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The Effect of Inquiry Learning on the Academic Achievement and Bilingual Verbal Cognition of Young Bilingual Students

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Abstract— The issues that prompt this study are based on current research indicating the positive effects of inquiry learning on the cognitive development of children. The purpose of this case study was to understand the effects of inquiry learning on the academic achievement and bilingual verbal cognition of 5th grade bilingual students in a French/English dual immersion program. The treatment group of students completed research projects through a guided inquiry learning approach, while the control group experienced the traditional problem-solving research approach. Empirical findings reported a significant mean increase in mathematics achievement, bilingual verbal cognitive ability, higher motivation to learn and increased self-efficacy in the treatment versus the control group of students.

Index Terms—young bilinguals, bilingual verbal cognition, inquiry learning, bilingual curriculum and instruction.

I. INTRODUCTION

Inquiry-based learning utilizes a child's natural curiosity to explore new information that is meaningful to the learner. It is a cyclical process by which the learner selects a topic or question, explores multiple sources of information with the intent to find and support a focused perspective, shares the discovery with others, and finally reflects on the process as a whole (Kuhlthau, Maniotes, & Caspari, 2007). Research reveals that inquiry-based learning can heighten a child's research skills (McNally, 2005), subject knowledge, writing (Chu, Chow, Luk, Cheung, & Sit, 2007; Chu, Chow, Tse, & Kuhlthau, 2008; Frank, Lavy & Elata, 2003) and motivation to read (Chu, Tse, Loh & Chow, 2011).

Research stemming from the cognitive sciences highlights the relationship between multilingual skills and cognition. Speaking more than one language brings cognitive benefits, which may be associated with increased use of the brain (Tokuhama-Espinoza, 2008). Possessing a broader capability to see the world through the multiple perspectives, studies have shown that multilinguals utilize more extensive social and cognitive capital than monolinguals (Singleton & Aronin, 2007). This ability results from the added value of knowing more than one language. Bilinguals are not merely duplicates of monolinguals with twice the language competence. They have multicompetence that describes an extra capacity that emerges from knowing multiple linguistic codes (Belz, 2002).

Knowledge of dually functioning language systems create added cognitive frameworks that support greater flexibility when problem solving. (Cook, 1992). When both languages interact within the brain, they produce a creative tension,

which activate the divergent and convergent thinking processes critical to the sophisticated information processing utilized in inquiry-based learning (Kharkhurin, 2008).

II. PURPOSE

While studies have been conducted on the development of cognitive academic language proficiency skills (CALPS) in young bilinguals (Fradd & Lee, 2001; García-Vásquez, Vásquez, López, & Ward, 1997; Laija-Rodríguez, Ochoa & Parker, 2006), no research has studied the effects of inquiry-based instruction on the academic and bilingual verbal cognitive development of bilingual children.

The purpose of this case study is to understand how inquiry-based learning affects the academic achievement and bilingual verbal cognition of thirty-two 5th grade students in a French dual immersion program. The study utilizes a treatment and control group to explore the cognitive, linguistic, and psychosocial effects of inquiry-based instruction compared to traditional problem-solving instruction.

III. RESEARCH QUESTIONS

Located in a private school in California, a mixed methods approach was used to examine the following questions:

1. How does inquiry-based instruction affect the academic achievement and bilingual verbal cognitive development of French/English speaking 5th grade students compared to a control group receiving traditional problem-solving instruction?
2. How do the students in the treatment group perceive the effects of inquiry learning on their language and cognition compared to the control group receiving problem-solving instruction?

IV. METHOD

A. Setting and Participants

This study was conducted in a private PreK-8th grade, French immersion school located in Northern California. The students spent approximately 80% of their instructional time in French and 20% in English. All content areas were taught in French. The English portion of the curriculum focused on language arts and social studies.

Thirty-two randomly assigned 5th grade bilingual children volunteered to participate in the study. The majority of the students came from high socioeconomic backgrounds, with college educated bilingual parents. Both the treatment and control groups had an equal number of students (N=16). There were 7 males and 9 females in the treatment group, and 6 males and 10 females in the control group. Each group had 11 native English speakers, 5 native French speakers, and 2 native Arabic speakers. All of the children were performing at grade level or above on English and French proficiency tests and all had been enrolled in the French dual immersion program for six years.

