Computers & Education 53 (2009) 419–428

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Implications of an experimental information technology curriculum for elementary students

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ARTICLE INFO

Article history:
Received 1 August 2008
Received in revised form 22 February 2009
Accepted 24 February 2009

Keywords:
Elementary education
Improving classroom teaching
Interdisciplinary project
Teaching/learning strategies

ABSTRACT

The information technology (IT) of today forms an integral part of everyday living, thus the nurture of children's IT awareness early in life is crucial. Young children have an innate curiosity for IT which suggests that in the school environment it can easily be integrated with other subjects in thematic and interdisciplinary curriculum. This quasi-experimental study used the Technology Foundation Standards for Students of the International Society for Technology in Education (ISTE) project on National Educational Technology Standards (NETS) as the basis to design a thematic and interdisciplinary IT curriculum for elementary students. A total of 1273 elementary students and 12 computer teachers were separated into either a control or experimental group. After one academic year, students' final scores in English, mathematics, science, social studies, and art were gathered and compared. Statistical analysis indicated that there were significant differences in the experimental group's academic scores. Findings also suggested that an interdisciplinary curriculum design opened opportunity for collaborative work and cohesiveness among faculty. Further longitudinal studies are recommended to examine the long-term implications of a thematic and interdisciplinary IT curriculum design.

1. Introduction

In the 21st century, information technology (IT) forms an integral part of the teaching learning process and has a tremendous impact on the character and functions of education in most countries. Children's innate curiosity for exploration of the world is often parallel to their inquisitiveness for IT. Scholars agree that in the school environment IT provides a forum for both teachers and students to engage with the learning process (Wegerif & Dawes, 2004). As a tool, technology contributes to authentic learning by improving students' access to knowledge, by adapting lessons to the needs of students, and by encouraging IT capability across the curriculum (Kong, 2008; Smeets, 2005; Thompson, 1991).

In the Philippines, technology improves schooling by enhancing accessibility to students and teachers. In recent decades technological change in the Philippines has brought interconnectivity to all aspects of life and everyday living. It has changed the way educators think of knowledge and information, as unbounded rather than bounded (Hewitt, 2006). At a private school in Manila; capital city of the Philippines, technology is transforming how teachers teach and how students learn, making it possible for both to meet the demands of schooling in the 21st century. Teachers and administrators therefore define IT as a content area to be learned and as a skill to be mastered. They rely on the design of interdisciplinary curriculum to make connections between and among key concepts of various academic disciplines, while acquiring a foundation in IT (Ellis & Fouts, 2001).

To examine the implications of an interdisciplinary IT curriculum, the following article details an empirical study conducted in a private school in Manila during the 2005–2006 academic year. This quasi-experimental study used the Technology Foundation Standards for Students of the International Society for Technology in Education (ISTE) project on National Educational Technology Standards of the United States (NETS) as a basis to design a thematic and interdisciplinary IT curriculum for elementary students. A thematic setup of the curriculum contributed to the personal development and social awareness of the students; it also supported their cognitive development as young learners (Hewitt, 2006). An interdisciplinary design was used to integrate the disciplines of English, mathematics, science, social studies, and art. The concept of spiral curriculum was utilized to identify key IT concepts, skills, and values by grade level. In an increasingly computer-dependent world, it is important to be aware of the possibilities that IT can contributes to learning. This study explored such

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doi:10.1016/j.compedu.2009.02.019

possibilities through the use of a thematic and interdisciplinary IT curriculum, which further expanded the ways that IT can help enhanced learning.

The following section reviews the guiding ideas of technology integration, along with frameworks for thematic, interdisciplinary, and spiral curriculum. A description of the research setting is provided in a subsequent section which leads into an outline of the methodological framework. Next, a summary of the statistical analyses is provided along with a discussion of the results. A concluding discussion offers insights and suggestions for curriculum planners and professionals alike, regarding the implications of a thematic and interdisciplinary IT curriculum.

1.1. Curriculum integration through technology and its benefits

Curriculum can be defined as the knowledge, skills, and values that students should learn in K-12 settings (Olivia, 2001). As a concept the term curriculum often implies formal definitions utilized to prescribe content by subject and grade level (Ross, 2001). As such it is commonly defined as the formal knowledge that students learn in school (Capel, Leask, & Turner, 1995). Although various arguments exist over exactly what curriculum includes and excludes, traditionalists contend that it is represented by textbooks, lectures, and other professional sources (Ellis & Stuen, 1998). This implies that curriculum is pre-existent to students encounter with it. The students' role is to acquire the concepts skills and values embedded in the curriculum.

