EDUCATION QUARTERLY, December 2009, Vol. *67* (1), 79-91
U.P. College of Education

Integration of Information and Communication Technology in Mathematics Teaching in Metro Manila Public Secondary Schools

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Abstract

This is an investigation on the adoption patterns of Metro Manila public secondary school teachers while information and communication technology (ICT) is being integrated into their teaching. Evidence shows that the majority of the teachers had highly favorable attitudes toward the use of new technologies in instruction. This disposition was brought about, among other things, by the influence of authority and/or the status individuals normally attach to technology innovation. This study further shows that while the enthusiasm level for integration was high, the extent of ICT implementation was poor mainly due to the lack of computer facilities and teacher training programs. It is recommended that the government take advantage of the teachers' enthusiasm by providing the teachers with necessary tools and opportunities to improve their teaching.

Keywords: ICT integration, technology adoption patterns, mathematics teaching, public secondary school teachers, computer attitude, willingness to integrate, innovation diffusion

In the Philippine school system, information and communication technology (ICT) is usually introduced in the elementary schools through the subject Home Economics and Livelihood Education (HELE), and in the secondary schools through Technology and Home Economics (THE). The idea is that "technology must be studied first as a separate subject, then applied in other learning areas as a tool for learning how to learn" (ICT in Education, UNESCO, Bangkok, 2007).

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Since 1997, the Department of Education (DepEd) has intensified the provision of ICT training to teachers of different subjects, including Mathematics. This was an important event because integration requires the teachers to become a skilled and competent user of computer technology when teaching.

The DepEd's interest in the innovative use of ICT in classroom teaching and learning is well understood. The global community as well as the neighboring countries in Asia is aggressively pursuing the technology-based approach to teaching called ICT integration. On top of it, for years the country has been battling poor academic performance in Mathematics. ICT Integration can be the key to the improvement of Mathematics education in the country. With this vision, it is imperative that the implementation of the ICT program, particularly in government schools, be examined to readily address the new educational problems that arise from it.

ICT integration is a technological innovation in education. Rogers (2003) believes that the implementation of an innovation is just one phase of a five-stage diffusion process. Diffusion here means "the process through which an innovation spreads via communication channels over time among the members of a social system" (Rogers, Medina, Rivera, & Wiley, 2003, p. 3). Rogers' theory explains how innovation is communicated to the would-be innovators in five stages, namely, knowledge, persuasion, decision, implementation, and confirmation. *Knowledge* requires exposure to the innovation and understanding how to use it. *Persuasion* refers to the development of a favorable attitude toward the innovation. *Decision* refers to the commitment to its adoption. *Implementation* is putting the innovation to use, whereas c*onfirmation* refers to the reinforcement resulting from favorable outcomes.

This study sought to determine the implementation level of the DepEd's ICT Integration program in Mathematics teaching. The degree to which technology was used in the classroom indicated the implementation level of the government's ICT integration program. The study focused on the public high schools in Metro Manila, the country's capital, which is expected to have the best ICT resources.

Guided by Rogers' theory, this study sought to answer the following questions:

1. What are the attitudes of public secondary school Mathematics teachers in Metro Manila toward the use of computers and other ICT facilities in teaching?
2. What are the factors related to computer attitude?
3. To what extent do these teachers show commitment to the use of computers in the classroom?
4. What is the implementation level of ICT integration in Mathematics teaching?
5. What problems are associated with ICT integration?

Methodology

To establish the extent to which ICT integration has been implemented in Mathematics teaching in the public high schools in Metro Manila, the study investigated the innovation's diffusion process. Among other things, it determined the teachers' computer attitudes and commitment to classroom use of ICT. C*omputer attitude* referred to teachers' disposition toward the use of computers and other ICT facilities in teaching Mathematics, and was measured using the researcher-made Computer Attitude Rating Scale (CARS). C*ommitment* to the use of ICT to achieve learning outcomes was indicated by the teachers' willingness to participate in the ICT integration program, and was measured using the score on a single 10-point willingness scale. Using t test and F test, the study likewise established the relationship between computer attitude and such factors as teachers' access to computer and school population. It used both quantitative and qualitative data generated through survey questionnaires and informal conversational interviews with a number of teachers, Mathematics head teachers, and school principals.

