ORIGINAL ARTICLE

MATHEMATICS AND SCIENCE ACTION-RESEARCH STUDIES IN ELEMENTARY AND MIDDLE SCHOOLS IN PUERTO RICO

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Abstract

This article presents the background and process followed to implement ten Action-Research (A-R) studies in public schools in Puerto Rico during the academic year 2008-2009. Volunteer teachers performed eight quantitative studies and two qualitative. Four studies were in Mathematics and six in Science. Eight studies were in middle school and two in elementary school. The objective was to investigate better ways to improve student’s performance in Mathematics and Science. The Turabo Mathematics and Science Alliance (AMCT, Spanish acronym) provided an initial training in A-R and advised the teachers on the application of the scientific method, instruments design, and data analysis. Besides the great enthusiasm generated by these initiatives, in teachers and students, the lessons learned are encouraging: Two studies focused on the preliminary phase; six out of the other eight studies obtained evidence to infer that the interventions produced significant improvements in the student’s academic performance. This initiative did not lack problems: Some confusion still exist regarding what Action-Research really is, and there is a long way to go before A-R can be adopted and integrated in the classroom as a common educational strategy.

Keywords: Action-Research, Mathematics, Science, elementary school, middle school
Resumen
Este artículo presenta el trasfondo y proceso seguido para implementar diez estudios de Investigación-Acción en escuelas públicas de Puerto Rico en el año académico 2008-2009. Maestros voluntarios ejecutaron ocho estudios cuantitativos y dos cualitativos. Cuatro estudios fueron en Matemáticas y seis en Ciencias. Ocho estudios fueron en nivel intermedio y dos en nivel elemental. El objetivo fue investigar mejores maneras para mejorar el aprovechamiento académico de los estudiantes en matemáticas y ciencias. El proyecto Alianza de Matemáticas y Ciencias del Turabo (AMCT) proveyó el entrenamiento inicial sobre el tema de Investigación-Acción y asesoró a los maestros en cuanto a la aplicación del método científico, diseño de instrumentos y análisis de datos. Aparte del gran entusiasmo generado por estas iniciativas, entre maestros y estudiantes, las lecciones aprendidas son alentadoras: Dos estudios se enfocaron en la fase preliminar de Investigación-Acción; seis de los otros ocho estudios obtuvieron evidencia para inferir que las intervenciones produjeron mejoras significativas en el desempeño académico de los estudiantes. Estas iniciativas no estuvieron exentas de problemas: Todavía existe confusión acerca de qué realmente es Investigación-Acción, y hay un largo camino por recorrer antes de que la Investigación-Acción sea adoptada e integrada en el salón de clases como una estrategia educativa común.

Palabras claves: Investigación-Acción, Matemáticas, Ciencias, escuela elemental, escuela intermedia

INTRODUCTION

Background

The Turabo Mathematics and Science Alliance (AMCT, Spanish acronym) is a professional development project created with the purpose of improving the command of content knowledge in the areas of mathematics and science of the participant teachers. The ultimate goal is to improve the academic performance of the teacher’s students in such content areas. The core professional development activities are content focused workshops. The members of the AMCT are the School of Engineering, the School of Science and Technology, and the School of Education, all from Universidad del Turabo, the Puerto Rico Department of Education (PRDE), and more than thirty schools from the Caguas Education Region of Puerto Rico. The Caguas Education Region has the following school districts: San Lorenzo, Gurabo, Caguas I, Caguas II, Aguas Buenas, Cayey, Cidra, Guayama, and Arroyo.

A total of 144 mathematics and science teachers from elementary and middle school participated in the AMCT project during the academic year 2008-2009. These teachers, in turn, served more than eleven thousand students. During this academic period, the project’s participants received Action-Research (A-R) training and were encouraged to develop A-R
studies. As a result, ten A-R studies were carried out by volunteer participants, all from public schools. Table 1 summarizes and identifies the ten studies by school, school district, area, and level.

