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Working Toward National Technology Standards:

Teacher Use of Computers in the Classroom

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Abstract

Technology, when properly implemented, can bring a new dimension to education. In addition to automating some applications, it can be used “to help us do things in education that were heretofore impossible” (Thornburg, 1999, p.1). This paper focuses on the results of a survey of almost two thousand teachers. The survey focuses on the teachers’ attitudes toward and use of computers in instruction, with specific emphasis on classroom uses. The study investigated the extent to which classroom teachers are prepared for meeting national standards through their use of technology for educational applications and instruction.

Review of the Literature

Access to Technology in Education

In recent years, states and districts have increased expenditures to equip schools with computers and related technology. In 1997-1998, a total of \$4.8 billion was spent on educational technology, up 12% from the previous year. The 1998-1999 estimated spending was \$5.4 billion (Quality Education Data, 1998).

The financial investment has resulted in both an improved student/computer ratio and increased connectivity to the Internet. Nationwide, the ratio of students per computer has fallen from an average of 10.8 in 1993 to 5.7 in 1999 (McQueen, 1999). During the same time period, the percentage of public schools that have Internet access has increased from 35% (1994) to 95%

(2000), and the percentage of public classrooms connected to the Internet has risen from 3% in 1994 to 72% in 2000 (CEO Forum, 2000).

As a result of the significant investments being made in hardware, software, and infrastructure, there is a call for evidence regarding the effectiveness and appropriate use of technology in K-12 schools (Panel on Educational Technology, 1997). Many researchers have “realized that technology cannot be treated as a single independent variable, and that student achievement is gauged not only by how well students perform on standardized tests but also by students’ ability to use higher-order thinking skills” (North Central Regional Educational Laboratory, 1999, p1). It also became apparent that with the acceleration in the pace of technological innovation, skills, such as problem solving with appropriate tools for learning, synthesizing information, and communicating are essential for today’s students (Panel on Educational Technology, 1997).

Use of Technology in Education

Although technology cannot solve all of the issues facing education, there is substantial evidence that, when used effectively, it can promote an improvement in student achievement, including higher-order thinking skills (CEO Forum, 2000; Means, Blando, Olson, Middleton, Morocco, Remz & Zorfass, 1993). The emphasis then shifts to *how* technology is used in the schools (by teachers and students), rather than simply the number of computers available (CEO Forum, 2000).

Through the appropriate integration of technology (i.e., for problem-solving, research, communication, etc.), students in our schools will have opportunities to improve achievement and develop essential skills (CEO Forum, 2000). However, in a 2000 survey by the National

Center for Education Statistics, it was reported that only 24% of the teachers who had access to computers at school made assignments involving the production of multimedia reports; 30% assigned research using the Internet; and 19% required graphical presentations of materials (Rowand, 2000).

In an attempt to provide guidelines and expectations of technology in education, several states have instituted standards related to competencies in the use of technology. One of the first, national movements toward establishing standards for technology was initiated by the International Society for Technology in Education (ISTE). Through their leadership, a consortium of organizations representing major professional education groups, government entities, foundations, and corporations was formed to create a national set of standards to govern the use of computers in schools.

National Educational Technology Standards (NETS)

The first set of standards, the National Educational Technology Standards (NETS) for Students was published in 1998. It categorizes recommended competencies into six areas: (a) basic operations and concepts, (b) social, ethical, and human issues, (c) technology productivity tools, (d) technology communication tools, (e) technology research tools, and (f) technology problem-solving and decision-making tools. The categories are a framework for linking performance indicators within the Profiles for Technology Literate Students to the standards. These general sets of profiles are indicators of achievement for technology skills developed at certain stages in PreK-12 education. It is recommended that the skills be integrated into a student's personal learning and social framework, by being introduced in the classroom,

reinforced, and finally mastered. It is intended that the standards be an integral component or tool for learning within the context of academic subject areas (ISTE, 2000).

Basic Operations and Concepts. The first category describes standards that meet the basic operations and concepts of technology. Students should be able to demonstrate a proper understanding of the nature and operation of technology systems. Students should be proficient in the use of technology, such as computers, televisions, VCRs, and audiotapes. This can be achieved by successfully operating parts of a computer, including input devices, such as a mouse and keyboard, and output devices, such as a monitor and printer. Another indicator would be students' use of terminology that accurately communicates about technology. Through everyday use of technology systems, students can apply proper strategies for identifying and solving routine hardware and software problems.

Social, Ethical, and Human Issues. The second category describes standards for social, ethical and human issues regarding technology. Students should exhibit legal and ethical behaviors when using technology systems, information technology, and software. They should be able to discuss basic issues related to responsible use of technology and information, and describe the consequences of inappropriate use. Students should develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits and productivity.

Technology Productivity Tools. The third category describes standards for students' use of technology as productivity tools. In this case, technology should enhance learning, increase productivity, and promote creativity. Use of technology allows students to collaborate with other students in constructing technology-enhanced models, preparing publications, and producing other creative works for both inside and outside the classroom. Students should be able to use

general productivity software, such as word processing, databases, spreadsheets, and presentations, in addition to simulation tools, such as probes and graphing calculators. Students should also be able to use additional hardware related to productivity such as digital cameras, scanners, or video cameras.

Technology Communications Tools. The fourth category describes standards for students' use of technology as a communication tool. Students use technology as a telecommunications tool to collaborate, publish, and interact with peers, experts, and other audiences. Students should be able to efficiently and effectively access remote information in support of independent learning. Students should use a variety of media and formats to communicate information and ideas effectively to multiple audiences.

Technology Research Tools. The fifth category describes standards for students' use of technology as a research tool. Students should use technology to locate, evaluate, and collect information from a variety of sources. They should use technology as a tool to gather data, process it, and report the results. Students should be able to evaluate and select new information resources and technological innovations based on the appropriateness for specific tasks.

Technology Problem-Solving and Decision-Making. The final category describes standards for students' use of technology for problem-solving and decision-making skills. Students should use technology resources for making informed decisions and developing strategies for solving problems in the real world.

These standards will be used as a framework for studying various aspects of computer use in schools.

Method

Instrumentation

In order to investigate the degree to which teachers are using computers in the classroom, a survey was designed and administered to teachers in a large urban school district (for details on survey development and validation, see Hogarty & Kromrey, 2000). The survey targeted the areas of teacher attitudes toward computer use, integration of computers into instruction, types of software used, and teacher confidence and comfort with computer use. Demographic information, including grade level and subject areas taught was also gathered. In the context of the NETS, the sections of primary interest for this study were those focusing on the integration of computers into instruction and teacher attitudes toward computer use.

The integration section of the survey was divided into three parts consisting of both the methods used and the extent to which teachers were integrating computers and technology in the classroom. Items included instructional strategies employed by the teacher in the classroom (e.g., individual and small group instruction), software used by both teachers and students to complete school related activities (e.g., word processors, spreadsheets, graphics programs), and teachers' personal use of computers (e.g., for fun/entertainment; as a communication or research tool).

Responses to items related to the integration of technology and types of software used were provided on a 5-point frequency scale (ranging from *Not at All* to *Every Day*). For all items concerned with the frequency of use (e.g., software use, integration, and personal use), an option of not applicable (NA) was also provided. In the survey section targeting general attitudes toward the use of computers in the classroom, items covered student access to computers, essential skills for students, the incorporation of computers in the classroom, and the impact of

technology on teachers. This portion of the survey contained 20 items reported on a 5-point Likert scale (ranging from *Strongly Disagree* to *Strongly Agree*).

