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Does it matter how Molly does it? Person-presentation of strategies and transfer in mathematics

Anne E. Riggs[a,*], Martha W. Alibali[b], Charles W. Kalish[c]

[a] Department of Psychology, Western Washington University, 516 High Street, Bellingham, WA 98225, United States
[b] Department of Psychology, University of Wisconsin-Madison, 1202 West Johnson Street, Madison, WI 53706, United States
[c] Department of Educational Psychology, University of Wisconsin-Madison, 1025 West Johnson Street, Madison, WI 53706, United States

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ABSTRACT

Educational materials often present general concepts or strategies via specific people. Although this practice may enhance interest, it may also have costs for learning and transfer. Linking a strategy to a person (e.g., "Molly's strategy") could result in narrower transfer because students infer that the strategy is specific to the person, rather than a general strategy they should adopt. The present study tested this hypothesis among middle school students ($N = 191$) who learned a novel strategy for solving a mathematics story problem. For some students, the strategy example was presented via a specific person, and for others it was not. Students then solved posttest problems and rated the generality of the strategy. Students who saw the example without the person were more likely to transfer the strategy to new problems, and this effect was mediated by students' perceptions of the strategy's generality. Thus, associating information with a person substantially limits the extent to which students transfer their knowledge.

1. Introduction

Educational materials often present general principles or concepts via specific people. In science textbooks, this practice is often used to provide a historical context—Natural Selection, for example, is introduced by recounting Darwin's observations on the Galapagos Islands. In mathematics textbooks, novel concepts or strategies are frequently associated with sample students (see Riggs, Alibali, & Kalish, 2015, for a textbook analysis). For example, a textbook might describe an individual encountering a problem ("Molly is trying to figure out…") along with a picture or personifying detail about the individual (Molly is 12-years-old and lives in Wisconsin). The solution strategy itself is often labeled as if it were generated by the individual ("Molly's strategy"). This practice, which we call *person-presentation*, reflects efforts to vivify curricular materials, spark student interest and, by extension, increase learning (Ainley, Hidi, & Berndorff, 2002; Magner, Schwonke, Aleven, Popescu, & Renkl, 2014). In fact, the National Council of Teachers of Mathematics encourages this practice in classrooms: "Some teachers find it effective to name a problem, conjecture or solution method after the student who proposed it" (NCTM, 2000, p. 259). However, research in social cognition suggests that person-presentation may have the opposite of its intended effect. When children learn information about a person, they often interpret that information as specific to that person, and this may inhibit their generalization of that information to new situations (Cimpian & Erickson, 2012; Riggs, Kalish, & Alibali, 2014a, 2014b). In the present research, we investigate whether this same phenomenon occurs when students learn information via person-presentation in curricular materials.

Person-presentation is sometimes used in textbooks in an effort to promote interest. A large body of research demonstrates that interest facilitates learning (see Renninger, Hidi, & Krapp, 2014, for a review). One form of interest that curricular materials can promote is situational interest, in which features of the text focus attention and produce an affective response in the learner (Hidi & Harackiewicz, 2000). Situational interest is thought to be especially important for learning in content domains in which students lack personal interest, such as mathematics (Clinton, Walkington, & Howell, 2013; Hidi, 1990; Hidi & Berndorff, 1998). Textbooks can promote situational interest by including concrete materials (e.g., colorful photographs; Ackerman & Leiser, 2014; Sadoski, Goetz, & Fritz, 1993) or information that demonstrates the relevance of the to-be learned content (Walkington, 2013). Person-presentation may increase situational interest either through the details associated with the person or by demonstrating the relevance of the content, because person-presentation often involves a student using the strategy in a real-world context. Increased interest might enhance students' comprehension of the strategy

* Corresponding author.
E-mail address: anne.riggs@wwu.edu (A.E. Riggs).

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(Cordova & Lepper, 1996; Renninger, 2000).