**Action-Research**

An essential characteristic of A-R is the interest in mitigating or solving human problems following an explicit process. A-R distinguishes itself because its interest in developing both, scientific and practical knowledge and the commitment to using the research results to execute specific action plans. So, A-R is seen as a process that integrates research and action in a series of cycles with distinctive phases where there is research, actions, assessment, and reflection (Bravo, 2005). Kember (1992) and Kember & Gow (1992) add that an A-R involves the stakeholders directly affected by the teaching-learning activity maintaining a collaborative effort.

Several types of A-R have been proposed: a) Organizational change and research work; b) Cooperative research; c) A-R in the sciences; d) Learning history; e) Appreciative research; f) Whole system research; g) Participative A-R; h) A-R in the arts, writing, and theater; and i) Public conversations (Reason, 2002). A shorter classification of A-R is proposed by O’Brien (2001): a) Traditional; b) Contextual; c) Radical; and d) Educational.

Irrespective of classification, the teacher participating in A-R is producing knowledge at the same time that is learning how students, the subjects of the A-R study, build the necessary knowledge to effectively reach the classroom goals. Through A-R, the teacher participates and develops insight on a process that will provide the necessary feedback to assess and to improve the teacher’s practice (Rivera, 2007).
<table>
<thead>
<tr>
<th>Action-Research Study</th>
<th>School/District</th>
<th>Area</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Math-Phobia</td>
<td>Dr. Ramón Emeterio Betances/Cayey</td>
<td>Mathematics</td>
<td>Middle</td>
</tr>
<tr>
<td>2. Solving Verbal Problems to Increase Student’s Academic Performance</td>
<td>Haydee Caballero/Caguas II</td>
<td>Mathematics</td>
<td>Middle</td>
</tr>
<tr>
<td>3. The Effect of Practice Exercises on Student’s Performance in the Division of Real Numbers</td>
<td>Jesús T. Piñero/Cidra</td>
<td>Mathematics</td>
<td>Middle</td>
</tr>
<tr>
<td>4. Guidelines for the Integration of Technology in the Math Classroom</td>
<td>Felipe Rivera Centeno/Caguas I</td>
<td>Mathematics</td>
<td>Middle</td>
</tr>
<tr>
<td>5. Little Scientists: Using the Scientific Method</td>
<td>Inés María Mendoza/San Lorenzo</td>
<td>Science</td>
<td>Elementary</td>
</tr>
<tr>
<td>6. The Effect of Fun Activities in the Learning of the Scientific Method</td>
<td>Eugenio María de Hostos/San Lorenzo</td>
<td>Science</td>
<td>Elementary</td>
</tr>
<tr>
<td>7. Frequent Practice to Develop Critical Thinking Skills in the Biology Class</td>
<td>Dr. Pedro Albizu Campos/Aguas Buenas</td>
<td>Science</td>
<td>Middle</td>
</tr>
<tr>
<td>8. Using the Scientific Calculator to Improve Academic Performance in the Science Class</td>
<td>Jesús T. Piñero/Cidra</td>
<td>Science</td>
<td>Middle</td>
</tr>
<tr>
<td>9. Integrating the Search and Use of Information in the Study of Environmental Pollution</td>
<td>Alfonso Díaz Lebrón/Juncos</td>
<td>Science</td>
<td>Middle</td>
</tr>
<tr>
<td>10. On the Effectiveness of Using Science Laboratories</td>
<td>Luis Muñoz Marín/Aguas Buenas</td>
<td>Science</td>
<td>Middle</td>
</tr>
</tbody>
</table>

The A-R process can be implemented in phases, such as: a) A set of critical research questions; b) Relevant data collection; c) Appropriate decision-making; d) Assess the impact of the action taken; and e) Disseminate the results so that others can benefit from the A-R findings (Khalid, 2010; Schoen, 2007). The A-R studies carried out by the AMCT teachers followed the following phases (Figure 1), proposed by Susman (1983): a) Problem identification and data collection for diagnostic purpose; b) postulation of possible solutions; c) selection of one for implementation; d) data collection and analysis on the results of the intervention, e) problem reassessment and beginning of another cycle. Interestingly, Kosky and Curtis (2008) found that giving students the choice of activities to perform, increased their motivation to participate in A-R.
METHODS

In more detail, the process followed by the AMCT to carry out the ten A-R studies consisted of:

A. Research and Action Research Training. The initial phase was to offer forty (40) hours of professional development workshops geared towards research (i.e., scientific method, statistics, data analysis, and A-R). All the participants (mathematics and science teachers, elementary and middle school teachers) received these workshops in the summer of 2008. As a deliverable, the participants submitted an A-R proposal.