Curriculum integration is a philosophy of teaching and learning in which content is drawn from several subject areas to focus an identified theme (ASCD, 2008). In recent years, the focus on information technology in education has shifted towards curriculum integration (Albion, 1999). Curriculum integration with technology involves the infusion of technology as a tool to enhance learning in multidisciplinary settings (ISTENETS., 2002c). A quasi-experimental studies conducted in Taiwan extend the positive aspects of IT integrated in the core curriculum. Jang (2006) investigated the integration of IT in a seventh grade science classroom by means of analysis of student scores, a completed survey questionnaire, and interviews with teachers. Results showed that students instructed with a technology enhanced curriculum scored higher than peers who were exposed to the same curriculum without a technology strand (Jang, 2006). Similarly, a quasi-experimental study involving grade 4 students suggested that the integration of reading with science resulted in more positive student attitudes toward the respective subjects (Romance & Vitale, 1992).

Additional studies in the UK support the positive results suggested by the research conducted in Taiwan. An experimental study conducted at the secondary level showed that technology integrated science teaching bridged the gap between scientific and informal knowledge (Hennessy et al., 2007). A second study suggested that a technology strand integrated with mathematics enabled higher levels of student achievement in mathematics (Taylor, 1999). The results of both studies support the use of technology to enhance thinking skills and strategies, from basic recall to higher level skills such as classification and inference (Henderson, Klemes, & Eshet, 2000). These studies also suggest that effective integration of technology is achieved when students are able to select technology tools to obtain information in a timely manner, analyze and synthesize information, and present it professionally (ISTENETS, 2002c).

Bell and Bell (2003) also mentioned that between 1994 and 2002, over 200 articles have been published that specifically address the integration of technology in the teaching of science content. Articles in this list represent all areas of scholarly work, including descriptions of technology use, theoretical and policy pieces, and qualitative and quantitative research. In addition, technology is an important factor in uplifting the quality of education and learning, by making it more accessible to people (Scott & Robinson, 1996), hence making life-long learning more realistic. The integration of technology in teaching increases the attentiveness of students in classroom learning (Powell, Aeby, & Carpenter-Aeby, 2003). A survey administered to elementary teachers in the Netherlands indicated that autonomous learning of students was enhanced with the use of technology in classroom learning activities (Smeets, 2005). In sum, IT enables students to learn in ways not previously possible.

1.2. Thematic, interdisciplinary, and spiral curriculum

The concept of interdisciplinary or integrated curriculum is not a new idea. According to Vars (1997), curriculum integration has been advocated for more than a century. Today's curriculum integration, resembles the problem centered curriculum of the 1930s Progressive Movement (Beane, 1997). Proponents argue that the interdisciplinary curriculum is less fragmented (Hennessy et al., 2007). It provides a more coherent set of learning experiences and therefore a more unified sense of process and content (Ellis & Stuen, 1998). Motivation to learn is improved in interdisciplinary settings (Romance & Vitale, 1992) as well as higher level thinking skills (Henderson et al., 2000).

In general, interdisciplinary curriculum includes the integration of different subject matter and places emphasis on the relationships among concepts that extend beyond textbooks. Shoemaker (1989) defines an interdisciplinary curriculum as education that cuts across subject-matter lines, bringing together various aspects of the curriculum into meaningful association to focus upon broad areas of study. He conceptualizes the teaching learning process as a holistic approach that reflects the interactive real world. Other scholars define interdisciplinary curriculum as one in which students broadly explore knowledge in various subjects related to certain aspects of the learning environment (Humphreys, Post, & Ellis, 1981).

Interdisciplinary curriculum designs are often cited as useful ways for teachers and students to make connections between and among subject area concepts (Ellis & Stuen, 1998). Hence the curriculum serves as a connector; it connects both academic and practical knowledge centered on an organizing theme (Hewitt, 2006). Thus, the choice of themes should be based on a vision for what students need to learn and the ways in which they might learn (Ellis & Stuen, 1998). In addition, learning standards like the ISTE–NETS can be adapted to inform the themes, skills, and knowledge for curriculum development.

A thematic approach in content area subjects promotes student motivation to learn creatively (Annarella, 2000). Olivia (2001) mentions that the thematic curriculum is based around a central theme which connects standard-based instruction to authentic learning contexts. A variety of traditional subject areas such as mathematics, language arts, science, and social studies – as well as dispositions such as critical thinking, cooperation, and collaboration can be woven into interdisciplinary thematic units, which are centered on a unifying theme.

