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INFORMATION SYSTEMS
EDUCATION JOURNAL

Information Technology Diffusion: Impact on Student Achievement

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Abstract

For student achievement, the diffusion and adoption of information technology (IT) infrastructure enabled by special funding was posited to have a positive impact on student achievement. Four urban school districts provided the context for this study to assess the impact of IT adoption on standardized test scores.

Keywords: E-Rate, student achievement gap, IT diffusion

1. INTRODUCTION

A significant amount of funding has been allocated by the Federal Communication Commission on infrastructure for Information Technology access in education to address a crisis in student achievement (Wise, 2008). The causality of the Information Technology access impact on student achievement is unclear. The infrastructure spending has been on Internet access, telecommunications, cabling, switches, and routers primarily for urban impoverished K-12 school districts (Arfstrom & Sechler, 2006) in order to reduce the digital divide between poor and affluent school districts. Through the E-Rate program (Jaeger, McClure, & Bertot, 2005) schools and libraries can purchase Internet access and telecommunication services at a discount (Universal Services Administrative Company (USAC), 2009). The focus of this study is to address if the IT Infrastructure afforded by the E-Rate program has had an impact on the student achievement gap.

2. THEORY

The objective of this research is to discern the impact of the diffusion of information technology on education in poverty stricken urban school districts. Swanson and Ramiller (1993) in their study of information research thematics reveal that research questions on information technology diffusion relate not only to the adoption of technology but to information systems implementation and organizational outcomes. The topics dealing with IT diffusion accounted for 13.6% of the research papers submitted. Lee, Lee, and Gosain (2004) pointed out no dominant framework exists in IS research after ranking 31 theoretical frameworks. The top category, economic theory, ranked first at 11.5% while IT diffusion and technology determinism combined ranked fifth at 5%.

Diffusion theory can be traced back to Everett M. Rogers' book, *Diffusion of Innovation,* first released in 1962. In its fifth edition (2003), Rogers defines diffusion as a process or a set of ideas that is disseminated through channels to members of a social system over a specified period. Rogers notes technological innovations have some benefits for potential adopters but the advantage is not as apparent to the intended audience. According to Rogers, diffusion transitions through five stages: knowledge, persuasion, decision, implementation, and confirmation. Closely associated with diffusion theory is the technology adoption model, pioneered by Fred Davis in 1989. The model outlines two basic parameters for adopting technology: perceived usefulness and perceived ease of use (Davis, 1989).

3. THEORETICAL BASIS of IT DIFFUSION

E. M. Rogers, a pioneer in classic diffusion theory, known for his book, *Diffusion of Innovation,* published in 1962, defines diffusion as a process in which an idea or innovation is communicated via a social network. Adoption or acceptance of an idea or process is dependent on the importance of the idea and space and time of the idea. The researcher insists adoption rate variance can be explained by five attributes: relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003). Relative advantage is a perception that a new idea or concept is better than an existing or older one. Compatibility is the degree to which a user perceives an innovation as being consistent with his or her world experiences. Complexity is a user's perception that an innovation is difficult to use and understand. Trialability is the degree to which an innovation can be tested before adoption. Observability is the degree to which an innovation appears to others. Four other attributes are important for rate of adoption: type of innovation, nature of communication channels diffusing the innovation, nature of the social system, and extent of change agent influence in diffusing the innovation.

Rogers categorizes adopters as innovators, early adopters, early majority, and laggards based on the rapidity of their adoption of a new idea, concept, or innovation. The researcher notes that computer networks have the capability to empower the underdogs of society. Rogers states the Internet has fueled interest in the study of diffusion in the analysis of communication networks in the diffusion process. Rogers contends computer networks have grown exponentially since 1990. The author credits this growth to the formation of the Internet. The Internet grew from 20 million computers in 1995 to over 500 million in 2002. The Internet represents the fastest diffusion or adoption rate in the history of humankind. Closely related to diffusion is user acceptance.

Davis (1989) researched factors associated with user acceptance of information technology. The researcher was interested in what caused users to accept or reject information technology. Davis focused his attention on two variables: perceived usefulness and perceived ease of use and concluded that perceived ease of use was the dominant factor.

Jeyaraj, Rottman, and Lacity (2006) examined the body of research on IT diffusion and adoption by individuals and organizations. They analyzed 48 empirical studies on individual and 51 studies on organizations published from 1992 to 2003. Their research showed the best predictors for individual IT adoption are perceived usefulness, computer experience, top management support, behavioral intention, and user support. The best predictors for organizational IT adoption are support by top management, external pressure, external information sources, and professionalism of the information systems division.

Not all researchers subscribe to the theory of diffusion. McMaster and Wastell (2005) dispute the concepts of diffusion as espoused by Rogers and other authors. Rogers (2003) defines diffusion as a process where innovation is communicated via various paths among members of a social system. The researchers contend the diffusionist view of the world is elitist where one distinguishes laggards from innovators thus creating a class distinction. They vehemently criticize the notion that there are a few innovators and that most people are imitators. This notion is central to diffusion theory. While the authors bring up some salient points, some of their points are extreme. They compare diffusion theory to early European colonialism. They contend there is no empirical support for diffusionism and that it has no basis in fact.

4. IT DIFFUSION RESEACH AND STUDENT ACHIEVEMENT

Schacter (1999) outlined the current research at that time regarding the impact of educational technology on learning. The author used the case study methodology in his paper. The report covered research on student achievement from 1994 to 1999. The document was published in 1999 and covers some of the large-scale state and national studies of that period. It also covered some of the innovative smaller studies such as the Apple Classrooms of Tomorrow (ACOT) and the Learning and Epistemology Group at MIT that provided insight for new and effective uses of technology in learning and instruction. The study highlighted by Schacter generally showed an increase in student achievement but not in all areas.