The very same features that promote student interest may also inhibit students' ability to transfer their knowledge to new contexts. People sometimes have difficulty transferring information learned in perceptually rich, concrete contexts to other contexts that are perceptually dissimilar (Bassok & Olseth, 1995; Day, Motz, & Goldstone, 2015; Rey, 2012). Gentner and colleagues have proposed that dissimilar surface features interfere with students' ability to notice shared relational structures between problems (Gentner & Medina, 1998; Markman & Gentner, 1993). If the initial learning context includes a person as a surface feature, it may be more difficult for students to recognize that a new problem has the same structure and should be solved in the same way. Thus, curricular materials that present information with less perceptual detail may promote greater learning and transfer (Kaminski, Sloutsky, & Heckler, 2008).

Person-presentation may be a special type of concrete detail with unique implications for learning. When there are cues that facts are specific to individuals (e.g., specific labels), children tend to assume that the information should be restricted to the individual in the initial learning context (e.g., Hollander, Gelman, & Raman, 2009; Riggs et al., 2014a). In contrast, when there are cues that the information is general (e.g., a generic label), children generalize the information widely (Cimpian, 2016; Graham, Nayer, & Gelman, 2011). Thus, if person-presentation leads students to assume that strategies are specific to the people presenting them, they may not see the strategy as one that is generally applicable and appropriate for them to adopt.

Past research on person-presentation in adults suggests that it may indeed inhibit transfer. Riggs et al. (2015) presented undergraduates with an example of a problem-solving strategy that was either linked to a specific person or presented without a person. Students who saw the example linked to a person received varying amounts of detail regarding that person (e.g., background information and a picture). Students were more likely to transfer the strategy when it was introduced without a person, regardless of the amount of additional detail associated with the person. These results suggest that person-presentation negatively affects adults' transfer, above and beyond the additional details that including a person entails.

In light of the frequency of person-presentation in middle-school mathematics textbooks (Riggs et al., 2015), it is important to know whether middle-school students also experience learning costs when strategies are associated with a person. Previous research has demonstrated the negative effect of person-presentation in a college-age population in a laboratory setting; however, this research may have limited applicability to younger students and authentic instructional contexts. A college student participating in a research study for course credit may have different motivations about learning than would a middle-school student in the course of their regular school day. Thus, the current study was conducted in middle school classrooms and the materials were administered by teachers.

The goal of the present research was to examine whether person-presentation of novel problem solving strategies affects middle school students' transfer. We hypothesized that strategies presented via person-presentation will be transferred at lower rates compared to strategies that are presented without a person. We also sought to extend prior research by investigating *why* person-presentation may incur such learning costs. Toward this end, we measured students' inferences about the generality of the strategy. We hypothesized that person-presentation would lead students to assume that the strategy is specific to the person presenting it. A strategy associated with Molly, for example, might be interpreted as information about Molly rather than as a strategy that other people should use. Thus, linking a strategy to a specific person may result in narrower transfer. If this is the case, then person-presentation may affect performance *via* its influence on participants' interpretation of the generality of the strategy.

We also examined the relationship between encoding of the person in the strategy example and transfer. Here, we consider two potential hypotheses. First, it may be that the more students encode about the person, the less likely they are to transfer the strategy. Children and adults show this pattern when learning facts about specific people (Archambault, O'Donnell, & Schyns, 1999; Riggs et al., 2014a, 2014b), so it is possible that this might apply to learning strategies, as well. Alternatively, if students are highly engaged in the strategy example, they may remember the person and transfer the strategy. If the first hypothesis is confirmed, it would suggest that person-presentation affects transfer by diverting students' attention away from the strategy itself. If the second hypothesis is confirmed, it would suggest that person-presentation increases situational interest, which leads to better encoding of the content of the example.

