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Student Experiences of Technology Integration in School Subjects: A Comparison Across Four Middle Schools

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Abstract

This research examined student perspectives on their in-school, subject specific, technology use in four U.S. public schools. Considering students' perspectives may provide a significant reframing of adult-created rhetoric of the utopian power of digital technologies for changing teaching and learning. A survey and focus group interviews were administered to 6th and 7th students (n=1,544) in four public middle schools, with varying demographics, that rely on local funding. These four schools revealed moderate use of many well-established digital technologies, such as word processing, presentation software, and quiz games. Students voiced outright hatred for teacher-directed PowerPoint-supported lectures, the most prominent technology activity students experienced, yet reported enjoying creation activities. The students in the rural school with a Hispanic-majority and high economically disadvantaged population reported much lower technology use. Discussion frame the digital inequities in the four schools and emphasizes the need for awareness and inclusion of students' digital experiences to form any trajectory toward establishing digital equity and learning in schools.

Introduction

Much rhetoric in educational technology argues for the integration of technological tools as a panacea to low student achievement and "failing" schools. Considering students' perspectives may provide a significant reframing of adult-created rhetoric of the utopian power of digital technologies for changing teaching and learning, an argument critiqued in our field (Cuban, 2001, 2013; Selwyn, 2011). We believe listening to students' voices is critical to represent learner experiences within what we call "typical" schools—schools that rely on local funding and do not have special technology projects, grants, or collaborations. This research describes student experiences with and perspectives on in-school, subject specific digital technology use in U.S. public schools.

Literature Review

Youth live in a society that is seemingly more digital, with ambient media and content served through ubiquitous digital devices (Roberts & Koliska, 2014). Some research on adolescents' use of digital technology often focuses on how young people use technology out-of-school rather than in-school (Ehrlich, Spote, & Sebring, 2013; Fitton, Ahmedani, Harold, & Shifflet, 2013; Ito et al., 2008; Pinkard, Barron, & Martin, 2008; Spires, Lee, Turner, & Johnson,

2008). Other research studies examine in-school technology use from student perspectives and they reveal less overall digital technology use in school than outside of school (Bulfin, Johnson, Nemorin, & Selwyn, 2016; Hughes, Read, Jones, & Mahometa, 2015; Peck, Hewitt, Mullen, Lashley, Eldridge, & Douglas, 2015; Spires et al., 2008; Stefl-Mabry, Radlick, & Doane, 2010; Steinberg & McCray, 2012).

Technology use in schools can be categorized in a variety of ways, including for productivity, instruction, and creation (Roblyer & Hughes, 2019). Productivity technology, such as word processors, spreadsheets, presentations, database and graphing tools, typically is void of built-in content and requires the teacher or the learner to build or engage with content using these tools. For example, students might analyze class-collected or publicly available weather data in a spreadsheet to identify local trends. Instructional software, such as drill and practice,

tutorials, simulations, games or gamification, problem-solving, and personalized learning, include sequenced curricular content that allow students to practice specific skills. Creation technologies are devices and software that allow students to create multi-modal representations such as digital art and images, video, audio, and websites often leading to book making, digital storytelling, and/or digital publishing with

frequent use of web 2.0 technologies including wikis, blogs, and websites. Web 2.0 technology allows students to share their creations with others and communicate and collaborate with topic experts and peers both within and outside their school to learn deeply about their topic. Studies examining technology use from the students' perspectives tend to reveal predominant technology use for productivity, while students yearn for more creative uses.

Spires et al. (2008) found middle school students were frustrated because they were not allowed to use the same kind of technology in-school that they used out of school and did not think their teachers knew enough about technology to provide them with the skills they would need later in life in their future careers. Similarly, Stefl-Mabry et al. (2010), in a case study of middle and high school students, found teachers used minimal technology in class and the slow, restrictive, and frequent crashing school computers inhibited learning. These middle and high school students felt deeply disconnected from school and disempowered by not being able to use their own personal devices to research information or to communicate at school like they were able to do at home and in their communities.

In a survey by Selwyn and Bulfin (2016), students across three secondary schools highlighted three areas of frustration, including personal devices being taken away from them, content filtering or blocking, and enforced/standardized technology uses, which was unlike their experiences out of school. These frustrations led to students "working around" school authority (Selwyn & Bulfin, 2016, p. 13), and Peck et al. (2015) referred to these students as "digital rebels" (p. 2).

Steinberg and McCray (2012) interviewed middle school students who sought more teacher-modeling of student-centered, active learning with technology. Wang, Hsu, Campbell, Coster, and Longhurst's (2014) study of middle school science classrooms found students reported using word processing, spreadsheets, presentation tools, and web searches most frequently in class. Peck et al. (2015) also found teachers primarily used technology administratively (e.g., grades) or for whole-class displays (e.g., daily agendas), some evidence of student-centered Internet research and projects, but overall, teachers maintained traditional approaches with lectures and pencil/paper

worksheets while their technology tools collected dust.

Across these studies of in-school technology integration, only Wang et al. (2014) specifically examined technology integration in a subject matter, science. While Bulfin et al. (2016) calls for more research to understand "the realities of school technology" and "the characteristics of contemporary schools as contexts for digital technology use" (p. 240), this literature review also reveals that the nature of technology integration in school subjects is understudied.

Theoretically, we situate our research within a socio-constructivist epistemology that positions learning as influenced by individuals' perspectives, experiences, and beliefs as well as interactions with other people, tools, and through language. Thus, our study forefronted students' digital technology practices and perspectives within school subject areas.

Theoretical Framework

We situate our research within a socio-constructivist epistemology that positions learning as influenced by individuals' perspectives, experiences, and beliefs as well as interactions with other people, tools, and through language. The technological experiences of individual youth in school will shape their multimodal, deictic "new literacies" (Leu, Kinzer, Coiro, Castek, & Henry, 2013), which have been construed as vital for participation in our global society. Thus, our study forefronted students' digital technology practices within school subject areas. We sought to privilege individual student experiences but still be sensitive to other socio-technical influences. In particular, given a history of digital inequities in the US that have roots in certain economic, ethnic, and geographic groups, our theoretical framework led us to seek participant schools with different characteristics of student ethnicity and economic (dis)advantage, school urbanicity, and pupil spending.

Research Questions

We framed children's digital technology use in school subjects within four school cases that varied by student demographic variables and school characteristics (see Tables 1 and 2). Our study was guided by the following research questions.

1. What are students' access to, use of, and perspectives on digital technology-supported learning in school?
2. How often and what kinds of digital technologies are students using in school subjects?
3. What policies do students see as supports or barriers to learning with digital technologies?

Methods

This research employed a mixed-methods, multiple case study methodology (Yin, 2003)

that included a descriptive survey and qualitative focus group interviews to examine middle school students' in-school digital technological activities.

Participants

Students ($n=1,544$) in the 6th and 7th grades in four middle schools in the southwestern US participated in the study (see Table 1). Saguario, located in a rural setting, serves a Hispanic-majority student population. Porter, an urban school, is diverse due to a district transfer

Table 1
Characteristics of Participating Middle Schools

	School			
	Saguario	Porter	Walnut	Verona
Year built	1972	1953	1995	1996
School type	Rural	Metropolitan	Suburban	Rural
Students (#) in School (6-8 grade)	1,000	973	1,317	812
Economically Disadvantaged (%)	74	40	12	53
Students (#) in District	9,555	82,000	32,034	32,034
School Accountability Rating ^a	Academically Acceptable	Academically Acceptable	Recognized	Recognized

Note: ^aThe state in which this study was conducted used a 4-point (Academically Unacceptable, Academically Acceptable, Recognized, Exemplary) accountability rating scale based on several factors including standardized student test performance, drop-out rates, and completion rates.

Table 2
Counts and Percentages of Ethnicity and Gender Breakdown within School for Participating Students

Gender	Ethnicity	School							
		Porter		Verona		Walnut		Saguario	
		<i>n</i>	% within School						
Male	Caucasian	57	24.8	75	28.7	251	34.2	17	5.3
	African American	12	5.2	3	1.2	11	1.5	22	6.9
	Hispanic	39	17.0	27	10.3	39	5.3	86	27.0
	Asian	1	.4	4	1.5	29	4.0	8	2.5
	Other	5	2.2	9	3.5	18	2.5	7	2.2
	Total Males	114	49.6	118	45.2	348	47.5	140	43.9
Female	Caucasian	65	28.3	73	28.0	301	41.0	14	4.4
	African American	6	2.6	11	4.2	6	.8	33	10.3
	Hispanic	36	15.7	48	18.4	34	4.6	119	37.3
	Asian	1	.4	3	1.1	25	3.4	4	1.3
	Other	8	3.4	8	3.1	20	2.7	9	2.8
	Total Females	116	50.4	143	54.8	386	52.5	179	56.1
Grand Totals		230	100	261	100	734	100	319	100

program that brings minority students (see Table 2) from minority-majority schools of this urban city to Porter. Walnut and Verona middle schools are located in the same rural/suburban district but vary widely due to geographic location and the district's neighborhood attendance zones.

Procedures

In consultation with teachers and the school principal at each school, all teachers in one subject area volunteered to assist with student data collection. Parent consent forms (with an active consent Yes/No option) were sent home with all 6th and 7th grade students and returned to the teacher who put them in an envelope for researcher pick-up. All students who returned the parent consent form received an incentive, a \$.25 university-logo pencil. Unclaimed pencils were donated to the teachers. Sixth and 7th grade students from each campus completed a printed research assent form at the time of the online survey administration. The questionnaire was hosted in Qualtrics and administered by the researchers in the subject area during one class period in school computer labs or with school laptops. The researchers deleted all respondents' survey information from the dataset for those students who did not assent and/or whose parent/guardian did not consent.

Data Sources and Analysis

The survey was developed after review of a range of existing surveys on technology integration in schools. Several middle school teachers and media specialists reviewed the survey items, which contributed to face validity. Several educational technology experts with PK-12 teaching experience reviewed appropriateness of items, which contributed to content validity. A selection of items related to in-class technology activity from our survey were used for this analysis.

Focus group interviews were conducted with students immediately after survey completion and were not audio-recorded due to IRB and consent constraints. Interviewers wrote field notes of student comments and quotes.

Descriptive statistics were used to characterize overall students' experiences with digital technologies in their school subjects. Analysis was completed using SPSS. Focus group discussion notes were coded and analyzed in

NVIVO 10.0. We used open-coding techniques reflecting emergent categories (Glaser & Strauss, 1967). A process of collaborative coding and checking occurred between researchers until 100% agreement on codes was achieved. We engaged in multi-faceted data queries within NVIVO. As we engaged with queries, we wrote emergent memos, shared these across researchers, and continued analyzing and examining patterns until our findings were saturated and no rival explanations existed.

Findings

We describe three foundations (technology access, technology-based homework, and students' perceptions of technology use for learning) that shape students' digital technology learning opportunities by revealing what students can do or may desire to do with digital technology in their respective schools. Then, we describe the nature of technology-supported teaching and learning in students' coursework and in subject areas within each school case. We conclude by considering essential cross-case themes that emerged.