B. Creating a guide for drafting the proposal. In order to support the writing of the above-mentioned A-R proposal, the AMCT Project devised a guide. This guide describes the basic components of an A-R proposal, such as problem statement, methodology, data collection, and analysis.
C. Recruitment efforts. This was a challenge, even though the AMCT delivered talks related to the importance of these A-R studies to improve student learning.

D. Logistic support. The AMCT Project supported each of the volunteer teachers during their studies. This support consisted of designing instruments and data collection methods, letters to get the parents’ permission, instrument validation, treatment implementation, data analysis, and writing of the final reports.

E. Literature Review. As part of the professional development, the AMCT Project delivered workshops where teachers received training on how to do literature reviews, particularly from scientific sources, and how to produce a document with citations and references following a reference style.

F. Permits and consents. Each A-R study obtained the authorization of the school and the parents. The teachers obtained online IRB certifications related to the protection and participation of humans in research by NIH Office Extramural Research and HIPPA by Collaborative Institutional Training Initiative.

G. Data Analysis. Using Excel© and SPSS©, the AMCT Project carried out all the necessary statistic calculations when called for.

H. Final Report. The AMCT collaborated with each A-R study in order to improve the write-up and reports’ content.

RESULTS

Ten A-R studies were carried out by volunteer participants in the AMCT Project (Table 2). Four studies were in Mathematics and six in Science. Eight studies were in middle school and two in elementary school. Eight studies were quantitative quasi-experimental designs and two were qualitative. Half of the quasi-experimental designs had a comparison group.

<table>
<thead>
<tr>
<th>Research Design Type</th>
<th>MATHEMATICS</th>
<th>SCIENCE</th>
<th>Number of Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Middle</td>
<td>Elementary</td>
<td>Middle</td>
</tr>
<tr>
<td>Qualitative</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Quantitative (Quasi-Experimental)</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4</strong></td>
<td><strong>0</strong></td>
<td><strong>4</strong></td>
</tr>
<tr>
<td>Use of Comparison Group</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>
The next section briefly describes each one of the A-R studies in terms of their purpose, study design, treatment, instruments, results, and lessons learned.

**Math-Phobia**

**Purpose:** This study attempts to find a solution to the Math-Phobia problem. The researcher wants to demonstrate that through the mastering of a math skill a student can overcome Math-Phobia. The researcher goal is to develop a scientific base to request appropriate school support for these students, which in turn will lead to better academic performance and a better student attitude towards Mathematics.

**Study Design:** This is a quasi-experimental design with comparison group. Each group had twelve students from 8th grade. A questionnaire was administered to the school’s 8th graders to detect students with Math-Phobia. Twenty-four students that expressed to feel Math-Phobia were selected and half of them were randomly assigned to the experimental group and the other 50 percent to the comparison group.

**Treatment:** The experimental group received additional support in the form of individual tutoring and practice with manipulatives. The subject was the Laws of Exponents.

**Instruments:** A questionnaire was administered to identify students with Math-Phobia. The first data collected were related to processing this questionnaire. After students were identified as having Math-Phobia, they were split into two groups, experimental and comparison. The same questionnaire was also administered after the post-test and intervention. A pre-test on the Laws of Exponents was administered to both groups before the intervention. A post-test on the Laws of Exponents was administered after the intervention. Both instruments, the questionnaire and the test, were properly validated by a panel of experts and pilot tested with the help of the AMCT’s Research Director.