2. Methods

2.1. Participants

Participants were recruited from private religious schools in a mid-sized city in the midwestern United States. We contacted schools until we had agreements from enough schools to insure a sufficient number of seventh and eighth grade pre-algebra students to attain the desired sample size. All pre-algebra students in the relevant grades participated as part of their regular math instruction. This recruitment method yielded a sample of 196 students. We excluded 3 students for leaving the posttest entirely blank and 2 students for writing the multiplicative strategy on their desks while they read the strategy example. Thus, the final sample included 191 participants.

The study was deemed to be exempt research by our institutional IRB because it involved normal educational practices in an established educational setting. As such, we did not collect demographic information from individual participants; however, we did obtain demographic information about each school (see Table 1). Because we included all pre-algebra students at each school, it is likely that our sample reflected the demographic makeup of the schools.

2.2. Task domain

As our experimental task, we selected algebra story problems about constant change. The teachers reported that students had not encountered constant change problems in their curriculum prior to the

Table 1
Demographics of participating schools.

School	n	% FRL	% Female	% White	% Black	% Hispanic	% Asian	% > 1 Race
1	54	0	54	75	6	4	11	4
2	17	16	51	76	9	5	4	6
3	15	1	60	62	20	7	5	6
4	30	2	45	97	1	1	1	0
5	13	0	75	81	6	6	3	4
6	26	0	48	77	7	8	3	5
7	36	9	49	82	11	4	2	1

Note. "FRL" indicates the percentage of students eligible for Free and Reduced lunch.

Table 2
Sample problems.

Discrete wording
In a library, there is a bookshelf with 6 shelves. The number of books on each successive shelf from top to bottom increases by a constant from the number of books on the shelf above it. There are 10 books on the first shelf, and 40 books on the sixth shelf. How many books are there in total on the six shelves?
Continuous wording
A plant grows for a period of 8 weeks. The rate at which it grows increases steadily over the interval, from 4 inches per week to 60 inches per week. How many inches does the plant grow in total over the 8-week interval?

study. Prior research with adults has demonstrated that variations in content and wording for such problems can elicit distinct mental models of the change process as either discrete or continuous (Alibali, Bassok, Solomon, Syc, & Goldin-Meadow, 1999). Discrete mental models are associated with use of an additive strategy, in which students determine the amount of the constant increase, use this constant to calculate the value for each interval, and sum those values. Continuous mental models often elicit a multiplicative strategy, in which students calculate the average rate per interval and multiply it by the number of intervals (see Table 2).

Although the multiplicative strategy is substantially faster and less prone to calculation errors than the additive strategy, the additive strategy is much more commonly used (see Alibali & Booth, 2002; Riggs et al., 2015). Thus, we taught students the multiplicative strategy under conditions that involved person-presentation and conditions that did not, and we then assessed whether they transferred the multiplicative strategy to new problems that were worded to elicit either a discrete or continuous model of change.

2.3. Design and materials

Each student received a large envelope that contained a pretest, a strategy example, a posttest, and a set of follow-up questions. The story problems used throughout the study were adapted from those used in previous studies with adults to be more appropriate for middle school students (Alibali et al., 1999; Bassok & Olseth, 1995; Riggs et al., 2015).

Students within each classroom were randomly assigned to either a person-presentation or a no person-presentation condition. All students completed a pretest containing one constant change problem that was worded to cue a discrete model of change and an additive strategy. The manipulation occurred with the strategy example, which students read after the pretest. The target strategy was a multiplicative strategy embedded in a story problem about filling a wading pool with water. The story problem was worded to cue a continuous model of change. In the person-presentation condition, the strategy example included a picture of a person (Molly) and some background detail about her, and the strategy was labeled with her name ("Molly's strategy"). In the no person-presentation condition, the strategy example included a picture related to the problem (a pool), and the strategy was labeled impersonally ("the continuous strategy"). We used the label "the continuous strategy" rather than the "multiplicative strategy" in the study materials because the word "multiplicative" provides a cue to the nature of the strategy. However, for clarity, we refer to the strategy as "the multiplicative strategy" to avoid confusion with problems worded to cue a continuous model of change (see Table 2). The examples were designed to have a comparable number of details (e.g., one picture for each example and a roughly equal number of words). All other components of the strategy example, including the problem content and the strategy itself, were identical across conditions.