Foundations for Digital Technology-Supported Learning

For teachers and learners to engage with digital learning, the first foundation is school-based technology access. Yet, students may also face homework gaps (Meyer, 2016; Rosenworcel, 2014) if they are assigned homework that requires the Internet or digital technology when they have access to neither at home. Further, students' dispositions and expectations toward focused work with technology may shape the possibility for engaged digital learning. This section reviews the students' perceptions of these foundations at each of the four schools, which consequently influenced what occurred in our exploration of digital technology use in subject areas.

Students in Porter, Walnut, and Verona schools tended to find it easy to find a computer to do work at school when needed. However, a large proportion (about 40%) of Saguaro students could not find a computer or sometimes found it difficult to find one at school (see Figure 1). The highest percentage of students at Porter found it always easy to find a computer at school. Walnut and Verona school children perceived access to computers nearly the same, which reveals

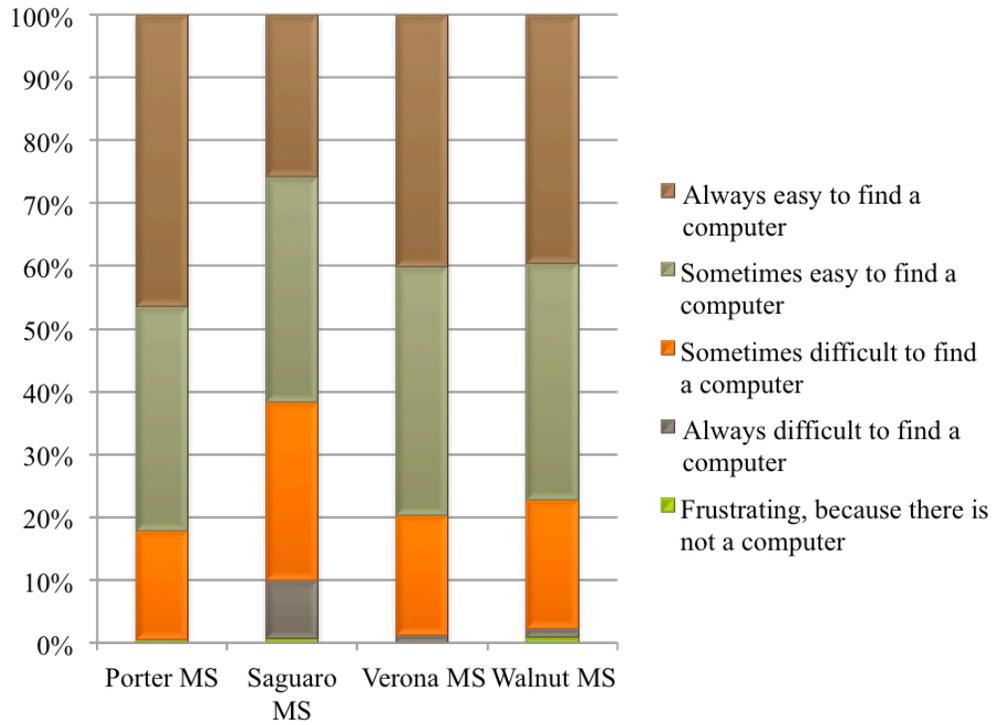


Figure 1. Percentage of Students Reporting Ease of Access to Computers in School

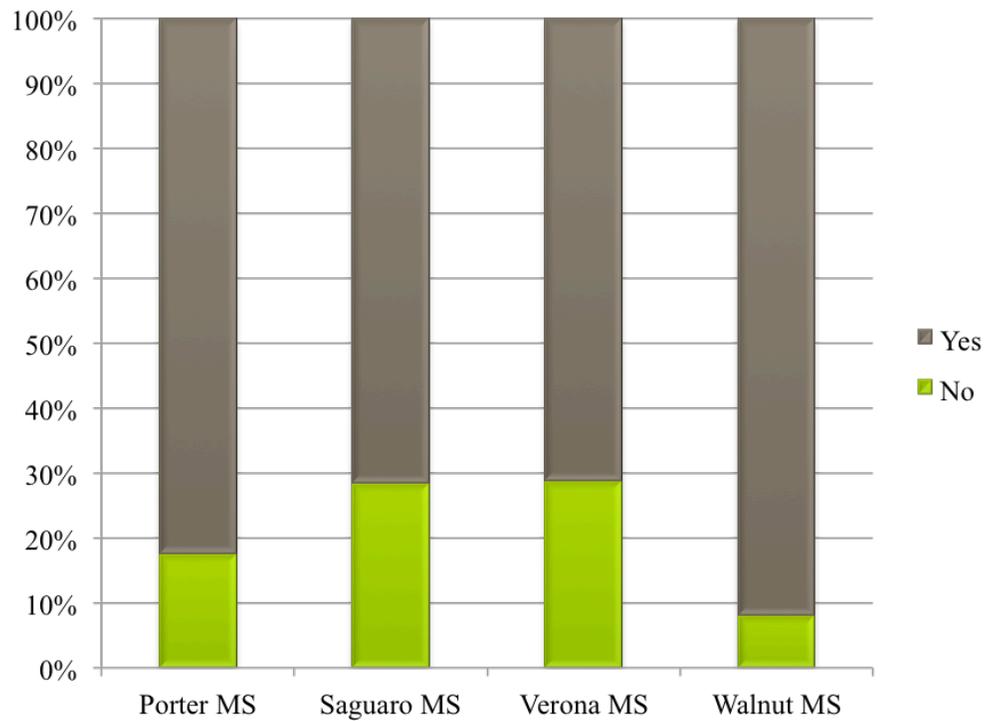


Figure 2. Percentage of Students Receiving Homework that Requires a Computer

equitable access given that these schools are located in the same school district.

A majority of the schools' students reported they were assigned homework that required using a computer (see Figure 2). However, more of the rural Saguaro and Verona schoolchildren reported not being assigned computer-based homework.

In terms of the students' outlook on the role of technology in their learning, students at these

schools tended to agree that the use of technology led them to be more actively involved in class and such use improved their learning (see Figure 3). They also disagreed that they became more off-task when technologies were used. The students from Saguaro school, who reported more difficult technology access, most strongly agreed (mean score 3.22) that they got more actively involved and most strongly disagreed (mean score 1.91) that they became off-task with the use of technology.

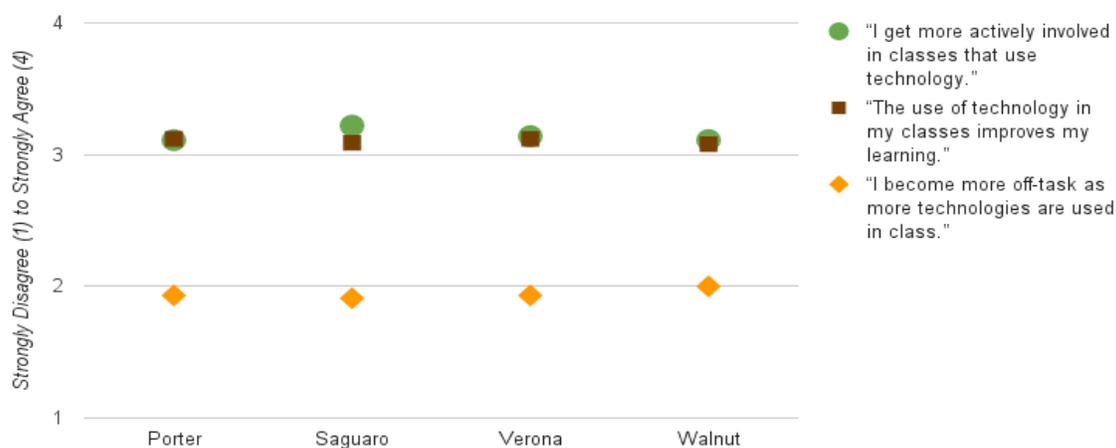


Figure 3. Mean Score of Students' Perceptions of How Use of Technology Affects Them in Class

Given this foundational context on technology access, digital homework expectations, and students' attitudes toward technology's role in their learning, next we reveal students' perspectives on the use of technology in their coursework at each school.

Porter Middle School

Students first reported their technological activities in school without respect to subject areas (see Figure 4). At Porter, the largest proportion of students (~80%) reported using productivity technologies, such as presentation software, word processing, desktop publishing, and spreadsheets. Further, large numbers of students also reported using instructional practice/quiz programs, library websites, concept maps, and search engines. Fewer than

40% of students reported doing creation activities, such as with digital art, pictures, video, or websites. Less than 25% of these students reported doing any web 2.0 technologies, such as blogging, sharing creations online, wiki writing, and microblogging.

Within school subjects, students reported their teachers had higher frequency of use of technologies (see Figure 5) than they did. Thus, technology was more in the hands of teachers. Students reported about 80-90% of their subject area teachers used technology some or a lot. In contrast, between 20-50% of students reported never using technologies in these subject area classes. Overall, students at Porter reported using technology the most in ELA and science classes and the least in mathematics.