Cuban et al. took a contrary view by questioning the premise that buying technology such as hardware and software for schools will lead to high use by teachers and students thus improving teaching and learning. The researchers did a quantitative analysis of surveys and interviews of 21 teachers and students at two high-tech schools in Silicon Valley near San Francisco and San Jose, California. They observed the student to computer ratio had improved in public schools from 92 students to one computer in 1983-1984, to 27 students to one computer in 1989, and to 6 students to one computer in 1999. They also noted a similar trend in wiring of schools for Internet access, 3% in 1994 and 90% in 1999. The researchers' found that three-fourths of the teachers in both schools were non-users of technology in their curriculum as indicated by the use of media center resources in each school. Students reported low-level use such as word processing and Internet searches. Cuban et al. attempted to explain this paradox in two ways: "slow revolution" or slow adoption of technology and context of the high school that has historically been teacher-centered with established and difficult to change practices. They suggested that fundamental changes are needed in teaching practices in order to allow the diffusion of technology in schools.

D'Souza and Woods (2003) outlined the need for more technology when they examined the attitudes of students concerning the infusion of technology into mathematics at a secondary school in Australia. They contended that literature on the use of computers varied. They believed that technology should be integrated into education since the technology had become an essential part of society. The researchers used surveys of 95 Australian students for their study. The mathematics students in the study resisted new technology because there were too few working computers, computers not working properly, the difficulty of learning new software, and fear or lack of confidence using computers. The researchers concluded in order to have a successful technology implementation there should be adequate computer resources and training for students and teachers when developing a new curriculum.

Fuchs and Woessmann (2004) found a lack of IT diffusion involving student achievement and computer use at school. The researchers examined the relationship between student achievement and the employment of computers at school and at home. They based their study on an international student assessment test. The researchers employed the quantitative approach and concluded that computers produced a positive outcome in student achievement. Fuchs and Woessman analyzed the dataset from the Programme for International Student Achievement (PISA). The PISA is an international achievement test conducted in 2000 of 15-year-old students. The test was sponsored by the Organization for Economic Co-Operation and Development (OECD). The results of their analysis revealed after factoring in family background and school characteristics, the relationship is negative for student home computer use and is insignificant for student computer use in school.

Wenglinsky (2005) received mixed results on the issue of whether technology in school improves student achievement. The researcher employed the National Assessment of Educational Progress database and survey results to ascertain the link between computer use and student test performance. In the new study, based on 12^{th} grade students' performance on the U.S. history assessment, technology was not the most relevant factor. Socioeconomic status and student use of computers at home were more important determining factors. Wenglinsky found more frequent student use of computers at home for school work correlated to higher scores on the history assessment. The researcher found the opposite from computers used in schools. The author concluded in this study that using technology does not automatically translate into higher performance on an assessment. The researcher suggested that schools need to teach not only basic computer skills but also technology skills needed for future white-collar jobs.

On the issue of IT diffusion, Simpson, Payne, and Condie (2005) found teacher attitude was critical. The researchers discussed the effect of information computer technology (ICT) in secondary schools. The study was conducted on schools in Scotland. Scotland has invested large sums of money for technology in their school systems but had not seen the rewards of this investment. The researchers used surveys and semi-structured interviews as the methodologies to collect data. Although 75% of the schools had ICT committees, the committees did not have the power to enforce their recommendations. Attitude was a key factor for the lack of ICT integration. The finding by the researchers was that teachers did not want to engage with colleagues or with information outside of their profession regarding the technology. In addition, they noted teachers preferred face-to-face encounters for disseminating and receiving new information, the subject area head was the decision-maker in any subject matter, and the reluctance of the departments to change. A key finding was the autonomy of individual teachers in rejecting efforts to integrate technology into their curriculum. All of these reasons pointed to possible reasons for the lack of diffusion of ICT in the secondary school systems.

Norris, Sullivan, Poirot, and Soloway (2003) studied the impact of IT diffusion in kindergarten to 12th grade (K-12). The researchers used the case study methodology and surveys for their research tools. They analyzed 3,665 teacher responses collected from late 2000 and early 2001 from California, Florida, Nebraska, and New York. They surmised from their Snapshot Survey that 14% of U.S. K-12 teachers did not use computers at all for instructions, 45% used computers less than 15 minutes a week with students, and 18% of teachers used computers for instructions more than 45 minutes a week. Their survey also revealed that two-thirds of teachers used the Internet with students less than 15 minutes a day. The teachers surveyed stated the lack of available computers as the reason for little or nonuse of computers. The researchers deduced it would take at least six computers per classroom to effectively solve the problem. In addition, they noted the intermittent use of computer laboratories had no positive impact on technology adoption. They argued the low use of the Internet was directly tied to a lack of computer resources. In their concluding remarks, Norris et al. (2003) refuted the argument that a lack IT diffusion in schools is based on teacher attitude. They state emphatically that teachers' use of technology is based almost entirely on their access to technology.

Staples, Pugach and Himes (2005) differed with Norris et al. in their study of three urban elementary schools in the Midwest given identical resources in order to document the integration of technology. They used qualitative research methods to examine how technology resources made available through a grant were used. Although the principals voiced commitment for implementing technology and professional training was provided, the teacher commitment to technology integration in the classroom was tentative. The findings by the researchers were that technology must be aligned with the curriculum, teacher leadership was important to getting technology acceptance, and there must be recognition for students and teachers who embraced technology.

Schrum (2005) points out that despite the introduction of advanced technologies in schools; there has been minimal impact on school reform. The author claims business, medicine, and entertainment have evolved because of the digital revolution while schools have demonstrated sporadic progress. Schrum contends effective returns for future educational investments is possible if research captures past impact and paves a path for future use. The author strongly argued there has been no documented systematic increase in student achievement linked to technological innovation. Schrum attributed this to three factors: unrealistic expectations for technology-based reform, lack of consensus on research questions and methodologies, and diminished role of research in school reforms. The author recommended research focused on research questions not yet articulated, realistic expectations for instructional strategies, and a more focused research agenda.

Azzam (2006) disagreed with Schrum that technology had minimum impact on school reform. Azzam touted the benefits of technology-enabled opportunities. The author suggested that technology had the potential to improve student achievement. Azzam also suggested students with digital skills will do better in the job market. Statistics were cited that indicated Asian American and white young adults have double the access to the Internet than poorer ethnic groups. The author did not provide information on linkage of Internet to student achievement. The author however recommends that society invest in technology, create benchmarks, and ensure all children have access to technology at home, in the community, and at school. March (2006) however warned that the unsupervised use of the Internet has the potential for more harm than good for students. The author stated the "whatever and whenever" mentality induced by the Internet does not lead to happiness nor meaningful actions by students. Young adults wanting to avoid stress or boredom turn to the Internet for a distraction from real life. March claims this can lead to addiction to the Internet. The author advocated a strategy for all teachers that involved building a web portal to attract student interest and involvement in the more positive educational aspects of the World Wide Web.