Thematic teaching accommodates new topics that are constantly emerging and blends discipline knowledge to enhance coherent learning (Ellis & Stuen, 1998). Themes that link concepts lead to deeper understanding and are more effective. Some themes naturally cluster concepts for integration, such as IT, mathematics and science or language arts and social studies. Within thematic units, technology supplements traditional educational tools and practices such as discussion, audiovisual aids, pencil and paper writing, and tests. In general, IT enhances the interdisciplinary thematic curriculum (Gardner, Wissick, Schweder, & Canter, 2003).

The spiral curriculum aligns concepts and skills from simple to complex, concrete to abstract, within succeeding years of schooling (Bruner, 1960). Tyler's (1969) concept of continuity is represented in Bruner's spiral curriculum. Tyler describes continuity as the reiteration of major curriculum elements, which means that over time the same kinds of skills are brought into the continuing operation. Experimental studies in middle school chemistry classrooms have shown that while a carefully planned spiral curriculum is advantageous (Bennett, Grasel, Parchmann, & Waddington, 2005; Bennetts, 2005) it requires the expertise of curriculum developers and teachers to determine the scope and sequence of content (Olivia, 2001).

Experiences and research findings clearly support the positive impact of an interdisciplinary curriculum. Several studies in Hong Kong regarding an interdisciplinary curriculum called General Studies (GS), which integrated three primary subject areas such as social studies, science, and health education, were also conducted. Results showed that the new interdisciplinary GS curriculum has made learning more interesting and relevant to the needs of Hong Kong pupils in the 21st century (Cheng & Lo-fu, 2008). In two quasi-experimental studies regarding the integration of Technology, Science, and Mathematics (TSM) in the US, Childress (1996) used the statistical methods like *T*-test and analysis of variance (ANOVA) to determine the effectiveness of the interdisciplinary curriculum. Although results revealed that there are no significant differences between those students who received correlated science and mathematics instruction and those students who did not, however, observation logs showed that the students did, in fact, attempt to apply what they learned in the correlated instruction (Childress, 1996). Satchwell and Loepp (2002) used the statistical method analysis of covariance (ANCOVA), which showed an increase in student performance in the subject area science. In addition, both studies mentioned the importance of teacher collaboration and commitment in the success of the implementation of the curriculum (Childress, 1996; Satchwell & Loepp, 2002).

Based on review of more than 100 studies, Vars (1991, 1996) concluded that students involved in interdisciplinary curriculum performed better than students in discipline based programs. Lake (1994) examined studies dating back as far as 1965 and pointed out that interdisciplinary curriculum shows no negative effects on students learning. Ellis and Fouts (2001) mentioned that the large number of educational variables involved in experimental research on interdisciplinary curriculum, make this research focus difficult to investigate. Similarly, Vars (1996) and Lake (1994) both noted the importance of realistic expectations regarding the benefits of interdisciplinary curriculum practices. However, significant findings suggest the positive effects with regards to teacher cooperation or collaboration (Lake, 1994).

1.3. Research questions

The goal of the present study was to examine the implications of a thematic and interdisciplinary IT curriculum for grade 1–6. The following questions guided the investigation:

1. What are the factors that influence the implementation of a thematic and interdisciplinary IT curriculum design?
2. What are the implications of the thematic and interdisciplinary IT curriculum with regards to the students' IT performance and to the other subject areas such as English, mathematics, science, social studies, and art?

2. Research setting and methodology

The study was carried out in a bilingual private school located in Manila. The school population included 4500 students from middle class socio-economic backgrounds. Students were assigned heterogeneously to classrooms averaging 35 students per section. At the time of the study there were 6 sections per elementary grade level and 6–8 for each year of high school. The school had a total of 4 computer laboratories, each equipped with 40 networked multi-media capable computers. Computers and digital projectors were available in all classrooms to facilitate a multi-media approach in teaching.

In the summer of 2005, numerous meetings with the school administrators and academic heads resulted in permission for implementation of an experimental thematic and interdisciplinary IT curriculum during the 2005–2006 academic year. Two weeks of intensive teacher training and planning provided a foundation for the pedagogy and curriculum objectives. Initial groundwork to design thematic lessons was also undertaken. Upon implementation, successive meetings were scheduled bi-weekly during the academic year with the IT and subject area teachers. These meetings enabled teachers to share their classroom experiences, discuss problems or issues and further their foundation for the integration of subject area content with an IT curriculum. Meeting minutes as well as observation notes from ongoing classroom observations conducted by the researcher to document the implementation of the experimental curriculum were also used as a data set.

