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# Young children's computer skills development from kindergarten to third grade

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ABSTRACT

This investigation explores young children's computer skills development from kindergarten to third grade using the Early Childhood Longitudinal Study–Kindergarten (ECLS–K) dataset. The sample size of the study was 8642 children. Latent growth curve modeling analysis was used as an analytical tool to examine the development of children's computer skills using LISREL software version 8.80. Results indicated, not surprisingly, that the availability of a computer at home and a high socio-economic status were statistically significant predictors of children's baseline computer skills in kindergarten. The availability of computers in kindergarten, however, was a statistically significant predictor of the development of children's computer skills from kindergarten to third grade. Although there was no difference between girls and boys in their baseline computer skills in kindergarten, the rate of development in computer skills was higher for girls than boys. Results suggest that the availability of an adequate level of computers in kindergarten classrooms can help close the initial gap in children's computer skills due to socio-economic status and lack of computer access prior to entering school. Supplying kindergarten classrooms with adequate computers could positively contribute to children's long-term development of computer skills.



## 1. Introduction

Computers have increasingly become a regular component of American classrooms, with the ratio of computers to children in the US increasing to one computer to every four children over the last two decades (Russell, Bebell, O'Dwyer, & O'Connor, 2003). Although some researchers question the effectiveness of computer-based instruction (Carlsen & Andre, 1992; Clark, 1994; Yaman, Nerdel, & Bayrhuber, 2008), a growing body of literature provides increasing evidence of the effectiveness of using computer technology to facilitate instruction and learning across a variety of school subjects (Bayraktar, 2002; Clements, 2002; Kulik & Kulik, 1991; McKenney & Voogt, 2009; Mioduser, Tur-Kaspa, & Leitner, 2000; Trundle & Bell, 2010). National academic content standards identify the use of technology among the skills that students should develop throughout their education (International Society for Technology in Education [ISTE], 2003). In recent studies, computer skills were reported to be one of the top skills parents expect their children to develop (Healy, 2000), and employers expect college graduates to have computer skills (Davis, 1997).

National standards encourage the use of computer technology in classrooms. For example, the *National Science Education Standards* (National Research Council [NRC], 1996) suggest that "all students in grades K-4 should develop the ability to use and understand science through technology and technological tools that help students make better observations and measurements" (p. 138). This increasing emphasis on the use of computer technology in schools highlights the importance of computer skills in children's academic success.

Previous research has demonstrated that children do not have equal opportunities to access computer technology at home and in schools (Attewell, 2001; Norris, Sullivan, Poirot, & Soloway, 2003). Researchers have reported that children with high socio-economic status and children who attend low-poverty schools are more likely to have access to computer technology (Calvert, Rideout, Woolard, Barr, & Strouse, 2005; Judge, Puckett, & Cabuk, 2004). This difference in access to computers changes as children move to the upper grades because the availability of computer technology between low-poverty and high-poverty schools becomes narrower or completely diminishes in the

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upper grades of school (Judge, Puckett, & Bell, 2006). Nevertheless, children with high socio-economic status continue to have better access to computer technology at home than children with a low socio-economic status. This differential access to a computer at home might provide an advantage to children with a high socio-economic status over children with a low socio-economic status in terms of developing their computer skills (Mumtaz, 2001). Some scholars have described this difference in availability of technology and the resulting gap in information access as a "digital divide" (Attewell, 2001). More and more children have access to computers at home and this access to technology seems to contribute to the development of children's cognitive and non-cognitive skills (Fiorini, 2010; Poynton, 2005). Previous studies have mainly focused on investigating children's computer access and its potential influence on academic performance (Poynton, 2005). However, the influence of the digital divide on the development of young children's computer skills has not been widely examined in the literature. Limited literature exists on the development of children's computer skills. These studies suggest that motor development, executive functioning abilities, and cognitive maturation influence children's use of computer technology and even five-year old children can effectively use computer input devices (Clements, 2002; Donker & Reitsma, 2007; Lane & Ziviani, 2010; Lauricella, Barr, & Calvert, 2009). Previous studies also demonstrated that although parental scaffolding is important, children are able to develop computer skills with minimal or no adult guidance, and access to computer technology can promote children's computer literacy (Inamdar, 2004; Lauricella et al., 2009; Mitra & Rana, 2001).