Wan, Fang, and Neufeld (2007) presented an integrated framework of technology-mediated learning research and highlighted the information technology component and its effects with other factors. They broadly defined information technology in their study as computing, communications, data management technologies, and their convergence. The researchers focused their research on four groups of relationships that involve IT: (1) the relationship between IT and students and teachers; (2) between IT and instructional design; (3) between IT and the learning process; and (4) between IT and learning outcomes. Wan et al. (2007) concluded information technology was an important part in diverse learning environments. The researchers recommended the need for research in several areas: (1) using non-student research subjects, (2) exploring the social nature of learning, (3) examining IT infrastructure and its effect on the learning environment, (4) investigating the applicability and efficacy of new learning models, and (5) examining learning processes and how they are facilitated by IT.

5. TECHNOLOGY AND THE DIGITAL DIVIDE

The digital divide refers to those that have access to technology and those that do not have access primarily because of an economic and social gap. Kennard (1999) called for federal support to reduce this divide when he was the chairperson of the Federal Communications Commission (FCC). With implementation of the Telecommunications Act of 1996 the FCC was directed to bring advanced technology to the nation's public schools and libraries. In 2004 Jayakar discussed the success of this initiative in term of the education rate (E-Rate) of these initiatives targeted at low income applicants, high cost areas, rural health care providers, and libraries mandated by Congress in the 1996 Telecommunications Act in order to bridge the technology gap between rich and poor communities. Schools received discounts ranging from 20 % to 90 % based on the number of their students enrolled in the national school lunch program. Then this money was spent on IT infrastructure such as telecommunication services, the Internet, and internal wiring or cabling. This successful program resulted in an investment of $1.7 billion in information technology infrastructure in over 80,000 schools.

Research has been mixed concerning the linkage of IT on student achievement and inconclusive on whether the E-Rate program has improved student achievement or narrowed the digital divide. Some researchers question the value of IT on student achievement (Cuban, Kirkpatrick & Peck, 2001) and question the assertion that buying technology such as hardware and software for schools will lead to effective use by teachers and students thus improve the learning environment

Ward (2005) analyzed the E-Rate program in Texas and its impact on public schools from 1994 to 2003. Ward's (2005) study revealed more teachers were allocated to E-Rate subsidy schools than non-E-Rate schools and the overall average college entrance scores (ACT and SAT) of E-Rate schools dropped. Ward theorized that the E-Rate subsidy motivated schools to encourage more marginal students to take the college entrance exams thus triggering a drop in average college entrance scores.

On the other hand, Arfstrom and Sechler (2006) laud the results of ten years of the E-Rate program. The authors point out the E-Rate program has provided almost $19 billion to schools and libraries. They claim that the E-Rate has been responsible for increasing Internet access in public schools from 14 % in 1996 to 94 % in 2005.

There has been little empirical research ascertaining whether the E-Rate program by providing better IT infrastructure improvements in impoverished urban school districts has narrowed the digital divide and has improved student achievement as measured on standardized nation-wide tests. Recently, the Government Accountability Office [GAO] reported the Federal Communications

Commission (FCC), which monitors the E-Rate program, lacks adequate performance goals and performance measures (U. S. Government Accountability Office (GAO), 2009).

There are very few current studies that link technology diffusion in secondary schools to student achievement as measured on a nation-wide standardized test such as the SAT or ACT. The studies that do exist are dated, very limited in scope, lack generalization, or lack empirical validation (Cuban et al., 2001; Goolsbee & Guryan, 2006; Schacter, 1999; Simpson et al., 2005; Ward, 2005; Wenglinsky, 2005). In addition, results of research on IT diffusion in education have been inconclusive. Chin and Marcolin (2001) argue success measures linked to diffusion should be the focus of future research and there needs to be a tighter relationship between diffusion and its performance impact. Schrum (2005) strongly articulates the need for focused research in this area since there has been no documented systematic increase in student achievement linked to technological innovation. This study (Lee and Lind, 2010) will discern whether there is an impact, linkage or correlation between IT funding levels and student achievement. The research will also add information to the debate on whether there is a correlation between IT diffusion and student achievement.

The literature is inconclusive on the effect of IT diffusion or adoption in an educational environment. Schacter (1999) found that IT diffusion was sufficient to improve student performance in an educational setting. Early research by Cuban, Kirkpatrick and Peck (2001) disagreed with Schacter's findings and suggested the infusion of technology (computers and wiring for Internet) into high schools had no effect on student achievement. Similar findings were supported by Simpson, Payne and Condie (2005) in their case study of secondary schools in Scotland and by D'Souza and Wood (2007) in their case study of secondary math students in Australia. Wenglinsky (2005) directly associated the use of technology to student achievement but his results were mixed. Norris, Sullivan, Poirot, and Soloway (2003) in their study of the impact of IT diffusion in kindergarten to 12th grade (K-12) found the lack of IT resources was a detriment to IT diffusion not teacher attitude. This study will add to the body of knowledge on the dynamic nature of IT and student achievement.

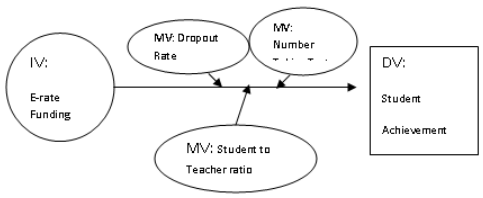
The FCC and other federal agencies that allocate monies to schools, specifically the E-Rate program, should know which programs are effective and which ones are not. This study is significant since massive amounts of federal monies are funneled to poverty stricken urban school districts for IT infrastructure each year with the inferred hope that it would spur student achievement. The GAO reports reveal a lack of accountability in this area. This study provides an initial baseline for assessing the effectiveness of the E-Rate program.