Respondent Sample

The sample of 1890 respondents represents an overall response rate of 39% and was 17% male and 83% female. Of these respondents, 1665 were identified as being classroom teachers (i.e., not guidance counselors), and their responses were used for data analysis. Sixty percent of the respondents held bachelor's degrees, one percent held either a master's degree or specialist degree, and 37% held doctoral degrees. The average amount of teaching experience for the survey respondents was approximately 15 years. Teachers reported an average number of students ranging from one to sixty with an average class size of 22. Information provided, regarding grade level and subject area taught, suggested the representation of a wide variety of disciplines and a diversity of teaching experience.

Data Collection

The instrument was sent to all of the teachers in a large urban school district in Florida. In order to yield a better response rate, both individual and school-based incentives were offered. At the individual level, participation was encouraged by allowing teachers to register for a chance to be one of ten to win a free technology workshop provided by the Florida Center for Instructional Technology. Participants were also informed that the three schools with the highest percentage of teachers responding would win an on-site training session of their choice. A website was provided to facilitate registration, and it allowed participants to keep track of the response rates for their school and other participating schools.

Data Analyses

Data were analyzed for differences between school level (i.e., elementary, middle, and high school) and subject area taught (i.e., English, math, science and social studies). The χ^2 test of independence was used to compare the amount of time spent on integrating technology into the classroom by teachers across both school level and subject area. The teaching modes included in the survey were representative of standards for students in the NETS. A series of ANOVAs were conducted to examine differences in affinity and aversion to technology across school level and subject area. Affinity to technology, in this case, implies a positive attitude towards technology. Aversion, on the other hand, indicates a negative feeling towards technology. The use of software to complete school related activities was examined for both teachers and their students.

Results

School Level Differences. The χ^2 test of independence was used to compare elementary, middle, and high school teachers' integration of computers in the classroom. The proportions are presented in Table 7 and graphically in Figures 1 and 2. A statistically significant difference was evidenced for computer use for *small group instruction*, $\chi^2 (2, N=1677)=34.0718, p<.0001$. The proportion of elementary teachers using the computer for small group instruction was 32%; while the proportion of middle school teachers was 20% and high school teachers was 18%.

A statistically significant difference was also found across the three levels for use of computers in *individual student instruction*, $\chi^2 (2, N=1682)=146.9041, p<.0001$. The proportion of elementary teachers using the computer for individual instruction was 60%, twice the

proportion observed for middle school (30%) teachers and nearly twice that for high school (32%) teachers.

A statistically significant difference was found in the three levels, when teachers used computers in *cooperative groups* $\chi^2 (2, N=1664)=72.4683, p<.0001$. The proportion for elementary teachers was 40%, while for middle school teachers it was 20% and for high school teachers 21%.

Similarly, differences across levels on use of computers for *independent learning* was statistically significant, $\chi^2 (2, N=1670)=257.1373, p<.0001$. The proportion of elementary teachers was 76%, followed by the high school teachers with 40%, and the middle school teachers with 35%.

In the use of computers for *tutoring* students, significant differences were also observed, $\chi^2 (2, N=1672)=226.8942, p<.0001$. The proportion of elementary teachers reporting that they used computers for tutoring was 57%, high school teachers 21%, and middle school teachers 29%.

A statistically significant difference was found in the three levels, when teachers used computers to *promote student centered learning* $\chi^2 (2, N=1655)=226.8942, p<.0001$. The proportion of elementary teachers was 65%, middle school teachers 29%, and high school teachers 27%.

A statistically significant difference was observed across the three levels, when teachers used computers for *problem-solving* with their students $\chi^2 (2, N=1654)=15.5317, p=.0004$. The proportion of elementary teachers was 29%, middle school teachers 23%, and high school teachers 20%.

Similarly, a statistically significant difference was found between the three levels, when teachers used the computer as a *communication tool* with their students $\chi^2 (2, N=1671)=14.3777$, $p=.0008$. The proportion of elementary teachers was 59%, the proportion of middle school teachers 54%, and that of high school teachers 48%.

While statistically significant differences were found in eight of the integration items, the remaining three items (computers used as a productivity tool, as a classroom presentation tool and as research tool) evidenced no statistically significant difference across school level.

Subject Area Differences. The χ^2 test of independence was also used to compare English, math, science, and social studies teachers' integration of computers in the classroom (Table 8 and Figures 3 and 4). In these analyses, only middle and high school teachers were used because these levels are subject specific.

A statistically significant difference was found across the subject areas, when teachers used computers with students to *tutor*, $\chi^2 (3, N=410)=8.5617$, $p=.0001$. The proportion of English teachers was 13%, math teachers 16%, science teachers 27%, and social studies teachers 21%.

Similarly, a statistically significant difference was found across subject areas, when teachers used computers as a *research tool for students*, $\chi^2 (3, N=413)=20.3431$, $p=.0001$. The proportion of science teachers was 51%, social studies teachers 44%, English teachers 30%, and math teachers 23%.

A statistically significant difference was also found across the subject areas, when teachers used computers as a *problem-solving and decision-making tool* with their students, χ^2

(3, N=409)=12.2470, $p=.0006$. The proportion of science teachers was 28%, social studies teachers 22%, math teachers 16%, and English teachers 10%.

For computer use as a classroom *presentation tool*, a statistically significant difference was obtained, χ^2 (3, N=410)=19.0215, $p=.0003$. The proportion of science teachers was 42%, social studies teachers 29%, English teachers 21%, and math teachers 16%.

No statistically significant differences were evidenced between the groups when computers were used for small group instruction, individual instruction, in cooperative groups, independent learning, to promote student center learning, as a productivity tool, or as a communication tool.

Teacher Software Use. The means and standard deviations for teachers' software use are presented in Tables 1 and 2 and graphically in Figures 5 through 8. The types of software used were divided into two groups, application software and instructional software. The following types of software were categorized as application software: word processing, spreadsheets, databases, desktop publishing, presentation, web publishing, programming/authoring, and web browsers. Instructional software included drill and practice, games, simulations, tutorials, and integrated learning systems. An examination of these means revealed that word processors and web browsers were used the most in high schools, with means of 4.22 and 3.41, respectively; in middle schools, with means of 4.18 and 3.47, respectively; and in elementary schools, with means of 4.20 and 3.41, respectively. In contrast, web publishing and programming tools were rarely used (in high schools, with means of 1.34 and 1.27, respectively; in middle schools, with means of 1.25 and 1.29, respectively; and in elementary schools, with means of 1.40 and 1.35, respectively).

In addition, the instructional software used the most was games and tutorials. It is important to note that instructional software was used significantly less than application software. Similar results were found when teacher use of application and instructional software was compared across subject area. This data is represented in Tables 3 and 4 and in Figures 7 and 8.

Student Software Use. To examine students' software use to complete school related activities, a composite was created based on the classifications described above. When examined by level, teachers reported that the students in elementary school used instructional software more than application software (with means of 2.56 and 1.92, respectively). This trend was not true for middle and high school students, who had a tendency to use application software more than instructional software (Figure 9). In contrast, when software use was compared across English, math, science and social studies classes, application software (with means of 2.01, 1.83, 2.12, and 2.04, respectively) was used more frequently than instructional software (with means of 1.92, 1.87, 1.85, and 1.63, respectively). These data are illustrated in Figure 10.

Teacher Attitude Toward Computers. When differences in technological aversion were examined, the results of an ANOVA suggested a statistically significant difference ($F(2,1694)=5.57, p=.0039$) across school level (see Table 1). Follow-up tests revealed a statistically significant difference in Technological Aversion between the elementary and high school teachers (with means of 3.99 and 3.88, respectively). Although statistically significant because of the large sample, a difference of this magnitude (Cohen's $f=.08$) is considered trivial. No statistically significant difference was evidenced when school level differences in Technological Affinity were investigated ($F(2,1694)=2.83, p=.0593$). Likewise, no statistically

significant differences were found in Technological Aversion ($F(3,410)=2.02, p=.1106$) or Technological Affinity ($F(3,410)=1.75, p=.1560$) across subject areas (see Table 2).