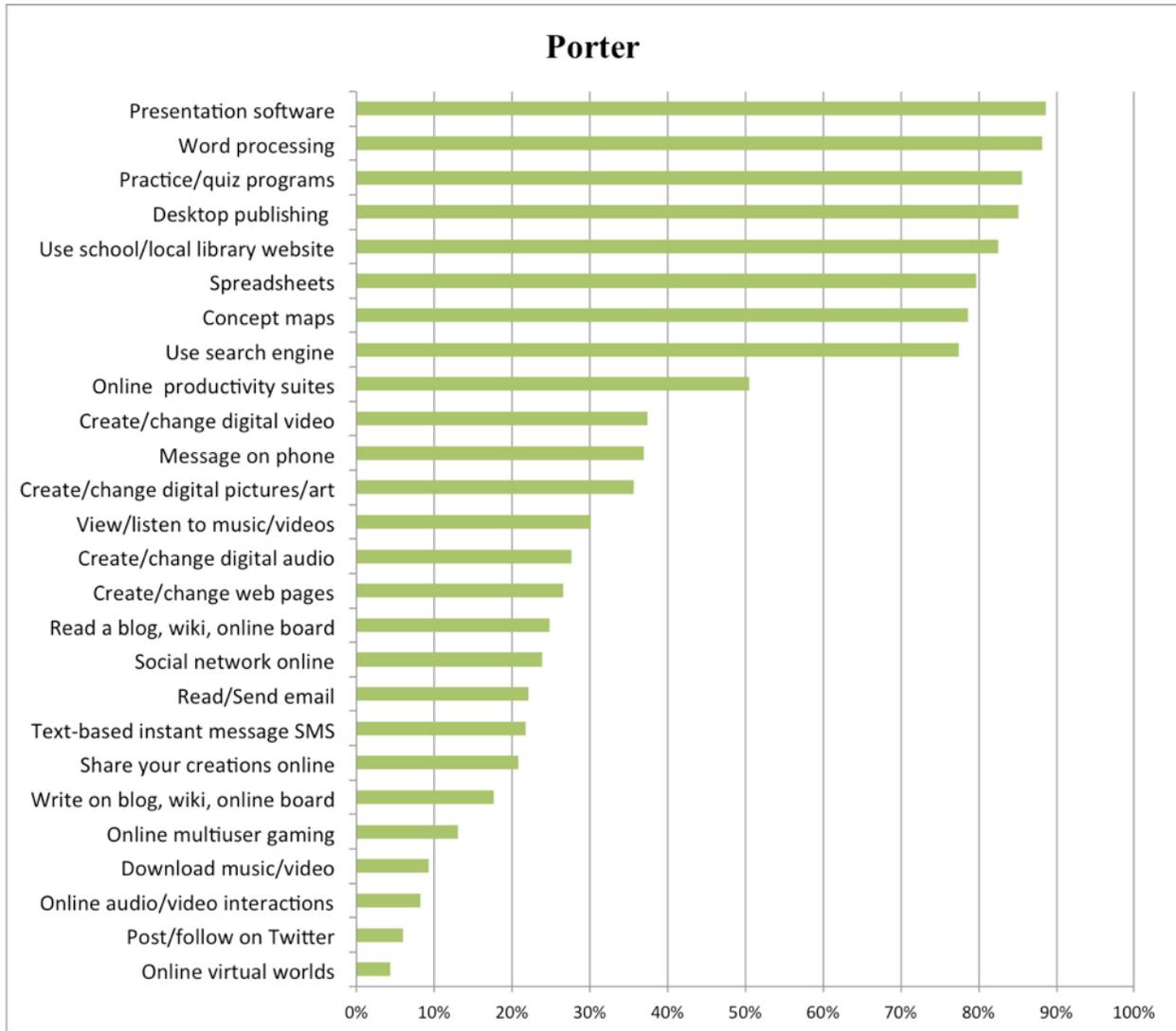


Figure 4. Percentage of students reporting doing these technology activities in school

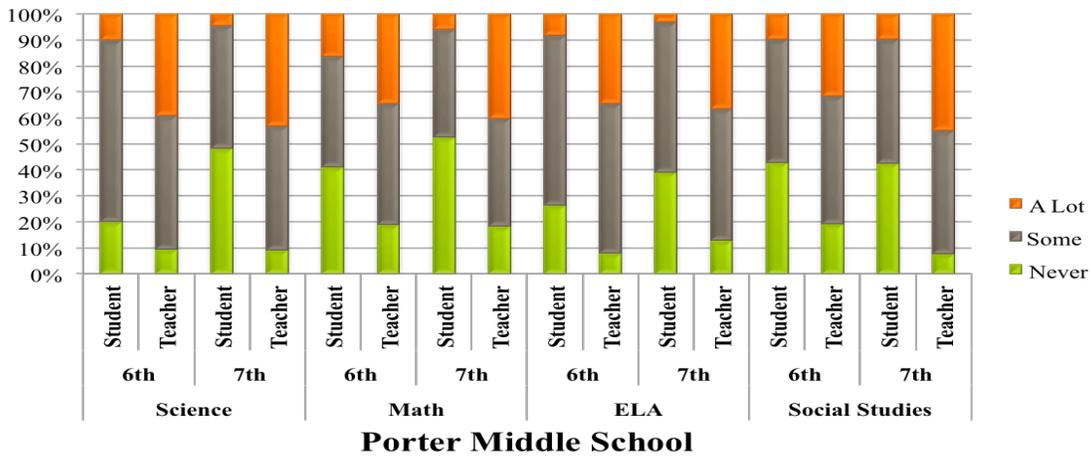


Figure 5. Percentage of students reporting their & their teachers' digital technology use in school subjects.

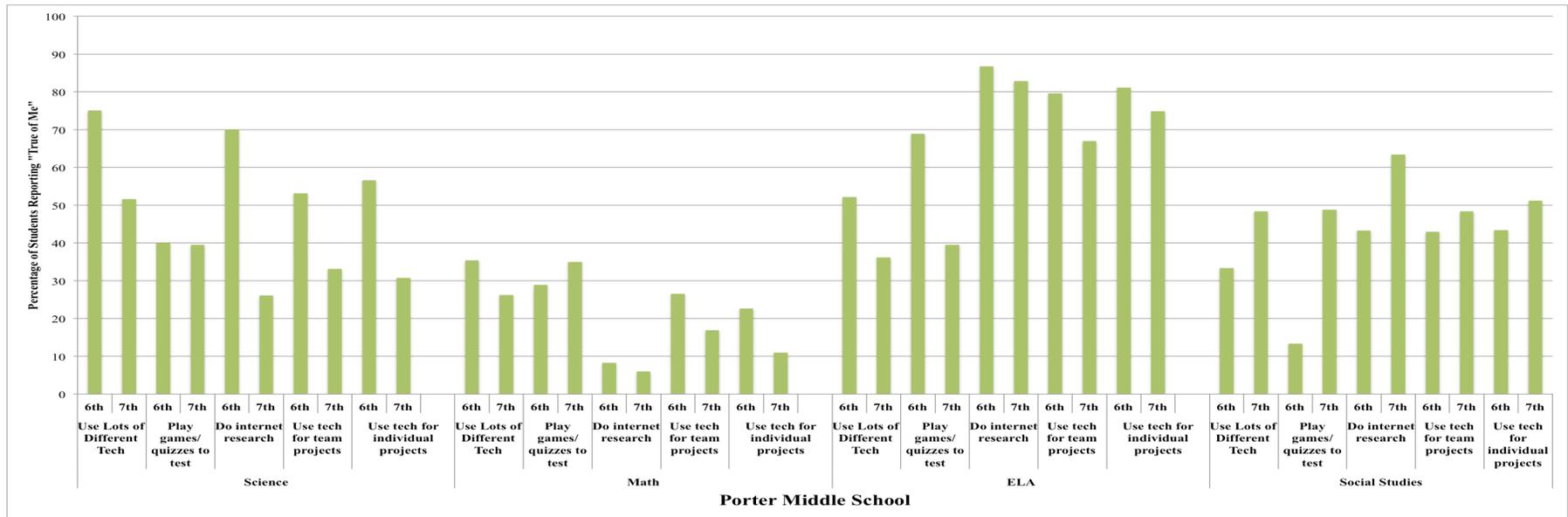


Figure 6. Percentage of students (who used technology in the subject area) reporting how they used digital technology in school subjects.

Science. While the students reported their 6th and 7th grade science teachers using technology at a similar frequency, the 6th grade students used technologies more often than the 7th graders at Porter. More 6th graders reported technology use, such as using lots of different technology, playing games/quizzes, researching, and for team projects, than 7th graders (see Figure 6). In the focus groups, the majority of students reported teacher-directed activities (26 comments). Students mentioned viewing PowerPoint presentations and notes displayed on a document camera. Some mentioned more subject-specific activities such as conducting virtual labs and microscope activities, and four reported creation activities such as research projects and recording scientific data.

Mathematics. More students reported mathematics class as the subject where they never used digital tools for learning than other subject areas (see Figure 5). It was also the class where students (20%) reported the most teachers never used technologies. Of those students who did use technology, mathematics class was the least likely class to find students using technology to do internet research, for team or individual projects, play games/quizzes, or use lots of different technologies (see Figure 6). Students told us activities in mathematics were often teacher directed, such as teacher use of PowerPoint, document camera, or content specific video presentations.

English Language Arts. On average, more students at Porter reported using technology some or a lot in ELA than the other subject areas. Like science, 6th graders reported more use than 7th graders, and 90% of them reported their teachers were using technology some or a lot. At Porter, students reported using technology in ELA for Internet research and in team or individual projects at a much higher percentage than in the other subject areas (see Figure 6). Twenty-four students described doing creation activities such as creating movie posters, PowerPoint presentations, comics, movie trailers, and documentaries most often in ELA.

Social studies. 6th graders reported their social studies teachers using technology somewhat less than the 45% of 7th graders who reported their teachers were using technology a lot in social studies. Despite the difference in the teachers' use, 6th and 7th graders reported nearly identical

frequency of use in social studies. Similar to mathematics class, more students in social studies (42%) reported never using technology (see Figure 5). About 10% of the students reported using technology a lot in social studies. Of those students who did use technology, about 50% felt they were using technologies for Internet research, team, and individual projects (see Figure 6). Fewer 6th graders reported these activities felt 'true,' while slightly more 7th graders reported them to feel 'true' to their experience. Another distinct pattern was a large increase in playing games/quizzes from 6th to 7th grade. Students participated in creation activities in social studies more often than in science or mathematics. They mentioned eight student creation activities such as creating comics in ComicLife, making a history related website, and using Google Earth to explore cities. Students described equal number student creation activities and teacher directed activities occurring in social studies, unlike the other subject areas in which students described more teacher directed activities.

Supports and Barriers to Learning Digitally. Many of the students expressed frustration at the rules imposed on them regarding technology. In the focus groups, 36 of the 55 (65%) comments related to blocked websites or to their cell phones or other mobile devices. Nineteen students mentioned websites being blocked as a technology rule they did not like. The websites most frequently mentioned as being blocked were social networking sites like Facebook or YouTube, and a couple of students mentioned not being able to access gaming sites. One student pointed out that even though this rule was in place for students, it sometimes limited teachers as well. Another student mentioned how these sites allowed them to communicate around the world, a benefit the student identified for the classroom. After blocked websites, students most mentioned (17 times) the barrier of not being able to use their cell phones or other mobile devices. Four of these students also mentioned having to pay a \$15 fine in order to get their phone back if it was confiscated. Four students mentioned not being allowed to use Wikipedia for research in their classes because teachers had told them that on Wikipedia "people can edit it...it might not be right."

Students identified some rules and procedures that were necessary and did not hinder their

learning. These involved classroom procedures, such as logging into the computers, waiting for a teacher before entering the lab, no food or drinks around the computers, not using computers to check email, not using computers during free time, and using a flash drive to save your work because information saved on the computers would be deleted. Some rules related to digital citizenship such as not making negative comments on school websites and using only information that could be verified across multiple sites. A few other students mentioned being allowed to play games sometimes, especially as a reward, being allowed to do research, and being allowed to study online with practice quizzes as benefits to their learning.

Overall, students at Porter Middle School enjoyed using technology most when they were allowed the freedom to play games or express themselves via platforms such as blogging in English language arts. They did not like using technology as much for activities such as

structured writing assignments or listening to and viewing teacher lectures in PowerPoint.

Saguaro Middle School

Less than half of the students at Saguaro reported using any technology at school (see Figure 7). Most students (~45%) reported using the productivity technologies like presentation software and word processing, but they also used instructional practice/quiz software, search engines, and library websites. Far fewer students (~10%) reported using any of the other technological activities we queried in school.