To collect data, seven public high schools in Quezon City were selected based on the information that they were among those that had an active tie-up with outside institutions committed to the promotion of ICT-integrated lessons, particularly in the teaching of Mathematics. It was expected then that the teachers would have much information to share about integration from personal experience. Likewise, these schools had a substantial number of Mathematics teachers who could adequately provide the information needed in the study. The seven schools were meant to represent Metro Manila with the view that ICT-related conditions within the National Capital Region are homogeneous.

One hundred eleven (n = 111) high school Mathematics teachers from these schools served as research respondents. Table 1 displays the number of teacher participants from each school.

Table 1
Distribution of Sample Teachers by School

School	n	%
School 1	33	29.73
School 2	8	7.21
School 3	19	17.12
School 4	11	9.91
School 5	8	7.21
School 6	17	15.32
School 7	15	13.51
Total	111	100.00

Thirty percent (30 %) of the teachers came from School 1 (n = 33). School 2 and School 5 each had eight teachers (7 %) in the sample. Most of these teachers were single (68 %), females (61 %), and had finished Bachelor of Science in Secondary Education

with major in Mathematics (54 %). They had an average age of 36.4 years (s = 8.7), and an average Mathematics teaching experience of 10.7 years
(s = 7.5). Eighty-three percent (83 %) of the teachers reported to have computer facilities at home.

A survey questionnaire was used to obtain information on the characteristics of the participants, professional development activities, and problems encountered in line with integration. The questionnaire included also the CARS and a one-item scale meant to gauge the teachers' commitment or willingness to use the computer in the teaching of Mathematics.

The CARS was a four-point rating scale which consisted of 11 items. There were four response categories with corresponding weights, as follows: Strongly Agree (4), Agree (3), Disagree (2) and Strongly Disagree (1). The middle response category "undecided" was excluded to "force" the respondents to make a stand regarding their attitudes toward computer use in the classroom thereby preventing the occurrence of a response bias (Nunnally, 2003).

A respondent's attitude score was obtained by getting the average score across the item ratings. However, in correlating attitude and commitment, the former was measured using the summation scores instead of the average item ratings. This was because the latter generated data with a very limited range (1 to 4), thereby reflecting a reduced correlation between two variables such as computer attitude and commitment (Urbina, 2004).

Initially, there were 30 items which resulted from the ratings given by three inter-raters tasked to classify the items into factors perceived to influence the teachers' attitude toward computer integration. The 30 items were then subjected to confirmatory factor analysis. One factor measured a teacher's "attitude toward computer integration arising from its usefulness in Mathematics teaching." This set of 11 items which constituted the CARS possessed high factor loadings ranging from .618 to .811. The results of the factor analysis also served as evidence of the scale's construct validity (Nunnally, 2003). The instrument had a Cronbach's alpha of .917. The following are examples of CARS items:

- *The computer can stimulate creativity and Mathematical thinking among students.*
- *With the computer, Mathematics teachers can create instructional materials to enhance their teaching competence.*

Agreement to such items should reflect one's recognition of the value of the computer in Mathematics teaching.

The researcher administered the questionnaires herself to the teachers and requested the head teachers to distribute them to those who were not available. The questionnaires were retrieved the day after.

Results and discussions

Teachers' attitudes toward computer integration

The second stage of innovation diffusion, according to Rogers' theory (2003), is the formation of a favorable attitude toward the innovation. The CARS was used to gather data in this respect.

Table 2 displays the 11 computer attitude items together with the distribution of the responses across the four categories (Strongly Agree to Strongly Disagree), and the item ratings with the corresponding standard deviations. Each rating represents the extent to which the teachers agreed or disagreed with the item. In all items except in Item 4, the teachers expressed a positive (3.00) to very_positive (4.00) attitude toward computer integration. It will be noted that the combined percent frequencies for the categories "Agree" and "Strongly Agree" were no less than 93 %, which translated to an overall mean attitude rating of 3.38 (s = .46).