B. Program

The inquiry-based learning program utilized in this study was used along with the 5th grade California English-Language Arts Standards (1998), and History-Social Science Content Standards (2000) to launch a language arts and social studies curricula. Within the 8 hours of English-language arts instruction time per week, the teacher organized inquiry-based learning for approximately 1 hour.

The control group of 5th graders in the school received traditional problem-solving research instruction in English-Language Arts and History-Social Science for approximately 1 hour per week. The teacher utilized role based literature circles, journals, history textbooks, vocabulary development, grammar lessons, and writing process instruction. The teacher assigned a topic as students researched resources from the library, took notes, wrote a report, or presented their findings using Keynote.

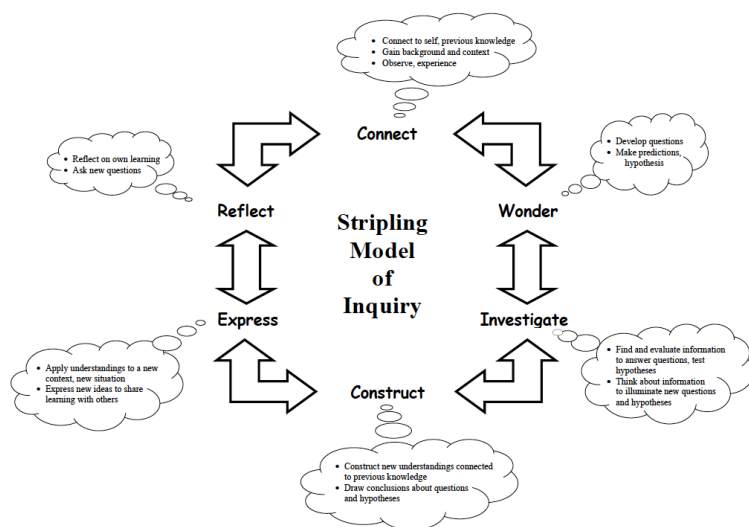
The inquiry-based learning program was guided by cyclical elements of inquiry found in the Stripling Model of Inquiry (2004). Originally intended to frame the learning of information technology, the model incorporates six phases in which the students connect, wonder, investigate, construct, express and reflect on their learning (see Figure 1). Throughout each phase, the students actively processed information with teacher guidance and feedback from peers, rather than passively receiving facts through a transmission oriented model of instruction (Castronova, 2002).

Stripling (2003) contrasts the processes between inquiry-based and problem-solving research processes. She notes that in the typical problem-solving model, the learner is asked to find an answer to an already existent problem introduced by the teacher. The process is controlled and usually results in a written report submitted to the teacher. The cognitive processing involved is minimal because learners are typically copying what others have deduced in their own inquiry.

In contrast, the inquiry-based learning model starts with a student posed question that is engaging and relevant. This

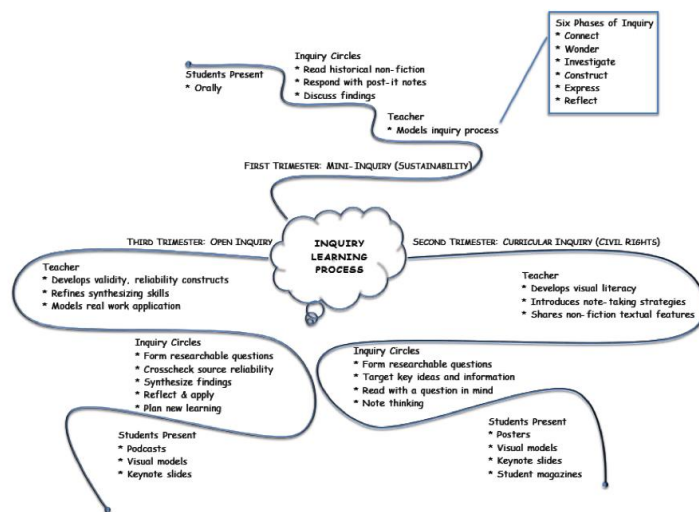
question guides a recursive investigation that is open ended and meaning centered. Often present in the construct phase, the learner discovers information that is not explicit. As the learner acquires new understandings and reflect on their learning, future questions are formed which influence the direction of the research. The teacher's role thus changes from providing information to guiding student discovering and facilitating transactional learning experiences.