Conclusion

When comparing elementary, middle and high school teachers, it was found that elementary school teachers were integrating computers into the classroom more frequently than middle and high school teachers. Elementary school teachers reported using computers primarily for independent learning, student centered learning, individual instruction, and as a communication tool. When the integration of computers in the classroom was compared by subject area, among middle and high school English, math, science and social studies teachers, it appeared that science teachers were using technology more frequently. Most significantly, the science teachers used technology for independent learning, as a communication tool, as a research tool for students, as a productivity tool and as a classroom presentation tool more often than for other reasons. Also, English, math, science and social studies teachers used technology as a communication tool more often than for any other reason.

Application software is that which is used to complete an activity such as writing a paper or preparing a presentation. Instructional software, on the other hand, is software that is designed as a teaching tool. A game that teaches math skills and the simulation of a frog dissection are examples of instructional software. When the software listed on the survey was divided into these two categories, it was found that instructional software was used more often at the elementary level and application software slightly more often at the middle and high school levels. The specific application software used most frequently by elementary, middle and high school teachers was word processing software and web browsers. Teachers reported using these

applications almost every day. On the other hand, the remainder of the application software and the instructional software were used much less. Results were very similar when software use was compared by subject area. Web publishing and programming/authoring tools were the applications used least frequently (virtually not at all).

With regard to the NETS guidelines, it appears that the following components are being addressed in the schools that were surveyed: technology productivity tools, technology communication tools, technology research tools, and technology problem-solving and decision-making. Although not directly measured, it can be inferred from the reported use of these more complex applications that basic operations and concepts are also being covered. In the productivity area, almost 40% of the schools are using computers as a productivity tool (across all levels). The largest use in this area (per subject field in middle and high schools) is found in science.

Using computers as communication tools ranks highest in the areas examined (across all grade levels), with over 50% usage at the elementary level. When examined by subject area, communication also exhibited large numbers, with over 50% in both science and social studies.

As a research tool, high schools were shown to be using computers more often than middle or elementary schools. However, even at the high school level, the total usage was less than 40%. When examined by subject area, science again ranked highest (50%), followed by social studies.

Problem-solving and decision-making scored lowest overall (with regard to the integration of computers across grade levels and subject areas). This can be a complex implementation of technology, and often requires sophisticated software or teaching strategies.

In summary, this research indicates that technology is being integrated in schools at various levels. As David Thornburg stated, “How you use technology in education is more important than if you use it at all” (1999, p. 1). With standards, such as the NETS, as guidelines, our students and our schools can gain increasing benefits from the technology investments in education.

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Figure 1
Integration of Computers by Level

