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ABSTRACT

This study investigated whether adapting instruction to gender-type preferences can improve the attitudes of students, especially female students, and their performance in mathematics. Subjects were 69 young adult college students in a remedial mathematics program whose interest in gender-type activities was determined. Students were randomly assigned to gender-adapted or gender-maladapted treatment conditions. In the gender-adapted condition, females received the feminine version of instruction, and males received the masculine version; in the maladapted condition, students received instruction designed for the other gender. The absence of performance differences between conditions supports previous research that found no effect on performance of problem context sex stereotype. This result, coupled with improved mathematics ability scores across conditions, suggests that dynamic worked-example mathematics instruction improves students' performance regardless of the story context in which it is set. Differential results in participants' attitudes, however, reveal the potential impact adapted instruction may have on internalized beliefs and attitudes about mathematics. (Contains 13 Power Point slides and 10 references.) (SLD)

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Can Gender-Adapted Instruction Improve Mathematics Performance and Attitudes?

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Introduction

The gender gap in mathematics, science and technology remains problematic, despite some evidence that it is shrinking (Hyde, Fennema & Lamon, 1990; NCES, 1998; AAUW, 1998; Meece & Eccles, 1993; NSF, 1990). Hyde, Fennema & Lamon (1990) concluded from their extensive research that "in explaining the lesser presence of women in college-level mathematics courses and in mathematical-related occupations, we must look to [operating] factors, such as internalized belief systems about mathematics" (p. 151). The body of cognitive science research reveals effects on cognition of affective variables such as interest, attributions, and beliefs. In the present experiment we investigate whether adapting instruction to gender-typed preferences can improve students', especially females', mathematics performance and attitudes.

Rationale

Chipman, Marshall, & Scott (1991) investigated the influence of gender and of prior knowledge, defined as familiarity with a problem context, on mathematics performance. Chipman et al. created masculine and feminine word problems by setting the problems in the context of stereotypically male and female activities. Chipman et al.'s study found no effect of sex-stereotypy on performance. However, the study reported "a highly significant but small effect of familiarity" (p. 897) on performance, indicating difficulty of mathematics word problems may be predicted by students' - especially females' - familiarity with the problem context. In their study, Chipman et al. did not investigate the impact of a second possible contributing factor - interest.

Sigmund Tobias concluded "there is a substantial linear relationship between interest and prior knowledge" (1994, p. 1). He noted that fully "80% of the variance in the effects of interest [on learning] is still unaccounted for by prior knowledge, leaving a considerable portion of independent variance with which interest can affect learning" (1994, p. 7). Tobias proposed a model of the relationship and interaction between interest and prior knowledge, or familiarity (Figure 1).

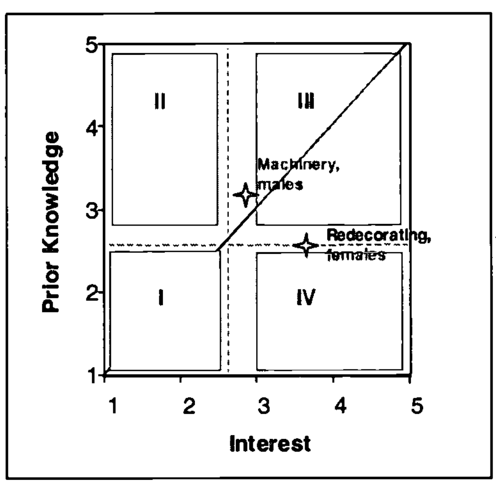

Figure 1: Interaction of interest and prior knowledge (familiarity).

It is easy to conceive that one's preference for a topic leads to greater engagement with it and therefore to accumulation of more knowledge. This state is represented by Quadrant III in Figure 1. Quadrant I holds topics for which individuals have little interest and consequently, of which they haven't pursued further knowledge. Quadrant II indicates topics of low interest but high knowledge. An individual may have been induced to learn about subjects in school, or to perform tasks on the job or at home, but for which they care little. This category may be transitory, as once external motivation is removed individuals are unlikely to renew or update their knowledge, causing it to become inert and effecting a transition to Quadrant I. Quadrant IV, topics of high interest but low knowledge, is the least obvious as well as the least stable. If one develops a long-term preference for a topic, she is unlikely to remain ignorant about it for long, effecting a move to Quadrant III. Conversely, as she learns more one may lose interest and opt to remain ignorant about the topic, settling in Quadrant I.