Participants included 1273 elementary students and 12 IT teachers. Students were randomly assigned by section into control and experimental groups. Each IT teacher was responsible for 3 sections with IT lessons conducted weekly in a 50 min period. Both control and experimental groups used the same IT learning objectives; however the experimental group utilized weekly thematic and interdisciplinary IT lessons as a treatment to reinforce other subject areas. Within each grade level, students from both groups had the same teachers for other subject areas such as English, mathematics, science, social studies, and art. This arrangement maintained the teacher factor as constant across all subject areas. Limitations of the study include the control over the assignment of students to the different sections at the beginning of the school year, and control on the number of subject(s) simultaneously being reinforce during the weekly thematic and interdisciplinary IT lessons.

Table 1 shows the frequency distribution of the participants in the study. Students with extreme low scores due to excessive absences were not included in the study. These students were omitted to prevent outliers; values that could exert a disproportionate effect on the data (Cohen, Manion, & Morrison, 2007), and interfere with the analysis.

The study was quasi-experimental, the methodology employed followed a quasi-experimental design (Cohen et al., 2007). The pre-test/post-test non-equivalent experimental control group design was used. This quasi-experimental design is referred to as the compromise design, because the random selection or assignment of schools and classrooms is impracticable (Kerlinger & Lee, 1999). Mostly, the

Table 1
Frequency of the student participants.

Grade level	Groups	
	Control	Experimental
1	113	95
2	98	123
3	115	101
4	114	117
5	111	92
6	104	90
Total (N^a = 1273)	655	618

[a] Students who incurred more than 30 days of absence are not included in this study.

researcher attempted to employ something approaching a true experimental design in which the control over what Campbell and Stanley (1963) refer to as to the who and whom of measurement was important.

In the fall of 2005, a pre-test was administered in all subject areas for all elementary level students. Results were used as a covariate in data analysis. The purpose of the pre-test was to remove the effects of the variables, to avoid modification of the relationship of the categorical independents (treatment) to the interval dependent (final scores). At the end of the academic year, final subject area scores were gathered and analyzed using the one-way multivariate analysis of covariance (MANCOVA). This procedure determined the effectiveness of the thematic and interdisciplinary IT curriculum (Kerlinger & Lee, 1999). An independent sample *T*-test determined statistical difference between the control and experimental groups' IT curriculum (Cohen et al., 2007). Analysis of the meeting minutes and observation notes were done, to summarized observations and re-occurring themes.

3. The thematic and interdisciplinary IT curriculum

The experimental thematic and interdisciplinary IT curriculum for elementary students was based on the Technology Foundation Standards for Students of the International Society for Technology in Education (ISTE) project on National Educational Technology Standards (NETS). ISTE and its accreditation standards committee established the de-facto guidelines for evaluating computing and technology programs in the United States. They also published guidelines for the fundamental concepts and skills for applying grade level information technology (Tomei, 2003). The NETS provides teachers, technology planners, teacher preparation programs, and educational decision-makers with the framework and standards to guide the establishment of learning supported by technology (ISTENETS, 2002a).

The technology foundation standards for students are divided into six broad categories. Within each category, standards are introduced, reinforced, and then mastered by students. The categories also provide a framework for linking different performance indicators within each profile for technology literate students. Teachers use the standards and profiles as guidelines for planning technology-based activities (ISTENETS, 2002b). Table 2 summarizes the different categories with corresponding standards.

The experimental curriculum conformed to the NETS standards, and was presented in a thematic environment. The curriculum design guided students to discover what could be accomplished with computers through informative thematic themes. Table 3 shows the experimental curriculum integrated with corresponding themes and learning objectives. These themes were selected and agreed upon by the researcher and teachers, with due consideration for what was familiar and interesting to students by grade level (Annarella, 2000; Ellis & Stuen, 1998).

Lessons were represented in spiraled levels, wherein complicacy increased as students learned more about the practical side of computing. Lectures and exercises were designed to develop and reinforce lessons from various academic subjects such as English, mathematics, science, social studies, and art. During the lessons, students were introduced to useful terms, ideas, and tasks relating to computers.

Table 2
Technology foundation standards for students.