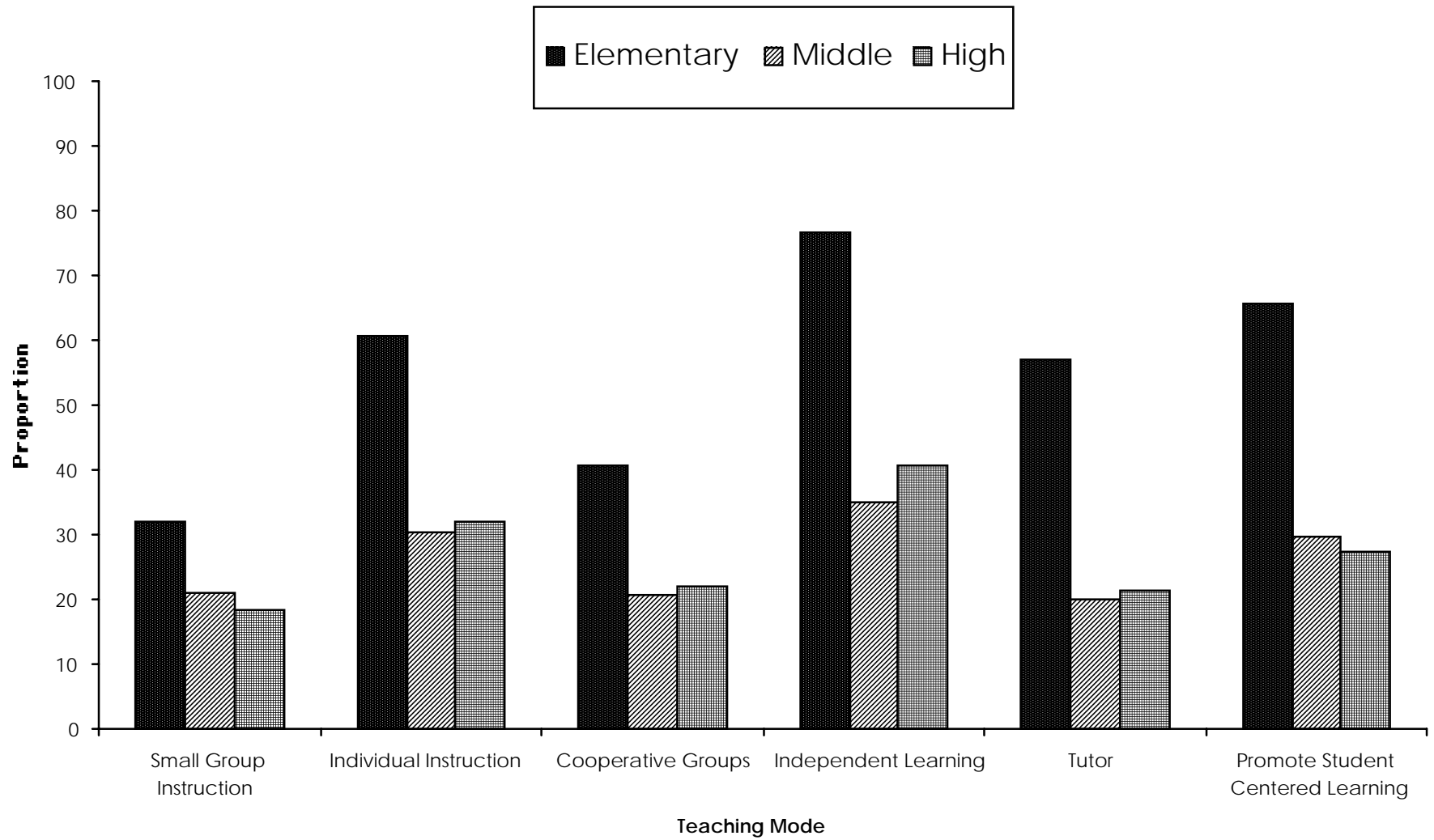


Figure 2
Integration of Computers in the Classroom by Lev

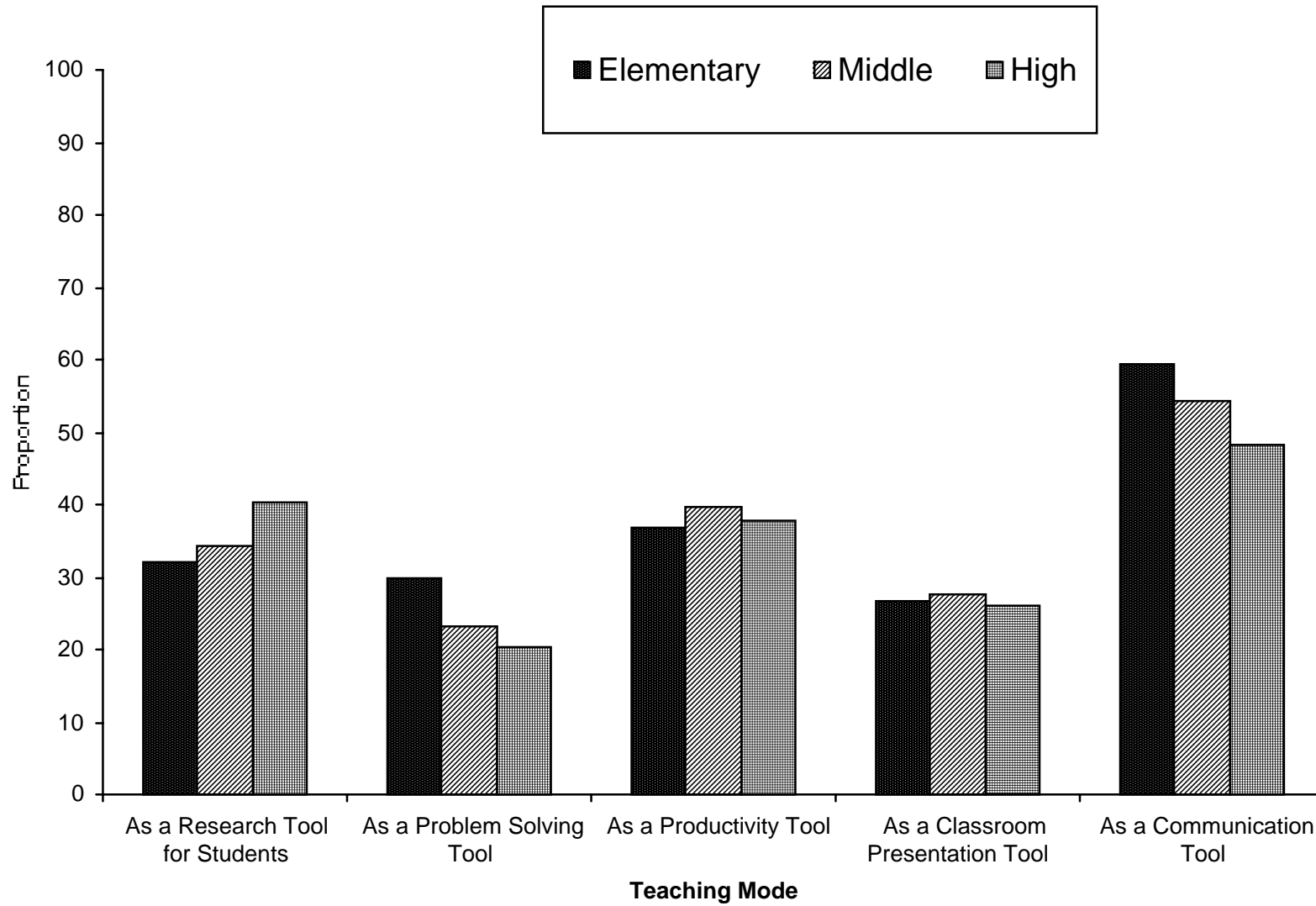


Figure 3
Integration of Computers in the Classroom by Subject

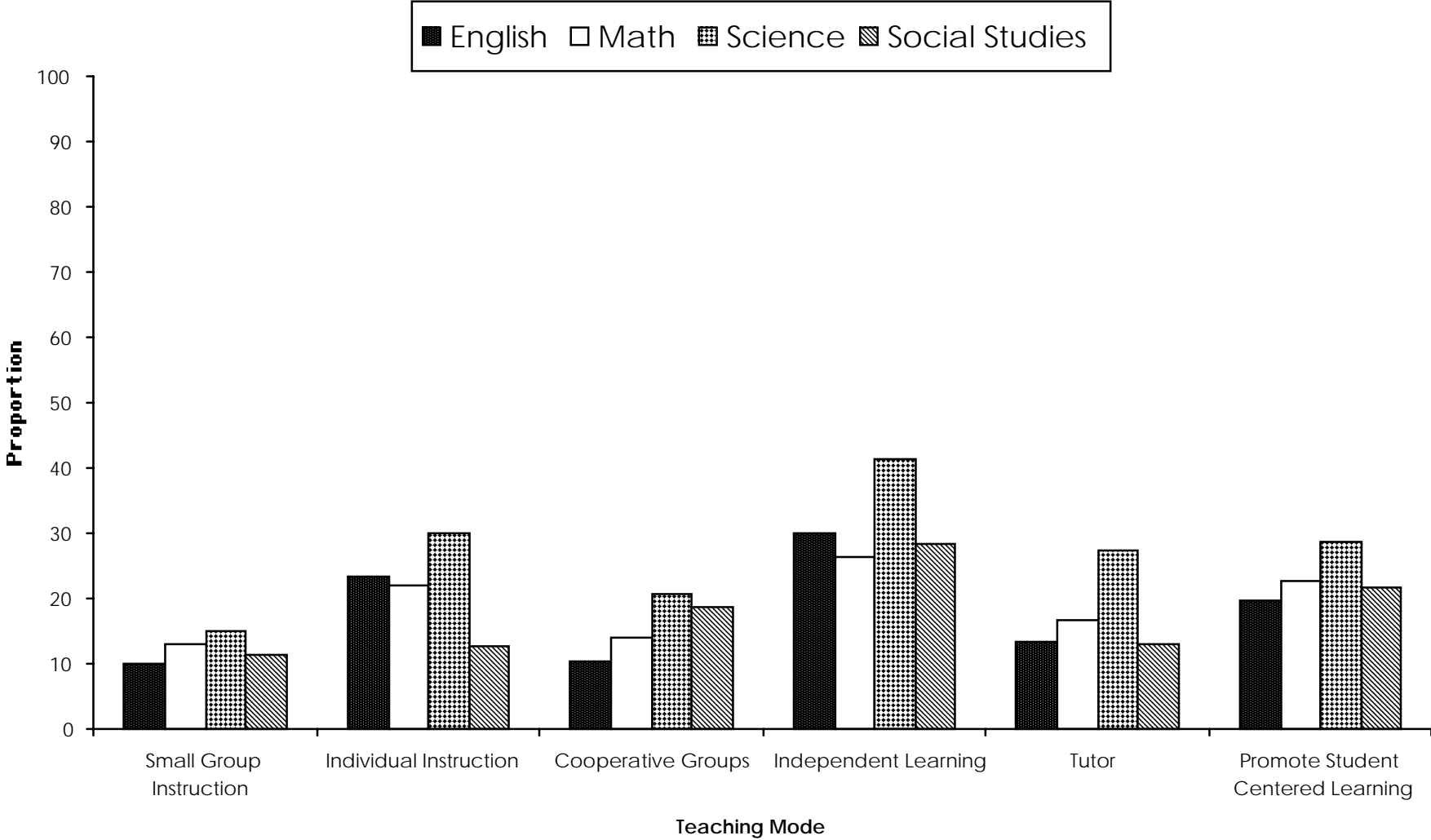


Figure 4