6. THE STUDY

For this study, information was obtained on IT federal funding to school districts over the last twelve years from the FCC through the E-Rate program. The study centered on school districts primarily in Los Angeles, California, Chicago, Illinois, Philadelphia, Pennsylvania, and Houston, Texas so the study could be generalized to other urban school districts throughout the United States receiving E-Rate funds. Test scores for students were collected from these selected school districts from the California Department of Education, Texas Education Agency, Illinois Department of Education, Pennsylvania Department of Education, and National Center for Education Statistics (NCES) as appropriate. To discern student achievement, the study measured scores in urban impoverished, affluent, non-impoverished schools as well as impoverished school districts to determine if changes that occur in each are similar or different. Since the four largest urban school districts are basically classified as urban impoverished entities based on their high percent of students in the free and reduced lunch (> 75%), four affluent school districts with a low percent (<15%) of students in the free and reduced lunch were selected for comparison. This served as a baseline of comparison.

Other collocated school districts (86) classified as impoverished and non-impoverished were analyzed in the study to determine if they followed similar patterns. School size, teacher to student ratio, and dropout rate were considered since they were potential moderating variables in the study (see Figure 1). Socioeconomic factors were accounted for by identifying the percent of students in each school district eligible for the federal free and reduced lunch program. In the quantitative study, the E-Rate funding was the independent variable, student achievement was the dependent variable, and number of students taking test, dropout rate, and student-to-teacher ratio were the moderating variables (Figure 1).

Figure 1 Research Model



7. RESEARCH DESIGN

The units of analysis for the study are the identified school districts. School districts were selected because E-Rate funding is primarily allocated by school district rather than individual school. School districts were selected because a more detailed analysis of student achievement based on the SAT and ACT is possible. There were several sources of data for the proposal. The first source was the U.S. Department of Education National Center for Education Statistics (NCES). This site contains information on student/teacher ratio and information on school districts (Institute of Education Sciences (IES), 2009). This information is online and free. The second sources of data were the Scholastic Aptitude Test (SAT) and American College Test (ACT). Information on aggregate school district SAT and ACT scores were obtained from the California Department of Education, Illinois Department of Education, Pennsylvania Department of Education, and Texas Education Agency Web sites. The third source of data was FCC's Schools and Libraries Division (SLD) information site at http://www.e-ratecentral.com/. This site contains information on which libraries, school districts, and schools have qualified and received IT infrastructure funding. The E-Rate discount rate based on a school district's free and reduced lunch program eligibility is available. The site also contains information on how the E-Rate funds are distributed for internal connections (cabling and equipment), Internet access, and telecomm (telephone service and wide area connectivity). A baseline for student achievement was established by assessing scores in urban impoverished, affluent, impoverished, and non-impoverished school districts to form a baseline for comparison. This process was accomplished by comparing school districts with a low percent of students in the national free and reduced lunch program to those with a higher percent in the program. The E-Rate program has traditionally fully funded urban school districts at the 80% or more free and reduced lunch eligibility level but has rarely fully funded those at the 20% or less level (E-Rate Central, 2009). Based on this observation, urban impoverished school districts were classified as those that have 80% or more students eligible for the free and reduced lunch program. Similarly, affluent school districts were defined as those that have less than 20% of their student population eligible for the free and reduced lunch program. The primary sources of information for free and reduced lunch data were the state educational web sites (California Department of Education, 2009; Illinois State Board of Education, 2009; Pennsylvania Department of Education, 2009; Texas Education Agency, 2009) and the SLD.

8. SAMPLE/DATA COLLECTION

The sample size for the school districts in the study was the eight primary urban impoverished and affluent school districts and the 86 collocated school districts near or within the same county as the major urban school districts. The 94 school districts in the study represented 801 high schools. The four urban impoverished school districts accounted for 411 or 51.3% of all high schools. The additional collocated school districts had the potential to refute or support findings from the initial sample. In addition, the collocated school districts were used as a control group to contrast any differences. The major urban impoverished school districts were Los Angeles Unified School District (SD), Chicago Public Schools, School District of Philadelphia, and Houston Independent School District (ISD). The selected affluent school districts were Irvine Unified SD in Irvine, CA, Central Bucks School District in Doylestown, PA, Clear Creek ISD in League City, TX, and Glenbard Township School District in Glen Ellyn, IL. Each of the selected affluent school districts had an average free and reduced lunch eligible population of less than 15% while the urban impoverished districts' numbers ranged from 75% to more than 90% (California Department of Education, 2009; Illinois State Board of Education, 2009; Pennsylvania Department of Education, 2009;

Texas Education Agency, 2009). All of the school districts were analyzed to discern changes in achievement gap. In order for the study results to be generalizable, geographically dispersed urban school districts were selected from the West (Los Angeles Unified), Midwest (Chicago Public Schools), East (The School District of Philadelphia), and Southwest (Houston ISD). All of the selected impoverished school districts are among the ten largest in the U.S. (Institute of Education Sciences [IES] National Center for Education Statistics, 2009). Each state where these districts are located is also an active participant in the E-Rate program (E-Rate Central, 2009). Some of the information such as the number of students testing was derived from raw data.

While the school districts selected were not completely random nevertheless the study should have reliability and validity for other urban school districts meeting the same or similar criteria. The California Department of Education, Chicago Public Schools, Illinois Department of Education, Pennsylvania Department of Education, and Texas Education Agency provide historical ACT and SAT scores for school districts to the public for research and other purposes therefore approval was not required from the College Board nor ACT, Inc. The strength of this strategy is the study employed data already collected by the SLD, educational entities, and National Center for Education Statistics.

9. DATA ANALYSIS

The study employed a pretest-posttest design to discern any changes between the groups based on the E-Rate program. Specifically, the study used the Solomon four-group design which permitted the authors to analyze the magnitude of effects caused by pretesting, history, maturation, and treatment. The pretest groups were the urban impoverished, affluent, impoverished, and non-impoverished groups before the effects of the E-Rate program (1997-2000). The posttest groups were the same groups after the effects of the E-Rate (post 2000). The study employed the analysis of variance (ANOVA) on gain scores. The study used descriptive statistics to analyze school size, school district student to teacher ratio, dropout rates, assessment tests, and E-Rate data. Then correlation and regression analysis was used to test the hypotheses. The results of the study ascertained the level of impact of E-Rate federal funding on student achievement and the achievement gap. It also discerned whether there was any moderating factors based on the variables identified that affected this result.