Categories	Standards
I. Basic operations and concepts	• Students demonstrate a sound understanding of the nature and operation of technology systems • Students are proficient in the use of technology
II. Social, ethical, and human issues	• Students understand the ethical, cultural, and societal issues related to technology • Students practice responsible use of technology systems, information, and software • Students develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits, and productivity
III. Technology productivity tools	• Students use technology tools to enhance learning, increase productivity, and promote creativity • Students use productivity tools to collaborate in constructing technology-enhanced models, prepare publications, and produce other creative works
IV. Technology communications tools	• Students use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences • Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences
V. Technology research tools	• Students use technology to locate, evaluate, and collect information from a variety of sources • Students use technology tools to process data and report results • Students evaluate and select new information resources and technological innovations based on the appropriateness for specific tasks
V. Technology problem-solving and decision-making tools	• Students use technology resources for solving problems and making informed decisions • Students employ technology in the development of strategies for solving problems in the real world

Source: http://cnets.iste.org/students/s_stands.html.

Table 3
The proposed thematic and interdisciplinary IT curriculum for elementary.

Grade level	Thematic environment	Learning objectives
1	Home – learning the concept of computers and technology right in their own homes	• Introduction to concepts of technology • Simple problem solving skills • Basic understanding of information
2	School – discovering new things about technology and computers, while going on in their school routines	• Usefulness of machines in everyday life • Part and peripherals of the computer • Pressing, clicking and dragging activities • Introduction to the use and concept of internet
3	Neighborhood – having new friends in the neighborhood and community, exchanging knowledge and information about computers	• Understanding the role of computer • Introduction to the part inside a computer • Differentiating software and hardware • Appreciation of the relevance of technology • Introduction to E-mail
4	City – learning the life in the city, while experiencing the tasks and functions that a computer can do	• Uses of the personal computer • Associating concepts with devices • Software that makes the computer works • Word processors and spreadsheets • Internet etiquette
5	Country – learning about the different places around the country, while experiencing the life in the provinces	• Concept of IT revolution • Understanding computer memory • Office productivity software • Introduction to programming • Knowing IT related "Rights"
6	World – meet new friends, together learn and experience the different cultures from other countries	• History of computer • Introduction to computer networking • Concept of databases • Multi-media presentations • Rules to prevent misuse of computers

Lessons exercises were designed to simultaneously reinforce target subject areas; they were collaboratively designed by the IT teachers and participating teachers.

4. Results and findings

4.1. Factors that influence the implementation of a thematic and interdisciplinary curriculum

Table 4 shows the elementary teachers mean age of 31 years, suggesting a fairly young and robust faculty line-up. Although there were some teachers in their fifties, a large majority of the faculty were in their twenties. However, during the teacher trainings, the researcher observed that all the teachers regardless of age were eager and enthusiastic in participating with the activities.

The interdisciplinary curriculum design afforded ongoing opportunity for collaborative work and cohesiveness among faculty. In turn this collaboration enhanced the production of knowledge and creativity as well as faculty growth. Teachers had to pool their subject area expertise in order to find the right connections that would cut across and form the interdisciplinary curriculum. During trainings and scheduled meetings, teacher collaboration and cohesiveness was observed by the researcher:

> Teacher A (mathematics teacher) said "this is my topic next week; I think we can combine it with Teacher B's (science teacher) topic". Teacher B replied "I was just thinking the very same idea". Teacher C (computer teacher) answered "Yes, I think this is great, let's go through the lesson plans now". - Teachers showed great enthusiasm in designing interdisciplinary lessons. Improved teacher collaboration and cohesiveness were clearly observed (Meeting minutes, January 10, 2006).

This finding supports previous research noting the significance of teacher collaboration and group cohesiveness for the success of interdisciplinary teaching (Austin & Baldwin, 1991; Barefield, 2005; Crow & Pounder, 2000).

Scholars agree that thematic interdisciplinary lessons enhance student interest in learning (Lattuca, Voigt, & Fath, 2004). Throughout the study, the researcher observed numerous carefully thought-out creative thematic and interdisciplinary IT lessons and exercises. During the observations, students were motivated and engaged:

Table 4
Age[a] of elementary teachers.

Gender	*n*	M	SD	Maximum	Minimum
Male	7	30.29	4.923	23	36
Female	33	31.15	10.097	22	56
Total	40	31	9.353	22	56

[a] Age is in years.

Teacher C (Grade 5 computer teacher) teaching the topic "creating presentations". Teacher C used a thematic setup in relating the contents of her lesson exercises to topics discussed in science and social studies. Students showed great interest; raises their hands immediately to answer the questions asked. Students are both motivated and engaged in the lessons (Field notes, February 16, 2006).