At Saguaro, students reported that their subject area teachers used technologies more than they, the students, did (see Figure 8). As compared with students' use, fewer teachers had 'never' used technologies in the subject areas and more used technology some or a lot. Overall, students used technology the most in social studies classrooms and least in mathematics.

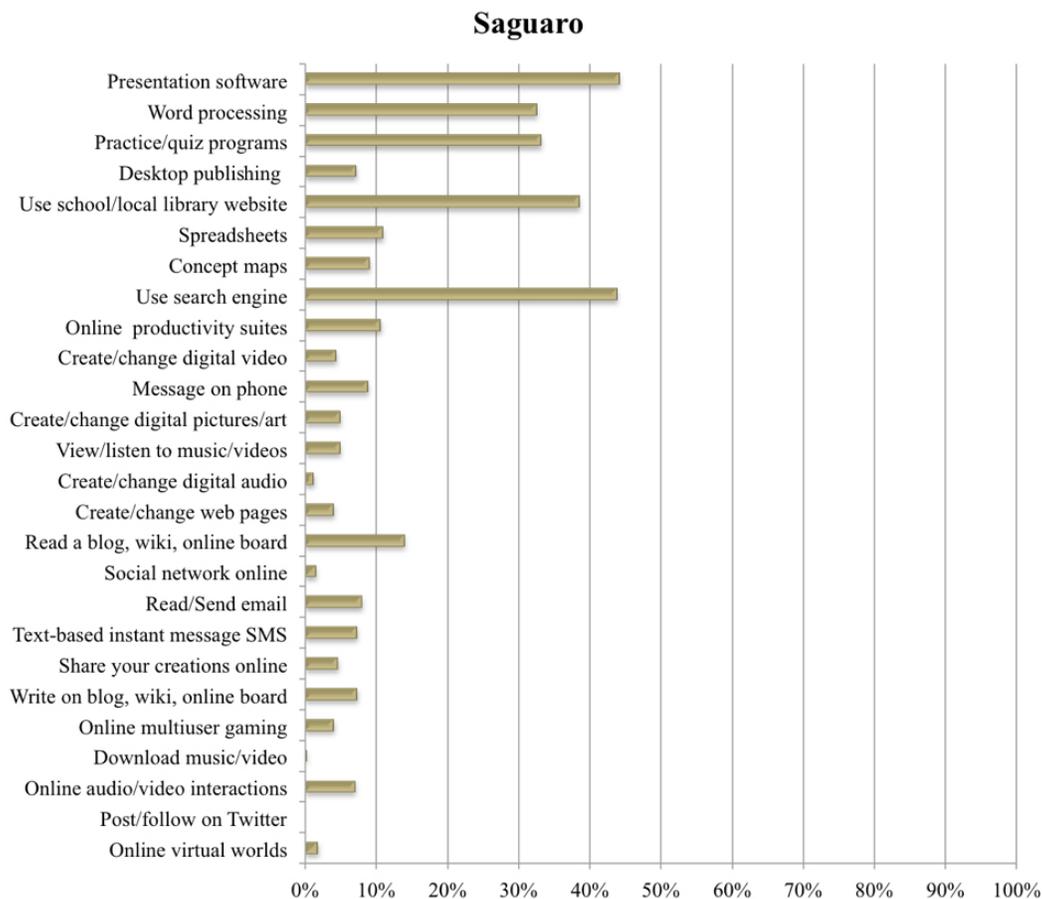


Figure 7. Percentage of students reporting they do these technology activities in school.

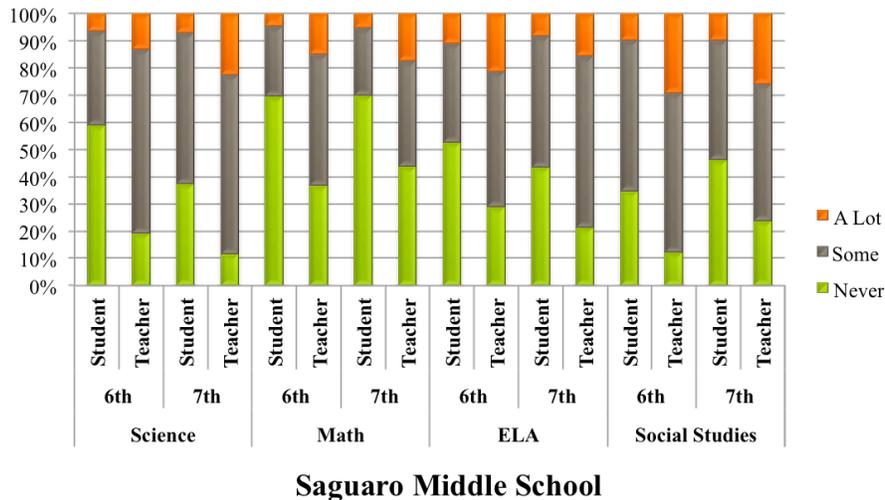


Figure 8. Percentage of students reporting their and their teachers' digital technology use in school subjects.

Science. Forty percent of 6th grade students reported using technologies in science, while 62% of 7th graders did, which was the highest use among the subject areas for 7th graders (see Figure 8). Ninety percent of students reported their 7th grade science teachers used technology some or a lot, as compared with 80% of the 6th grade students, which could have contributed to the higher reported student use in 7th grade. Sixty percent of 7th grade students who used technologies in science also reported they used lots of different technologies (see Figure 9). The 6th graders who used technologies were rarely using them for Internet research or team or individual projects in science (see Figure 9). More 7th graders, on the other hand, reported use of technology for individual or team projects and Internet research. In focus groups with students, they reported more teacher-directed technology activities in science than in any of their other classes, mainly involving watching videos. A few students mentioned they used Google to do research on science related topics. One student reported they used computers more in science than in their other classes.

Mathematics. Saguaro students reported nearly identical technology use in their 6th and 7th grade mathematics classes, with 70% reporting never using technology (see Figure 8). Of the few who did use technologies, about 20% reported using games and less than 10% reported doing Internet research or projects with technology in their mathematics classes (see Figure 9). In focus group interviews, the

students reported that the class in which they used technology the least was mathematics, which is supported by the survey results. When it was used, students reported it as mostly teacher directed activities, such as watching videos or PowerPoint presentations. They did report playing mathematics related games on FunBrain, an activity in which students actually touched the computers.

English Language Arts. About 50% of the students reported never using technology in their ELA classes at Saguaro, with just a few more 7th graders reporting use than 6th graders (see Figure 8). Again, the students reported fewer 7th grade teachers never use technology in ELA classes, which could be related to why slightly more 7th grade students used some or a lot of technology in ELA. Of the 50% of students who used technologies, fewest (15%) reported using it for games or quizzes and more (40-50%) reported doing Internet research and using technology for individual or team projects (see Figure 9). In particular, more than 60% of 7th grade students reported doing Internet research in their ELA class. In focus groups, the students reported using technology in class most frequently in their English language arts (and social studies) classes. Eleven students mentioned using computers in their language arts classes to type their papers and to “look up the thing I’m writing about.” Thus, they engaged in Internet-based research. The students reported using the computers for various writing projects from research papers to poems and short stories.

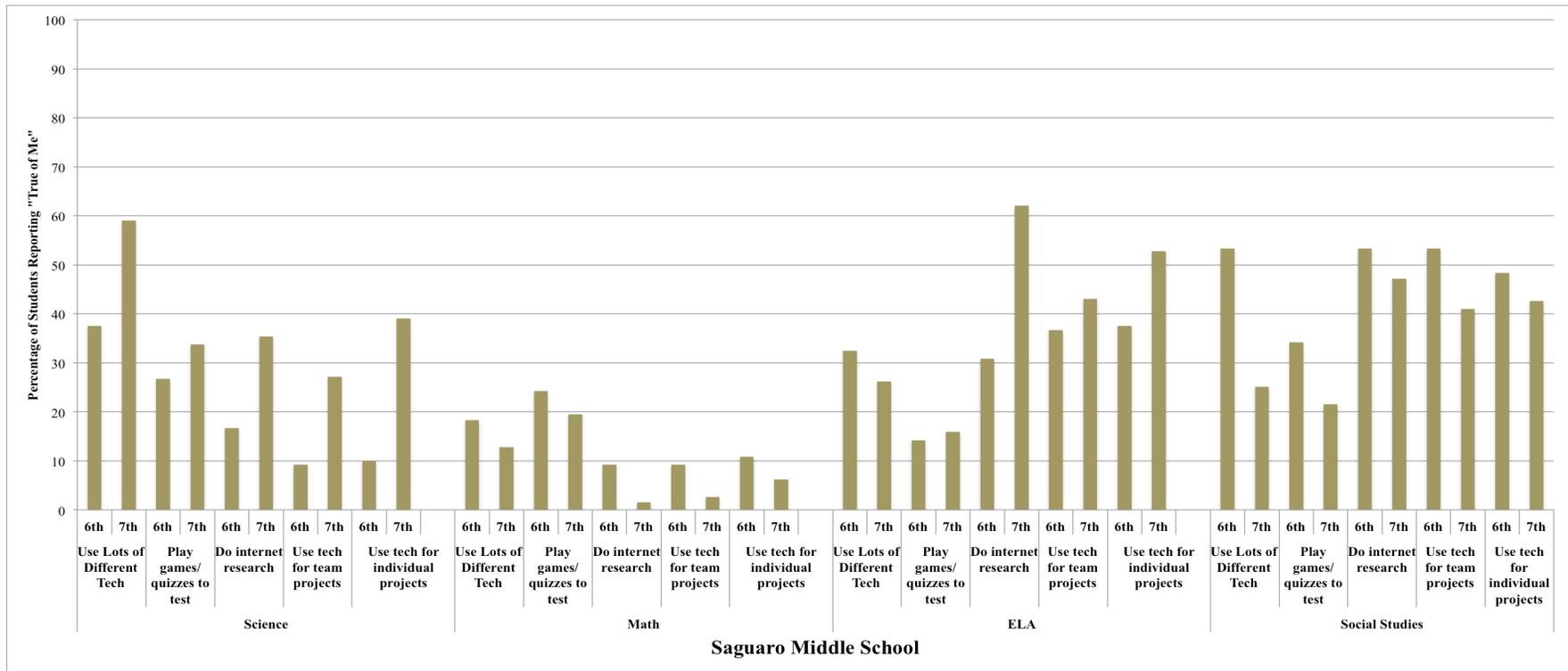


Figure 9. Percentage of students (who used technology in the subject area) reporting how they used digital technology in school subjects.

Social studies. More Saguaro 6th grade students (62%) used digital tools in social studies than in their other subject areas, and 54% of 7th graders reported using some or a lot of technology in social studies (second highest to science) (see Figure 8). About 55% of 6th graders also reported using lots of different technologies in social studies, whereas fewer 7th graders felt this (see Figure 9). About 50% of 6th and 7th graders reported using technologies for Internet research and individual or team projects. Social studies was the class in which the most students consistently reported doing these kinds of activities with technology. In conversations with the students, some reported using technology more in social studies class than in any other classes, which accords with the survey data. They reported varied activities from teacher directed activities, such as viewing PowerPoint presentations, to student creation activities, such as doing online research and creating PowerPoint presentations.

