

## MQM Preliminary Examination Scoring Guide (2004)

Fennema, E., Carpenter, T.P., Jacobs, V.R., Franke, M.L., and Levi, L.W. (1998). Longitudinal study of gender differences in young children's mathematical thinking. *Educational Researcher*, 27(5), 6-11.

### I. Theoretical Framework

#### A. Summary

1. Several unexpressed premises: a) there are gender differences in mathematics achievement and math-related careers, and b) assumption of homogeneity within genders in choice of strategies.
2. In this study, boys and girls used different strategies to solve mathematical problems; boys used more abstract algorithms and girls used more concrete strategies.
3. The authors imply that a) the use of invented algorithms reflects a better conceptual understanding, b) the use of more standard strategies suggests less understanding, and c) differences in strategy use may impact the mathematical development of the students.
4. The authors would like to address whether the difference in use of strategies by gender may lead to the gender differences found in mathematics achievement (as indicated by correctness on a variety of grade 1-3 tasks) OR whether this difference is just a consequence of 'women's ways of knowing' (gender-related choices of strategy) and both strategies lead to the same end goal (indicated by parity of achievement on the tasks by girls and boys).
5. The hypotheses of the article:
  - a. Are there gender differences between choices of strategies while learning complex mathematics?
  - b. Are these differences reflective of different pathways to learning complex mathematics or are they reflective of differential understanding?

#### B. Critique

1. Conceptual framework: The conceptual framework is not stated explicitly.
  - It seems to be that gender differences exist in mathematics achievement and math-related careers, males and females use different strategies to solve complex mathematical problems, and these differences in strategies may influence these gender differences.
  - Authors do not clearly define some of the constructs that are important to their argument (e.g., 'complex mathematics', the relationship between abstract and invented strategies).
  - The authors do not explicitly describe their conceptual model of cognitive development of mathematical learning
  - The authors assume that the use of invented algorithms (in contrast to standard algorithms) implies deeper or greater understanding of number and place value. No evidence is offered to support this.
2. Importance: The study has some merit: the authors can confirm previous studies that found differences in strategies. However, the authors never really address how instruction should be changed to address the differences in strategies.
  - The true importance seems to be in sorting out whether the gender differences in strategies are related to achievement or just different pathways to learning complex

## **MQM Preliminary Examination Scoring Guide (2004)**

mathematical problems. If the latter is proven, the research suggests that different instructional methods need to be developed that take account of the differences in strategy uses for boys and girls.

3. Ties to prior research: This seems somewhat inadequate because the authors spend very little space building the importance of their study on prior research. There are also some leaps in logic.
  - The authors state that there are gender differences in learning complex mathematics and these differences are well-documented. However, they provide minimal cites for this statement.
  - The authors rightly assert that few studies have been done that examine gender differences in strategy use.
  - Prior research that the authors cite discuss ‘abstract’ versus ‘concrete’ algorithms, and ‘conventional strategies’ versus ‘untaught strategies’, but its unclear how ‘standard algorithms’ and ‘invented algorithms’ fit into this framework. The authors gloss over this.
  - The authors do not provide any references to the model of cognitive development that they rely on (their conceptual model of mathematical learning).
  - Causal inferences are faulty (for example, authors assume if there is an association between differences in strategy use and percent correct, then strategy use is linked to achievement, but there is no basis for causality).
4. Hypotheses: The hypotheses of the article do not address the research questions laid out in the summary above because there is no causal link established between strategy differences and how the children did on the mathematical tasks.
  - The second research question (Are these differences reflective of different pathways to learning complex mathematics or are they reflective of differential understanding?) is ‘proved’ because the strategy use was not associated with ‘number correct’. However, there are many more rival hypotheses that compete with the second research question.

### **C. Scoring Guidelines**

4: Identify several of the criticisms listed, accurately summarizes the conceptual framework and literature review, and identifies the problem statement and hypotheses.

3: Identifies a few criticisms and may be overly critical of minor problems with the literature review. May have minor interpretive errors relating to the literature review, problem statement, or hypotheses.