10. METHODOLOGY

The period for the study was 1997 to 2008. The four groups were urban impoverished, affluent, impoverished, and non- impoverished. The pretest period was 1997 to 2000. Although the Schools and Libraries started dispensing funds in 1998, some major school districts such as the Schools of Philadelphia did not take advantage of the program until 2000. In addition, according to previous research by Goolsbee and Guryan (2006), there can be a significant lag time before the results of E-Rate funding materialize. Based on this research E-Rate results would be expected two or more years after funding because of implementation of the IT infrastructure and integration into the school district's curriculum.

Pre-E-Rate Analysis

Using SPSS, a bivariate correlation was run on the variables for the pre-E-Rate group (1997-2000). There was a significant negative correlation of -.231, -.248, -.234 and -.250 at the 0.05 level between school size and SAT scores for 1997, 1998, 1999, and 2000. This indicated the larger the school district, the lower the SAT scores. There was a significant negative correlation of -.672, -.699, -.703, and -.700 at the 0.01 significance level for E-Rate discount and SAT scores for 1997, 1998, 1999 and 2000. This suggested socioeconomic factors based on the free and reduced lunch program were negatively correlated with SAT scores. Student to teacher ratio and number of students tested while slightly negative did not exhibit significant correlation with SAT scores. Number of students testing was correlated with the E-Rate discount at the 0.05 significance level at .234, .232, .226 and .212 for 1997, 1998, 1999 and 2000 respectively. These results show a higher E-Rate discount was positively related to the number of students testing. This supported Ward's observation that higher E-Rate funding levels stimulated a higher number of students testing. Number of students testing however was not correlated with SAT scores at a significant level. Dropout rate was significant and negatively correlated with SAT scores. The 1997 dropout rate was correlated with SAT97, SAT98, and SAT99 at the 0.01 significant level at -.605, -.605, and -.585 respectively. The 1998 dropout rate was correlated with SAT98 and SAT99 at the 0.01 significant level at -.520 and -.566 respectively. The 1999 dropout rate was correlated with SAT99 at the 0.01 significant level of -.637 and 2000 dropout rate was correlated with SAT00 at the 0.01 significant level of -.633. These results suggest school districts with higher dropout rate have lower SAT scores. Dropout rate also relate to socioeconomic factors.

The One-Way Analysis of Variance or ANOVA was used to analyze the data since the study involves examining the sample means of SAT scores for different categories of school districts receiving E-Rate funds and drawing conclusions about the resultant SAT means. The ANOVA requires the data to be independent and normal with equal variances (Norusis, 2008). The data for each district is independent since SAT scores are not dependent upon scores in other districts – this was examined with histograms and boxplots available from the 1st author.

The Levene's Test of Homogeneity was employed to determine equal variance. Large significances above .5 show equal variance (Norusis 2008). Table 1 shows equal variance for most of the years of SAT testing. The df1 or degrees of freedom one (3) is the number of categories (4) minus one. The df2 or degrees of freedom two is the total number of districts (94) minus four, one from each category. The requirements to proceed with ANOVA are fulfilled by SAT scores being independent and normal with equal variance.

Table 1. *Test of* Homogeneity *of Variances*

	Levene Statistic	df1	df2	Sig.
SAT97	2.959	3	90	.037
SAT98	1.554	3	90	.206
SAT99	1.654	3	90	.183
SAT00	.772	3	90	.513
SAT01	2.490	3	90	.065
SAT02	.550	3	90	.649
SAT03	.987	3	90	.403
SAT04	.424	3	90	.737
SAT05	.192	3	90	.902
SAT06	.338	3	90	.798
SAT07	.197	3	90	.898
SAT08	.802	3	90	.496

The One-Way ANOVA run on the pre-E-Rate (1997-2000) dataset revealed F=25.363 at sig=.000 for SAT97, F=25.127 at sig=000 for SAT98, and F=25.972 at sig=.000 for SAT99, and F=25.001 at sig=000 for SAT00. The significant values demonstrate the mean comparisons were significant for 1997 through 2000. The Post Hoc Test confirms this observation. The Post Hoc Test reveals some noteworthy comparisons. The mean comparison for SAT scores between urban impoverished and affluent districts (primary groups) was -223.25, -229.75, -230.0, and -238.0 significant at the 0.05 level for SAT97, SAT98, SAT99, and SAT00 respectively. The mean comparison between the impoverished and non-impoverished districts was -111.791, -117.047, -127.488 and -120.558 significant at the 0.05 level for SAT97, SAT98, SAT99, and SAT00 respectively. The trend demonstrated a slow but widening gap of SAT scores between urban impoverished and affluent districts between 1997 and 2000 where the gap widened from -223.25 points to -238.0. A similar trend was noted between impoverished and non-impoverished districts where the gap widened from -111.791 in 1997 to -120.558 points in 2000.

Post E-Rate Analysis

Table 2. *Correlation of E-Rate Funding and SAT Scores*

	SAT01	SAT02	SAT03	SAT04	SAT05	SAT06	SAT07	SAT08
E-Rate98	-.306**	-.291**	-.173	-.260*	-.243*	-.219*	-.236*	-.229*
E-Rate99	-.306**	-.299**	-.180	-.263*	-.249*	-.227*	-.240*	-.233*
E-Rate00	-.320**	-.324**	-.197*	-.280**	-.276*	-.254*	-.255*	-.247*
E-Rate01	-.288**	-.259*	-.165	-240*	-236*	-.228*	-.226*	-.234*
E-Rate02	-.303**	-.287**	-.179	-.280**	-.282*	-.256*	-.275**	-.255*
E-Rate03	-.245*	-.221*	-.147	-.226*	-.221	-.211*	-.232*	-.217*
E-Rate04	-.277**	-.267**	-.169	-.252**	-.253	-.230*	-.233*	-.224*
E-Rate05	-.269**	-.255*	-.153	-.229*	-.223*	-.213*	-.234*	-.219*
E-Rate06	-.308**	-.297**	-.180	-.266**	-.255*	-.241*	-.259*	-.247*
E-Rate07	-.227*	-.209*	-.126	-.191	-.181	-.177	-.195	-.188
E-Rate08	-.281**	-.258**	-.164	-.245*	-.241*	-.233*	-.258**	-.239*