Success of computer-assisted instructional strategies is largely seen as dependent on teachers' acceptance of the use of technology in their classrooms and teachers' own skills and experiences in using technology (Hu, Clark, & Ma, 2003). Although children's computer skills also seem to be a vital part of the success of computer-assisted instruction, the importance of children's computer skills have been largely overlooked in the literature partly because such data have not been available. However, the Early Childhood Longitudinal Study–Kindergarten (ECLS–K) data set provides nationally representative data to address these types of questions. Therefore, this study used the ECLS–K data to explore the development of children's computer skills from kindergarten to third grade by considering their access to computer technology in kindergarten.

## 2. Conceptual model tested in the study

The latent growth curve modeling approach was used to model the development of children's computer skills from kindergarten to third grade. Four variables were used as predictors of children's computer skills in the model. While gender, socio-economic status, and the availability of a computer at home were used as predictors of both children's initial computer skills and the development of children's computer skills, the availability of computers in kindergarten classrooms was only used as a predictor of the development of children's computer skills. The availability of a computer at home and children's socio-economic status were allowed to covary as children with high socio-economic status were expected to be more likely to have access to a computer at home.

Although earlier studies indicated a possible gender difference that favors older boys over older girls in computer usage (Essa, 1987; Hess & Miura, 1985), more recent studies suggest that there might be no longer a gender difference among 3–17 year old children in computer usage (Newburger, 2001). Nevertheless, the use of computers seems to appeal to boys more than girls, which might lead boys to have better computer skills than girls. Therefore, gender was used as a potential predictor of children's initial computer skills as well as the development of children's computer skills in the model. Socio-economic status appears to be another potential predictor of children's computer skills. Children with a high SES are more likely to have access to a computer at home and parents with higher computer literacy. Thus they are more likely to have opportunities to develop their computer skills (Becker, 2000; Calvert et al., 2005). Moreover, the research literature suggests a positive link between children's home experiences and their mathematics, reading, and science learning skills at schools. Results of these studies demonstrated that children who had access to materials, such as print media, educational toys, and other learning materials, at home were more likely to perform better on academic tasks than their peers who did not have access to such materials at home (e.g., LeFevre, Polyzoi, Skwarchuk, Fast, & Sowinski, 2010; Yaghoub Zadeh, Farnia, & Ungerleider, 2010). Therefore, SES and the availability of a computer at home were used as potential predictors of children's initial computer skills and the development of children's computer skills. The availability of computers at school is a potential predictor of the development of children's computer skills (Becker, 2000). Children who don't have access to a computer at home might find opportunities to develop their computer skills in classrooms where computers are available. Thus, the availability of computer technology in kindergarten classrooms was used as a predictor of the development of children's computer skills in the model. The main purpose of this study was to examine the impact of the availability of computers in kindergarten classrooms on the development of children's computer skills, rather than to examine the change in children's access to computers in the early years. Because, the change in children's access to computers in schools was investigated in previous studies (Judge et al., 2004, 2006) the availability of computers in the first and third grade classrooms was not included in the model tested in the current study.

## 3. Purpose of the study

The purpose of this study was to investigate the development of children's computer skills from kindergarten to third grade and the predictors of children's computer skills. More specifically, answers to the following research questions were sought in the study: (1) Do the socio-economic status, gender, and availability of a computer at home predict children's initial computer skills at kindergarten and the development of children's computer skills from kindergarten to third grade? (2) Does the availability of computers in kindergarten classrooms predict the development of children's computer skills from kindergarten to third grade?

## 4. Methodology

### 4.1. Sample

The ECLS–K cohort data were collected using a multistage probability sample design that included stratification, clustering, and oversampling of certain subpopulations (National Center for Educational Statistics [NCES], 2002). The base year sample (1998–1999) consisted of 22,666 children from 953 public and 460 private schools, and children were followed from kindergarten until the eighth grade. ECLS–K sample is a nationally representative sample of the children who started kindergarten in the academic years of 1998–99 in the United States. A subset of the ECLS–K dataset, kindergarten to third grade, was analyzed in the present study. The sample for the current study included only first-time kindergarten students and students who remained in the same school until the end of third grade. These criteria were used to avoid potential confounding effects of repeating kindergarten and/or changing schools. Children whose computer skills were rated by their teachers from kindergarten to third grade were included in the analysis. The sample resulting from these selection criteria included 8642 children from the ECLS–K data set. Table 1 presents the distribution of the study sample by gender and race.