**Results:** Students of both groups, experimental and comparison, expressed to have no previous knowledge of the subject, so the pre-test average score was zero. The post-test average score of the experimental group was 12.43 while the post-test average of the comparison group was 2.08 and p-value < 0.001 for the independent samples t-test; so there was a statistically significant difference in favor of the experimental group, meaning that there is evidence to support the claim that the intervention had a positive effect on the learning of the Laws of
Exponents. Another result is that, after the intervention, the number of students feeling Math-Phobia decreased from 12 to 3, a 75% reduction (Table 3).

<table>
<thead>
<tr>
<th>Total students surveyed</th>
<th>Experimental Group Students with Math-Phobia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BEFORE Treatment</td>
</tr>
<tr>
<td>57</td>
<td>12</td>
</tr>
</tbody>
</table>

**Lessons Learned:** The effect of more and personalized attention to students expressing Math-Phobia feelings, together with the resources and formal mathematic training, promotes the building of the necessary math skills and confidence to overcome such phobia. The strategies used to achieve this study goal were to: a) establish a quiet environment, b) reinforce students’ self-confidence in regard to that they have the ability to learn, and c) work with a small and enthusiastic group.

**Solving Verbal Problems to Increase Student’s Academic Performance**

**Purpose:** To solve mathematics verbal problems more effectively.

**Study Design:** Quasi-experimental, no comparison group. Sample: twenty one (21) 8th grade students.

**Treatment:** Expose students to pertinent everyday (real life) problems where the use of mathematics is necessary (problem based learning, PBL). Provide students with the math vocabulary linked to the basic arithmetic operations (i.e., sum, subtraction, multiplication, and division). Additionally, the teacher used the following strategies: a) Lecture targeting the subject; b) individual tutoring in class by the Title I teacher; c) examples discussion on the board; d) provide handouts; e) use of portable white-boards; f) moving students to avoid excessive off-topic conversations; and g) daily feedback.

**Instruments:** The teacher designed a test made up of five sections, each section to be administered after each lesson. The tests were validated by the AMCT’s Research Director. Table 4 describes these instruments.
### Table 4. Instruments by Subject

<table>
<thead>
<tr>
<th>Test</th>
<th>Subject</th>
<th>Points Possible</th>
<th>Number of Exercises</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section # 1</td>
<td>Evaluate and simplify expression – Real Numbers</td>
<td>20 points</td>
<td>10</td>
</tr>
<tr>
<td>Section # 2</td>
<td>Similar terms and algebraic expressions</td>
<td>20 points</td>
<td>10</td>
</tr>
<tr>
<td>Section # 3</td>
<td>Patterns</td>
<td>20 points</td>
<td>10</td>
</tr>
<tr>
<td>Section # 4</td>
<td>Definitions</td>
<td>20 points</td>
<td>10</td>
</tr>
<tr>
<td>Section # 5</td>
<td>Geometry</td>
<td>20 points</td>
<td>10</td>
</tr>
</tbody>
</table>

**Results:** The pre-test average score was 4.06 and the post-test average score was 8.02. The standard deviation was almost the same for both and the p-value < 0.001 for the paired t-test, so there is a statistically significant difference in favor of the post-test.

**Lessons Learned:** To continue using the PBL technique together with the selected strategies (i.e., tutoring, practice, handouts, portable white-boards, and classroom control) and to provide the students with daily evaluations and feedback. Frequent evaluations allow to pinpoint content areas that pose greater challenges to the student and to make improvements to the strategy being employed.

**The Effect of Practice Exercises on Student’s Performance in the Division of Real Numbers**

**Purpose:** Increase academic performance of 9th grade students in the division of real numbers.

**Study Design:** Quasi-experimental with comparison group. Sample: Fourteen (14) students of 9th grade.

**Treatment:** A practice with a set of more challenging exercises together with games and student interaction, highlighting the importance of mathematics in our daily lives in order to motivate the students.

**Instruments:** The AMCT’s Research Director designed and validated a test with 20 items.
Results: Students of both groups, experimental and comparison, expressed to have no previous knowledge of the subject, so the pre-test average score was zero. The comparison group (M= 8.1) performed significantly better in the post-test than the experimental group (M=5.13 and p-value = 0.006 for the independent samples t-test).