Supports and Barriers to Learning Digitally. Students often raised the same issues as supports and barriers. For example, many students at Saguaro felt that the rule that cell phones and other mobile devices should be kept in lockers kept people from cheating and getting distracted. One student suggested cell phones must be off during class but wanted to be able to check it during a free period. Several students also felt that website filters were beneficial because they prevent students or the school from getting into trouble. One student mentioned that these types of restrictions deterred online predators. Four students stated they were unable use Facebook and thought this was good because there was no educational value in the site.

On the other hand, students mentioned these same issues in much greater frequency as inhibiting learning or being “ridiculous.” Many students wanted to have their cell phone with them for emergencies or because it would be faster to call their parents than to use the school phone. One student was frustrated because students were no longer allowed to listen to iPods while exercising because people were stealing them. One student said, “Everything would be better if we could have phones.” Others said being allowed to listen to music on an iPod helped him concentrate. Another student found it unfair that teachers were allowed to use their phones while students were not and resented having their personal property taken from them if they were caught using it.

Many students saw the web filters as a hindrance to learning. Blocking YouTube was mentioned more than any other, and the students felt that much good material and information was being blocked by not having access to YouTube. One student even said, “You can learn to cook on YouTube.” Twelve more students mentioned website blocking as problematic, and one student pointed out that the sites the school blocked were accessible at the public library, and another said that parents were not as strict as the school. Students suggested that teachers walk around the room to monitor students instead of just blocking websites. As one student said, these are “rules that we can do without.”

Overall, students told us they did not use technology much in school and when they did try, many websites were blocked and unavailable to them. The activities they did mention as more enjoyable were using PowerPoint to create presentations, using the computer to communicate for projects, making videos, creating things such as a video, song, game, or website, playing games, and doing research. Some students did not like using the programmed curriculum that involved teachers showing videos in class and some mentioned struggling to find what they were looking for while doing Internet research.

Verona Middle School

Most students at Verona reported using productivity tools, particularly presentation software, word processing, and desktop publishing more than tools used for working with multimedia elements or social media related activities (0-62% of students), with the exception of creating/changing digital audio, which approximately 75% of the students reported doing (see Figure 10). Over 85% of students noted using computers for browsing the school/local library websites. Also, many students reported using the computer for searching search engines (75%) and developing concept maps (81%).

Overall, Verona students described heavier teacher use of technology across both grades and all subject areas (see Figure 11). Considering all students, more students used technology some and a lot in science and mathematics at Verona. Most 6th graders (85%) reported using technology some or a lot in mathematics, while most 7th graders (81%) reported using technology some or a lot in science.

Verona

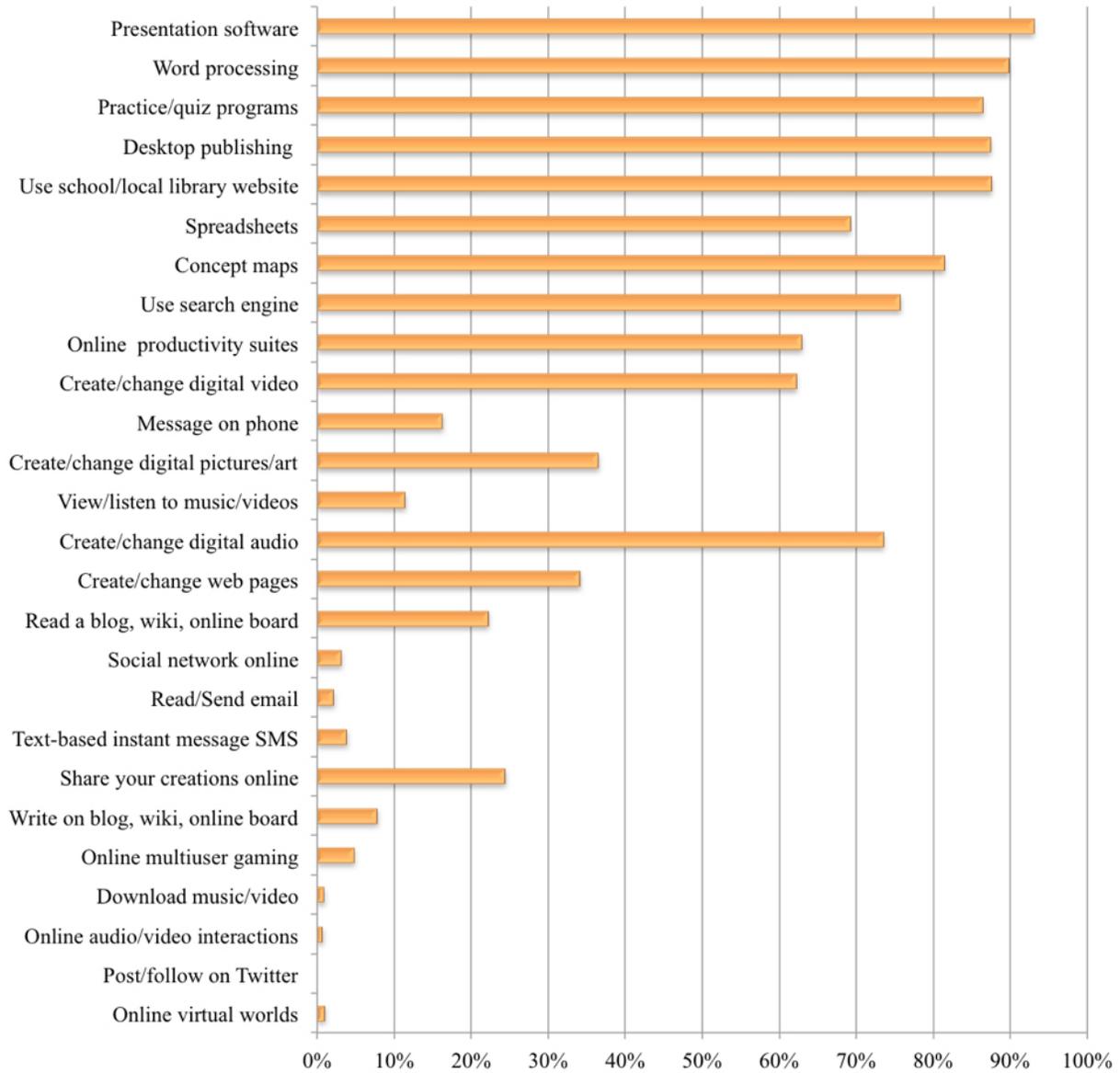
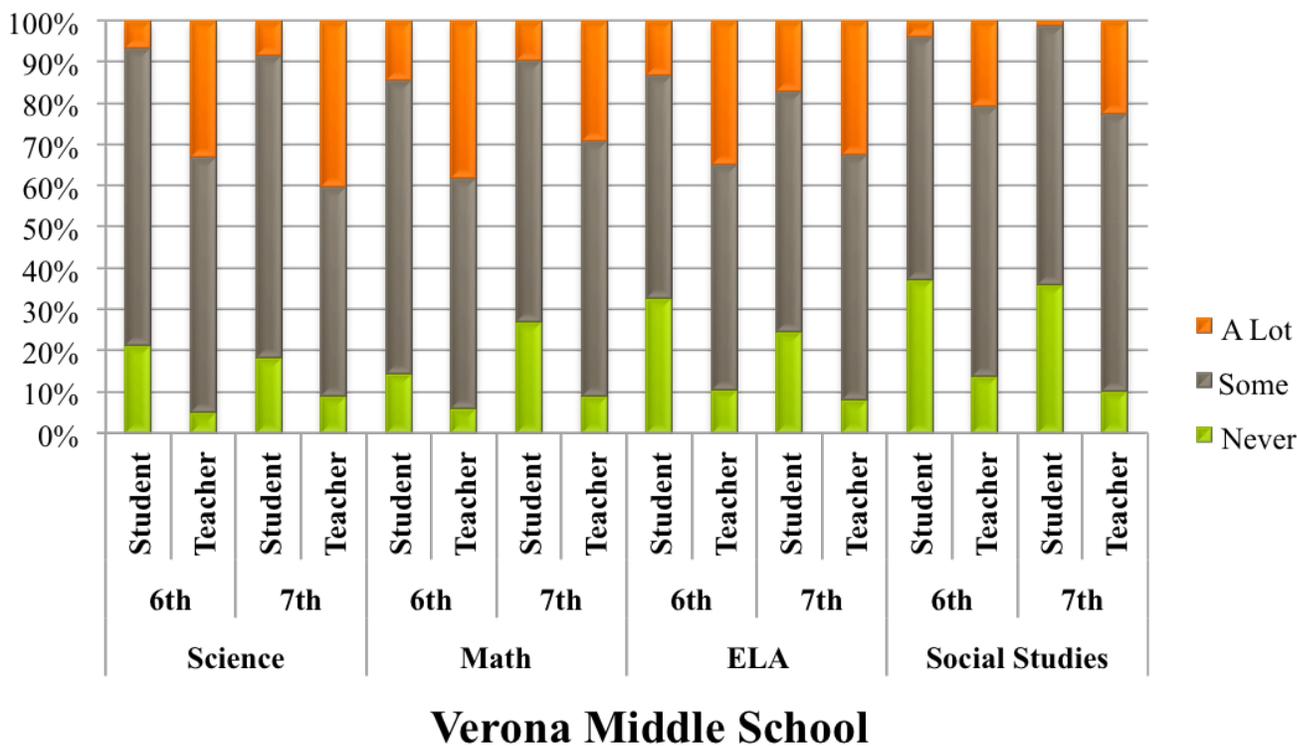


Figure 10. Percentage of students reporting they do these technology activities in school.



Verona Middle School

Figure 11. Percentage of students reporting their and their teachers' digital technology use in school subjects.

Science. In both 6th and 7th grades, students were far less likely to use technology than their teachers (see Figure 11). For example, 33%-40% of all students described their science teacher using technology a lot compared to only about 8% of students reporting they used it a lot. Figure 12 shows more sixth graders (75%) used lots of different tech than 7th graders (57%) and slightly more often playing games in science (6th= 23%; 7th= 19%). Large portions of 6th (57%) and 7th graders (83%) reported doing Internet research in science. Nearly 80% of students reported using that technology for individual and team projects. This use of technology for project work was more than in any other subject area at Verona. Students described their teachers used technology for showing PowerPoints and videos; whereas, students described they did more innovative projects for student engagement such as designing a roller coaster on the computer and using software such as Comic Life or Photo Booth to create projects.