### 4.2. Instruments

The *Teacher Questionnaire*, which was developed by experts from the ECLS–K advisory board (NCES, 2005a,b), was used to collect information about teachers' backgrounds, training, and classroom practices. The content of the *Kindergarten Teacher Questionnaire* was designed by the experts of the ECLS–K advisory board. Data obtained through the questionnaire, which was administered during spring 1999, were utilized to determine the availability of computer technology in kindergarten classrooms. Teachers' responses to the question regarding the availability of instructional materials in their kindergarten classrooms were examined. The response categories for this question were *never adequate, often not adequate, sometimes not adequate, and always adequate*. Teachers' response to an item related to instructional materials, availability of computer equipment, was extracted from the database. This variable was used as an indicator of the availability of computers in kindergarten classrooms.

Teachers' responses to the following question were used as a measure of children's computer use skills: "*Uses the computer for a variety of purposes (for example, by drawing a picture, or counting objects, or typing numbers, letters, or words)*." Response categories include *not yet (1)*, *beginning (2)*, *in progress (3)*, *intermediate (4)*, and *proficient (5)*. These data were collected from teachers' responses to the *Teacher Questionnaire* three times for the children included in this study: fall kindergarten, spring first grade, and spring third grade.

While the information about children's gender was obtained from the *Teacher Questionnaire*, children's level of socio-economic status was determined based on the responses of parents to the questions in the *Parent Questionnaire* (NCES, 2005a,b). Parents' responses to two questions about their yearly income and their highest educational level were used to create a composite socio-economic status variable (SES), which was included in the analysis for this study. Data concerning the availability of a computer at home also were extracted from the *Parent Questionnaire*. A more detailed description of the development and validation of the Teacher and Parent Questionnaires can be found in ECLS–K psychometrics and methodology reports (NCES, 2005a,b). Copies of the questionnaires also can be obtained from the ECLS–K website (http://nces.ed.gov/ecls/kindergarten.asp).

### 4.3. Data analysis

The main objective of this study was to examine the development of children's computer skills and investigate the impact of factors that are responsible for the observed change in children's computer skills from kindergarten to third grade. Thus, the latent growth curve modeling approach (LGM) was utilized as an analytical technique to examine the development of children's computer skills and the causes of the differences in children's individual growth patterns (McArdle & Epstein, 1987). LGM is a special application of structural equation modeling (SEM) that accommodates the analysis of longitudinal data. With LGM, researchers can model change and examine the antecedents and results of change (Preacher, Wichman, MacCallum, & Briggs, 2008). A basic LGM framework includes two latent factors: intercept and slope. While the intercept factor represents baseline scores, the slope factor represents the growth in scores. Observed scores at different times are used as indicators of latent intercept and slope factors. Researchers can include other variables as predictors of baseline scores and growth in the model. See Preacher et al. (2008) and Hancock and Lawrence (2006) for a more detailed description of the LGM framework.

The loadings of the children's computer skills scores observed in kindergarten, first, and third grades on the *intercept* factor were fixed to 1, and the loadings on the *slope* factor were fixed to 0, 21, and 45 respectively to reflect the amount of time in months that passed between each assessment (as per Hancock & Lawrence, 2006; Schumacker & Lomax, 1996). While the intercept factor represents children's baseline skills, the slope factor represents the development of children's skills from kindergarten to third grade in the model.

Data in the present study were weighted to correct for the study design effect to ensure that results were nationally representative for the children who started kindergarten in the academic years of 1998–99 in the US. The complex survey design estimation procedure, which