Lessons Learned: The teacher-researcher carrying out this study concluded that, although encouraging the students to study mathematics (by providing resources to improve their basic skills, reinforcing with practice and promoting diverse educational experiences in math) may constitute an effective teaching strategy, ultimately, it was the individual student’s disposition toward learning that prevailed and determined the results.

Guidelines for the Integration of Technology in the Math Classroom

Purpose: Demonstrate that teachers need a guide that supports the integration of technology in the middle school Mathematics classroom.

Study Design: Qualitative. Sample: Thirteen (13) teachers from four (4) schools.

Treatment: No treatment.

Instruments: A survey was designed and validated (pilot tested with five teachers that were not part of the sample). The survey has sixteen (16) items. Besides demographics, teachers’ opinion were collected in four areas: a) Use of technology in the classroom; b) attitude towards the use of technology; c) training needs in order to integrate technology in the classroom; and d) availability of equipment and software in the classroom.

Results: Teachers from the Caguas School District need a guide that supports them in the integration of technology in the mathematics class. The State Standards of Measurement, Probability and Statistics, Geometry, and Algebra are the ones where the need to integrate technology is most needed. It is the teachers’ opinions that they need to have tutorials to make Excel exercises and to make concept maps.

Lessons Learned: Besides the need to have some guidelines and the corresponding training to integrate technology in the mathematics classroom, it was very interesting to see a group of teachers collaborating in order to get data that may support a request of additional resources to support such technology integration. The survey results showed that the participating teachers are aware of the need of changing their teaching strategies towards ones that are innovative, using technology (e.g., Internet) as a valuable teaching and learning resource.
Now, in terms of A-R, this may be considered an initial phase. Subsequent phases must involve students to test the effectiveness of the “Guide” to integrate technology in the classroom (in different grades and areas).

**Little Scientists: Using the Scientific Method**

**Purpose:** To get 4th grade students to use high level cognitive skills related to the use of the scientific method.

**Study Design:** Quasi-experimental. Experimental group only. Sample: Sixty nine (69) students from 4th grade.

**Treatment:** Active and fun learning of each step of the scientific method. The teacher-researcher used a combination of theory and practical exercises, along with diverse materials.

The implementation procedure was the following:

a. Use of drawings to relate and organize the steps of the scientific method

b. Observation activities and write problems

c. Information search and hypothesis formulation

d. Experimental design

e. Experimentation and use of materials

f. Review activity

**Instruments:** The teacher together with the AMCT’s Research Director designed and validated a test. The test had three parts. Part 1 has eight multiple choice exercises to measure the student’s knowledge of the scientific method. Part 2 measures communication skills through the ordered steps of the scientific method. Part 3 has ten multiple choice exercises to identify the steps of the scientific method in a simple research endeavor. The test was administered once, at the end of the intervention. The objective is that students obtain at least a 70% of right answers.

**Results:** The test’s average score was close to 90% with a p-value < 0.001 (compared with test value of 70%). So, the intervention was effective for these participating students.

**Lessons Learned:** The use of the selected strategies again is recommended as part of the teaching-learning process. Also, it may be inferred that the combination of theory and practical exercises, along with the use of diverse materials, is more enjoyable and motivating.
The Effect of Fun Activities in the Learning of the Scientific Method

**Purpose:** To understand and to apply the scientific method as required by the Science State Standards.

**Study Design:** Experimental group only. Sample size: 24 students from 6th grade.

**Treatment:** To develop and to teach activities for 6th graders, so that they have to identify the phases of the scientific method: Observation, problem set up, hypothesis formulation, experimental design, data collection and analysis, and conclusion. This knowledge is the basis for students to progress to middle school and to apply the scientific method as required by the Science State Standards. In order to develop the activities, the teacher-researcher took into account student’s opinions to choose the problems on which to apply the scientific method. The teacher-researcher used color drawing, videos, games, and objects to motivate and visually help students.

**Instruments:** A test was designed and validated by the AMCT’s Research Director. This test has eighteen multiple choice items. All the items were related to the basic concepts and phases of the scientific method.