Mathematics. Seventh graders (27%) claimed they never used technology in mathematics compared to 14% 6th graders indicating they

never used technology (see Figure 11). As with science, more 6th graders (71%) used lots of different tech than the 42% of 7th graders (see Figure 12). Additionally, more 6th graders did Internet research and used technology for team or individual projects. Overall, the students noted less technology use in mathematics than in science or ELA classes, but mathematics was the class in which most students reported playing games (see Figure 12). In focus groups, 27 students mentioned playing games in mathematics class. Software used for these games included direct-teach learning programs such as Compass Learning, and others like Cool Math, and FunBrain. Students also told us their mathematics teachers used document cameras and PowerPoints to teach.

English Language Arts. The percentage of students who never used technology in their ELA classes was between 25-30% (see Figure 11). However, less than 10% of students reported their English teachers never used technology and about 35% reported their ELA teachers used technology a lot. Sixty to 70% of students in both grades used the Internet for research in their

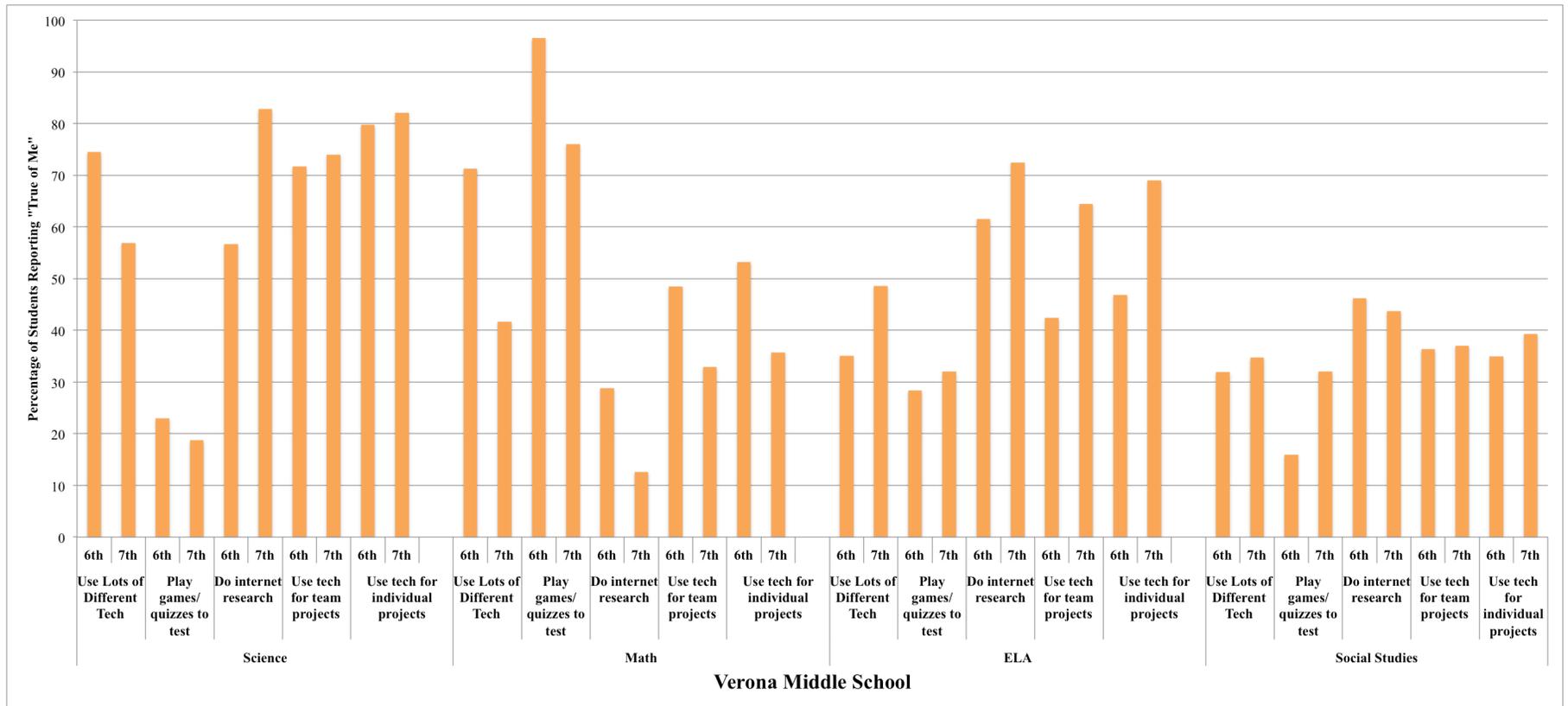


Figure 12. Percentage of students (who used technology in the subject area) reporting how they used digital technology in school subjects.

ELA classes, which was slightly lower than students doing Internet research in science (see Figure 12). More 7th graders used lots of different tech, played games, did Internet research, and used technology for team and independent projects in their ELA classes, as compared with 6th graders. Students told us their ELA teachers mainly used technology to present material. Some student-centered activities included independent study projects using creation software such as Comic Life, iMovie, and GarageBand. They also frequently mentioned activities such as using the computer to write, do research, or create PowerPoint presentations. They also described using NoodleTools and EasyBib to help with bibliography development. The most innovative projects and activities mentioned were in Quest, a more advanced ELA course, such as doing 3D models for a society project and creating public service announcements (PSAs). Non-Quest students reported mainly using computers to write/type stories, create PowerPoint presentations, or research topics online.

Social Studies. In comparison to other subject areas, students in social studies and their teachers used technology the least. About 35% of students reported never using technology in their social studies classes, and 10-12% of students reported their social studies teachers never used technology (see Figure 11). While social studies teachers still used technology in their classes more than students, students were less likely in both grades to say those teachers used technology a lot compared to the other subject areas. In terms of how the students used technology, the fewer students reported using lots of different technologies, playing games, or using technology for project work, as compared to the other subject areas, and slightly more 7th graders reported doing these activities as compared to the 6th graders at Verona (see Figure 12). In focus groups, only a few students specifically described creation activities, including creating videos in Photo Booth and using PowerPoint to make presentations on various topics. Students also described teacher-directed activity that involved playing content-related videos.

Supports and Barriers to Learning Digitally. At Verona, students expressed their frustration at the variety of technology that was forbidden or restricted. Fifteen of the 27

comments regarding rules that the students thought were “ridiculous” were regarding restrictions to Internet use. YouTube was mentioned five times, and students were asking questions such as, “Why should school block things that parents don’t?” Some of the students mentioned being over-monitored, that the school’s blocks and filters were “oversensitive,” inconsistent, and blocked helpful content, and wished the adults would trust them more. Eight students mentioned not being allowed to use their phones in school and four students mentioned not being able to listen to or download music.

On the other hand, five students said the ban on phones was a good rule because it helped students stay focused. Eight students felt that the restrictions to chat rooms, Facebook, YouTube, other social networking sites, games, and virtual worlds also helped them stay on task. Two students said blocking bad sites kept them from seeing inappropriate material and kept bad people away. Some students felt that needing permission to use Google and Wikipedia was also helpful.

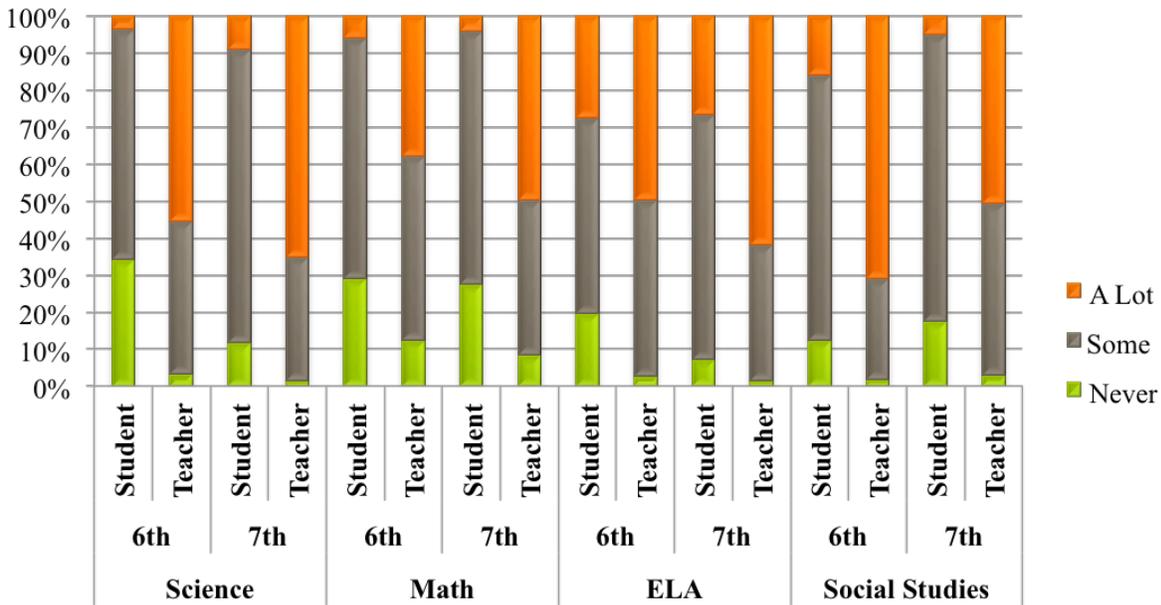
Overall, students at Verona Middle School enjoyed using technology to create things such as PowerPoints as opposed to taking online quizzes or the teacher using the document cameras. They were mixed on their opinions to watching videos with some describing them as “annoying” and others as enjoyable. In general, being on the receiving end rather than creation end of these technologies seemed to make them less enjoyable for students at Verona.

Walnut Middle School

Ninety percent or more of students at Walnut Middle School reported use of productivity type tools such as presentation software, word processing, and library website (see Figure 13). About 80% of students also reported using instructional practice/quiz programs, desktop publishing, spreadsheets, search engines, and concept maps. Large numbers of students also reported engaging with tools for creation such as creating/changing digital art and pictures (42%), digital video (72%), and webpages (53%). Fewer students reported using social media related activities such as writing to a blog, wiki, or online discussion board (26%) or sharing their creations online (30%) in school.



Figure 13. Percentage of students reporting they do these technology activities in school.



Walnut Middle School

Figure 14. Percentage of students reporting their and their teachers' digital technology use in school subjects.

In the subject area classrooms, students reported that their teachers used technology considerably more than they did (see Figure 14). More students reported their teachers were using technology a lot, as compared to student use in both grades and across all subject areas. Students also reported very few of their subject area teachers never used technology. More 6th graders reported never using technologies than their older peers in each subject with the exception of social studies. Overall, at Walnut the most students used technology some or a lot in English language arts and social studies. Yet, the most 6th graders used technology some or a lot in social studies, while the most 7th graders used technology some or a lot in ELA.

