Educational Research:
The Art of Problem Solving

Prepared for the
Solomon R. Guggenheim Museum
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EXECUTIVE SUMMARY

INTRODUCTION

The Solomon R. Guggenheim Museum contracted with Randi Korn & Associates, Inc. (RK&A) for the 2007-2009 study *The Art of Problem Solving* (*APS*). The research study examined the Guggenheim's long-standing teaching artist in residency program *Learning Through Art* (*LTA*); specifically, the study was designed to explore *LTA*'s pedagogical model of building problem-solving skills using art and to determine the effectiveness of the *LTA* program in teaching problem-solving skills. This study was made possible through a three-year Arts in Education Model Development and Dissemination (AEMDD) grant from the U.S. Department of Education. The major findings from the study are presented below by methodology.

> **The findings presented here are among the most salient. Please read the body of the report for a more comprehensive presentation of findings.**

STUDENT QUESTIONNAIRES

A total of 418 fifth-grade students from six schools completed a questionnaire at the start of the school year (pre-test) and again at the conclusion of the school year (post-test); one-half of students received the *LTA* program (treatment student n = 209), while one-half did not (control student n = 209). Questionnaire findings describe students' attitudes about school and art, schoolwork and art work practices, and perceptions of a good artist. For treatment group students, findings also describe students' evaluations of various aspects of *LTA*. Findings are as follows:

BASELINE FINDINGS

♦ At baseline, control and treatment students expressed positive attitudes about school, art, and art museums. They also responded positively to questions about art work practices and their ideas about artists as well as about solving math problems, puzzles, and difficulties with art projects.

♦ Of all the responses, there was only one significant difference between control and treatment students; when asked about art project work practices, treatment group students were more likely than were control group students to say they would keep working on an art project at school even if they made mistakes.

PRE-TEST TO POST-TEST CHANGES

♦ Control and treatment students expressed less positive attitudes about school at the end of the school year (ratings on four of the seven statements about school decreased significantly from pre-test to post-test).

♦ Control and treatment students' attitudes about art remained about the same over the year (treatment students' ratings for all six statements about art did not differ, while control students' ratings for one of the six statements improved significantly).

- Control and treatment students' attitudes about art museums remained the same over the year (students' ratings of the five statements about art museums did not change significantly from pre-test to post-test).

- Control and treatment students' strategies for solving a math problem and puzzle remained about the same from pre-to post-test. However, more control and treatment students reported asking another student or family member for help when encountering difficulties solving a math problem or a puzzle (as well as an art project) on post-test than pre-test.

- Control and treatment students' strategies for solving a problem with an art project stayed about the same during the year. However, treatment students' responses for two of the 12 statements—"do you feel mad?" and "do you try to fix it by using different materials?"— improved.

- Control and treatments students reported more favorable art work practices at post-test than pre-test (students' responses for five of the 12 statements improved significantly from pre- to post-test; additionally, more control students reported that they wouldn't use the materials with which they are most comfortable on post-test than pre-test, while treatment students' responses to this item remained the same; finally, more treatment students reported planning for their art project on post-test than pre-test while control students' responses remained the same).

- Control and treatment students' ideas about the qualities of a good artist improved over the year (responses for three of the eight sentence completions about the qualities of a good artist improved significantly from pre- to post-test while their other responses stayed the same).

DESIGN-A-CHAIR STUDENT INTERVIEWS AND OBSERVATIONS

A total of 447 fifth-grade students from six schools completed the Design-a-Chair activity; one-half of students received the *LTA* program (treatment student *n* = 218), while one-half did not (control student *n* = 229). As part of the activity, students were presented with a bag of art materials and asked to design a chair using at least three different materials in 15 minutes. Specially-trained data collectors observed students as they did the activity and interviewed them immediately after. The Design-a-Chair activity was administered at the end of each school year in May (May 2008 and May 2009). Findings are as follows:

- Treatment students scored higher than control students on Connection of Ends and Aims I, a measure that explored the extent to which students make intentional decisions and choices when working on art projects.

- Treatment students scored higher than control students on Flexibility, a measure that explored the extent to which students approach accidents, difficulties, and frustration with focus, patience, and further exploration.