Table 2
The Computer Attitude Scale with Mean Item Ratings

Attitude Item	Rating				Mean Rating	Std Dev
	SD (1)	D (2)	A (3)	SA (4)		
1. Enjoyable to work on computer	0.90	3.6	36.9	58.6	3.5	.62
2. Wishing for more computer training	0.09	3.6	27.0	67.6	3.6	.60
3. Expecting increased use of computers in daily life	0.00	2.7	48.6	45.9	3.4	.55
4. Some school needs are more important than computers	10.80	40.5	35.1	13.5	2.5	.86
5. Computer, a useful instructional aid in Math	0.90	3.6	46.8	48.6	3.4	.61
6. Computer, needed to improve Math education in the country	1.80	3.6	52.3	42.3	3.4	.64
7. Computer can stimulate creativity and math thinking	0.00	2.7	54.1	43.2	3.4	.55
8. Computer enhances Math teaching	0.00	4.5	46.8	48.6	3.4	.58
9. Computer makes mathematical activities more interesting	0.00	6.3	47.7	45.9	3.4	.61
10. Wishing to learn more about computer and software routines	0.00	1.8	37.8	60.4	3.6	.53
11. Computer provides richer learning experiences in Mathematics	0.00	1.8	53.2	45.0	3.4	.53

Item 4 registered the lowest mean attitude rating of 2.51 which was lower than the agree-level of 3.00. It was a negatively stated item in which scoring had to be reversed. It was expected that one who supported computer integration would "disagree" or "strongly disagree" with this item. Stated positively, it may read: "Our greatest need in school is access to more computers." The low rating this item received suggests that in spite the advantages in using the computer in the classroom, the teachers believed that there were other school needs that required greater attention.

Despite Item 4, computer attitude reached an overall mean rating of 3.38 (s = 0 .46) in a scale from 1 to 4. The small standard deviation of 0.46 shows that the group was_homogenous. Clearly, the teachers as a group exhibited a very favorable attitude toward the use of ICT facilities in the teaching of Mathematics.

Factors related to computer attitude

At the start of the study, it was expected that computer attitude would correlate with teacher's age and number of years teaching Mathematics; however, the data did not support these research hypotheses.

The t test and the F test were likewise used to determine any significant association between computer attitude and certain teacher characteristics, namely, sex, civil status, presence of computer at home, year level, school and highest educational attainment. The lack of variation in the attitude scores, however, made it difficult to detect any significant mean differences.

Availability of computer at home. Using the t test for independent means, the study investigated the connection between attitude and each of the following factors: sex, civil status, and presence of a computer at home. The results are shown in Table 3.

Table 3

Results of t Test on Sex, Civil Status and Access to Home Computer

Variable	N	Mean Diff	SE	t –value	Sig
* Sex	111	0.06	0.09	0.66	.11
* Civil status: single/married	108	0.12	0.10	1.22	.86
* With / without computer at home	109	0.23	0.07	3.21	.002

. * *Some N's not equal to 111 due to missing data.*

*** The mean difference is significant at the 0.01 level*

The t tests showed that there was neither a significant difference between males and females nor between single and married teachers. However, the statistical test implied that having a home computer (or laptop) is related to a more favorable attitude toward making use of ICT to improve teaching and learning. Owning a personal computer was seen to result in professional gains as what Khambari, Moses and Luan (2009) found in their study on laptop ownership. They claimed that having a laptop led to increased selfconfidence and greater mastery of basic computer skills as well as improved quality teaching materials.

School. The F test or One-Way ANOVA was used to answer the question: Are there significant mean differences in computer attitude ratings in terms of each of the following: year level of Mathematics subjects taught , school where teacher taught Mathematics , and educational attainment? The results of the test revealed a significant difference in terms of school categories ($F = 4.213$, $p = .001$) but not in terms of year level and educational attainment. The Scheffe test was used to further identify among the seven schools which pairs of attitude mean ratings were significantly different. The results are given in Table 4.