Findings suggested that the success of the experimental curriculum was dependent on teacher commitment and collaboration along with the ongoing support of stake holders. Faculty collaboration can offer potentially rich benefits in terms of the production of knowledge and creativity, faculty growth, which leads to institutional excellence. The teachers' ability to link standards with curriculum integration, along with support from school administrators, colleagues, and parents were also equally important in providing positive encouragement from the planning to the implementation stages of the curriculum. Consequently, teacher education programs need to prepare graduates for teaching with IT (Albion, 1999; Vars, 1991). Successful integration requires teachers to have a good understanding of integrated teaching (Huntley, 1998; Watanabe & Huntley, 1998). Graduates should possess both skills in the use of IT and belief in their capacity to integrate IT into teaching (Albion & Ertmer, 2002).

4.2. Implications of the thematic and interdisciplinary IT curriculum with regards to the students' IT performance and to the other subject areas

In order to determine statistical difference between the regular and experimental IT curriculum, an independent sample *T*-test was used to compare IT scores. Table 5 shows that there was a significant difference between the control and experimental groups at all grade levels. To further express the importance of the findings, the *effect size;* also known as *strength of association* was calculated. This set of statistics indicated the relative magnitude of difference between means. It described the amount of the total variance in the dependent variable that was predictable from the levels of the independent variable (Tabachnick & Fidell, 2006).

Table 5
Independent samples *T*-test for the control and experimental groups' IT scores.[a]

Grade level	Groups						d*f*	*t*	*p*	η^2
	Control			Experimental						
	n	**M**	SD	*n*	M	SD				
1	113	**85.954**	4.164	95	84.116	3.709	206	3.331	0.001	0.051
2	98	82.934	4.163	123	**84.144**	4.221	219	−2.122	0.035	0.020
3	115	85.704	4.002	101	**87.017**	4.023	214	−2.400	0.017	0.026
4	114	91.160	1.409	117	**92.611**	1.183	229	−8.486	0.000	0.239
5	111	92.259	1.293	92	**93.003**	1.306	201	−4.061	0.000	0.076
6	104	92.510	0.661	90	**93.689**	0.594	192	−12.985	0.000	0.468

[a] Numbers in bold indicate the higher mean scores among the control and experimental group.

Table 6
One-way MANCOVA[a] for Grade 1 students' subject areas mean scores[b] (adjusted means).

Subject area	Groups				*F*	*p*	η^2
	Control (*n* = 113)		Experimental (*n* = 95)				
	M	SD	M	SD			
English	82.299	0.197	82.876	0.221	2.939	0.088	0.015
Mathematics	**83.304**	0.258	81.964	0.289	9.254	0.003	0.044
Science	83.357	0.250	83.733	0.279	0.775	0.380	0.004
Social studies	85.763	0.224	**86.590**	0.250	4.687	0.032	0.023
Art	84.015	0.265	83.795	0.297	0.236	0.628	0.001
IT	84.769	0.209	**85.525**	0.234	4.482	0.035	0.022

[a] Pre-test scores used as covariates for each subject area.
[b] Numbers in bold indicate the higher mean scores among the control and experimental group.

Table 7
One-way MANCOVA[a] for Grade 2 students' subject areas mean scores[b] (adjusted means).

Subject area	Groups				*F*	*p*	η^2
	Control (*n* = 98)		Experimental (*n* = 123)				
	M	SD	M	SD			
English	82.571	0.204	**83.653**	0.174	11.866	0.001	0.053
Mathematics	82.148	0.263	**82.990**	0.225	4.316	0.039	0.020
Science	81.849	0.253	81.529	0.216	0.676	0.412	0.003
Social studies	85.787	0.267	86.516	0.228	3.148	0.077	0.015
Art	84.406	0.341	**86.335**	0.292	13.452	0.000	0.060
IT	83.323	0.210	83.838	0.179	2.550	0.112	0.012

[a] Pre-test scores used as covariates for each subject area.
[b] Numbers in bold indicate the higher mean scores among the control and experimental group.

Looking at the results, the effect size (Eta squared, η^2) for the grade 6 (0.468) and grade 4 (0.239), both indicated a very large effect (Cohen, 1988). In other words, 46.8% and 23.9% of the variance of the IT scores in grade 6 and 4, respectively, was attributed to whether or not students were assigned to the regular or the experimental curriculum. Further comparison of the IT mean scores showed that with the exception of grade 1 the experimental group had a higher value than the control group. This confirmed that the experimental curriculum was effective in increasing grade 2–6 student scores; however to establish a more accurate analysis and avoid selection bias, the inclusion of the pre-test as a covariate in the computation is needed (Kerlinger & Lee, 1999).