**Results:** The pre-test’s average score was 48.96 and the post-test’s average score was 83.54. The corresponding paired t-test rendered a p-value < 0.001. There is a statistically significant difference in favor of the post-test, that is, there is evidence to claim that the intervention had a positive impact on the students’ knowledge of the scientific method.

**Lessons Learned:** The active learning strategies used motivated the students and, as a consequence, improved their academic performance regarding conceptual and practical command of the scientific method. A derivative benefit noticed by the teacher-researcher is that students also showed an improvement in writing skills.

Frequent Practice to Develop Critical Thinking Skills in the Biology Class

**Purpose:** To develop critical thinking skills of 7th grade students in the Biology class in order to improve their academic performance.

**Study Design:** Quasi-experimental with comparison group. Sample size: 23 students from 7th grade.
Treatment: In order to develop critical thinking skills, students were exposed, during two months, to a specific solving exercises practice. Diverse teaching strategies were used, such as lectures, laboratories, cooperative learning, watching films, and reading.

Instruments: The teacher-researcher designed a test that was validated by the AMCT’s Research Director. The test included items to measure knowledge, analysis, synthesis, and evaluation (by inference and comparison). Rubrics were used to assess these different critical thinking skills.

Results: An independent samples t-test was performed to compare the performance of the experimental group with the comparison group. The p-value = 0.0539 is borderline, so there is not enough evidence to claim that the experimental group performed better than the comparison group. Paired t-tests within each group did not reflect statistically significant differences between the pre-test and the post-test in neither group (experimental group’s p-value=0.06 and comparison group’s p-value=0.089).

Lessons Learned: A structured approach to teach a subject is not guarantee, by itself, to produce better results. Another aspect that may require further study is the baseline equivalence (comparability) of the experimental and the comparison groups at the onset of the intervention. It is worth noting that, as opposed to other A-R studies, this one excluded individual tutoring.

Using the Scientific Calculator to Improve Academic Performance in the Science Class

Purpose: To improve students’ skills in integrating mathematics and science, particularly, using descriptive statistics.


Treatment: The experimental group received ten workshops on the use of the scientific calculator and practicing several science examples. AMCT’s staff offered two of the ten workshops, covering an introduction to the use of the scientific calculator, and later, calculating descriptive statistics.

Instruments: The teacher-researcher designed a test; this test was validated by the AMCT’s Research Director. The test has fifteen multiple choice items measuring basic knowledge of descriptive statistics and using the graph function of the scientific calculator.
Results: Pre- and post-tests were administered to both the experimental and the comparison groups. Paired t-tests were calculated. The pre- and post- average scores were 52 and 63 for the experimental group (p-value=0.001). The pre- and post- average scores were 59 and 57 for the comparison group. There is evidence to claim that the intervention led to a better performance in the experimental group.

Lessons Learned: The students not only learned how to use the scientific calculator, but also learned the concepts and use of descriptive statistics as applied to scientific topics.

Integrating the Search and Use of Information in the Study of Environmental Pollution

Purpose: To make students effective researchers and users of information by presenting findings about environmental pollution in their community.


Treatment: Students visited the school library and received workshops on information search and information use. Students performed information search about environmental pollution in Puerto Rico, identified causes of pollution and the current state of pollution in their communities. In the classroom, students wrote reports about environmental problems faced by their communities. Afterwards, students visited and used the city laboratory, the “Juncos Science Center”, in order to perform laboratory analysis on water samples collected at the town river.

Instrument: The teacher-researcher designed a test. The test had nineteen (19) multiple choice items and six fill in the blank (6) questions. The test was validated by the AMCT’s Research Director.

Results: The average pre-test score was 13.5 and the average post-test score was 17.5, with a paired t-test p-value = 0.002 in favor of the post-test. Therefore, there is evidence to claim that the students benefited from the intervention.

Lessons Learned: The opportunity to “close-the-loop” from identifying and voicing information needs, accessing, evaluating and selecting the required information in order to work on their selected topics, perform laboratory analysis, formulate conclusions, integrate previous knowledge, and share results, not only motivated the students but positively impacted their academic performance.
On the Effectiveness of Using Science Laboratories

**Purpose:** The teacher-researcher wanted to know the student’s opinion on the contribution of the science labs to the learning of science topics.