2: Has unwarranted criticisms or very few criticisms to make of the literature review, problem statement, or research questions. Demonstrate errors in interpreting these elements. May demonstrate minor conceptual or factual errors.

1: Commits a serious errors in interpretation, states incorrect facts and concepts, and fails to comprehend the basis of the study.

## **II. Design & Analysis**

### **A. Summary**

## MQM Preliminary Examination Scoring Guide (2004)

1.  $N = 82$ , but gender is unbalanced. The subjects were part of a longitudinal study that began with  $N=132$ , evenly split between genders. Attrition was the result of nonresponse (-17) and a boundary change in the middle of the study (-33). The students were first graders in the first year of study; 89% white, 11% received free/reduced lunch.
2. Sample is mostly white; cultural/racial differences not explored
3. The design is a weak quasi-experimentation. There are several possible design problems.
  - Different 'parallel' instruments are used throughout the longitudinal study.
  - Gender is considered to be the 'treatment'
  - There is no control group
  - History and other contextual variables are not controlled.
  - Treatment and subject interaction cannot be explored as part
4. The instrument has been developed as part of the researchers' previous work. Potential problems include:
  - No description or example of the items
  - No evidence of validity
  - No evidence of reliability

### B. Critique

5. Design: The design is not well-suited to the hypotheses because it fails to take into account potential rival hypotheses by utilizing the following features.
  - Parallel test forms (testing)
  - Control group (maturation)
  - Multiple sites (history)
  - Also, authors assume that provision/no provision of pencil and paper will impact cognitive thinking; no evidence of this is provided.
  - No rationale given how often and when measurements would be taken on students.
  - Authors do not adequately define the differences between 'basic' and 'complex' problems.
6. Sampling: The sample is not described in sufficient detail. The students were split somewhat evenly between gender, a plus. However, it is clear that the students are not a random sample because they are part of a classroom of a teacher participating in an intervention study by the authors. We could consider this a cluster sample, with the teacher randomly chosen, but this is not clear from the text. These issues limit the scope of generalizations severely because we don't know how representative these students are of the general student population. Furthermore, these students are potentially exposed to a novel math instruction method because the teachers are part of the authors' intervention study; the method may very well be different from the usual math instruction method used in most schools.
7. Procedures: The procedures are adequately described. However, the choice of procedures is problematic because they do not allow for control of important subject characteristics such as SES. The authors test gender differences between each type of strategy and correctness using a separate t-test for each variable. The authors chose to use an ad-hoc correction for Type I error inflation due to the repeated measures (divide the familywise desired alpha of 0.10 by the number of t-tests done to produce an individual alpha for each t-test). A more appropriate Repeated Measures analytic approach could account for multiple measurements as well as allow incorporation of

## **MQM Preliminary Examination Scoring Guide (2004)**

important covariates (although most of the students will not be able to suggest another appropriate analysis if they have no statistical background and have not completed 933—don't penalize students for failing to suggest a different procedure).

8. Instruments: Inadequate information is given concerning the quality of the instrument. The reliability is unknown, and no validation evidence is provided. More details should have been provided about the interviewers such as training. Possible problems include:
  - Content representativeness is questionable
  - Use of 'parallel' tests that may not be parallel
  - Use of few items for measurement may increase measurement error
  - A single rater is used which may cause unreliable measurements
  - Authors did check instruments for gender bias and used only items that did not exhibit this bias.
  
9. Analysis: The analyses are overly simplistic considering the research hypotheses. In addition, important aspects of the design that may influence the interpret ability of the results are ignored. Problems include:
  - Ad-hoc methods are used to address the repeated measures. a repeated measures ANOVA or MANOVA would have been more appropriate.
  - The authors report effect sizes; this is helpful to the reader.
  - No discussion or evidence provided concerning whether statistical assumptions are met for the t-tests
  - The intervention of a novel instruction method is never addressed within the scope of the analysis; there may very well be an interaction between this invention and strategy use, but since no control group is used, this interaction cannot be explored.