**Table 1**
Distribution of the sample by gender and race.

| Variable | *N* | Unweighted % | Weighted% |
|---|---|---|---|
| Child Gender | | | |
| Boys | 4281 | 49.5 | 49.7 |
| Girls | 4361 | 50.5 | 50.3 |
| Child Composite Race | | | |
| White, non-Hispanic | 5268 | 61.0 | 63.5 |
| Black or African American, non-Hispanic | 967 | 11.2 | 12.4 |
| Hispanic, race specified | 720 | 8.3 | 8.6 |
| Hispanic, race not specified | 710 | 8.2 | 8.6 |
| Asian | 473 | 5.5 | 2.4 |
| Native Hawaiian, other Pacific Islander | 116 | 1.3 | 0.6 |
| American Indian or Alaska native | 148 | 1.7 | 1.7 |
| More than one race, non-Hispanic | 234 | 2.7 | 2.1 |
| Not ascertained | 6 | 0.1 | 0.1 |
| Total | 8642 | 100 | 100 |

utilizes the full information maximum likelihood estimation method (FIML), was employed using LISREL version 8.80 to analyze the data (Jöreskog & Sorbom, 2006). The complex stratified cluster sampling design of the ECLS–K data was taken into account using the appropriate stratification, cluster, and child level weight variables.

For a complex survey design analysis, the LISREL software provided the following values to evaluate the fit of the model tested: the full information maximum likelihood chi-square, its corresponding $p$ value, and the root mean square error of approximation (RMSEA). Therefore, these values were used to evaluate the model fit in the study. The chi-square statistic and RMSEA value are used to evaluate the degree of misfit or the discrepancy between the true model and the hypothesized model. In other words, these values are indicative of whether the model tested in the study significantly differs from the true population model that generated the data. A statistically significant chi-square value indicates that the model is not a good fit to the sample data, while a non-significant value suggests that the model does not significantly differ from the hypothetical true population model that generated the data (Schumacker & Lomax, 1996). A chi-square test is very sensitive to large sample sizes. Therefore, researchers developed and proposed alternative measures of model fit, such as RMSEA, that are not affected by large sample sizes (Browne & Cudeck, 1993). A value of zero RMSEA suggests exact model fit, whereas larger RMSEA values suggest poorer model fit.

## 5. Results

### *5.1. Children's initial computer skills and availability of computers at home and in kindergarten*

Descriptive statistics demonstrated that boys tended to have higher computer skills than girls at the beginning of kindergarten. However, girls obtained higher scores than boys on the first and the third grade assessments. While, the difference in computer skills between children with low and high SES was large at the beginning of kindergarten, the magnitude of this difference became much lower as children moved toward the upper grades. Table 2 presents the descriptive statistics for children's computer skills by gender and SES.

Results demonstrated that more than half of the children (57.8%) had a computer at home while 42.2% of the children did not. Almost 15% of the teachers reported that the availability of computer equipment in their classrooms is never adequate, and 44% reported that they have always adequate computer equipment. Table 3 presents the weighted percentages of the availability of computers in kindergarten classrooms and at home.

### *5.2. Assessment of model fit*

The model tested in this study provided a good fit to the data (Full Information ML Chi-Square = 101.48, df = 10, $p < .001$). The chi-square value was significant, which is not surprising as the $\chi^2$ statistic is easily influenced by large sample sizes (Bentler & Bonett, 1980). Given the large sample size of the study, we based our evaluation of the model fit on the RMSEA value, which is not affected by sample size. The RMSEA value was 0.033 (90% CI: 0.027–0.038), which is below the suggested cut-off value of 0.06, indicating the model fits the data very well (Hu & Bentler, 1999; Schumacker & Lomax, 1996).

### *5.3. Development of children's computer skills*

The estimate of the intercept mean (initial computer skills) was 2.03 on a scale of 1–5. The estimate of the slope mean (rate of development) was 0.01 ($p < .01$) suggesting development of computer skills from kindergarten to third grade was in a positive direction with an average increase of 0.01 unit per month. The estimate of the intercept variance was 0.25 indicating a statistically significant difference in children's computer skills at the beginning of kindergarten ($p < .01$). The estimate of the slope variance was 0.001 ($p < .01$), suggesting that differences among the children in the rates of change in their computer skills from kindergarten to third grade was statistically significant. The estimated covariance between children's baseline computer skills and development in their skills was −0.28 ($p > .05$), suggesting children with low level computer skills at the beginning of kindergarten tended to develop at a higher rate than their peers who started with high level computer skills. However, this tendency was not statistically significant. Fig. 1 illustrates the model tested in the study.