Table 4

Multiple Comparisons among School Attitude Ratings (Using Scheffe)

School Comparison		Mean Difference	Std Error	Sig.
School 5 vis a vis each of six other schools (at right)	School 1	0.531	0.121	.001
	School 2	0.192	0.153	.872
	School 3	0.472	0.129	.007
	School 4	0.318	0.142	.288
	School 6	0.420	0.131	.029
	School 7	0.426	0.136	.035

* *Mean difference is significant at the 0.05 level*

The teachers from School 5 displayed a more positive attitude than those from Schools 1, 3, 6 and 7 which were characterized by large school populations of about 10,000. In contrast, School 5 had a population of only about 3,000 which, understandably, could have enabled the school head to manage more easily both teachers and ICT resources. This condition could also have positively influenced the school head’s own attitude toward ICT integration which could have led to greater support for the integration program.

These ideas emerged during the informal interviews with a number of respondents. For example, one teacher who claimed to practice ICT integration in a relatively small school remarked, “A leader who shows interest in ICT will surely find ways to procure computer facilities, or improve the present facilities… so, we need not use our own resources.”

School 2’s principal expressed a similar view, “School heads have different attitudes toward the use of ICT in classroom teaching. One who has a positive attitude toward ICT-based lessons will use his influence in the community to make the needed resources available.” On the other hand, School 3’s principal said, “What will you do when so many classes require computers? The local government provided computer units… but that was years ago. Besides, they were not intended for regular classroom use."

Thus, two conditions turned out to be significantly related to teacher attitude. These were the availability of a computer at home and small school population which is believed to be closely related to better school management. The mean differences, although highly significant ($p < .01$) were minimal owing to the fact that the attitude ratings (1 to 4) did not vary much.

Commitment to the use of computer in teaching mathematics

Rogers' Innovation Diffusion Theory (2003) holds that next to the formation of a favorable attitude toward an innovation is the decision to adopt or reject it. In this study, this phase was exemplified by the teachers' response to the question: Would you be willing to use the computer in teaching Mathematics?

The teachers expressed their willingness on a 10-point item wherein 10 meant "most" and 1 "least" willing. The overall mean rating is 8.56 ($s = 1.99$).

Table 5

Teacher Willingness Ratings

Rating Interval	n	%
10	47	42.3
8-9	25	22.5
6-7	11	10.0
5 and below	8	7.2
No answer	20	18.0
Total	111	100.0

Almost half (42 %) of the teachers gave themselves a "10," while 23 % were willing at 8-9 level. Overall, 65 % of the respondents manifested willingness at 8-10 level signifying a strong teacher commitment to the use and adoption of ICT to enhance teaching. In fact, the two variables, computer attitude and commitment to ICT utilization in teaching, displayed a high correlation ($r = .91$, $p = .007$).

Although, the members of an organization are free to adopt or reject an innovation, in some cases, decisions are based on group consensus, or are dictated upon by authority (Rogers, 2003). In this study, the teachers virtually moved as one embracing this technology-based approach to teaching. This phenomenon might have been brought about by DepEd's influence on the teachers through the school officials. This means that the teachers' position with regard to the use of ICT in classroom instruction might have been the result of the direct or indirect influence of school superiors on their teachers, or of DepEd's pronouncements in various forms.

However, some teachers who were interviewed thought differently. They believed that using a computer in teaching was in itself worthwhile as it was associated with high status. A teacher who claimed to practice ICT integration in the classroom, recalled, "Some teachers would watch me get the equipment ready for an integration class demonstration. They would express their wish to be able to do the same thing." Another teacher who believed in the usefulness of the computer in the classroom, remarked, "I would like to think that I am tecchy just like some other teachers."