After reading the strategy example, students completed a four-item posttest. The first two posttest problems were worded to cue a continuous model of change. In addition, the first problem used a problem scenario with surface features similar to the strategy example (water being added to a wading pool), in order to scaffold students' transfer and promote their use of the multiplicative strategy (see Holyoak & Koh, 1987; Klahr & Chen, 2011). The second two posttest problems were worded to cue a discrete model of change. Note that none of the posttest problems contained a visual image. After the posttest, students answered a set of follow-up questions assessing their perception of the generality of the strategy and, for students in the person-presentation condition, their memory for the person in the example. The generalization questions asked students to rate the likelihood that another middle school student, a teacher, and the students themselves in the future would use the strategy. Students responded using a 1–5 Likert scale ranging from "not at all likely" to "very likely." The memory questions asked students to recall various features of the person in the strategy example, including her name, the color of her shirt, and the state she was from. Students in the no person-presentation condition did not answer memory questions because they did not see the person.

2.4. Procedure

The study was administered by students' math teachers during their regular math classes. A researcher was present in the classroom. She was introduced as "a practicum student who is observing the class" in order to minimize students' perceptions that they were being tested. This also provided a way for the researcher to monitor adherence to the procedure.

Prior to the class period, the researcher put a large envelope on each student's desk. Enclosed in each envelope was a pretest, a strategy example, a posttest and follow-up questions. At the beginning of the class period, the teacher announced that students would be solving a set of problems to evaluate their prior knowledge. The teacher then explained each step of the study procedure, which was also written on the board: First students were to remove the sheet of paper with the pretest and attempt to solve the problem. Then, students put the pretest back into the large envelope and removed the strategy example. Students were then asked to read the strategy example, but not to write anything on the page. After they were done reading the strategy example, they raised their hands and the teacher collected the examples (so as to prevent students from looking back at them during the posttest). Students were then instructed to remove the posttest problems and follow-up questions and answer them in the order they were presented. Students were not allowed to use calculators or to speak to their classmates during the study.

The study took approximately 30 min for students to complete. All students were given their entire class period, which ranged from 40 to 45 min across schools. At the end of the study, the researcher explained the goals of the study. In the schools in which students in multiple class periods participated in the study, the teacher debriefed the students on the following day to ensure that students did not alert students in later class periods about the study.

2.5. Coding

Participants' strategy use on the pretest and posttest problems was coded using the scheme presented in Table 3. Problems were coded as using the multiplicative strategy correctly if they were set up correctly,

Table 3
Coding criteria for additive and multiplicative strategies.

Strategy type	Procedure
Additive strategy	Participant finds the constant increase, calculates the value for each interval, and adds those values together
Multiplicative strategy	Participant finds average rate by averaging the initial and final rates, and then multiplies by the number of intervals

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even if they contained a calculation error. Problems were coded as attempting to use the multiplicative strategy if they attempted to apply the multiplicative strategy but made a structural error in setting up or applying the strategy. For example, some students forgot one step in the procedure (e.g., they added the initial and final rates, but forgot to divide by two before multiplying by the number of intervals). Strategies that were coded as "other" were typically conceptually flawed (e.g., subtracting the initial from the final amount to find the average). Data from 50 participants was recoded by a second coder who was blind to condition. Inter-rater reliability was 92% (N = 200).

Ratings on the generalization questions were averaged to create a single generalization score for each participant (range 1–5). Similarly, the number of memory questions answered correctly was summed to create a single memory score for each participant (range 0–3).

