) = 9.37, p = .003\). Control students, by contrast, largely ignored the simulation and spent most of their time creating and testing their model, \(F(1, 80) = 57.00, p < .001\). This proved rather ineffective, as students in the worked example condition performed significantly better, \(F(2, 79) = 7.65, p = .001\). That is, their models contained both correct variables, \(F(1, 80) = 15.38, p < .001\), and relations, \(F(1, 80) = 9.45, p = .003\). Despite this performance difference, posttest scores were comparable across conditions, \(F(1, 75) = 0.10, p = .759\), suggesting that worked example students performed better, but did not learn more.

Conclusion
These results confirm two of the three expectations. As predicted, heuristic worked examples caused students to perform the inquiry and modeling activities as intended, and enhanced the quality of their models. The expected difference in posttest scores failed to show, which suggests that heuristic worked examples have an immediate effect on students’ learning activities and performance, but little impact on the knowledge students (should) attain from these activities. This suggests that scaffolding inquiry learning strategies is insufficient to acquire domain knowledge; additional content explanations might be needed for students to develop (a deep) understanding of the topic of inquiry.

References