Participants in our research, adult remedial mathematics students, would likely situate mathematics in Quadrant II of Tobias' model. Our goal was to create mathematics instruction that moved students' attitudes about mathematics toward Quadrant III. Tobias' model leads to two key research questions: Can interest in one area, i.e., problem context, be leveraged to engender interest in another, i.e., mathematics? Can interest in problem context lead to improved performance in mathematics?

<u>Design and Procedure</u>

We first surveyed a group of 69 young adults (20 female, 49 male) in a remedial mathematics program to establish gender-typed activities. The survey asked students to indicate their levels of familiarity with and interest in 23 hobby, home improvement, and recreational activities. Respondents ranked each activity on a Likert scale, where 1 meant "not familiar/interested" and 5, "very familiar/interested". Significant gender differences in preferences surfaced. Activities emerging as masculine included: "using or operating machinery, for example, a chainsaw" (Interest: $\underline{M}_{male} = 2.91$, $\underline{M}_{female} = 2.25$, $t_{\underline{d}} = .037$, $p < .05$; Familiarity: $\underline{M}_{male} = 3.12$, $\underline{M}_{female} = 2.15$, $t_{\underline{d}} = .008$, $p < .05$). Activities that may be considered feminine included "redecorating the interior of your house, apartment or room" (Interest: $\underline{M}_{male} = 2.81$, $\underline{M}_{female} = 3.65$, $t_{\underline{d}} = .009$, $p < .05$; Familiarity: NS). These topics met the condition of falling into either Quadrant III (high-interest, high-familiarity) or Quadrant IV (high-interest, low-familiarity), and formed the basis for our masculine- and feminine-typed mathematics instruction.

Two parallel story lines, anchored in real life, were developed; masculine centering around building a deck; feminine, redecorating an apartment. Story lines were implemented in a multi-media instructional software environment as a video "slice of life" followed by two lessons in proportional reasoning. Lesson formats followed those of the Tutorials in Problem Solving (TiPS) (Derry et al., 1994) system, using example-based problem solving instruction (Atkinson, et al., 1999) comprising a dynamic worked example followed by two similar practice problems. Word problems were isomorphic in difficulty, form, and presentation across feminine and masculine versions.

Students were randomly assigned to one of two treatment conditions: gender-adapted or gender-maladapted. The gender-adapted condition was, for example, a female receiving the feminine version of instruction; gender-maladapted, a female receiving the masculine version. The experiment was a pre-test post-test design. The pre-test included a mathematics ability assessment and attitudinal questionnaire. Participants scoring above the mean on the ability pretest were eliminated from the study, as they were unlikely to benefit from the remedial instruction. The post-test included a mathematics ability assessment equivalent to the pretest plus a more extended attitudinal questionnaire. The 35-item post-treatment questionnaire assessed attitudes toward math and the instruction itself, and included questions drawn from Views About Mathematics Survey (VAMS) (Halloun & Hestenes, 1996).

Seventy-seven student volunteers from two educational psychology undergraduate classes received extra credit for taking the mathematics screening test. Of the 77 students screened, 29 (4 male, 25 female) continued in the 2-hour treatment, for which they were paid.

Results

Gender-type of the two instructional contexts was supported by participants' ratings of interest in and familiarity with the activity central to the instruction. Participants in the adapted condition situated the activity in Quadrant IV of Tobias' (1994) model (mid-point = 4; $\underline{M}_{interest} = 4.28$, $\underline{M}_{familiarity} = 3.21$); participants' in the maladapted condition placed the activity in Quadrant I ($\underline{M}_{interest} = 3.87$, $\underline{M}_{familiarity} = 3.80$). This trend was bolstered by participants' rating of personal relevance of the instruction; those in the adapted condition considered the instructional context to be more personally relevant (toward "1" on a scale of 1-7) than those in the maladapted condition ($\underline{M}_{Adapted} = 2.21$, $\underline{M}_{Maladapted} = 4.20$, $\underline{M}_{d} = 1.99$).