**. Correlation is significant at the 0.01 level (2-tailed0
*. Correlation is significant at the 0.05 level (2-tailed)

Bivariate correlation of variables was run on the post-E-Rate (2001-2008) dataset. This dataset included E-Rate funding. The correlation results revealed similar findings on school size, and E-Rate discount, and SAT scores. Large district size was negatively correlated with SAT scores. The E-Rate discount indicated socioeconomic factors based on the free and reduced lunch program correlated negatively with SAT scores. Student to teacher ratio and number of students tested while slightly negative did not exhibit significant correlation with SAT scores. The number of students tested was positively correlated with E-Rate funding at the 0.01

significance level for 2001 to 2008, varying from .535 to .931. These results show that higher E-Rate funding was positively related to the number of students testing. There was a negative correlation between E-Rate funding and SAT scores from 2001 to 2008. This summary information is highlighted in Table 2.

These results can be interpreted several ways. One researcher (Ward, 2005) suggested that E-Rate funding had a negative impact on SAT scores because it motivated more students to test. Another interpretation is that larger E-Rate funding went to school districts that traditionally score lower on the SAT test versus more affluent or non-impoverished school districts with less E-Rate funding.

Table 3 shows the mean SAT scores for each category of school district from 1997 to 2008. There has been little change in each category. Urban impoverished school districts had a period from 2003 to 2008 where there was minor SAT improvement of .69%, .57%, .46%, .58%, .58%, and 1.04% respectively from 1997. This was a change from a steady decline of from 1997 to 2000 of -.115%, -.347%, and -1.042 in 1998, 1999, and 2000 respectively.

Table 3. ***Mean SAT Scores 1997-2008***

Year	Urban Improv	Affluent	Impov	NonImpov
1997	864	1087	932	1044
1998	863	1092	935	1052
1999	861	1091	925	1052
2000	856	1094	924	1044
2001	859	1078	920	1063
2002	860	1080	918	1054
2003	870	1089	900	1054
2004	869	1091	926	1057
2005	868	1091	928	1061
2006	869	1098	923	1049
2007	869	1092	928	1053
2008	873	1089	919	1058

Table 4 shows the mean differences or gap for SAT scores between the various school district categories. All of the means were significant at the 0.05 level. The result shows a widening of the SAT gap between urban impoverished and affluent school districts increasing from-223.25 in 1997 to -238 in 2000. The gap narrowed slightly starting in 2001 and maintained a positive trend except for 2005 when it slipped -.335% and 2006 when it fell -2.57%. The overall trend was positive culminating in a +3.47% in 2008 when compared to the 1997 SAT gap. Unlike the urban impoverished and affluent school districts, the gap between impoverished and non-impoverished school districts never improved or exceeded the 1997 SAT gap. The mean average SAT score for the urban impoverished school districts was at a 12-year high in 2008 (+1.041%) and the gap between affluent school districts was at a 12-year low (+3.47) using 1997 as the baseline year. A summary of the significant gains and losses is shown in Table 5.

Table 4. ***ANOVA Post Hoc Mean Differences 1997-2008 SAT Scores***

	Urb/Affl	SAT Gap since'97	Imp/ Non-Imp	SAT Gap since'97
'97	-223.25	0	-111.791	0
'98	-229.75	-6.5	-117.047	-5.256
'99	-230	-6.75	-127.488	-15.697
'00	-238	-14.75	-120.558	-8.767
'01	-218	+5.25	-143.05	-31.259
'02	-219.75	+3.5	-136.14	-24.349
'03	-218.5	+4.75	-153.79	-41.999
'04	-221.75	+1.5	-131.628	-19.837
'05	-224	-.75	-132.93	-21.139
'06	-228	-5.75	-126.047	-14.256
'07	-222.75	+.5	-124.721	-12.93
'08	-215.5	+7.75	-138.488	-26.697

Table 5. ***E-Rate Funding 1997-2008***

	Urban Impov	Affluent	Impoverished	Non Impov
E-Rate98	$18,910,561.75	$135,756.00	$1,020,603.49	$83,670.21
E-Rate99	$39,001,565.00	$94,840.00	$1,208,115.49	$106,529.88
E-Rate00	$27,773,048.00	$130,202.75	$1,400,259.95	$63,264.44
E-Rate01	$47,077,809.00	$155,204.50	$1,527,777.00	$78,572.35
E-Rate02	$37,633,302.00	$134,926.75	$1,149,118.88	$81,423.60
E-Rate03	$60,055,459.75	$136,970.00	$1,172,323.70	$91,208.98
E-Rate04	$37,342,813.00	$148,587.50	$1,071,467.47	$96,026.72
E-Rate05	$37,230,749.50	$150,369.50	$1,135,617.37	$127,606.30
E-Rate06	$30,365,988.75	$212,318.25	$902,440.93	$139,960.37
E-Rate07	$49,261,999.00	$202,213.50	$978,334.14	$135,579.05
E-Rate08	$31,689,157.25	$193,258.50	$943,463.33	$164,020.51

Figure 2 graphically shows the SAT achievement for all of the categories. The changes are hard to discern because they are small. SAT scores in general have remained flat for all school district categories.