Figure 1. Stripling Model of Inquiry



For this study, the teacher developed an interdisciplinary approach to Stripling's inquiry learning model. Each trimester students participated in the following inquiry-based learning activities: 1) a mini inquiry, 2) a curricular inquiry, and 3) an open inquiry (see Figure 2).

Figure 2. Trimester Inquiry Learning Process



C. Measures

This 10-month study used a mixed methods approach to ascertain the effects of inquiry-based learning on the academic achievement, bilingual verbal cognitive development, and student learning perceptions of thirty-six, 5th grade students randomly assigned to a treatment or control instructional environment. Triangulated data were collected from the Educational Records Bureau's (2002) *Comprehensive Testing Program 4*, (CTP4), the *Bilingual Verbal Ability Test* (BVAT), and 3 student questionnaires.

V. DATA ANALYSIS AND RESULTS

The data analysis and results identifying the cognitive and psychosocial impact of inquiry-based learning on the academic achievement and bilingual verbal cognitive development of a treatment group of 5th grade students compared to their control peer group are presented as they relate to the two research questions posed for this study. Academic achievement and language development data were analyzed using a repeated measures analysis of variance (ANOVA). Content analysis and descriptive statistics were used to analyze emerging themes from the student questionnaires.

A. Research Question 1

How does inquiry-based instruction affect the academic achievement and bilingual verbal cognitive development of French/English speaking 5th grade students compared to a control group receiving traditional problem-solving instruction? A repeated measures, one-way ANOVA test of within-subject contrasts was performed for each CTP 4 subtest and the BVAT (see Table 1). The analysis reported a statistically significant linear trend in favor of the treatment group in the CTP 4 Mathematics Subtest, $F(1,1) = 8.3$, $p < .05$. The partial η^2 indicated that the linear trend accounted for 22% of the variance in scores. Similarly the ANOVA analysis revealed that the bilingual verbal ability (BVA) for the treatment group increased at a statistically significant faster rate than the control group $F(1,1) = 4.2$, $p < .05$.

Table 1

Analysis of Variance Results for CTP 4 and BVAT Scores

		Treatment		Control		ANOVA	Partial η^2
		Pre/Post M	Pre/Post M	Pre/Post M	Pre/Post M		
CTP 4	1 - Verbal Reasoning	3.19 2.95	3.00 2.62			$F(1,1) = .14$.005
	2 - Vocabulary	2.56 2.19	2.13 2.31			$F(1,1) = 2.5$.077
	3 - Reading Comprehension	2.94 3.00	2.94 2.37			$F(1,1) = 1.9$.060
	4 - Writing Mechanics	2.44 1.88	2.56 1.88			$F(1,1) = .16$.005
	5 - Writing Concepts/Skills	3.19 3.19	2.50 2.81			$F(1,1) = .54$.018
	6 - Quantitative Reasoning	2.19 2.00	2.31 1.69			$F(1,1) = 2.5$.078
	7 - Mathematics	2.50 3.06	2.56 2.31			$F(1,1) = 8.3^*$.218
BVAT	Bilingual Verbal Ability	82.4 95.2	90.2 95.1			$F(1,1) = 4.2^*$.123

Note. * $p < .05$

B. Research Question 2

How do the students in the treatment group perceive the effects of inquiry learning on their language and cognition compared to the control group receiving problem-solving instruction? The researchers examined the short answer response items collected in the fall and spring, and a third Likert-type, short answer questionnaire distributed in the late spring. The questionnaires were initially divided into two corpus units separating the treatment and control groups. Questions were categorized into 3 areas of student perception: (a) learning, (b) inquiry research, and (c) bilingual cognition. Each answer set was coded separately into themed meaning units and analyzed using Giorgi's (1975) empirical phenomenological method of analysis. This method analyzes texts by looking for natural meaning units and discovering emerging themes. When substantive differences in interpretation arose, the researchers worked them together into a dialogue leading to an intersubjective agreement of .92 (Krippendorff, 1980). The Likert-type response items in the third questionnaire were tallied and analyzed using descriptive statistics.