Integration of Computers into the Classroom by Subject

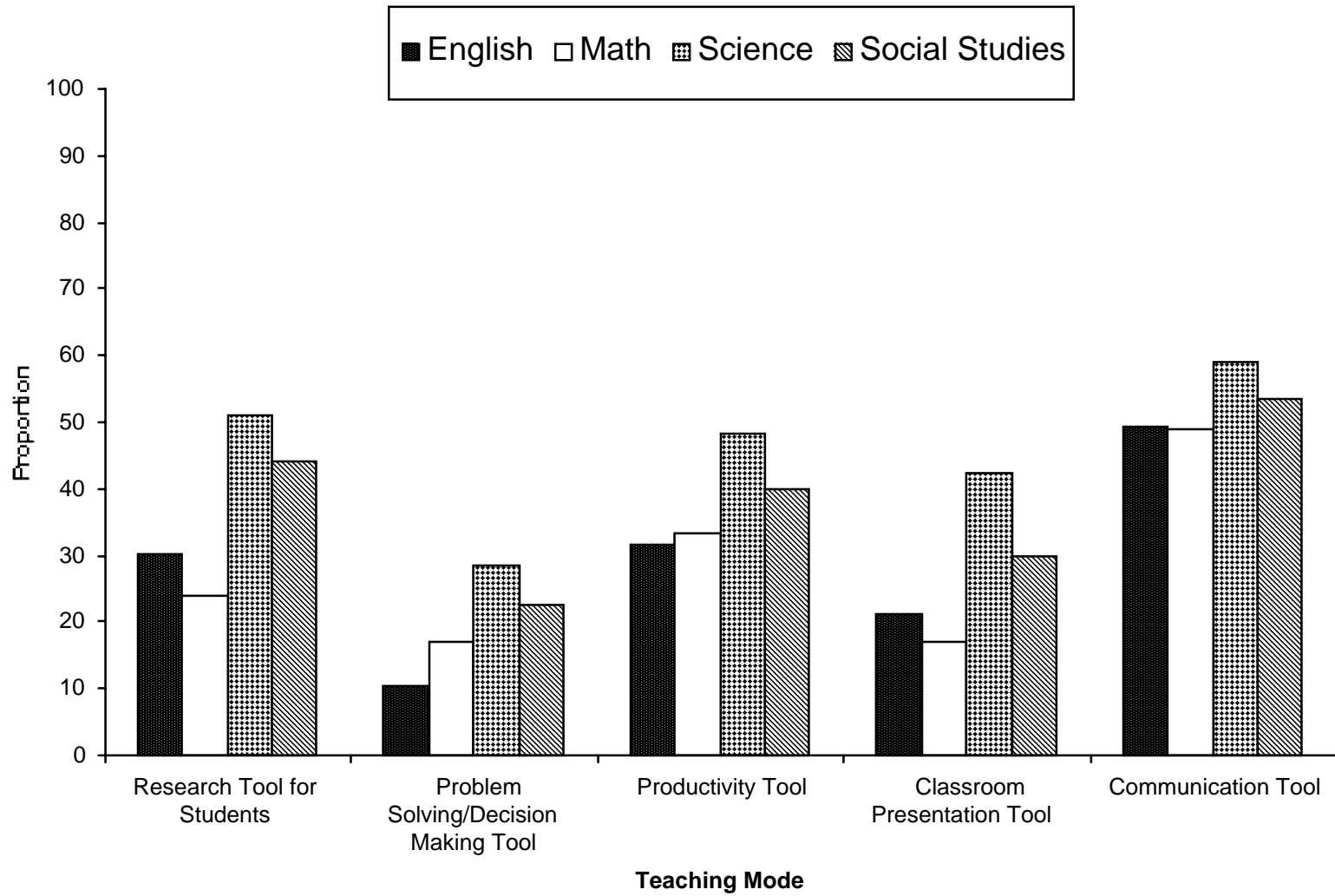


Figure 5
Application Software Use to Complete School Related Activities by Level

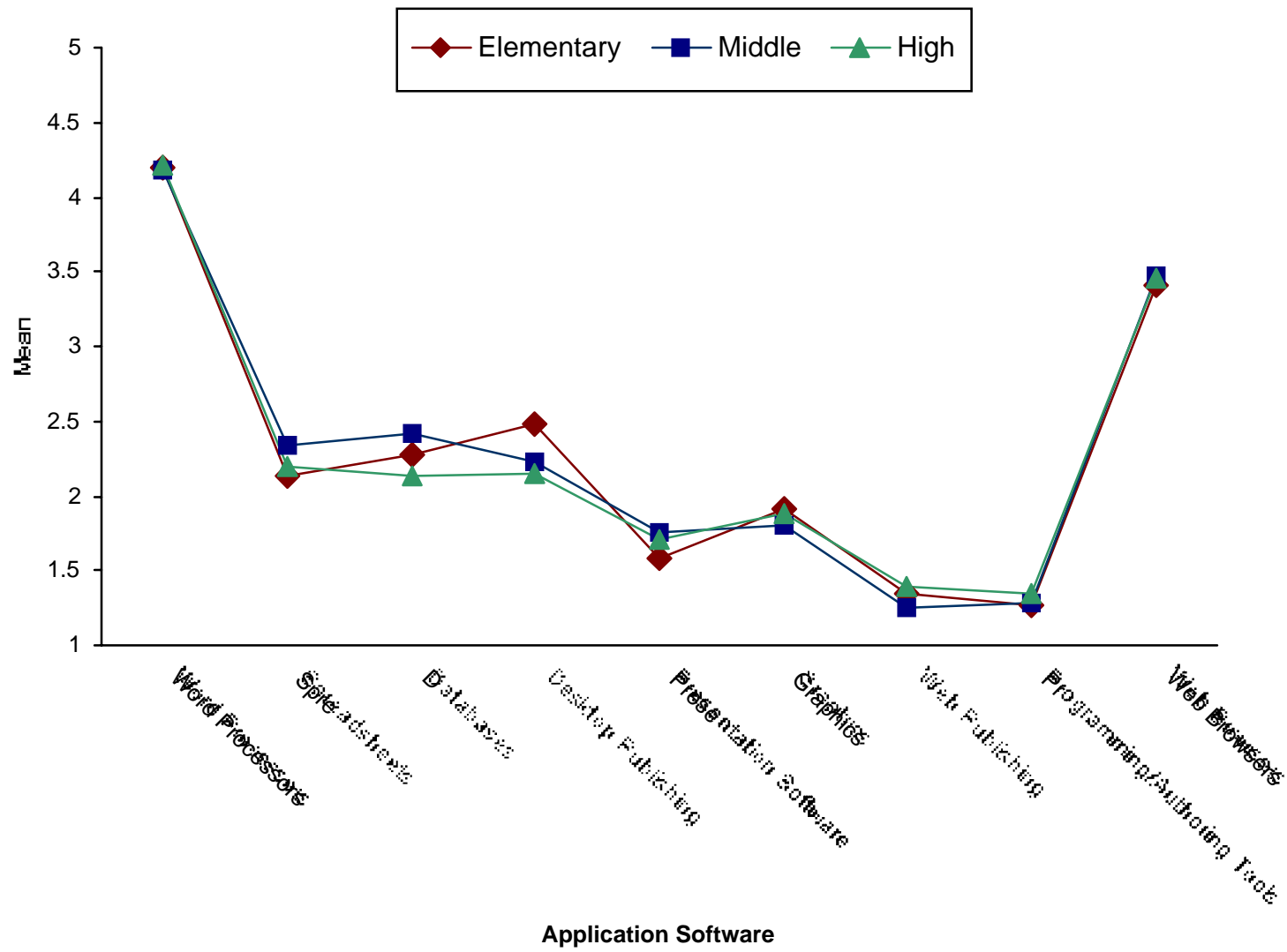


Figure 6
Instructional Software Used to Complete School Related Activities by Level