3. Results

3.1. Analytical approach

We investigated whether transfer of a novel problem-solving strategy varied as a function of condition (person-presentation and no person-presentation) and problem type (continuous or discrete wording). Data were analyzed using generalized estimating equations (GEE), an extension of generalized linear models that account for the dependence among repeated measures within individual participants (Agresti, 2013). The binary outcome variables were attempted transfer and correct transfer. Inferences for predictor effects were conducted using Wald test model comparisons and Wald 95% confidence intervals (Højsgaard, Halekoh, & Yan, 2006). Additionally, we report effects in terms of odds-ratios (OR), which should be interpreted as in other common logistic regression frameworks. We included pretest answer (correct or incorrect) as a covariate because it significantly improved the fit of the models reported below. Pretest scores did not differ across conditions, $t(189) = -0.55$, $p > 0.250$. No students used a multiplicative strategy on the pretest item.

3.2. Attempted transfer

Our primary question was whether person-presentation affected students' transfer of the multiplicative strategy. We first examined the effect of person-presentation on students' attempted transfer (see Fig. 1). Participants in the no-person-presentation condition were more likely to attempt to transfer the multiplicative strategy than participants

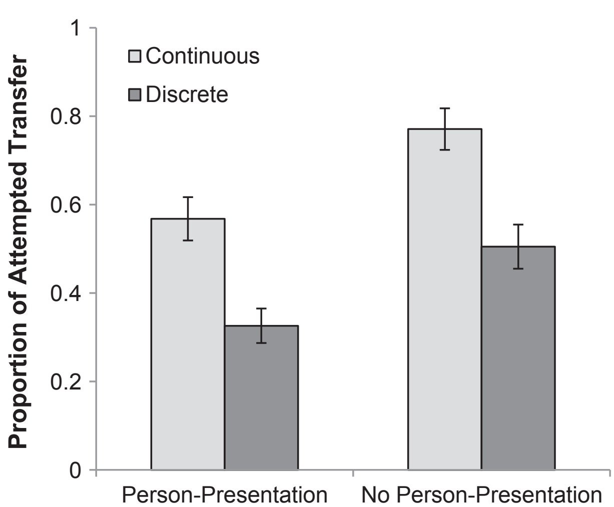

Fig. 1. Average proportion of problems (out of 4) on which students attempted to transfer the multiplicative strategy across conditions and problem types. Error bars represent standard errors.

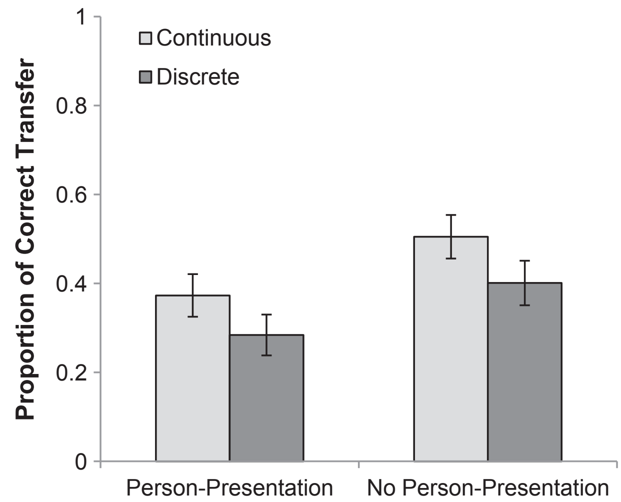

Fig. 2. Average proportion of problems (out of 4) on which students correctly transferred the multiplicative strategy across conditions and problem types. Error bars represent standard errors.

in the person-presentation condition, *Wald's* $X^2(1) = 31.69$, $p < 0.001$, $OR = 2.42$, 95% CI [1.78, 3.29]. Additionally, participants were more likely to attempt to transfer the multiplicative strategy on continuously-worded than discretely-worded problems, *Wald's* $X^2(1) = 50.98$, $p < 0.001$, $OR = 3.06$, 95% CI [2.25, 4.17]. There was no significant interaction between condition and problem type, suggesting that the increased likelihood of implementing the multiplicative strategy on continuous problems relative to discrete problems did not vary by condition.