The first question in the fall/spring short answer survey asked students to describe their favorite and least favorite way to learn. Most of the students in both the treatment group and control groups felt that their favorite way to learn was "listening to the teacher" and "field trips". In contrast, both groups felt that their least favorite way to learn was through "memorizing exercises", "writing" and "reading". There were no response differences between the fall and spring questionnaires on this item.

The first question on the Likert-type questionnaire distributed in the spring reported that both the treatment and control group of students strongly felt that the research activities they experienced helped them learn (Treatment $M=1.8$, Control $M=1.6$). Over half of the children in the treatment group reported that research activities helped them direct their own learning. Many reported improved subject matter comprehension, enhanced technology skills, better understanding of bilingual conversations with their parents, and higher confidence levels in class presentations.

The second question in the survey asked students to define what it meant to do inquiry research. More students in the treatment group ($N=8$) reported that they had fewer research experiences than the control group of students ($N=4$). In the fall, both groups used typical problem-solving terms to describe inquiry research such as "search for information on the internet", "look up words on a computer", or "look up information in a book". On the spring questionnaire, while the control group continued using problem-solving terms to describe their research experience, the treatment group described inquiry-based learning in terms such as "choose an interesting big question", "find out cool facts", "dig deeper into the topic", "build a project", and "have fun".

Through inquiry-based research, the treatment group reported learning how to "understand the research process", "answer questions by researching different sources", "use key words in a search", and "research bilingually". When asked what they liked best about inquiry learning, the treatment group listed reasons such as "choose my own topic", "develop my

own question”, “build projects” and “make class presentations”. What they liked least included “struggling to find information”, “choosing a big idea question” and “researching books that were hard to read”. More than half of the children in the treatment group stated that they enjoyed everything about inquiry research. Analysis of the second question on the Likert-type questionnaire reported that treatment group felt more motivated to learn through inquiry-based research projects ($M= 1.4$) than the control group ($M= 2.0$).

The third question in the short answer survey asked students to describe their biggest challenges in bilingual learning and the difficulties they encountered when doing research in two languages. Most of the students in both groups identified few challenges in bilingual learning and research on the fall questionnaires. Of the students who identified challenges, the majority listed “confusion”, “vocabulary”, “grammar”, “pronunciation”, “spelling” and “parent’s linguistic background” more often. The spring questionnaires revealed no differences in the control group responses. However, 81% of the students in the treatment group reported that it was easier to do research bilingually because multiple sources in two languages increased their information access.

The third question on the Likert-type questionnaire asked students how well their research activities positively impacted their bilingual cognition. Both the treatment ($M=2.8$) and control ($M=2.5$) group of students rated the effect as “moderately strong”. Most of the students in the control group stated that research activities “partially helped” bilingual cognition, or that they “didn’t know”. Of the students that commented, there were mixed reviews. Some students responded positively with, “my learning transferred”, “it increased my class participation in both languages”, and “I could compare both languages while learning”. Others responded negatively with comments such as, “it was hard and confusing”.

Contrastingly, the students in the treatment group had positive reviews. Most of the students stated that their research experiences positively impacted their bilingual cognition with comments. One student commented, “I could choose the subjects that helped me learn in 2 languages.” Another stated, “I learned more things in two languages because my research was self directed.” A third replied, “My bilingual learning increased because the activities were project based.” Several students in the treatment group observed that inquiry-based research activities “provided a deeper understanding of the topic”, “increased reading comprehension”, and “improved my vocabulary” in both languages.