Figure 2. SAT achievement gap 1997-2008

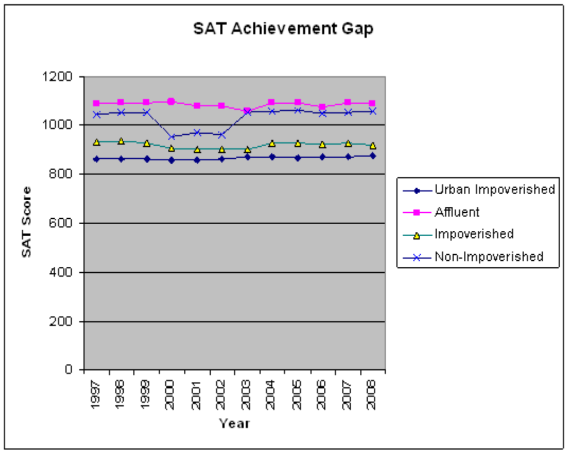
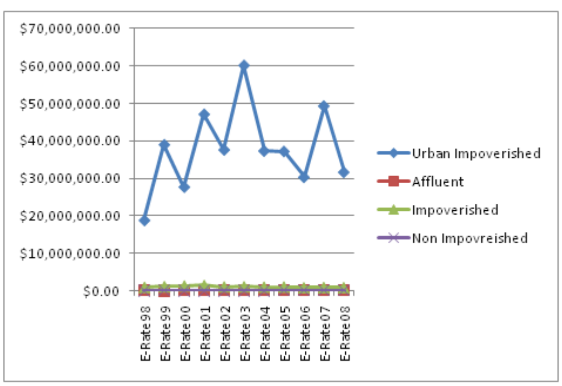


Table 5 summarizes the average funding for the various categories of school districts and Figure 3 graphically illustrates this funding level. E-Rate funding to urban impoverished school districts peaked in 2003. The graph shows the stark differences between the urban impoverished school districts and the other categories which varied from 18 to over 30 times more than the other categories combined. See Table 5.

There were no significant changes in dropout rate for urban impoverished school districts to merit the increase in SAT scores. An examination of the mean in Table 6 for dropout rate between 1997 and 2008 revealed that dropout rate had worsened from 1997.

Figure 3. E-Rate funding by school district category



Since dropout rate was negatively correlated with higher SAT scores, it would be expected there would be a drop rather than an increase in SAT scores. Table 6 conveys this information. The conclusion is dropout rate was not a factor in the SAT increase. The other factors such as student to teacher ratio and number of students testing were insignificant statistically according to the ANOVA analysis.

Table 6. Dropout Rate (%)

	Urban Imp	Aff	Impov	Non-Imp
Drop97	9.83	4.2	8.01	2.90
Drop98	16.72	4.8	10.59	4.04
Drop99	16.65	2.38	9.43	3.04
Drop00	15.1	2.02	8.61	3.08
Drop01	14.35	1.95	9.3	2.46
Drop02	15.77	1.5	8.08	3.88
Drop03	16.82	1.55	8.73	3.24
Drop04	13.22	1.4	8.92	3.58
Drop05	13.56	1.58	10.56	3.32
Drop06	15.12	1.72	14.05	5.96
Drop07	13.7	1.78	15.01	4.35
Drop08	15.8	1.6	15.27	4.82

11. SUMMARY OF FINDINGS

The hypothesis that increased funding had no impact on student achievement is not supported by the data because of the increase in SAT scores from 2003 (+.69%) to 2008 (+1.041%) when compared to 1997. Increased funding most likely accounted for SAT improvements from 2003 to 2008 for urban impoverished school districts because similar gains were not evident in the other school district categories except the non-impoverished category. Affluent school district SAT scores climbed +.183% in 2003 and remained steady at +.183% in 2008 when compared to 1997 SAT scores. Impoverished school districts fell by -.3.43% in 2003 and -1.39% in 2008 in comparison to 1997. The non-impoverished school districts showed a rise in 2003 of +.96% and rise of 1.34% in 2008. Non-impoverished school districts without massive E-Rate funding showed a steady decline from 1997 SAT scores. There appears to be an impact from E-Rate funding but it was small and almost imperceptible for urban impoverished school districts. In any case, SAT scores for the urban impoverished school district category were at a 12-year high in 2008.

Hypothesis 2 that the E-Rate program has not narrowed the student achievement gap between poor and affluent schools as measured on nation-wide assessment tests is not supported by the data. The achievement or SAT gap began narrowing in 2001 (+2.35%) and continued to make progress to 2008 (+3.47%) between urban impoverished and affluent school districts. There was no mirrored or similar improvement in impoverished versus non-impoverished school districts when compared to SAT 1997 scores. The gap between these categories fluctuated between -4.4% and -26.6% below the 1997 baseline. E-Rate funding may not have had a great effect on the achievement gap but it may have been enough to slightly improve and prevent further degradation of SAT scores and deterioration of the student achievement gap for urban impoverished school districts. In any case, the gap was at a 12-year low between urban impoverished and affluent school districts in 2008 indicating noteworthy progress.

12. DISCUSSION OF RESULTS

The purpose of this study was to examine the effect of E-Rate and its impact on student achievement. Student achievement was defined as scores on the SAT and ACT. The E-Rate is a program that funds IT infrastructure projects such as the Internet and network wiring for schools. Variables for the study included SAT scores, student-to-teacher-ratio, number of students testing, dropout rate, and E-Rate funding. Education data was gathered primarily from state educational databases and the National Center for Education Statistics. E-Rate data was assembled from the FCC's Schools and Libraries Division (SLD). The SLD is charged with administering the E-Rate program. There was a total of 94 geographically separated school districts in the study representing 801 high schools categorized into urban impoverished, affluent, impoverished, and non-impoverished. The urban impoverished school districts included Los Angeles Unified, Chicago Public Schools, Houston Independent School District, and the School District of Philadelphia. The urban impoverished school districts had a free and reduced eligibility population greater than 80%. The affluent schools districts included four school districts with free and reduced eligibility population of less than 15%. The impoverished school districts included 43 school districts collocated (same county) with the urban impoverished school districts with a free and reduced eligibility population greater than 50%. The non-impoverished school districts included 43 school districts collocated with the urban impoverished school districts with a free and reduced lunch eligibility population of less than 50%. Data collected covered a 12-year period from 1997 to 2008. The following questions motivated the study:

1. What has been the impact of the E-Rate program that has funneled over $18 billion dollars in IT infrastructure (Arfstrom & Sechler, 2006) for impoverished urban school districts on student achievement in secondary schools as measured on nation-wide assessment tests such as the Scholastic Aptitude Test (SAT) and American College Test (ACT)?
2. To what extent has the E-Rate narrowed the student achievement gap between poor and affluent schools as measured on nation-wide assessment tests such as the SAT and ACT?