- Treatment students scored higher than control students for Resource Recognition III; that is, when asked what other materials they would have liked to use, treatment students named materials other than those already available.

- Treatment students scored lower than control students on Experimentation II, a measure that explored the extent to which students tested the properties of the materials when working on art projects.

- ♦ In all other areas—Imagining, Experimentation I, Resource Recognition I & II, Connection of Ends and Aims II & III—there was no statistically significant difference between treatment and control students.

STUDENT CASE STUDIES

RK&A conducted 25 case studies over the 2007-2008 and 2008-2009 school years. Through case studies, RK&A looked at how students responded to *LTA*—particularly in relation to five problem-solving criteria—as well as investigated students' performance outside *LTA*. As part of each case study, RK&A observed the student during two or three *LTA* lessons between December and April, interviewed the student about an artwork s/he created during *LTA*, and interviewed the student's classroom teacher. Findings are as follows:

- ♦ Some case study students struggled in class but excelled in *LTA*; the converse is also true.

- ♦ About one-half of case study students achieved low levels of Experimentation, which explores the extent to which students try a number of materials, tools, techniques, or ideas.

- ♦ More than one-half of case study students achieved high levels of Connection of Ends and Aims, which explores the extent to which students make intentional decisions and choices in when working on their art project.

- ♦ Case study students' achievement of Imagining, Flexibility, and Resource Recognition ranged approximately evenly along a continuum from high to low achievement.

TEACHING ARTIST OBSERVATIONS

RK&A observed each of the three teaching artists during the 2007-2008 school year and each of the three teaching artists—two of whom also taught during the 2007-2008 school year—during the 2008-2009 school year. Each teaching artist was observed nine times between December and April in each school year (e.g., each teaching artist was observed three times while teaching to three classrooms). Observations explore the extent to which teaching artists employ general *LTA* teaching strategies—considered best practice by the Guggenheim—as well as strategies for cultivating students' problem-solving skills. Findings are as follows:

- ♦ Of the four general *LTA* teaching strategies, teaching artists least frequently referred to students as artists; this occurred in less than two-thirds of observations

- ♦ Of the four lessons that cultivate students' problem-solving abilities, teaching artists most frequently taught students to think intentionally and make deliberate choices; they did so in all observations

- ♦ Of the four lessons that cultivate students' problem-solving abilities, teaching artists least frequently taught students to see problems/mistakes/challenges as opportunities; this occurred in slightly more than one-half of observations.

TEACHING ARTIST INTERVIEWS

In June following the 2007-2008 school year and the 2008-2009 school year, RK&A conducted telephone interviews with the three participating teaching artists from each school year. Two of the teaching artists who participated in the study during the 2007-2008 school year also participated in the

study during the 2008-2009 school year; thus, six interviews were conducted with four teaching artists. Findings are as follows:

- ◆ Teaching artists described their relationship with classroom teachers as one of the greatest challenges of *LTA*. Teaching artists had trouble communicating with teachers and gaining their support.

- ◆ Teaching artists described positive experiences with the students. They said that students thrived in the program and felt that they enjoyed it and were even empowered by it.

- ◆ Teaching artists valued the professional development the Guggenheim provided, specifically the teaching strategies they acquired.

- ◆ Teaching artists said that their experiences with *LTA* made them more reflective teachers.

DISCUSSION

INTRODUCTION

Over the years, the Solomon R. Guggenheim Museum's *LTA* has used evaluation for institutional learning and program improvement. Evaluation and self assessment are embedded in the program, and used successfully among the teaching artists. As a result of this iterative cycle of continual improvement, *LTA* has developed into a highly effective program. In a previous study, titled *Teaching Literacy Through Art* (TLTA), funded by the U.S. Department of Education's Arts in Education Model Development and Dissemination (AEMDD) grant, participation in *LTA* was shown to have a positive impact on students' literacy and critical thinking skills (RK&A, 2007). This follow-up study, also funded by the AEMDD grant, sought to examine another area important to *LTA*—problem solving. Findings of this important study, titled *The Art of Problem Solving*, are discussed below.