In order to study the effectiveness of the experimental curriculum, the one-way MANCOVA method was used to control initial differences in pre-test scores in quasi-experimental designs (Kerlinger & Lee, 1999). In MANCOVA, the dependent variable was adjusted statistically to remove the effects of the portion of uncontrolled variation represented by the covariate (Garson, 2008). Basically, the covariate was used to: reduce error variance and selection bias, account for any pre-existing mean group difference on the covariate, consider the relationship between the covariate and the dependent variable, and yield a more precise estimate of group effects (Sherry, 1997).

Tables 6–11 present the one-way MANCOVA results for all grade levels using the corresponding pre-test scores of the different subject areas as covariates. The tables also display the adjusted mean scores of the control and experimental groups, the results in bold indicate the higher value among the two. MANCOVA demonstrated different results across grade levels. Grade level MANCOVA results indicated significant difference in 3 subject areas, with the exception of grade 3 which extended to 5 subject areas only. In sum, results indicated that there was a significant difference between the control and experimental group academic scores which varied by grade level.

A summary of Tables 6–11 is provided in Table 12. In Table 12 the plus (+) symbol indicates an increase in the adjusted mean scores between the control and experimental groups. This specifies that students exposed to the experimental curriculum scored higher by subject area. The negative (−) symbol indicates a decrease in the adjusted mean scores between the control and experimental groups, indi-

Table 8
One-way MANCOVA[a] for Grade 3 students' subject areas mean scores[b] (adjusted means).

Subject area	Groups				F	p	η^2
	Control (n = 115)		Experimental (n = 101)				
	M	SD	M	SD			
English	**82.345**	0.124	81.551	0.134	16.062	0.000	0.072
Mathematics	**82.521**	0.212	81.033	0.229	19.339	0.000	0.085
Science	**80.421**	0.164	78.189	0.177	73.191	0.000	0.261
Social studies	85.236	0.175	84.719	0.189	3.429	0.065	0.016
Art	82.815	0.199	**84.433**	0.215	25.927	0.000	0.111
IT	85.682	0.178	**87.043**	0.192	22.968	0.000	0.100

[a] Pre-test scores used as covariates for each subject area.
[b] Numbers in bold indicate the higher mean scores among the control and experimental group.

Table 9
One-way MANCOVA[a] for Grade 4 students' subject areas mean scores[b] (adjusted means).

Subject area	Groups				F	p	η^2
	Control (n = 114)		Experimental (n = 117)				
	M	SD	M	SD			
English	81.844	0.144	81.622	0.141	0.933	0.335	0.004
Mathematics	80.410	0.204	80.686	0.201	0.720	0.397	0.003
Science	**82.131**	0.208	79.368	0.205	69.311	0.000	0.238
Social studies	85.125	0.197	85.218	0.194	0.087	0.768	0.000
Art	83.224	0.244	**84.194**	0.240	6.189	0.014	0.027
IT	91.215	0.119	**92.557**	0.117	49.905	0.000	0.184

[a] Pre-test scores used as covariates for each subject area.
[b] Numbers in bold indicate the higher mean scores among the control and experimental group.

Table 10
One-way MANCOVA[a] for Grade 5 students' subject areas mean scores[b] (adjusted means).

Subject area	Groups				F	p	η^2
	Control (n = 111)		Experimental (n = 92)				
	M	SD	M	SD			
English	79.560	0.150	79.292	0.172	0.950	0.331	0.005
Mathematics	79.780	0.226	**80.754**	0.259	5.526	0.020	0.028
Science	81.777	0.227	**82.661**	0.260	4.513	0.035	0.023
Social studies	84.247	0.253	83.400	0.290	3.333	0.069	0.017
Art	81.285	0.258	81.543	0.296	0.296	0.587	0.002
IT	92.208	0.139	**93.064**	0.159	11.316	0.001	0.055

[a] Pre-test scores used as covariates for each subject area.
[b] Numbers in bold indicate the higher mean scores among the control and experimental group.

Table 11
One-way MANCOVA[a] for Grade 6 students' subject areas mean scores[b] (adjusted means).

Subject area	Groups				F	p	η^2
	Control (n = 111)		Experimental (n = 92)				
	M	SD	M	SD			
English	80.651	0.178	80.495	0.200	0.213	0.645	0.001
Mathematics	80.022	0.306	**81.941**	0.344	10.751	0.001	0.055
Science	80.285	0.276	**81.346**	0.310	4.043	0.046	0.021
Social studies	86.173	0.303	85.200	0.341	2.817	0.095	0.015
Art	83.144	0.326	82.794	0.367	0.314	0.576	0.002
IT	92.421	0.079	**93.792**	0.089	81.318	0.000	0.305

[a] Pre-test scores used as covariates for each subject area.
[b] Numbers in bold indicate the higher mean scores among the control and experimental group.