In response to the first question, there has been progress on SAT scores in the post E-Rate period. If the 1997 baseline year is used, then progress started in 2003 when SAT scores exceeded the 1997 level. There was improvement in the urban impoverished school districts versus the affluent and impoverished school district categories. The SAT scores for urban impoverished increased from +.69% in 2003 to +1.042 in 2008 when compared to 1997. The SAT scores for urban impoverished school districts were at a 12-year high in 2008. No comparable increase in SAT scores was evident in the other categories except for the non-impoverished school district category. Affluent school district SAT scores climbed +.183% in 2003 and remained stable at +.183% in 2008 when compared to 1997 SAT scores. Impoverished school districts declined by -.3.43% in 2003 and -1.39% in 2008 in comparison to 1997. The non-impoverished school districts showed a rise in 2003 of +.96% and rise of 1.34% in 2008. In response to the second question, there was a narrowing of the achievement gap between poor (urban impoverished) and affluent school districts between 2001 and 2008 except for slippages in 2005 and 2006. The urban impoverished districts reduced the gap between affluent school districts by 2.35% in 2001 and 3.47% in 2008 using 1997 as the baseline year. The achievement gap between urban impoverished and affluent school districts was at a 12-year low in 2008. There was no similar narrowing of the student achievement gap between the other categories. The gap between impoverished and non-impoverished never declined from the 1997 level. The gap has fluctuated between -4.4% and -26.6% below the 1997 baseline.

13. CONCLUSIONS

The results of the study are in contrast to research results by Cuban, Kirkpatrick, and Peck (2001) and Wenglinsky (2005) that showed technology in schools does not improve student achievement. Ward (2005) who studied the impact of the E-Rate in Texas from 1994 to 2003 noted no improvement in SAT scores. Goolsbee and Guryan (2006) also studied effects of the E-Rate program from 1996 to 2001 in California and found no impact. This study contradicts Ward's and Goolsbee and Guryan's findings since improvement albeit small was observed starting in 2003. The methodology used in this study most likely accounted for this disparity. The school districts in this study were segmented and categorized therefore there was greater focus on the urban impoverished school districts. If school districts are not categorized as in this study then changes in SAT scores could be masked by the total numbers.

E-Rate is an IT specific initiative that had as its goal to narrow the achievement gap and it has achieved this goal in a limited fashion. The pre-E-Rate period (1997-2000) was a time period of slipping SAT scores (-.92%) and widening of the achievement gap (-6.6%) between urban impoverished and affluent school districts. The post E-Rate era (2001-2008) exhibited a reversal of the trends initiated in the pre-E-Rate period. The achievement gap narrowed between urban impoverished and affluent school districts by +3.47% between 1997 and 2008. In contrast, the gap between impoverished and non-impoverished school districts increased by -23.88% between 1997 and 2008. The results in this study support the contention that there has been some IT diffusion into the aforementioned urban impoverished school districts. Perhaps the gap between urban impoverished and affluent school districts would have been less positive without the impact of the E-Rate program.

14. RESEARCH CONTRIBUTIONS

With the exception of the studies by Ward, Goolsbee and Guryan, and Imazeki and Reschovsky, there are very few known studies that have attempted to quantify the effect of the E-Rate program on student achievement through empirical research. There has been a lack of credible measurement factors of the success of the E-Rate program as critiqued by the GAO. Nevertheless, billions of federal monies are funneled to poverty stricken urban school districts for IT infrastructure each year with the inferred hope that these funds spur student achievement (Arfstrom & Sechler, 2006). This study addressed the linkage between funding levels and student achievement. In addition, results of research on IT diffusion in education have been inconclusive where Chin and Marcolin (2001) stated that success measures linked to diffusion should be addressed and Schrum (2005) strongly argued that there was little documented systematic increase in student achievement linked to technological innovation and called for research in this area. Wan et al. (2007) concluded information technology was an important part in diverse learning environments but there was a particular need to examine the IT infrastructure and its effect in the learning environment

This research added information to the debate on whether there is a correlation between IT diffusion and student achievement by addressing some of the recommendations of past researchers (Chin & Marcolin, 2001; Schrum, 2005; Wan et al., 2007). These results provide important results to the FCC and other federal agencies that allocate monies to schools, specifically the E-Rate program in assessing effectiveness of these programs. GAO reports reveal a lack of accountability in this area. This study provided an initial baseline for assessing the effectiveness of the E-Rate Program. The study also showed a narrowing of the digital divide resulting from the E-Rate program.

15. POTENTIAL BIASES

There are several potential biases in the study from a methodological perspective. One potential bias is the selection of the urban areas for the study may not be representative of other urban areas that receive E-Rate funding in spite of the geographical dispersion. A second potential bias is the selection of the ACT and SAT may not be the best parameters to measure student achievement across various school districts. The third bias is there is an assumption that there has been some degree of integration of IT diffusion into the curricula based on the high level of targeted funding. There are also potential biases inherent in diffusion of innovations theory as outlined by Rogers (2003). The first implied assumption is a pro-innovation bias where the innovation or new idea is positive and will be readily adopted by users. Another bias from diffusion theory as articulated by McMaster and Wastell is the delineation of laggards from innovators is an arbitrary concept and not completely supported in empirical research. The researchers also contest the opinion that the majority of adopters are imitators. The researchers insist diffusion studies have been slanted toward innovation successes rather than failures.

16. RECOMMENDATIONS FOR FUTURE RESEARCH

The study needs expansion to include the impact of E-Rate on SAT scores for the top 50 urban school districts versus the four in this study to determine if the results from this study would be supported. A possible road block for a broader study would be obtaining permission to use the performance data since some states treat SAT scores and school district data as confidential data. Another potential research topic could be an in-depth analysis of the impoverished urban school districts between 2001 and 2007 to pinpoint what had been implemented to improve student achievement. This would involve surveys of the urban impoverished school districts to determine things such as what IT technology was established and how the technology was used in the curriculum.

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