VI. DISCUSSION

The emerging findings of the effects of inquiry-based instruction on the academic achievement of the treatment group compared to the control group of students receiving problem-solving instruction report a significant increase in mathematics scores in favor of the treatment group on the CTP 4 subtest. The positive effect of inquiry-based instruction on the mathematics achievement in the treatment group could possibly be explained by skills students attained through inquiry learning versus traditional problem-solving instruction. In the inquiry learning environment, students in the treatment group

experienced what Stripling (2003) describes is a recursive “relationship between thinking skills and content” (p. 6). Students were not just passively constructing knowledge by searching for answers to problems - a practice commonly found in the problem-solving approach. In contrast, the treatment group of students actively engaged in subject matter learning, which deepened their content knowledge and strengthened the critical thinking processes needed to solve complex problems in mathematics. Posing questions, synthesizing relevant information, and forming plausible conclusions likely motivated student confidence and catalyzed essential cognitive reasoning skills.

The significant increase in bilingual verbal cognitive ability experienced by the treatment group could possibly be explained by enhanced executive functioning, strengthened through inquiry-learning tasks, that activated students’ heightened bilingual ability to monitor their environment. Collective evidence from a number of studies suggest that when bilingual children are engaged in active learning environments, they experience finely tuned metalinguistic awareness, and attention processes used for planning, increased cognitive flexibility, multicompetence in problem solving, and the ability to form conclusions utilizing divergent and convergent thinking (Cook, 1992; Kharkhurin, 2008; Bialystok & Shapero, 2005; Bialystok, 2006). Through inquiry learning, the children in the treatment group learned how to interpret and process information through student centered investigations that taught them how to discern important from unimportant questions and facts. This process likely activated strategic bilingual problem solving competence that led to an increase in bilingual verbal cognitive ability.

The data regarding student program perceptions indicated that both the control and sample group of students preferred active, teacher guided learning activities. Although both groups specified that research activities strongly correlated with their learning, children in the treatment group demonstrated a better understanding of the research process. Because students directed their own research inquiries, children reported increased self-efficacy and a stronger motivation to learn. This could possibly be explained by the constructivist philosophy embedded in the inquiry learning approach. Through their inquiry learning experience, children in the treatment group were taught how to regulate their behaviors. They learned such strategies as predicting outcomes, planning ahead, time management, comprehension monitoring, and how to use background knowledge. These metacognitive processes and self-regulatory capabilities were not developed in the problem-solving learning experiences of the children in the control group.

Although both groups of children indicated that their learning programs moderately impacted their bilingual cognition, children in the treatment group indicated the presence of a more dynamic relationship. Children reported that doing research bilingually significantly increased their comprehension of the subject matter. Because these children were mindful of themselves as learners and thinkers, they became independent learners capable of sustaining their own learning at a deeper level. Skills normally associated with the bilingual cognitive advantage were activated, resulting in an increased understanding and subject matter retention.

VII. LIMITATIONS

Several limitations found in this study preclude generalizability in its findings. The small sample size limited the statistical power in the treatment group's increased mathematic and bilingual verbal cognitive development; therefore generalizations cannot be made to broader bilingual student populations without further research.

VIII. CONCLUSION

The inquiry-based instructional approach purported in this study supports our current understanding of how people learn. It is evident that stimulating learning environments are linked to issues that are especially important in processes of bilingual cognition and competence. These processes seem to be positively or negatively affected by the degree to which learning is student-centered, knowledge-centered, community-centered and authentically assessed.

Effective instruction for bilingual students begins with acknowledging what the learners bring to the setting. This includes celebrating individual student interests and levels of understanding. Bilingual students also benefit from instructional practices that promote the inquiry process. The ability to cognitively process learning in two languages is strengthened when students' form their own questions, deep understandings, and conclusions. Creative learning experiences that are presented within an authentic community context enable bilingual students to build a body of shared knowledge that motivates future learning. Finally, effective instruction must include projects that are authentically assessed. Bilingual cognition is recursive and interactive in its design. Inquiry-based learning provides an empowering platform for students to exercise the practical benefits of their bilingual abilities in an increasingly globalized world.

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