### *5.4. Predictors of the development of computer skills*

Results indicated that the availability of a computer at home ($p < .01$) and children's socio-economic status ($p < .01$) were statistically significant predictors of children's initial computer skills at the beginning of kindergarten. Not surprisingly, children with a high socio-economic status and children who had access to a computer at home were more likely to have higher level computer use skills than their peers with a low socio-economic status and children who did not have access to a computer at home. These two variables also were related. There was a positive correlation between socio-economic status and availability of a computer at home. Children with higher socio-economic status were more likely to have a computer at home (0.41, $p < .01$).

**Table 2**
Means and standard deviations of computer skills by gender and SES.[a]

| | Kindergarten | | First Grade | | Third Grade | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| Girls | 2.00 | 1.04 | 2.40 | 1.31 | 2.56 | 1.29 |
| Boys | 2.05 | 1.08 | 2.32 | 1.30 | 2.49 | 1.29 |
| Low SES | 2.00 | 1.04 | 2.35 | 1.30 | 2.51 | 1.29 |
| High SES | 2.61 | 1.28 | 2.65 | 1.36 | 2.85 | 1.41 |

[a] Weighted.

**Table 3**
Availability of computers at kindergarten and at home.

| Response Categories | Computers |
|---|---|
| Never adequate | 14.9% |
| Often not adequate | 14.9% |
| Sometimes not adequate | 26.2% |
| Always adequate | 44.0% |
| Total | 100.0% |
| Computer is available at home | 57.8% |
| Computer is not available at home | 42.2% |
| Total | 100.0% |

Availability of computers in kindergarten classrooms ($p < .01$) was statistically significant predictors of the development of children's computer skills from kindergarten to third grade. Children who were in kindergarten classrooms with adequate levels of computers were more likely to be rated by their 3rd grade teachers as having higher computer skills.

Gender was not a statistically significant predictor of children's initial computer skills ($p > .05$), but it was a significant predictor of the development of children's computer skills ($p < .01$). The rate of development in computer skills was higher for girls than boys ($p < .01$). Interestingly, socio-economic status ($p > .05$) and availability of a computer at home ($p > .05$) were not statistically significant predictors of the development of children's computer skills over time. Socio-economic status, gender, and the availability of a computer at home explained 16% variance in children's initial computer skills in kindergarten. Socio-economic status, gender, the availability of a computer at home, and the availability of computers in kindergarten classrooms explained 2% of the variance in the development of children's computer skills from kindergarten to third grade. Table 4 presents the path coefficients and associated *z*-scores for the model.

## 6. Discussion

This study sought to investigate the development of children's computer skills from kindergarten to third grade by considering their access to computer technology. Results suggest that the availability of an adequate level of computers in kindergarten classrooms reduces the initial performance gap in children's computer skills due to socio-economic status over time, and especially by third grade. Thus, supplying kindergarten classrooms with adequate computers could positively contribute to young children's long-term development of computer skills throughout their early childhood school experiences.

The success of computer-based instruction in schools partly depends on the children's computer skills. Results of this study demonstrated that children with high socio-economic status and children who have access to a computer at home initially were more competent using computers than their peers with a lower socio-economic status and peers who did not have access to a computer at home. These results suggest that children with high socio-economic status are more likely to begin their schooling with the skills necessary for them to benefit from computer-assisted instructional activities in kindergarten. Therefore, early childhood teachers should make an extra effort to assess and develop the computer skills of children with lower socio-economic status and children who do not have access to a computer at home.

The results of previous studies indicated that access to computers in schools changed as children progress through school so that all children tended to have more equal access in the upper grades (Becker, 2000; Judge et al., 2004). However, the results of this study indicate that the *digital divide* related to the gap in the computer skills that children bring to school seems to close due to computer experiences provided in schools. While children who had access to a computer at home were more likely to have higher levels of computer skills at the beginning of kindergarten, the advantage of having a computer at home vanished as children moved from kindergarten classrooms where there was an adequate number of computers to the upper grades in schools. Becker (2000) contended that access to a computer at home is a major source of inequality and schools should play a critical role in helping less-advantaged children in having access to computer technology. Results of this study suggest that school experiences do play an important role in helping children with low SES to develop their computer skills.