**Study Design:** Qualitative. Sample size: 50 students, 7th grade.

**Instrument:** A questionnaire was designed by the teacher-researcher and latter validated by the AMCT’s Research Director. This questionnaire has ten questions and, using a Likert scale (1 to 4, from very effective to not effective), students expressed their opinion on the equipment, time, materials, safety rules, instructions, opportunity to work with the lab equipment, teamwork, and application of the scientific method in the science lab. This instrument included an open comments section at the end.

**Results:** Ninety percent (90%) of the students said that the utilization of the laboratory is good for learning. However, in the comments section, students expressed that better materials, equipment, and laboratory experiments are needed in order to motivate them. Students also mentioned that they need more time to prepare before the lab activities to take better advantage of this experience, and complained about students that do not work but take advantage of the group to obtain a grade.

**Lessons Learned:** Although student’s opinions are quite important, they may be considered just the beginning of A-R. Further work is needed to make this effort an actual A-R study, particularly introducing changes to the class, measuring results, and conclude on the effectiveness of these changes in terms of academic performance.

**DISCUSSION**

All the participant teacher-researchers expressed that performing these A-R studies was a great learning experience. They also reported that all the participating students expressed great satisfaction with the experience. On the other hand, the following year after these studies, there was only one more volunteer teacher that performed an A-R study. The perception of the AMCT Project is that teachers consider A-R as additional work and, more importantly, it seems hard for them to integrate A-R as a common educational strategy.
Nevertheless, the results of this first attempt are encouraging. Six out of the eight quasi-experimental studies obtained evidence to claim that the A-R interventions produced improvements in the students’ academic performance. The authors of this article noted that all the studies that reported improvement in student’s academic performance used individual tutoring and, all except one, coupled individual tutoring with some group control strategy to maintain the student focus on the task at hand. Another general lesson learned is that, probably because this was their first attempt, teachers need significant guidance during the whole A-R process, including the Internal Review Board (IRB) procedures. On the drawbacks, some confusion still exist regarding what really Action-Research is, which lead to the two studies still in its preliminary phase. Table 5 below summarizes the final results of these A-R studies.

**Table 5. Summary of Results**

<table>
<thead>
<tr>
<th>Action-Research Study</th>
<th>Improvement</th>
<th>Individual tutoring</th>
<th>Used some additional form of group control strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Math-Phobia</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2. Solving Verbal Problems to Increase Student’s Academic Performance</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3. The Effect of Practice Exercises on Student’s Performance in the Division of Real Numbers</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>4. Guidelines for the Integration of Technology in the Math Classroom</td>
<td>Not applicable. Preliminary phase of A-R</td>
<td>Not applicable (no student participation)</td>
<td>Not applicable</td>
</tr>
<tr>
<td>5. Little Scientists: Using the Scientific Method</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>6. The Effect of Fun Activities in the Learning of the Scientific Method</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>7. Frequent Practice to Develop Critical Thinking Skills in the Biology Class</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>8. Using the Scientific Calculator to Improve Academic Performance in the Science Class</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>9. Integrating the Search and Use of Information in the Study of Environmental Pollution</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>10. On the Effectiveness of Using Science Laboratories</td>
<td>Not applicable. Preliminary phase of A-R</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
CONCLUSIONS

Following a systematic approach toward A-R together with tutoring and appropriate classroom management strategies may lead to improvements in academic achievement in mathematics and science. There is still much work to be done in order to stimulate the use of A-R in the classroom as an educational strategy, particularly in terms of integrating it as part of the teacher’s common practices.

The implications of these results for the teacher’s practice are promising, since A-R can be seen as a complementary strategy with the potential to contribute to the improvement of academic performance in mathematics and science and, eventually, shape public policy to include A-R as a common classroom practice.

Further opportunities exist that lend themselves to A-R. For example, others have reported that there is a gender gap in academic performance, that males have lower academic performance, more discipline problems, and more cases referred to special education than females (Clark, Lee, Goodman, & Yacco, 2008).

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REFERENCES


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