Science. Both 6th and 7th grade students reported almost all their science teachers used technology. Yet, 34% of 6th grade students and 12% of 7th graders reported never using technology themselves (see Figure 14). According to students, teachers primarily used the technology to show TeacherTube and Bill Nye videos as often as twice per week and project PowerPoint lectures daily. More 6th graders (36%) reported using lots of different tech in their classes compared to 29% of 7th graders (see Figure 15). More 6th graders (44%)

played games and took online quizzes than 7th graders (30%). However, more 7th graders used the Internet for research and used technology for team and individual projects than their younger counterparts (see Figure 15). One 7th grade focus group discussed the student use of software such as iMovie, Comic Life, and PowerPoint in their science classes as the coolest thing they had done with technology in school. Students also reported completing online crossword puzzles and seemed to appreciate being allowed to use Google to find resources versus having to use the library databases which they found "hard to use."

Mathematics. Students in focus groups reported mixed descriptions of technology use in mathematics with some claiming technology was "barely used" and others suggesting that mathematics was one of the subject areas with the most technology use. The survey data, however, reveals that mathematics class was where technology was least used. More students,

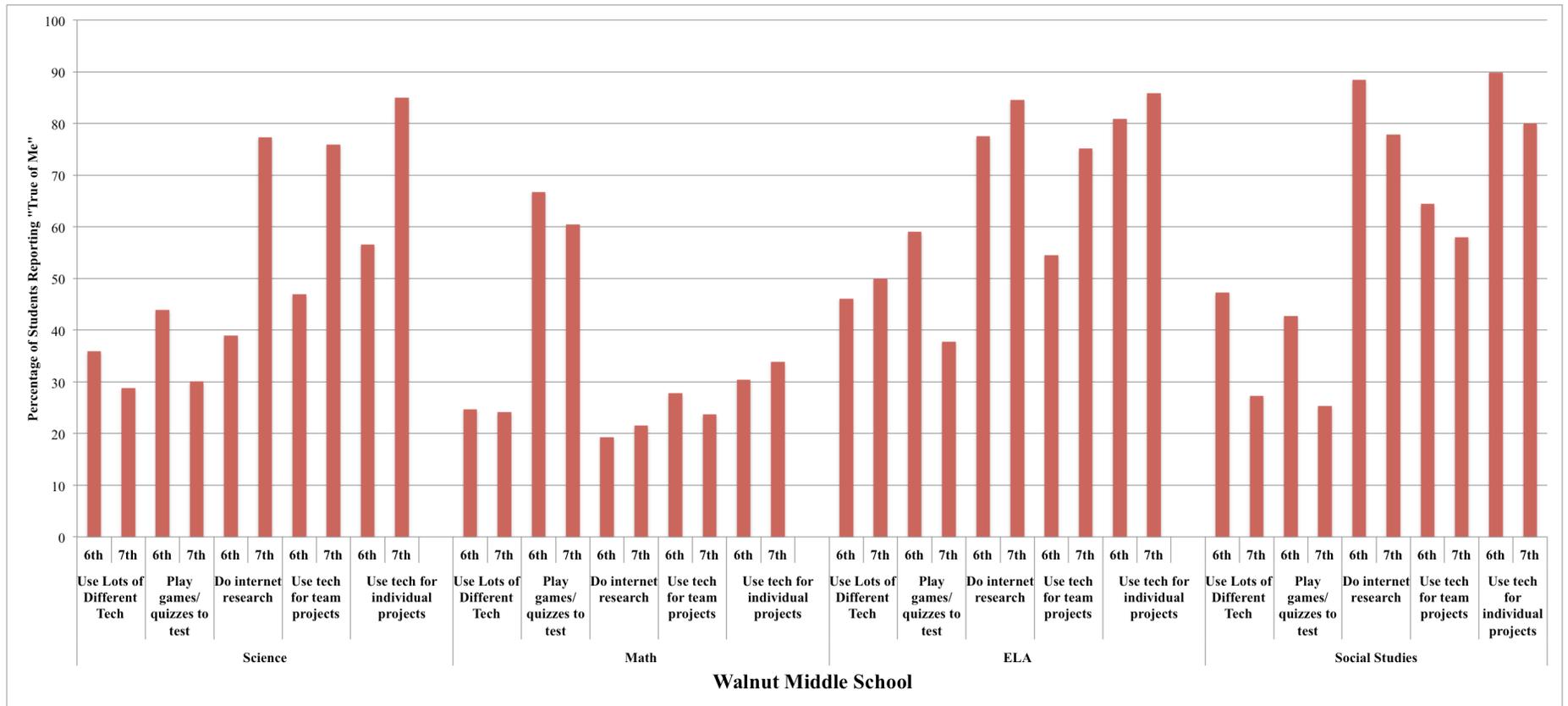


Figure 15. Percentage of students (who used technology in the subject area) reporting how they used digital technology in school subjects.

as compared with other subject areas, reported never using technology in mathematics, and the fewest students reporting they used technology a lot (see Figure 14). Further, mathematics was where students reported more teachers never used technology, as compared with other subject areas. Of those students who did report using technology in mathematics, most (~60%) reported using it to play games/quizzes for testing (see Figure 15). Fewer than 30% of students in both grades reported using lots of different tech, doing Internet research, or using technology for team or individual projects. In focus groups, students primarily reported that their mathematics teachers used the ELMO, or document camera, and the projection system. One student noted, “Teacher uses it [technology] a lot, but we don’t really.” Some students reported their mathematics teacher used the slate and projection system to allow student contribution in lessons. Students also reported using calculators regularly and the clickers “maybe once.” In addition, students reported that mathematics teachers showed videos to help demonstrate mathematics concepts. Finally, students seemed to value the videotaped notes recorded on the document camera that mathematics teachers published on the school website.

English Language Arts. In ELA, teachers used technology some or a lot more than students (see Figure 14). Seventh grade students reported using technology some or a lot more than 6th graders. Of those students who used technology, a large percentage of 6th and 7th graders (~80%) reported doing Internet research and using technology for individual and team projects, with slightly more 7th graders reporting they did these activities (see Figure 15). In focus groups, students told us they used the Compass Learning website, did online research, typed in word processing software, and iMovie creations. They reported their language arts teachers used the projection system every day for PowerPoints and occasionally used the interactive white board and a tablet for controlling the computer/interactive whiteboard system. Students in Quest (an advanced language arts class) reported more student use than students in the non-Quest ELA classes. The Quest classes completed research and used MS Word for typing, used iMovie for video creation such as newscasts and commercials, and created Animoto video slides, PowerPoints, Prezis, music in GarageBand, and websites. The Quest teacher also used Prezi and YouTube videos for

presentations. Quest students were taught to evaluate the validity of websites and use NoodleTools for bibliographies.

Social Studies. Between 82-88% of 6th and 7th graders reported using technology in social studies some or a lot (see Figure 14). Sixth graders (16%) were more likely to report a lot of student use compared to 7th graders (5%). Of the technology activities we queried (see Figure 15), more 6th graders reported using technology for all these activities than the 7th graders. Between 80-90% of both 6th and 7th graders were using technology for Internet research and for individual projects, but fewer students (~60%) reported using technology for team projects. In focus groups, the students reported regular teacher use of PowerPoints for presentations and note taking, use of Ion and National Geographic videos, and websites for learning information via the projection system. Students told us they created brochures, studied historical figures, and used ComicLife to create newspaper pages on their person of interest. Students from both grades worked on independent study projects within their social studies classes using websites such as CIA.gov. Other activities included Kids’ Jeopardy and limited student use of MS Word for activities such as writing to the editor for the “Patriots” or “Loyalists” viewpoint and using PowerPoint. Students also mentioned using online simulations about the Boston Massacre, a witch trial virtual world, and a Lewis and Clark Expedition simulation. These were not mentioned in other classes at Walnut or at other schools.

Supports and Barriers to Learning Digitally. Students mentioned special rules and privileges for “good” students, teachers being able to override blocked sites, permission to bring your own technology, especially cell phones, and fewer restrictions on email and games as productive for learning. Some mentioned that classes would be better if iPods, iPads, or iPhones were issued to classes for research. Twenty-five students said blocking certain websites was good because it could prevent viruses, prevent students from accessing inappropriate material, and prevent students from wasting time on sites like Facebook. Sixteen students said that forbidding the use of cell phones and other mobile devices meant to keep students on task.

However, many students said the very supports were barriers to learning. Most frequently

mentioned was a ban on personal digital devices. Twenty-three students mentioned how they were not able to use devices such as cell phones, iPods, laptops, and e-readers at school, and 17 students said forbidding the use of cell phones was ridiculous or unnecessary. Another frequently mentioned (22) restriction was on content in which they were not able to access “inappropriate sites” and also “no fun sites” while they were at school, specifically mentioning Facebook and YouTube as examples, and 23 students said that blocking certain websites and forbidding the use of certain applications was ridiculous or unnecessary. They felt that they were over monitored and that a lot of educational or helpful content was being filtered out along with the inappropriate or time-wasting content.

Overall, Walnut students really enjoyed the opportunity to build and create with various tools including the ones their own teachers used for lectures. Listening to teacher directed PowerPoint lectures was mentioned 27 times as their least favorite learning activity. One student even said that he “wished PowerPoint didn’t exist” because it was so boring. Students also mentioned watching videos or seeing information displayed with a document camera as some of their least favorite activities. On the other hand, creating their own PowerPoints was one of the groups’ favorite activities. Other tools used to create projects were also on the list of favorites, such as iMovie, GarageBand, Photoshop and Comic Life. While no specific tool was mentioned, eight students reported enjoying creating their own websites.

Cross-Case Analysis

Table 3 is a case-ordered descriptive meta-matrix (Miles, Huberman & Saldaña, 2014), which orders the cases by the percentage of students’ reporting technology use, along with descriptive data that helps answer the research questions. All schools had relatively good access to technology, but the rural, high minority Saguaro MS, had somewhat less robust access. The urban and suburban schools had somewhat more web-based homework assigned than the rural schools, Verona and Saguaro. All students perceived technology made their learning more active and less prone to off task behaviors. Saguaro students, overall, reported far less use of technologies in their coursework than the other schools.

Several patterns stand out across these cases. First, all the students at all four schools reported that their teachers used technology more than they did. These teacher-directed technology uses primarily consisted of presentation of information, using either video, PowerPoint, the document camera, or rarely an interactive whiteboard. Yet, most students expressed hatred or disdain for their teachers’ use of PowerPoint.

The three schools, Walnut, Verona, and Porter, with higher overall student technology use also revealed a wider range of types of technology use, such as uses for productivity, instruction, and creation. The students appreciated opportunities to create with technology, such as authoring comics, brochures, or movies.

There was no consistency in terms of subject areas that might use more technology; it varied by schools. However, mathematics was the subject area where technology was least used in three of the schools. When technology was used in mathematics, students only reported using instructional games. Social studies and English language arts offered students a broader repertoire of technology activities for productivity, instruction, and creation. Students in science tended to do web-based research, use virtual labs, or create scientific representations of content in iMovie or PowerPoint. Again, these latter creation uses occurred at Walnut MS.