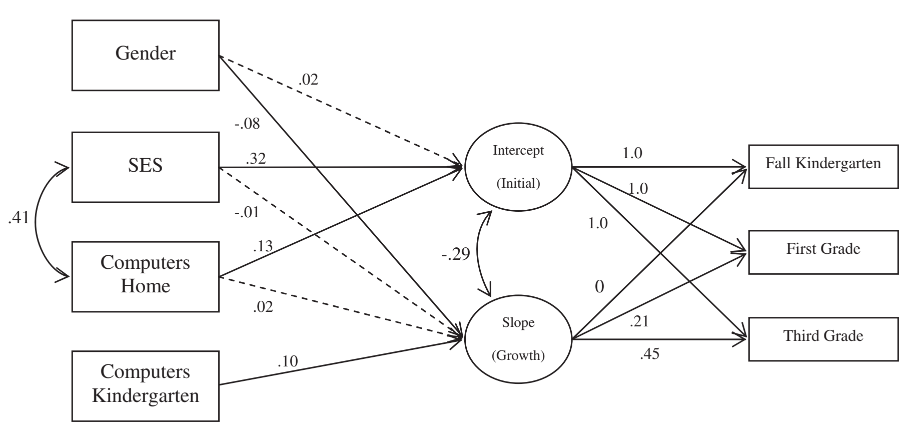


**Fig. 1.** Model tested in the study. Dashed lines indicates non significant paths at $\alpha = .05$.

**Table 4**
Path coefficients and *z*-scores.

| Antecedent Variables | Path Coefficient | *z*-scores |
|---|---|---|
| SES → Intercept (initial computer skills) | 0.32 | 7.01* |
| SES → Slope (development of computer skills) | −0.01 | −0.31 |
| Gender → Intercept (initial computer skills) | 0.02 | 0.96 |
| Gender → Slope (development of computer skills) | −0.08 | −3.51* |
| Computer Home → Intercept (initial computer skills) | 0.13 | 4.81* |
| Computer Home → Slope (development of computer skills) | 0.02 | 0.62 |
| Computer Kindergarten → Slope (development of computer skills) | 0.10 | 2.77* |
| SES ↔ Computer Home | 0.41 | 27.26* |

National academic content standards emphasize computer skills as an integral part of children's academic development. For example, the *National Science Education Standards* (NRC, 1996) and the *National Mathematics Education Standards* (NCTM, 2000) advocate the use of technology in classrooms and suggest that students should be able to develop technology skills to better benefit from the resources and opportunities technological tools readily offer. Children who have access to a computer at home start the first step of their academic life with the advantage of entering school with higher levels of computer skills. These children might be more likely and ready to benefit from computer-assisted instructional activities than their peers who do not have the same access to computers in their homes. However, the availability of computers in classrooms seems to help children who do not have computers in their homes to overcome their initial technology disadvantage. Providing adequate levels of computers to kindergarten classrooms could help children to be better prepared for the demand of more highly computerized environments in their future academic lives and careers.

Use of the ECLS–K data set resulted in limitations that should be considered in interpreting the results and should be addressed in future investigations. For example, the present study examined the impact of the availability of computers in kindergarten classrooms and did not focus on the quality of the children's computer experience. Future studies should examine the types of computer activities available in kindergarten classrooms and the impact of these activities on the development of children's computer skills. In the current study, children's computer skills assessments were based on teachers' ratings. Future studies should include other measures of children's computer skills, such as children's efficacy beliefs for using computers and performance based assessments of children's computer skills. Finally, future studies can include predictors of children's computer skills other than the ones included in the present study, including teacher-level variables, (e.g., teachers' efficacy beliefs for and perceptions of using computers and teachers' level of computer literacy) and student-level variables (e.g., children's aptitude, level of motor development, and interest in using computers). Results of such studies can contribute to the development of a theoretical framework for describing and understanding the development of children's computer skills in early years.

## 7. Conclusion

This study examined the availability of computers in kindergarten classrooms on the development of children' computer skills from kindergarten to third grade using a nationally representative sample of kindergarten children in the USA. LGM analysis was utilized as an analytical technique to examine the development of children's computer skills and the predictors (gender, SES, availability of computers in home, and the availability of computers in kindergarten classrooms) of the differences in children's individual growth patterns (McArdle & Epstein, 1987). Results demonstrated the positive influence of the availability of computers in kindergarten classrooms on the long-term development of children's computer skills and provided empirical evidence for the rationale for inclusion of computers in kindergarten classrooms.

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