Another perspective that challenged Rogers' theory came from a head teacher, who, when asked to what factor she would attribute the teachers' enthusiasm in using ICT in the classroom, quipped, "But there are teachers who have this sincere desire to see their students improve in Mathematics." Thus, these three attributed the teachers' strong commitment to ICT use in teaching not to pressures from school authorities, but to a desire for social recognition, an experience with the innovation itself, and responding to the call of duty.

Yet another view emerged. When informed that generally teachers were very willing to use computers in teaching, one teacher observed, "These teachers just don't know how much effort you have to make…and it's very frustrating…you worked so hard, then,…you have to set aside what you prepared because the computer failed, and there was no one to trouble-shoot.." She believed that probably the ICT non-users were not aware of the standards of ICT integration and the realities surrounding it. Based on Rogers' theory, the teachers might not have a genuine understanding of the elements of integration, suggesting that many teachers were yet in the *knowledge* stage, the first stage of Rogers' five-phase innovation adoption process.

Level of ICT integration

This section discusses two indicators of extent of implementation of ICT in teaching and learning, namely, the proportion of teachers who were actually using the computer in teaching and the breadth of curricular content being tapped for technology-aided lessons.

Small Proportion of Innovating Teachers. The study revealed three types of teachers based on computer utilization:

- Those who used a computer in teaching as well as in preparing their Mathematics lessons. In this study, these teachers were called the *innovating teachers.*
- Those who used a computer only in preparing a lesson, but not during actual teaching. These were the *planning teachers.*
- Those who neither used a computer in preparing their lessons nor in doing actual teaching. These were the *computer non-users.*

Table 6 reveals that 80 % of the teachers were *computer non-users, with* only 12 % as *innovating* and 8 % *planning teachers.*

Table 6

Distribution of Teachers by Computer Utilization

Computer Utilization Category	n	%
Innovating teachers	13	11.71
Planning teachers	9	8.11

Although the *planning teachers* used a computer, they performed administration rather than integration tasks. Examples of administration tasks are encoding lesson plans, preparing examinations and surfing the Internet for visual aids. Integration includes such activities as showing the relationship between the surface area of a cube and its nets by way of PowerPoint presentation , or making students investigate interactively on a computer how the graph of a straight line equation changes as the slope of the equation is modified (Khambari ,et al., 2009). Thus, in this sense, only the *innovating teachers* truly engaged in ICT integration. Given the very small proportion of this group (12 %), the level of ICT integration was poor.

Few curricular topics for ICT-aided lessons. What computer-based lessons did the *innovating teachers* teach? According to seven teachers belonging to this category, their technology–assisted lessons involved the teaching of graphs of functions, specifically systems of linear equations and inequalities, exponential, circular, and trigonometric functions. The few others mentioned surface area, volume, and the Pythagorean Theorem.

In response to the comment that there were many topics in the Mathematics curriculum that could be developed into ICT-aided lessons, an *innovating teacher*, replied, "Certainly, we can do a lot more, but we have problems with facilities."

The constraint on the choice of topics for integration is related to the frequency with which integration was carried out. The results of the survey disclosed that on the average, the teachers used integration lessons from 10 to 12 times a year. There was one teacher who claimed to have used a computer in teaching just once.

When asked what they thought was the ideal frequency for teaching computer-based lessons, a number of *innovating teachers* believed that it should be far more often than what they were actually doing. One said, "For me it should be more often, two to three times a week."

Barriers to integration

Of the 111 teachers who were surveyed, only 28 responded to the question about problems and concerns in integrating technology in Mathematics teaching. This was probably because most of the teachers did not have actual experience with integration of technology as a tool for enhancing instruction, thus they could not respond to the question meaningfully. Those who provided answers to this survey question included all the *innovating*, *planning*, and a few *non-user teachers.* Their responses were summarized in Table 7. Basic among the problems was the lack of computers and computer-based facilities such as LCD projector and Internet connection.