Math ability scores improved across both conditions, but there was no statistically significant difference between conditions ($F = .45$, sig = .51, $\eta^2 = 0.17$). As for resultant attitudes toward mathematics, a chi-square test was not significant ($\chi^2 = 0.56$, NS at $\alpha = .05$). However, a chi-square test was significant for a difference in attitudes toward the instruction itself ($\chi^2 = 15.00$, sig. < .01). The source of significant difference was in perceived benefits of the instruction ($\chi^2 = 10.61$, sig. < .01). The majority of participants in the adapted condition expressed positive views about the instruction's benefits (64.3%), while the majority in the maladapted condition were neutral about its benefits (75.6%). The estimated strength of association between condition and perceived benefit was 0.35 (Cramer's V coefficient).

Conclusions

The absence of performance differences between conditions supports Chipman et al's (1991) findings of no effect on performance of problem context sex-stereotype. This result, coupled with improved math ability scores across conditions, suggests that dynamic worked-example math instruction improves students' performance regardless of the story context in which it is set.

Differential results in participants' attitudes, however, reveal the potential impact adapted instruction may have on internalized beliefs and attitudes about math. Although they didn't score significantly differently on the ability test, students in the adapted condition believed the instruction helped their understanding and performance in mathematics more than did students in the maladapted condition. Setting math instruction in a context of personal relevance to students may improve their attitudes about math and perhaps make them more inclined to continue its study. This research should be replicated, and furthered by assessing effects of more extensive interventions that leverage gender-typed or individual interests in mathematics instruction.

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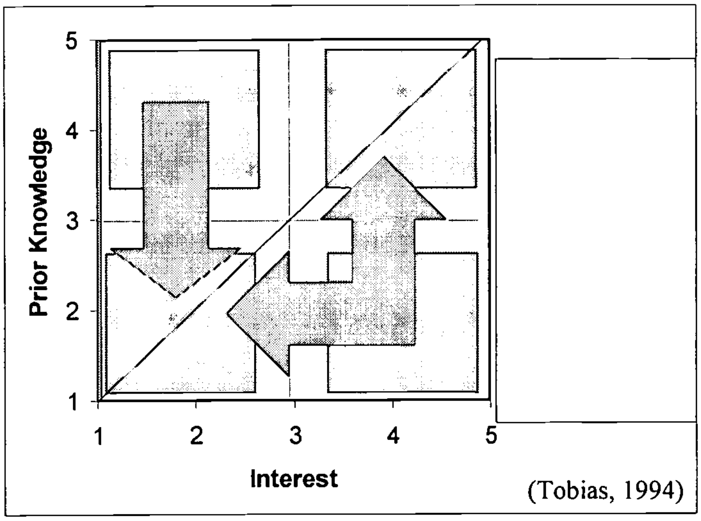
Rationale for study