3.3. Correct transfer

We next examined whether students in the person-presentation condition were differentially likely to correctly transfer the multiplicative strategy (see Fig. 2). Participants in the no person-presentation condition were more likely to correctly transfer the multiplicative strategy than participants in the person-presentation condition, *Wald's* $X^2(1) = 14.26$, $p < 0.001$, $OR = 1.79$, 95% CI [1.13, 3.31]. Participants were also more likely to correctly transfer the multiplicative strategy on continuously-worded problems than on discretely-worded problems, *Wald's* $X^2(1) = 7.87$, $p = 0.005$, $OR = 1.54$, 95% CI [1.14, 0.2.08]. As with attempted transfer, there was not a significant interaction between problem type and condition.

3.4. Generalization and attempted transfer

We first compared average generalization scores across conditions. Students in the person-presentation condition ($M = 0.36$, $SD = 0.39$) rated the generality of the strategy significantly lower than students in the no person-presentation condition ($M = 0.52$, $SD = 0.53$), $t(189) = 2.49$, $p = 0.013$. We hypothesized that the effect of person-presentation on transfer would be mediated by participants' evaluations of the generality of the multiplicative strategy. To test this, we used a non-parametric bootstrapping procedure, which generates 95% confidence intervals for the indirect effects by resampling the data 1000 times (see Preacher & Hayes, 2004). In line with the recommendation of Preacher and Hayes, we demonstrate that our data satisfy two preconditions. First, the predictor variable has a significant effect on the outcome variable. Second, that the predictor variable has a significant effect on the proposed mediator variable (generalization; see above). Given the significant effect of condition on both attempted transfer and generalization, we then estimated the average causal mediated effect (i.e., A-CME; the indirect effect) of generalization scores on attempted transfer.

The 95% CIs of the ACME did not include zero [−0.161, −0.078], suggesting that generalization mediates the effect of condition on attempted transfer. However, even when including the mediator, the direct effect of condition on attempted transfer remained significant, 95% CI [−0.117, −0.036], suggesting that generalization serves as a *partial* mediator. Overall, the mediational model explained 61% of the variance in attempted transfer, confirming our prediction that participants' views of the generality of strategies would affect the likelihood of transfer.

3.5. Memory and attempted transfer

We next conducted a linear regression including memory score, condition, and pretest as predictors of attempted transfer, and found that memory was a significant predictor, $\beta = 0.29, p = 0.041$. Students who remembered more details of the person in the example were *more* likely to attempt to transfer the multiplicative strategy than students who remembered fewer details about the person. Additionally, memory was also a significant predictor of generalization, $\beta = 0.52, p = 0.040$, such that those who exhibited strong memory were also more likely to generalize the multiplicative strategy. We consider explanations for these results in the Discussion.

4. Discussion

A central goal of formal education is for students to apply examples learned from curricular materials to new and varied contexts. The findings from this study demonstrate that using a specific person to present a new strategy substantially limits the extent to which students transfer that strategy. This effect held for both attempted and correct transfer of the strategy and for problems that used wording highly similar to that in the example as well as more dissimilar problems. Thus, these findings extend past work on person-presentation in adult learners to a younger age group, and demonstrate that the negative effects of person-presentation occur even when strategies are presented in authentic instructional contexts.

Furthermore, the present results identify one mechanism that underlies person-presentation's effect on transfer. When the target strategy was associated with a specific person, students tended to rate it as less likely to be used by others than when it was not associated with a specific person. These generality ratings mediated the likelihood that students used the strategy on the posttest problems. This finding is consistent with developmental work demonstrating that specific labels often lead children to form narrow inferences about the generalizability of novel information (Cimpian & Erickson, 2012; Riggs et al., 2014a). Curriculum designers may assume that educational materials themselves are a strong and obvious cue that the information they contain is general and the target of learning. The current findings suggest that this is not always the case, especially when there are competing cues that the information is specific to a person.