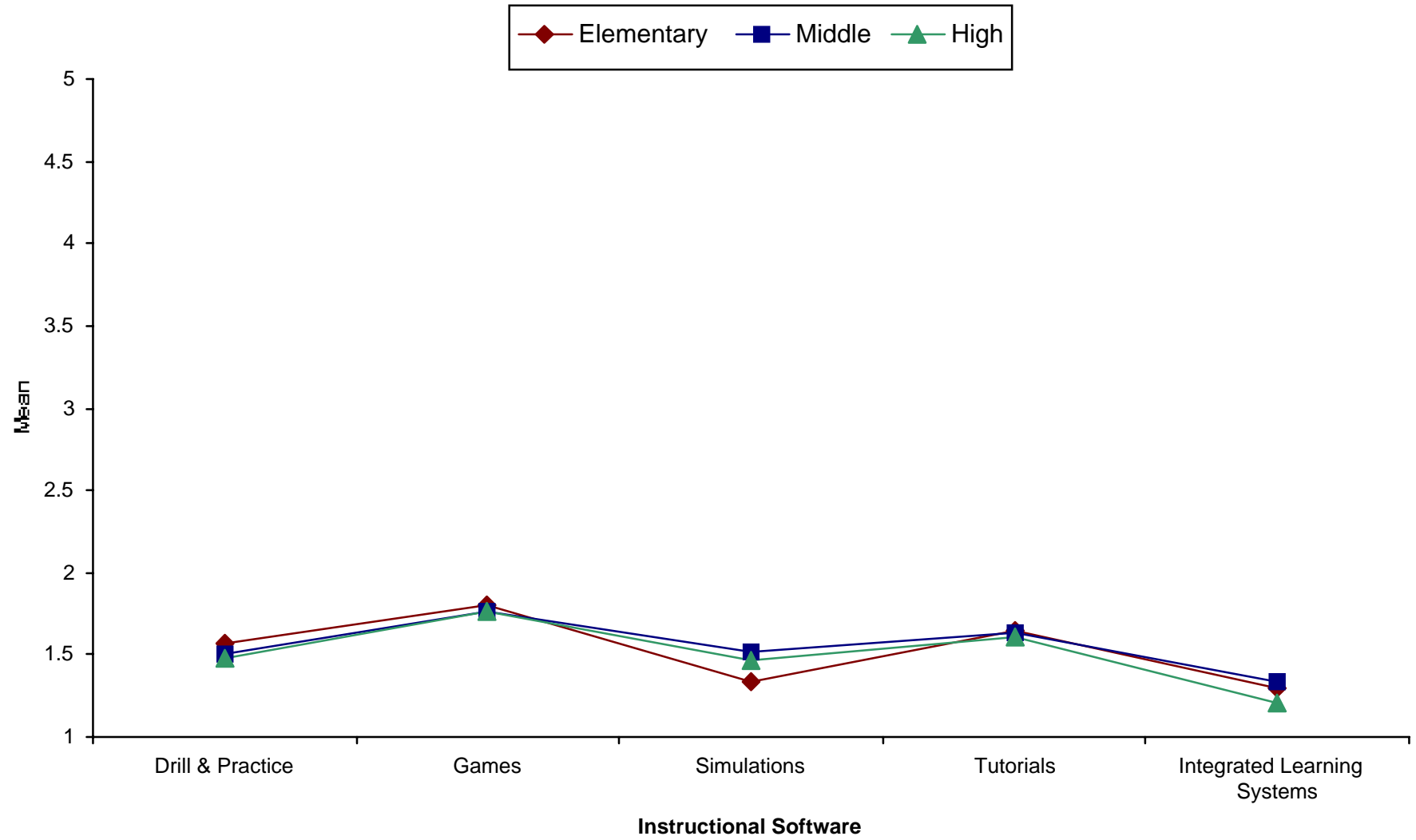


Figure 7
Application Software Used to Complete School Related Activities by Subject

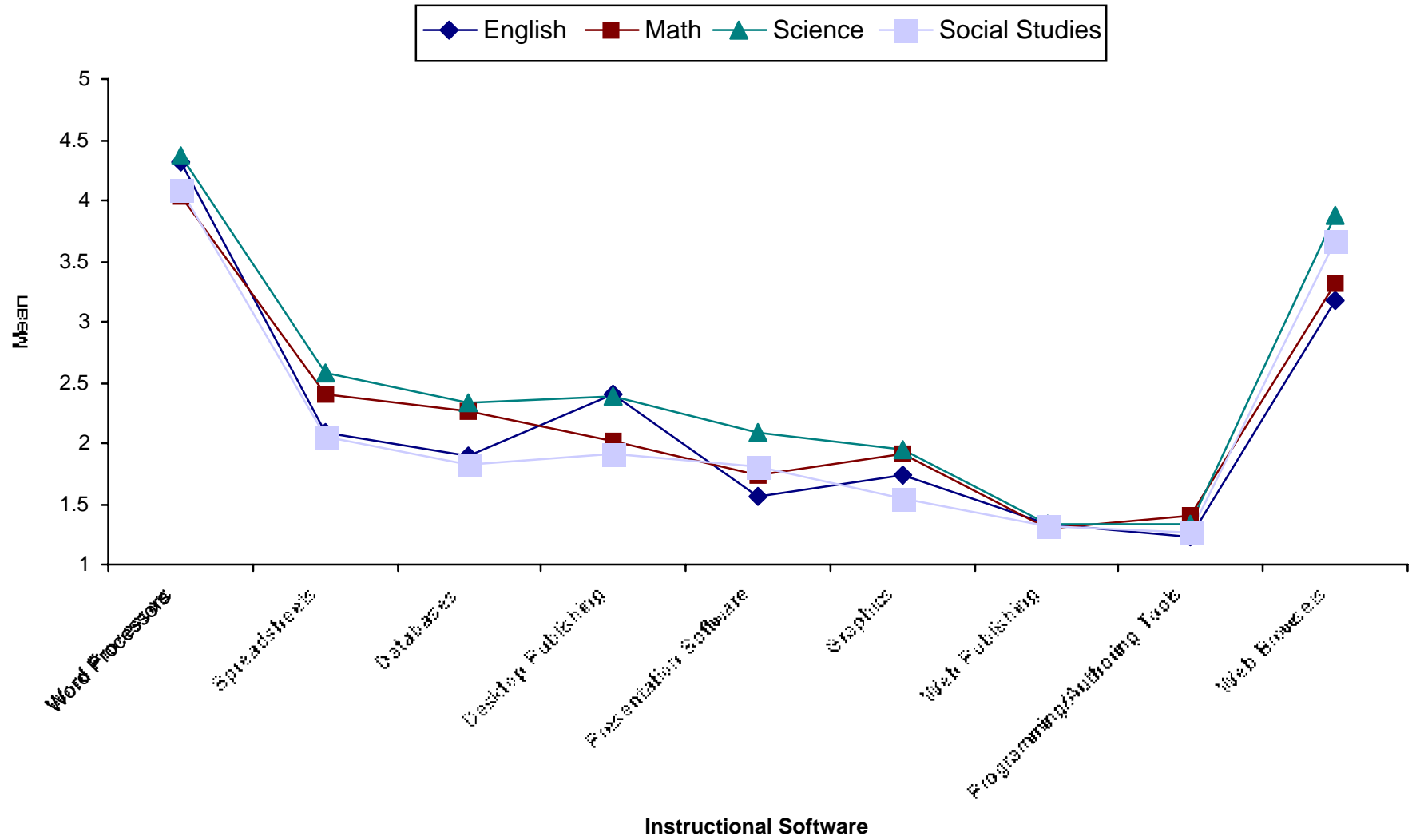


Figure 8
Instructional Software Used to Complete School Related Activities by Subject