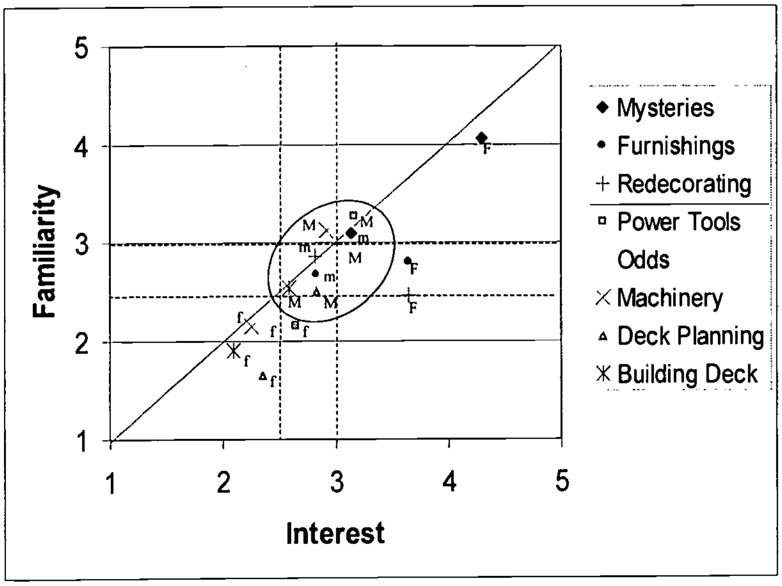
- Gender differences in math performance & retention
  - (Fennema & Carpenter, 1998; NCES, 1998; Meece & Eccles, 1993
- Motivational factors affecting cognition
  - Prior knowledge and experience (Chipman, Marshall & Scott, 1991; Larkin, McDermott, Simon, & Simon, 1980)
  - Interests (Tobias, 1994; Noddings, 1998)
  - Perceived relevance (Baker & Jones, 1992; Kahle, Parker, Rennie, & Riley, 1993)
- Computer-delivered instruction
  - Adapted to individual interests (Anand & Ross, 1987)
  - Self-pacing (Schofield, Eurich-Fulcer, & Britt, 1994)
  - Technology skills (AAUW, 1998)

Motivational factors:
Interest vs. prior knowledge model



(Tobias, 1994)

Plot of gender-typed activities



Study Design

- 29 Participants, Age 18-44
- 2 Computer-based lessons in proportional reasoning
- 2 Instructional conditions
- Pre- and Post-treatment measures of mathematics performance and attitude

		Gender Female	Male	
Version	Feminine	12*	2#	14
	Masculine	13#	2*	15
		25	4	29

Instructional Conditions:
**Adapted*
#Maladapted

Worked Example A

Feminine Version

Denise found a color for her walls that matches her new curtain fabric. Denise needs to have paint specially mixed to get the exact color.

The paint store clerk said she could match Denise's color. One gallon of her color would use 7 parts blue and 3 parts white pigments.

Pigment is measured by the number of ounces used. For one gallon of Denise's color, the clerk would use 7 ounces blue and 3 ounces white pigment.

Denise ordered a 5-gallon can of paint. How many ounces of blue pigment will the clerk use to make 5 gallons of paint, using the same proportions as before?

Masculine Version

Ray bought a chainsaw to cut down some shrubs where he plans to build a deck. Now Ray needs to mix gasoline and oil to make fuel for the chainsaw.

His neighbor tells him to use 7 parts gasoline and 3 parts oil to make 1 gallon.

Ray decides to use a jar to measure out the amounts of oil and gasoline he'll need. For 1 gallon of fuel, Ray would use 7 jars of gasoline and 3 jars of oil.

He plans to take his neighbor's advice, so he'll mix up 5 gallons of chainsaw fuel. How many jars of gasoline will Ray use to make 5 gallons of fuel, using the same proportions as before?

Practice Problem 1

Feminine Version

This is what we learned in the last lesson. The clerk will use 35 ounces blue pigment to mix 5 gallons of Denise's color.

Remember that the color analyzer called for two pigments to be used in Denise's color. One gallon of Denise's paint could be made by using 7 ounces blue and 3 ounces white.

Now solve the second part of this problem. How many ounces of white pigment will be used in 5 gallons of paint, using the same proportions as before?

Masculine Version

This is what we learned in the last lesson. Ray will use 35 jars gasoline to mix 5 gallons of chainsaw fuel.

Remember that his neighbor told Ray to use a certain proportion of gasoline and oil. One gallon of chainsaw fuel could be made by using 7 jars gasoline and 3 jars oil.

Now solve the second part of this problem. How many jars of oil will Ray use to make 5 gallons of fuel, using the same proportions as before?