### **C. Scoring guidelines**

4: The student identifies a majority of the cited criticisms, identifies why these issues are problematic, and suggests alternative methods of analysis. Generally, the student should identify at least one criticism per area and the response should be free of serious conceptual or factual errors.

3: The student identifies only a portion of decided criticisms, may fail to identify appropriate criticisms for some areas, and may fail to identify reasons why these issues are problems or alternative methods of analysis. The response may also contain several minor or a few major errors in concepts or facts.

2: The student identifies few of the cited criticisms, and does not identify appropriate criticisms for some areas. Few reasons are given to identify why the issue is a problem and few alternatives are identified. The response will also contain multiple major errors and minor errors in concepts or facts.

1: The student identifies few of the cited criticisms, and may identify inappropriate criticisms. Generally, support for why an issue is a problem and alternatives are not identified. The response will contain serious errors in concepts or facts.

## MQM Preliminary Examination Scoring Guide (2004)

### III. Interpretation

#### A. Summary

1. No gender differences in number of correct solutions during the three years for number facts, addition/subtraction, or non-routine problems.
2. Males solved significantly more extension problems than females in grade 3.
3. Significant gender differences in strategy use choices throughout all grades
  - a. Girls used more modeling or counting strategies
  - b. Boys used more abstract strategies
  - c. Effect sizes are substantial
4. The interaction between standard/invented algorithms and success in solving extension problems was investigated in a posteriori analyses that looked at the correctness percent between (a) students who used invented algorithms by the fall of grade 2 (invented group) and (b) students who did not use the invented algorithm, but used the standard algorithms by grade 2 (standard group). Significant differences were found, favoring the invented group
5. The authors drew the following conclusions:
  - a. No gender differences in solving number fact, addition/subtraction, or non-routine problems throughout the study.
  - b. Significant gender differences in strategy choices.
  - c. By the end of third grade, girls used more standard algorithms than boys.
  - d. Boys outperformed girls on problems that required flexibility in extending one's procedures.
  - e. Ability to perform on extension problems in the third grade was related to the use of invented algorithms
6. The authors draw two implications from these results.
  - a. Invented algorithms promote success in solving extension problems, therefore this practice should be encouraged
  - b. Boys and girls are using different algorithms to solve problems, with girls being more inflexible than boys.

#### B. Critique

10. Discussion of Results & Limitations: The authors do not discuss the methodological and conceptual limitations of the results. They also fail to discuss their results in a way that ties their research back to their original research questions. They do not touch on differential instructional approaches for males and females, which is surprising, given that they seem to have suggested that their findings point to strategy differences as merely differential pathways to solving problems (for the most part).
11. Consistency with Results: The authors do a good job of summarizing the results. However, they really don't offer any concrete conclusions, and the discussion of the results is very sparse.
12. Results Related to Theoretical Base: the authors do not do a good job of relating the results to prior research.
13. Significance of the study: The significance of this study seems to be that males and females use different strategies and this should be taken into account in instructional choices. However, the authors offer not direction on modification of instruction.

## **MQM Preliminary Examination Scoring Guide (2004)**

### **C. Scoring Guide**

4: The student will point out that the author did not discuss methodological or conceptual limitations of the results. The student will also identify the serious lack of discussion in the piece. The student should point out that the author does not do an adequate job of relating to results to prior research. The student should also state the study has some practical significance, but that that significance is inferred rather than presented by the authors.

3: The student will point out that the author did not discuss methodological or conceptual limitations of the results. The student will also identify a serious lack of discussion in the piece. They student should also realize that the author has not tied the results to prior research. The student will only have a weak understanding of what is an appropriate level of practical significance of the results.

2: The student may point out that the author does not discuss the methodological or conceptual limitations of the study. The student may or may not understand the importance of the fact that the author has tied the results to prior research. The student may fail to realize an appropriate level of practical significance of the results.

1: Student may or may not realize that the author has not discussed the methodological or conceptual limitations of the study. The student will generally fail to recognize that the results of the study are not tied to prior research. The student will generally demonstrate no understanding of what is an appropriate level of practical significance for these results and that the authors did not explicitly discuss this.