ATTITUDES TOWARD SCHOOL, ART, AND ART MUSEUMS

The research study hypothesized that students who participate in *LTA* would have more positive attitudes toward school, art, and art museums than those who do not participate in *LTA*. Similar to the 2007 *TLTA* study, findings demonstrate that *LTA* did not have a significant impact on students' attitudes toward school, art or art museums—there were no statistically significant differences between the treatment and control students. Generally, students in both groups had positive attitudes in these three areas at the beginning of the school year, while students' (in both groups) attitudes toward school were significantly less positive at the end of the school year than at the beginning (attitudes toward art and art museums remained unchanged). Such a finding is not surprising, considering that other studies have shown that negative attitudes toward school begin to develop around middle school (Anderman & Midgley, 1998; Eccles & Midgley, 1989; Hogsten & Peregoy, 1999). The students in this study were fifth graders, and thus, on the cusp of middle school by the end of the school year.

PROBLEM-SOLVING BELIEFS AND ABILITIES

While this study examined attitudes as described above, the primary focus of the research was the hypothesis that students who participate in *LTA* will develop greater problem-solving skills than those who do not participate in *LTA*. Problem solving has long been an important objective for *LTA*, but its relevance to today's world has been heightened in the current global economy, which demands that our workforce develop higher-order thinking skills like critical thinking and problem solving. These kinds of skills have been coined "21st Century Skills" and embraced by educators, policy makers, and business leaders as essential to success in today's society. The premise is that *thinking* skills are far more valuable than encyclopedic knowledge of content. "21st Century Skills" have also taken hold in the museum field. A 2009 publication by the Institute of Museum and Library Services (IMLS) emphasizes that museums have an important role in helping citizens build thinking skills, listing problem solving among the top of its learning and innovation skills, along with critical thinking and creativity (IMLS, 2009).

This notion of "21st Century Skills" is not new to art museums. For decades, many art museums have sought to translate the power of art (looking at, thinking about, and making art) into programs meant to

develop participants' thinking skills through such means as inquiry, experimentation, and observation. Small-scale studies, evaluations, and arts education advocates have argued that the methods of instruction typically delivered in arts-based programming has a high probability of cultivating higher-order habits of mind and thinking skills (Constantino, 2002; Perkins & Jay 1995; Pitri, 2003; Tishman, 2002; Kowalchuk, 1999). However, few art programs have had the resources to conduct rigorous studies to attempt to demonstrate the positive effects of arts programming on student learning (McCarthy, Ondaatje, Zakaras, & Brooks, 2004). A couple of large-scale, quantitative studies have examined the impact of multi-arts programming on student learning, and findings were promising. For example, Burton et al. (1999) showed that students attending arts-rich schools outscored students in arts-poor schools in measures of creative thinking. Catterall and Waldorf (1999) found that students who were highly involved in the arts outperformed students who had low arts involvement on a variety of academic measures. But these examples are few and far between.

It is within this context that *LTA* sought to show a link between its programming and problem solving skills. *LTA* hypothesized that the program would give students the skills necessary to persistently and adaptively work through problems. However, before moving forward on this research, *LTA* had to first clearly define what it meant by problem solving, given that there is little available consensus on the meaning of the term. While problem solving may be simply defined as "the analysis and transformation of information toward a goal" (Lovett, 2002), a review of literature quickly reveals that no standard set of behaviors is associated with problem solving. Rather, many skills and behaviors are associated with problem solving—including exploration, analysis, synthesis, curiosity, persistence, planning, risk taking, and elaboration (Costa & Kallick, 2000; IMLS, 2009; Weisburg, 2006). Moreover, there is much overlap among definitions of problem solving, creativity, and critical thinking. Thus, the first step in the research study was to identify the exact characteristics of "problem solving" as manifested in the *LTA* program. In the project's first year, *LTA* staff assembled the *Art of Problem Solving* (*APS*) advisory team (see Appendix U) to develop a rubric to define the behaviors associated with problem solving in *LTA*. This process was long, arduous, and exhilarating. In the end, the *APS* advisory team created a list of six skills to most accurately define problem solving in *LTA*. They are listed and described, in brief, below (for the complete rubric, see Appendix L).

