Children's Learning from Multiple Media

in Informal Mathematics Education

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EXECUTIVE SUMMARY

Many informal science and mathematics education projects employ multiple media, but studies typically have investigated learning from a single medium, rather than multiple media. The present research, funded by the National Science Foundation, used *Cyberchase* (a multiple-media, informal mathematics project targeting 8- to 11-year-olds, produced by Thirteen/WNET) to investigate synergy among multiple media components and how they interact to yield cumulative educational outcomes.

A total of 672 children, in nine public elementary schools in Michigan and Indiana, participated in the study. The research incorporated both naturalistic and experimental methods, to investigate children's use of *Cyberchase* media, ways in which use of one medium feeds into use of another, and the educational impact of *Cyberchase* on children's problem solving and attitudes toward mathematics.

The study was designed to address the following research questions:

1) How does the mathematics learned from multiple media differ from mathematics learned from a single medium?
2) What outcomes derive from engagement with different types of media, and what types of synergy occur?
3) How can reliable research methods be developed to assess contributions of individual media and their interactions?
4) How can informal education projects capitalize on the strengths of each medium?
5) How can media components be designed and employed to best complement each other?

Highlights of the results include the following:

Patterns of Naturalistic Use

- Use of each form of *Cyberchase* media (TV and Web site) was fairly consistent over time. Those children who watched *Cyberchase* on TV in one month tended to do so in subsequent months as well. A similar pattern was found for month-to-month use of the Web site.

- Children's use of *Cyberchase* also tended to span media; each month, children who watched the *Cyberchase* TV series more frequently also tended to visit its Web site more often. Thus, in naturalistic use, some children do indeed use multiple media when they are available (which lends real-world validity to the question of how children learn from multiple media).

- Because most users' first encounter with *Cyberchase* occurred long before we began collecting data, the present data cannot determine which medium came first. However, past research found that children more often begin by watching the TV series and subsequently expand to using the Web site as well.

Learning from Cyberchase

- Past research (which evaluated the educational effects of the *Cyberchase* TV series alone) found evidence of significant impact on both the process of children's mathematical problem solving and the sophistication of their solutions. The present study replicated that finding, and extended it by finding more consistent effects of video plus online games than of either medium alone (especially in comparison to online games alone). Interestingly, learning from *Cyberchase* was not manifest in children's simply doing a greater number of things while working on the tasks, but rather in their using a greater *variety* of strategies and heuristics, and in using those strategies and heuristics more effectively. In addition to quantitative, statistical comparisons, qualitative observations revealed that children demonstrated persistence and top-down planning while working on tasks in the posttest. As in past research, effects emerged more consistently in tasks about organizing data (e.g., combinatorics, predicting from data) than in tasks about measurement.

- Surprisingly, however, children in the DVD + Web group also showed consistently greater gains than children in the All Materials group (which used the same materials plus hands-on classroom activities). Although we cannot be certain, we believe that the less consistent performance of the All Materials group may have been influenced by cues from teachers in response to the demands of having to make time for *Cyberchase* media or hands-on activities every day.

- Effects on problem solving often appeared to be driven more by the TV series than by the online games. We suspect that this is due to the fact that television is designed to serve as the central component of *Cyberchase*, and provides greater explanation of mathematical concepts than the games (which allow children opportunities to exercise skills, but present less overt explanation). Such explanation -- embedded in the context of appealing characters and a compelling narrative -- appeared to provide both the necessary understanding and modeling of processes and dispositions for effective problem solving (e.g., persistence, top-down planning). However, games designed for more overt instruction and explanation (e.g., via online agent characters who scaffold children's performance) might produce stronger effects of their own.

- Although the television series produced stronger pretest-posttest effects than the online games did, online tracking data indicated that the games provided a context for children to engage in rich mathematical reasoning – and that this process of reasoning was detectable, not only through in-person observations, but also

through data mining of online tracking data. Parallel to prior research on formal classroom mathematics, children engaged in cycles of increasingly sophisticated mathematical thinking over the course of playing an online game, with shifts in strategies indicated by predictable patterns of responses, such as clusters of errors or use of a "clear" button to try again.

Multiple-Media Learning

- Data on children's performance while playing the online games revealed evidence of transfer of learning, not only from the treatment to our posttest measures, but also from children's experience with one *Cyberchase* medium to another. This points to a significant strength of learning from multiple media: The lessons learned from one medium can be applied to enrich children's experience while learning from a second medium as well.

Attitude

- Paper-and-pencil measures of attitude revealed only one pair of significant effects: From pretest to posttest, all of the *Cyberchase* groups sustained their interest and (to a lesser degree) confidence in doing school math, while the attitudes of the control group declined. No significant effects appeared for other domains of out-of-school mathematics.

- However, we also found behavioral evidence of an effect on children's motivation: In two of the three *Cyberchase* online games, users of multiple media were more likely to continue playing beyond the end of the game than children in the Web Only group, pointing to their greater motivation to engage in a fun, mathematical activity.

Conclusions and Implications

- Together, these data suggest that children use multiple related media during naturalistic use, and that such use can promote both learning and motivation toward engaging in additional, related activities for informal education. Cross-platform learning can elicit transfer of learning, both from one medium to another (resulting in richer engagement with the material) and from educational media to subsequent assessments.

- Indeed, the presence of a consistent world and cast of characters across media has the potential to serve as a bridge that not only elicits, but also facilitates, transfer of learning. In the case of *Cyberchase*, compelling narrative is used to carry both explanations of content and examples of characters who model successful approaches to problem solving, whereas participatory (interactive and hands-on)

media provide opportunities for children to exercise these skills themselves. The use of a common world and characters can encourage children to connect related mathematics content across these media. At the same time, appealing experiences in one medium can stimulate children's motivation to engage in other educational activities with the same familiar characters. Over time, such experiences have the potential to stimulate interest in the embedded mathematics as well.