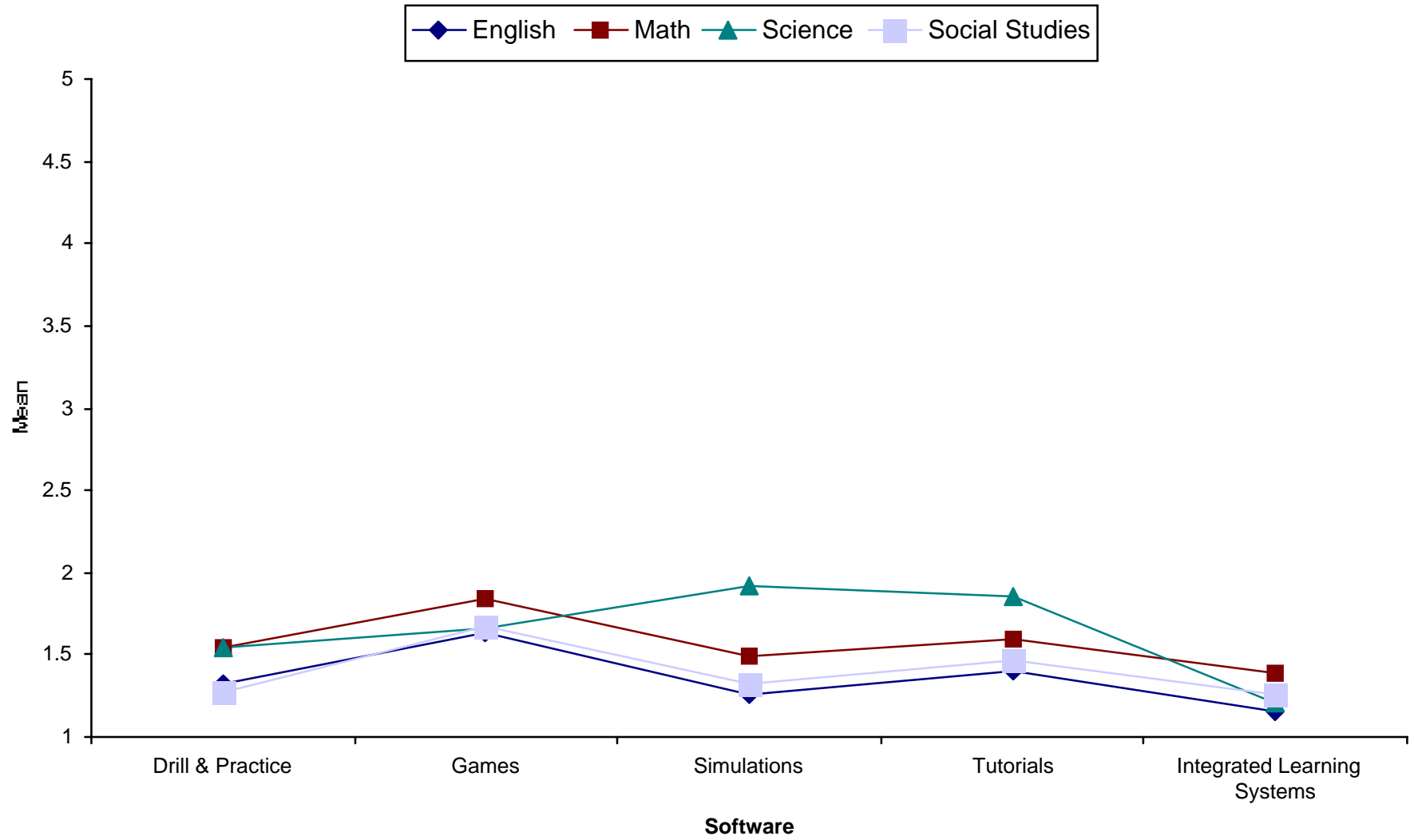


Figure 9
Average Student Software Use

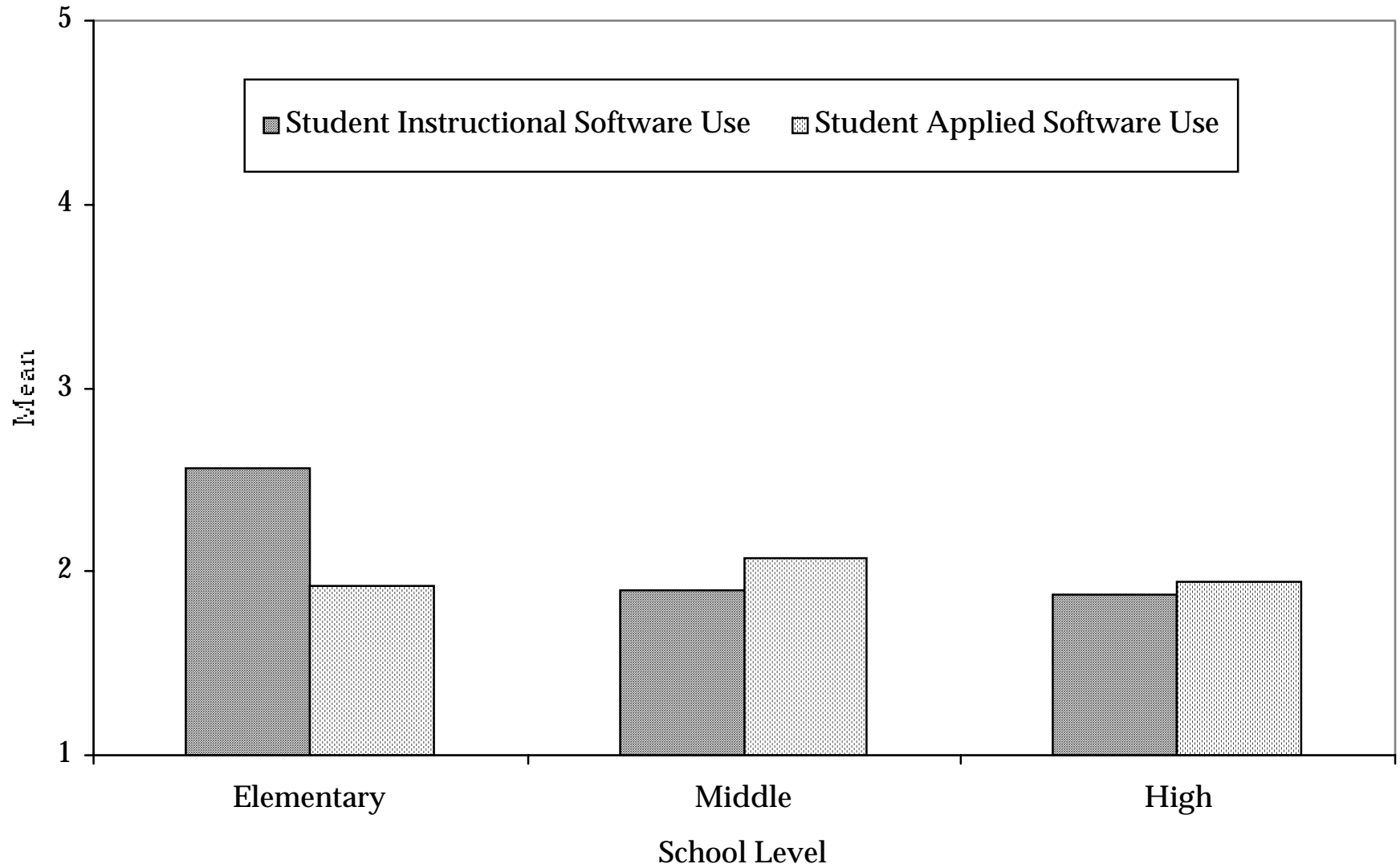


Figure 10
Average Student Software Use

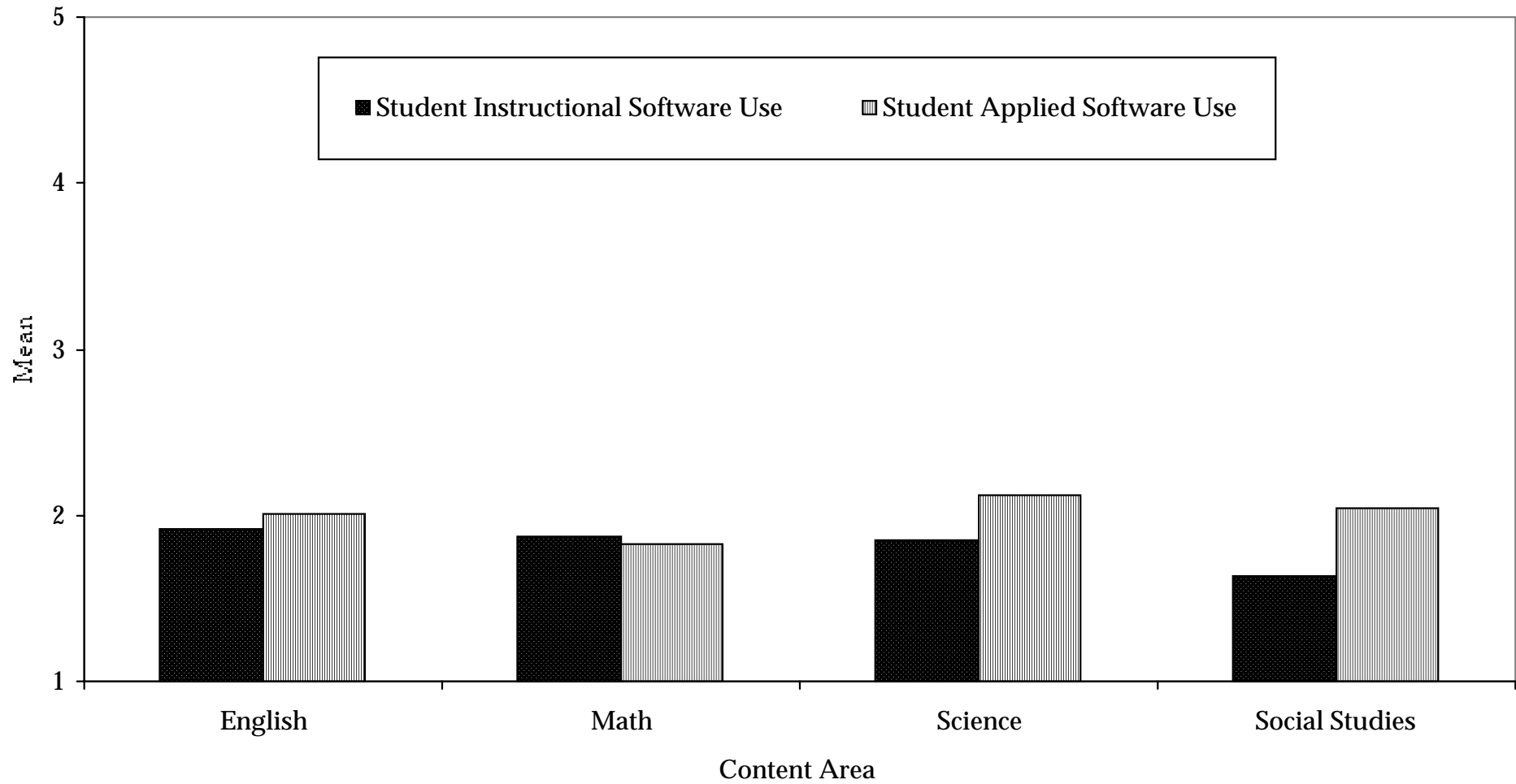


Table 1**Application Software Used to Complete School Related Activities by Level**

Level	Elementary		Middle		High	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Software						
Word Processors	4.20	.99	4.18	1.04	4.22	1.01
Spreadsheets	2.13	1.12	2.34	1.34	2.19	1.27
Databases	2.28	1.38	2.41	1.43	2.13	1.33
Desktop Publishing	2.48	1.22	2.23	1.14	2.15	1.27
Presentation Software	1.59	.87	1.75	1.09	1.71	1.03
Web Publishing	1.34	.80	1.25	.70	1.40	.86
Programming/Authoring Tools	1.27	.74	1.29	.74	1.35	.87
Web Browsers	3.41	1.43	3.47	1.48	3.46	1.53

Note: approximate sample size = 1665

Table 2**Instructional Software Used to Complete School Related Activities by Level**

Level	Elementary		Middle		High	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Software						
Drill and Practice	1.57	1.10	1.50	.99	1.48	.93
Games	1.80	1.21	1.77	1.14	1.76	1.13
Simulations	1.34	.79	1.52	.98	1.46	.85
Tutorials	1.65	.98	1.63	1.00	1.61	.95
Integrated Learning Systems	1.30	.78	1.34	.86	1.21	.65

Note: approximate sample size = 1665

Table 3**Application Software Used to Complete School Related Activities by Subject**

Subject	English		Math		Science		Social Studies	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Software								
Word Processors	4.31	1.01	4.04	1.13	4.37	.91	4.09	1.13
Spreadsheets	2.08	1.28	2.41	1.52	2.58	1.24	2.05	1.23
Databases	1.90	1.24	2.27	1.47	2.33	1.30	1.83	1.18
Desktop Publishing	2.40	1.34	2.02	1.09	2.39	1.23	1.91	1.18
Presentation Software	1.56	.85	1.73	1.16	2.09	1.12	1.81	1.16
Graphics	1.73	1.05	1.92	1.13	1.94	1.04	1.55	.79
Web Publishing	1.33	.76	1.30	.78	1.34	.73	1.32	.89
Programming/Authoring Tools	1.23	.66	1.41	.94	1.33	.85	1.26	.75
Web Browsers	3.17	1.47	3.32	1.58	3.87	1.35	3.67	1.50

Note: approximate sample size = 410

Table 4**Instructional Software Used to Complete School Related Activities by Subject**

Subject	English		Math		Science		Social Studies	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Software								