Table 7
ICT Integration Problems

Problem	n
• Lack of ICT facilities: computers, computer room, LCD projector, and Internet connection	17
• Lack of software	4
• Lacks basic computer competency	17
• Lesson preparation too long	2
Total	40

* *Total are more than 28 due to multiple responses.*

According to another innovating teacher, "Yes, we do have software, but the problem is that we lack facilities. You will still need more computer units for the entire class… You see, it is not enough that you have software."

Thus the lack of ICT facilities limited seriously the choice of topics that could be developed into a lesson, and, consequently, it also restricted the level of ICT application in teaching.

She continued, "Given the available resources, the only thing that we can do in class is make a PowerPoint presentation. You show figures on the screen… then, the students watch. They like the colors, but you cannot maximize their learning. They enjoy the presentation because for them it is something new." The other teachers had similar observations. For them, ICT-based lessons presented in this manner provided no more than superficial learning. According to some teachers, they preferred to engage the students in interactive activities, but this would require the latter to work on several computers but which were not available in the classrooms. When doing a PowerPoint presentation, the teachers would normally bring their own laptops to school.

The teachers also believed that the lack of computer skills prevented them from using the computer in teaching Mathematics. The teachers articulated the need for more training programs on computer operations during the informal interviews as well as in responding to the CARS. It will be noted in Table 2 that the CAR items that received the highest ratings were Item 2(wishing *for more computer training*, 3.63) and Item 10 (wishing *to learn more about computers and software routines*, 3.59).

The data collected on ICT training programs revealed the scarcity of professional development opportunities. For example, *out* of 111 teachers only 30 % were able to attend ICT training programs that were spread over a 15-year period, from 1994 to early 2009. The training contents are shown in Figure 1.

- Computer-aided teaching:
  IntelTeach to the Future, Text tot each, Micro lessons, Algebra through visual representations, Knowledge Networking (Korea)
- Using software to enhance understanding of math concepts through software such as Statistica, Blender , TOPED, sketchpad
- Developing presentations using PowerPoint, Hyperlink Computer literacy training: Balik-bayan Educational Caravan
- Locating new math lessons and more math software in the Internet
- Facilitating computation of grades using Excel and Visual Basics

Figure 1
Content of ICT Training Programs, 1994 - 2009

The training contents were varied and may be classified into general areas such as computer-aided teaching, use of software, PowerPoint presentation techniques, computer literacy, the Internet as source of teaching ideas, and using the computer for doing administration tasks.

While the teachers clamored for more training activities to enable them to use technology in teaching, attendance in training programs did not guarantee success in using ICT in the classroom. It will be observed that among the 33 teachers (30%) who attended training programs, only 13 teachers (12%) engaged in actual integration. What happened to the other 18%? Two things were possible: That the training opportunities were not sufficient to enable a teacher to use technology in actual teaching, and /or the content of the training programs had to be more responsive to specific pedagogical needs.

Conclusions

- Mathematics teachers from public secondary schools in Metro Manila have a very favorable attitude toward ICT integration. This is matched by a strong resolve to put this educational innovation to use.
- Teachers' computer attitudes are positively related to the availability of computer at home, and school population. The latter is related to school management. Teachers from large schools tend to have less favorable attitude toward the use of ICT.
- Teachers are very willing to implement ICT integration in their own teaching. This strong teacher support for ICT integration may be attributed to DepEd's influence and teachers' desire for recognition.
- However, despite the strong teacher support for ICT integration, its level of implementation is poor primarily due to lack of computer facilities, inadequate teacher computer competency and computer-based pedagogical skills.

Recommendations

- The government can take advantage of the Mathematics teachers' enthusiasm to bring technology into the classroom by providing them with the necessary tools and greater access to ICT-infused training programs.
- DepEd's channels of communication with teachers regarding ICT integration program in Mathematics can be maintained and exemplary integration accomplishments can be recognized.
- That a leadership training be conducted for school managers specifically on sustaining teacher motivation for ICT integration and sourcing funds from local initiatives; and
- Assistance be extended to teachers who wish to acquire a personal computer or laptop to help build basic computer competence and ICT pedagogical skills.

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Date received: October 2009

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