Table 12
Difference between the control and experimental group's subject areas mean scores[a] (adjusted means) according to grade levels.

Grade level	English	Mathematics	Science	Social studies	Art	IT
1	n.s.	–	n.s.	+	n.s.	+
2	+	+	n.s.	n.s.	+	n.s.
3	–	–	–	n.s.	+	+
4	n.s.	n.s.	–	n.s.	+	+
5	n.s.	+	+	n.s.	n.s.	+
6	n.s.	+	+	n.s.	n.s.	+

[a] A '+' symbol indicates that the experimental group scored higher than the control group, a '–' symbol indicates that the experimental group scored lower than the control group, while a 'n.s.' symbol indicates that there is no statistical difference between the groups.

cating that students exposed to the regular curriculum scored higher by subject area. The initials "n.s." indicates that there was no significant difference between groups.

The implications of Table 12 summarize some insightful details. Consideration of the pre-test as covariates, the adjusted IT mean scores showed that the experimental group had a higher value than the control group at all grade levels except grade 2. This indicated a more precise account of the effect of the experimental curriculum. Additional observation also indicated other results such as the proposed thematic and interdisciplinary IT curriculum effectively reinforced the art subject only in the grade 2–4 levels and not in the grades 1, 5, and 6 levels; while for social studies having no significant effect in the grade 2–6 levels, but only effective in the grade 1 level; and for mathematics having a positive effect on the grade 2, 5, and 6 levels. However, results for subject areas like English and science seems to have no consistency or specific pattern at all, but at the least was effective in some of the grade levels if not all. A likely cause for this inconsistency was probably due to the limited time spent by the teachers during their IT sessions. Additional IT sessions (more than once a week) were suggested in the future; to further lengthen the student's exposure with the interdisciplinary IT curriculum.

The development and implementation of a standards-based technology curriculum is filled with many challenges, but these are balanced by strong indicators showing student benefits (Satchwell & Loepp, 2002). In addition, the implementation of an integrated curriculum is also a demanding process. In the planning process, two or more teachers must work together, this requires common planning time. The extra effort it takes to develop and implement an interdisciplinary technology curriculum produces significant benefits. Students are able to link concepts learned in one discipline to related concepts in another. Although, results showed that there was inconsistencies in the subject areas reinforcement. Observation logs showed that students are more motivated to learn, which one of the major goals in education is.

5. Conclusion

This study examined the implementation of an experimental interdisciplinary curriculum linking core subjects with an IT strand to enhance meaningful learning experiences for elementary level students. Results indicated that the experimental curriculum positively affected the academic performance of students by grade level and subject area. Implications suggested that the success of the experimental curriculum was dependent on teacher commitment and collaboration along with the ongoing support of stake holders. The teachers' ability to link standards with curriculum integration, along with support from school administrators, colleagues, and parents was essential for positive results from the planning to the evaluation of the curriculum. During the initial planning stages teachers became increasingly involved in the integration of the interdisciplinary curriculum; as a result, new and unanticipated curricular connections became evident. The teachers, like the students, benefitted from interdisciplinary learning as it enhanced understanding of other subject areas and fostered appreciation of the knowledge and expertise of colleagues. Thus teamwork was facilitated as teachers worked together to weave themes across several subject areas. Through the planning and implementation of the curriculum teachers noted that the IT strand improved their teaching and strengthened learning. The technology strand enhanced opportunities to access, evaluate, and communicate knowledge. It also demonstrated that the success of this design required vision, professional development, ongoing curriculum development, and teacher creativity.

In closing it is important to note that while the study of interdisciplinary curriculum is not new, it continues to receive a great deal of attention in educational settings worldwide. The examination of an IT strand linked with an interdisciplinary curriculum within the private school in Manila contributes to new and compelling ideas to the education of children in the 21st century. In addition, for IT to make a lasting impact, educators must use a variety of teaching and learning approaches in their classroom instruction. Technology implementation should be initiated at the core of curriculum planning and professional development opportunities should be made available to the teachers. Lastly, further longitudinal studies are recommended to examine the long-term implications of a thematic and interdisciplinary IT curriculum design.

Acknowledgements

First of all, I want to express my gratitude to all the hardworking and dedicated teachers who participated in this project, without them this endeavor is impossible. Second, I want to thank the administrators of the Philippine High School for giving me the opportunity to work with their teachers and the permission to undertake this project. Lastly, I would like to express my deepest gratitude to my mentor, Prof. Amy Roberts of University of Wyoming, whose guidance and encouragement help make this manuscript a possibility.

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