1. Imagining – Students place themselves within the task to the extent that he/she can envision the problem beyond the assignment given, including opportunities and constraints.

2. Experimentation – Students try a number of materials and/or tools as they create their art project.

3. Flexibility – Students approach accidents, difficulties, and frustration with focus, patience, and further exploration.

4. Resource Recognition – Students pay attention to the resources provided and seek out resources appropriate for the task.

5. Connection of Ends and Aims – Students describe intentional and deliberate decisions and choices they made in creating art.

6. Self-reflection – Students express explicit and thoughtful opinions or critiques of their art project and/or identify problems/difficulties.

In the end, the study provides strong evidence that *LTA* enhanced students' abilities in three of the six areas of the problem-solving rubric: 1) Flexibility, 2) Connections of Ends to Aims, and 3) Resource

Recognition[1]. *LTA* students scored significantly higher than non-*LTA* students in these three areas on the problem-solving activity (see page 8 for a full description of the Design-a-Chair activity). Furthermore, questionnaire findings also show that participation in *LTA* is correlated with more positive attitudes in the areas of Flexibility (i.e., not giving up when encountering problems) and Connections of Ends and Aims (i.e., planning). Moreover, case study findings show that students participating in *LTA* exhibited Connections of Ends and Aims more often than the other problem-solving skills during LTA sessions, and deliberate decision-making was a strategy that the teaching artists used consistently and frequently. On the other hand, evidence indicates that *LTA* did not affect students' abilities in the other areas of the rubric, including: Imagining, Experimentation, and Self-reflection. In each of these areas, treatment students did not score significantly higher than control students on the problem-solving activity. In fact, in one area—Experimentation—control students scored higher than treatment students. Notably, case study findings provide support for this last finding, in that *LTA* case study students infrequently experimented during *LTA* sessions.

CONCLUSION

What do these findings tell us? In plain language, the findings indicate that students who participate in *LTA* are more likely to plan, persist, be deliberate and thoughtful, approach difficulties with focus, and have greater knowledge of art materials. On the other hand, students who participate in *LTA* are no more likely to imagine beyond the task at hand or self critique, and they are less likely to try a number of materials. Though these findings are not entirely positive, they are encouraging and have positive implications, especially when considered in the context of "21st Century Skills." For instance, though the study did not test for transfer, one could hypothesize that Connections of Ends to Aims and Flexibility, in particular, are skills with wide application across students' academic careers and highly relevant to "21st Century Skills" described earlier. Planning, intentionality, adaptability, and persistence are all skills that will benefit students in school and as they move into the workforce.

Ultimately, the study raises important questions about what problem solving is, especially in the context of arts programming. This study took preliminary steps in defining and measuring problem solving—a complex thinking skill—and raised interesting questions for further research. These questions include: How can teachers cultivate students' abilities to experiment, imagine, and self-reflect? Is the ability to experiment, imagine, and self-reflect linked to developmental stages, and if so, at what age is it appropriate to expect children to experiment, imagine, and self-reflect? How does achievement of Flexibility and Connection of Ends and Aims transfer to other subjects or real world experiences? Are there stages to problem solving in the way there are stages to one's aesthetic development? How does Resource Recognition relate to Experimentation (e.g., does achievement of resource recognition help or hinder students' achievement of Experimentation)?

Ultimately, these findings beg the question: If *LTA* affects half of the six problem-solving skills defined by the *APS* advisory team, does that mean *LTA* does not affect students' problem-solving skills? As discussed previously, problem solving is a somewhat nebulous term without a standard list of behaviors to use as a barometer of its accomplishment. Its definition is at least somewhat dependent on the context in which it is used, and it is often referred to interchangeably with other higher-order skills, like creativity and critical thinking. While the *APS* advisory team set out to capture problem solving in terms accepted in the field *and* most consistent with what one would expect from *LTA*, the definition of problem solving must be further refined as researchers and practitioners continue to explore what problem solving is, particularly given its prominence in literature about "21st Century Skills."

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[1] Resource Recognition was broken into three categories and treatment students scored significantly higher on Resource Recognition III, which assessed whether students asked for materials not provided.

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