Practice Problem 2

Feminine Version

Denise looked around the store and found a display about sponge painting. "This is great!" she said, "I can make my walls look like an adobe house." She read the brochure. "But to get the right look, I really should paint my walls a darker color than I planned."

Denise hurried back to the clerk. They picked out a darker color from the charts. The clerk read from the color analyzer: "To make 5 gallons of this color we need 3 ounces (oz) white for every 55 ounces (oz) blue pigment."

"I already started mixing your old color," the clerk said. "I mixed in 35 oz blue but I didn't add any white yet." To be safe, the clerk suggested they stay with 35 oz blue, but add less white than before. Denise agreed when the clerk told her, "If you don't like the color, we can still add more blue later."

How many oz white should the clerk now add to 35 oz blue, to get the new proportions described above?

Masculine Version

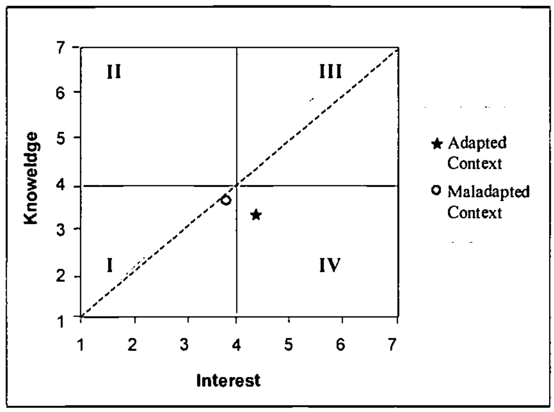
Ray mixed some fuel using the proportions of gas and oil that his neighbor suggested. He filled up the chainsaw and tried to start it, but it wouldn't run!

"Something has to be wrong with the fuel mixture", he thought. "I'd better get some professional advice."

The hardware store clerk shook his head when Ray described the amounts of gas and oil he used. "Let me see that jar you're measuring with," he said. "The jar is fine, but you need 3 jars oil to every 55 jars gasoline. You used way too much oil in your fuel."

We know from the last problem that Ray used 35 jars gasoline to make his "bad" fuel. If Ray could do it over again, how many jars of oil would you tell him to mix with 35 jars gasoline to make a "good" mixture, using the proportions the clerk described?

Results: Gender-Type of Instruction



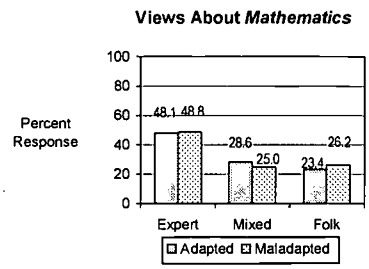
Results: Math Performance

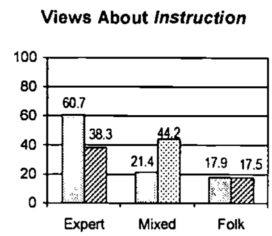
- No statistically significant difference.

	$\underline{M}_{\text{Pre-test}}$	$S_{\text{Pre-test}}$	$\underline{M}_{\text{Post-Test}}$	$S_{\text{Post-test}}$	$\underline{M}_{d}$
Adapted_	17.57	3.47	20.68	2.82	+3.11
Maladapted	17.47	3.91	20.20	3.41	+2.73

Results: Attitudes

- No statistically significant difference in VAM.
  - Chi-Square = .56, NS at alpha = .05
- Statistically significant difference in VAI.
  - Chi-Square = 15.00, sig. < .01





Results: Attitudes, cont.

- Components of VAI
  - Interest - *NS*
  - Prior Knowledge - *NS*
  - Personal Relevance - *NS*
  - Perceived Benefits
    - Chi-Square = 10.61, sig. < .01, Cramer's V = .35

Conclusions & Implications

Findings ...

- Support previous findings of no effect on performance of problem context sex-stereotype.
- Students perceived adapted instruction more beneficial than maladapted.

Implications ...

- Adapting instruction to interest can effect positive view of mathematics instruction.
- Positive attitude toward instruction might lead to persistence in study of mathematics.

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