We also tested whether students' memory for the person in the strategy example was related to their transfer. Some prior work has found an inverse relationship between younger children's generalization of social information and their memory for the specific people present in the initial learning episode (Riggs et al., 2014a, 2014b). In the present study, students who remembered individuating features of the person presenting the strategy were *more* likely to transfer the strategy to new problems and generalize it to others. One interpretation of this result is that when encountering person-presentation, some students dismiss the strategy immediately, leading them to encode very little about the example, both the person and the strategy itself. Other students interpret the strategy as generalizable and/or interesting, leading them to attend closely to all aspects of the example. To address this possibility, future research could measure the amount of time devoted to reading the strategy example or use eye tracking methods to examine which aspects of the strategy example students are attending to.

Using person-presentation to introduce new concepts may not be an effective way to promote students' learning and transfer. However, including people in curricular materials likely serves other important goals. For example, person-presentation may increase students' perception that information is relevant to them if they see students similar to themselves applying concepts in meaningful ways. This perception aligns with one key objective of mathematics education, which is to increase students' *productive disposition*, or the tendency to see math as useful and to believe in one's own efficacy as a "doer of mathematics" (Kilpatrick, Swafford, & Findell, 2001). If person-presentation promotes productive disposition but limits transfer, can it be implemented in ways that facilitate both sets of goals?

To answer this question, future studies need to identify which elements of person-presentation lead to low transfer and narrow generalization. Is any inclusion of a person harmful for learning or does the specific format of person-presentation matter? Prior research has demonstrated that learning episodes containing identical content but marked with specific rather than generic labels are generalized narrowly. This suggests that a more effective way to implement person-presentation would be to associate a strategy with a student, but to give the strategy a generic label (e.g., "Molly is using the continuous strategy"). Additionally, to discourage the inference that any one strategy is specific to a single person, textbooks could present a student demonstrating multiple strategies, or multiple students demonstrating the same strategy. Thus, the focus of future research will be to investigate how to reduce learning costs while still garnering the potential generative benefits associated with incorporating people into curricular materials.

Some limitations of the present study also suggest directions for future work. First, we studied person-presentation and transfer in a single problem context. Additional studies are needed to confirm the generalizability of our findings to other types of problem-solving strategies and to domains such as science or literature, in which concepts are frequently embedded in personal narratives. Second, we tested students' transfer immediately following their exposure to the strategy example. Research demonstrates that episodic information tends to fade more quickly than semantic information (Sabbagh & Shafman, 2009). This suggests that the limited transfer in the person-presentation condition might have been more pronounced after a delay, particularly for students who perceived the strategy to be specific to the person and thus more episodic in nature. Third, we were not able to collect information about individual students, so we cannot examine whether student characteristics (such as mathematical ability) moderate the effects of person-presentation. Students already interested in mathematics may tend to "overlook" the person-presentation format and focus on the mathematics content. Students less engaged with mathematics may be more likely to focus on the person or dismiss the example.

Our findings are also limited to person-presentation via unfamiliar people in curricular materials. Of course, specific people also present information in classroom settings, such as when a student solves a problem on the board, and teachers may then refer to individual children's strategies using the children's names. It remains an open question whether marking information with a child's name in real-time classroom interactions also leads to limited transfer, or whether different factors are at play in familiar contexts and with familiar peers.

The results of this study make clear that using specific people to present general strategies comes at the cost of students' abilities to learn and transfer new information. Our findings demonstrate that one source of this cost is that students perceive strategies associated with a person to be specific to that person, rather than general strategies that they should learn and adopt. Thus, these results have important implications for curricular design. Instructors and textbook designers should carefully consider when and how they use specific people to present new information to students.

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