Drill and Practice	1.33	.70	1.54	1.07	1.55	.99	1.27	.63
Games	1.64	1.09	1.84	1.21	1.66	1.18	1.67	.98
Simulations	1.26	.58	1.49	1.00	1.92	1.09	1.33	.60
Tutorials	1.40	.74	1.59	1.06	1.85	1.05	1.47	.80
Integrated Learning Systems	1.15	.52	1.39	.91	1.21	.66	1.26	.74

Note: approximate sample size = 410

Table 5**Teacher Attitudes by Subject**

		English	Math	Science	Social Studies	
Affinity	Mean	4.0914	3.9419	3.9870	4.1004	$F=1.75$
	Standard Deviation	.5574	.5813	.6572	.6650	$p>.05$
Aversion	Mean	3.8482	3.9362	3.9718	3.7684	$F=2.02$
	Standard Deviation	.6139	.5994	.5560	.6885	$p>.05$

Table 6**Teacher Attitudes by Level**

		Elementary	Middle	High	
Affinity	Mean	4.0767	4.0160	4.1101	$F=2.83$
	Standard Deviation	.5513	.6043	.6131	$p>.05$
Aversion	Mean	3.9893	3.8770	3.9658	$F=5.57$
	Standard Deviation	.5511	.6004	.6016	$p=.0039$

Table 7

**Integration of Computers in the Classroom by Level:
Proportion of Teachers Using Computers in Various Teaching Modes**

School Level	Elementary	Middle	High
Teaching Mode			
Small Group Instruction	32.05	20.92	18.50
Individual Instruction	60.72	30.36	32.08
Cooperative Groups	40.58	20.62	21.85
Independent Learning	76.61	35.11	40.76
Tutor	57.11	19.95	21.28
Promote Student Centered Learning	65.57	29.82	27.47
Research Tool	32.05	34.35	40.43
Problem Solving Tool	29.95	23.26	20.29
Productivity Tool	36.78	39.54	37.77
Classroom Presentation Tool	26.53	27.69	26.14
Communication Tool	59.35	54.34	48.23

Table 8

**Integration of Computers in the Classroom by Subject
Proportion of Teachers Using Computers in Various Teaching Modes**

Subject	English	Math	Science	Social Studies
Teaching Mode				
Small Group Instruction	10.16	13.16	14.94	11.49
Individual Instruction	23.44	21.93	29.89	12.79
Cooperative Groups	10.40	14.16	20.69	18.82
Independent Learning	29.92	26.32	41.38	28.24
Tutor	13.39	16.67	27.38	12.94
Promote Student Centered Learning	19.69	22.52	28.74	21.69
Research Tool	30.16	23.89	51.14	44.19
Problem Solving Tool	10.40	16.96	28.41	22.62
Productivity Tool	31.50	33.33	48.28	40.00
Classroom Presentation Tool	21.26	16.96	42.53	29.76
Communication Tool	49.21	49.12	59.09	53.57