All the students noted that blocked/filtered websites and monitoring or prohibited digital devices were barriers to their learning. Yet, they also acknowledged the possibility that less access to personal devices or social media helped them stay on task. Walnut students felt teacher overrides on blocked content was essential to supporting their research and learning processes.

Discussion

Our discussion centers on (a) the students’ sense of Internet filtering within schools as a barrier to learning and its possible disproportionate effect on students who do not have open Internet at home, (b) inequity in how technology is used in the classroom and in subject areas, and (c) approaches teachers might use to reshape their curriculum with students’ digital knowledge, interests, and experiences in mind.

Table 3
Case-ordered Descriptive Meta-Matrix: Technology Access and Use by School Case

	Walnut MS (Suburban, Low Minority)	Verona MS (Rural, Majority Caucasian)	Porter MS (Metropolitan, Majority Caucasian)	Saguaro MS (Rural, High Minority)
% Economically Disadvantaged	12%	53%	40%	74%
Easy technology access	Yes	Yes	Yes	Somewhat
Assigned homework requiring tech	91%	70%	82%	70%
Students more active, learning and less off-task with technology	Yes	Yes	Yes	Yes
High % of students using technology	Yes	Yes	Yes	No
Most common types of technology use	Productivity Instruction Creation	Productivity Creation	Productivity Instruction	Productivity Instruction
Technology most used in:	ELA Social Studies	Science Mathematics	ELA Science	Social Studies
Technology least used in:	Mathematics	Social Studies	Mathematics	Mathematics
Technology most used in subject areas by:	Teachers	Teachers	Teachers	Teachers
Technology Use in Science				
Teachers	Pa: Videos, PPT ^b	P: PPT	P: Doc Camera, PPT	P: Videos
Students	P: Web research Cr: iMovie, PPT	P: Web research	In: Virtual labs Cr: Research Projects	P: Web research (infrequent)
Technology Use in Mathematics				
Teachers	P: Doc Camera, PPT	P: Doc Camera, PPT	P: Doc Camera, PPT	P: Videos, PPT
Students	In: Games, Quizzes	In: Games	<i>None mentioned</i>	In: Games
Technology Use in ELA				
Teachers	P: Doc Camera, PPT, IWB ^c	P: Doc Camera, PPT	<i>None mentioned</i>	<i>None mentioned</i>
Students	P: Web research In: Compass Learning Cr: iMovie	P: Web research, Word Processing Cr: iMovie, Comics, Writing	P: Web research Cr: iMovie, PPT, Comics	P: Web research, Word Processing

Technology Use in Social Studies	Teachers	P: PPT, Videos, Websites	P: Videos	P: PPT, Videos, Websites	P: PPT
	Students	P: Web research, MS Word In: Simulations Cr: Comics, Brochures	Cr: PPT	In: Games, GoogleEarth Cr: Comics	P: Web research Cr: PPT (infrequent)
Barriers		Overmonitoring, Blocked/filtered websites & content	Blocked/filtered websites & content	Blocked/filtered websites & content, Prohibited mobile devices	Blocked/filtered websites & content, Prohibited mobile devices
Supports		Teacher overrides on blocked content, no phones or social media = more on task	No phones or social media = more on task	Digital citizenship, web research	No phones or social media = more on task

Note. ^aP=Productivity; In=Instruction; Cr=Creation; ^bPPT=Powerpoint; ^cIWB=Interactive whiteboard

Similar to findings in other studies (Peck et al. 2015; Selwyn & Bulfin, 2016), students at all four schools expressed frustration with blocked websites, including YouTube. While students acknowledged the need for filtering, they found the blockages a hindrance to both their learning and teachers' instruction (Hughes, Boklage, & Ok, 2016; Willard, 2010). Although the federal government requires blocking of inappropriate images as part of a comprehensive Internet safety policy for E-rate funding through the 2000 Children's Internet Protection Act (CIPA), it does not extend this mandated filter to entire sites (Batch, Magi, & Luhtala, 2015; CIPA, 2000). Karen Cator, former Department of Education's Director of Education Technology, noted that accessing YouTube is not a violation of CIPA, acknowledging, "All sorts of YouTube videos are helpful in explaining complex concepts or telling a story, or for hearing an expert or an authentic voice—they present learning opportunities that are really helpful" (Barseghian, 2011). Moreover, she added that websites do not need to be blocked for teachers and that teachers should be trusted to impose their professional judgment, which occurred at Walnut MS where teachers could override blocked content. Students in our study felt they should be trusted more when using the Internet.

Since 2008, CIPA also demands educating minors about online behavior including cyberbullying and interacting with other individuals on social networking sites and in chat rooms (Batch et al., 2015). Schools that offer instruction about Internet use and develop acceptable use policies for both staff and students that outline rights and responsibilities and describe unacceptable behavior and penalties for violations (Batch et al., 2015; Willard, 2010) may create a trusting environment for rich learning experiences across all subject areas inside schools. Only the students at Porter identified learning some digital citizenship skills that they noted as supportive of their learning.

The over-filtering of the Internet in schools creates two classes of students: a) the advantaged group with unfiltered Internet access at home, and b) the disadvantaged group with only filtered access at school (Batch et al., 2015). This widens an already existing divide of digital device access to include digital, web-based content access gap. Further, a second-level digital divide refers to *how* technology is used by groups of students (Reinhart, Thomas &

Toriskie, 2011), based on factors such as age, education level, experience, and social capital (Hargittai, 2002). Warschauer (2007) extends this to school and home access, and school use. Research findings reveal that schools with higher percentages of students from economically disadvantaged homes are using technology more for skill reinforcement and remediation than for research, high-level analysis, and synthesis activities (Reinhart et al., 2011; Warschauer, Knobel, & Stone, 2004), which accords with the experiences reported by students at Saguro MS who typically used instructional games. Students who experience over-filtered Internet at school and lower-cognitive technology activities in the classroom are not developing robust digital literacy skills (Vuorikari, Punie, Carretero, & Van den Brande, 2016) needed in today's society and workforce and are falling behind their peers in higher SES populations.

In our study, the schools' percentages of economically disadvantaged students appeared to correlate with differences in how students reported technological uses in their different subject areas, confirming similar findings by Warschauer et al. (2004). For example, Saguro and Verona with higher economically disadvantaged student populations reported less technology use for independent projects or research activities and more use of technology for playing instructional games and quizzes. Warschauer et al. (2004) argues that teachers in schools with higher percentages of economically disadvantaged students, where high-stakes testing scores are often lower, feel pressured to teach only the standardized curriculum in order to raise scores.

Overall, Saguro students revealed much lower technology use in school and in subjects. As a rural school with a Hispanic-majority and high economically disadvantaged student population, it is concerning that these children have much less exposure to digital technologies, as it may represent inequities shown in research to be correlated with the number of at-risk students in the school (Guertz, 2015; Warschauer, 2007; Warschauer, Zheng, Niiya, Cotton, & Farkas, 2014). When this is coupled with widely varied uses of digital technology as evidenced in our study, at-risk students exposed primarily to solo-performed, lower cognitive level technology-based exercises, are particularly vulnerable to missing connected learning opportunities built on individual interest and social support that

enhances overall academic achievement (Ito et al., 2013).

Subject area differences can also be explained by subject-area cultures (Hew & Brush, 2007; Selwyn, 1999), which direct pedagogical practices and teaching approaches in the classroom that may or may not align with the pedagogies and teaching approaches afforded by technology and the Internet. In our study, no school reported equal student use across subject areas, suggesting teachers may perceive some subjects as more technology-supportable than others. For example, students conducted Internet research mostly in ELA and social studies and some in science (at Verona) but rarely in mathematics. Likewise, Porter, Saguaro, and Walnut schools shared similar trends of highest student use occurring in either social studies or ELA and lowest use in mathematics class. Verona was the opposite, with students reporting most use in science and mathematics and least use in social studies, but that use tended to be instructional games. Ertmer and Ottenbreit-Leftwich (2010) describe culture as an intersecting construct with knowledge, confidence, and beliefs needed for teacher technology change.

Collectively, these four school cases studies exemplify inequity in digital infrastructure (e.g., access), pedagogy (e.g., more teacher-directed technology use), and content area learning (e.g., less technology use in science and mathematics). Krueger and James (2017) frame digital equity as “the civil rights issue of our time.” We advocate for understanding the students’ perspectives and experiences of technology integration as a necessary component for curriculum planning, professional development, technology procurement, policy making, and technology visioning in schools that work towards establishing digital equity and future-ready learning (U.S. Department of Education, 2016).

For example, Alvermann, Hutchins, and McDevitt (2012) argue for teachers and schools to create informal or formal ways to understand students’ technological experiences. They argue having a better understanding of students’ past experiences, knowledge and attitudes is a “turn-around pedagogy,” a practice that prioritizes students’ digital technology interests and turns students’ interest toward subject-area learning. Krueger and James (2017) similarly emphasize the need to survey students, families, and the

community. By listening to students, the learning experience may be (re)designed for the learners to advance themselves in all school subjects (Alvermann et al., 2012). The teachers in these four schools could have recognized their reliance on teacher-directed, Power-Point supported instruction while students’ preferences for interest-driven creating and making with digital technology, often in collaboration with other learners, aligned with competencies, standards, and visions for digital literacy and future-ready learning (ISTE, 2016; U.S. Department of Education, 2016; Vuorikari et al., 2016). Yet, creation was the least common technology-learning activity middle school students reported experiencing. Ito et al. (2013) describe an approach to education called *connected learning* that capitalizes on socially-embedded, interest-driven, academically-oriented learning that has community impact. This is a useful framework that involves turn-around pedagogy by placing students’ interests at the heart of any curriculum.

Conclusion and Recommendations

We acknowledge school-based technology integration and adoption processes are influenced by a complex ecology of people, organizations, policies, and available technology (Bull, Spector, Persichitte, & Meier, 2017; Ertmer & Ottenbreit-Leftwich, 2010; Hughes, Ko, & Boklage, 2017; Zhao, Pugh, Sheldon, & Byers, 2002; Zhao & Frank, 2003). Schools might start with understanding students’ digital perspectives, but then must push deeper to understand other conditions within the classroom, school, or district ecology that may support or undermine movement toward digital equity and future ready learning in subject areas to ultimately develop holistic change.

We recommend these starting strategies to work towards more equitable technology integration across subject areas:

1. Survey and engage in meetings with students, families, and the community to understand their digital technology interests and needs.
2. Conduct a digital technology use audit to examine indicators of equity or inequity across the school, subject areas, and the community.
3. Listen to and trust student and teacher voices regarding what technology is and

- is not working.
4. Understand that different subject areas have different technological needs. Teachers, instructional coaches, technology specialists, and administrators must work together to identify and purchase technology that transforms teaching and learning and solves subject-specific challenges.
 5. Prioritize technology tools that foster higher-level thinking skills and active learning through exploration and hands-on experience and de-emphasize technologies that situate students strictly as passive learners.
 6. Provide meaningful subject-specific professional development, such as Professional Learning Communities (PLCs) involving instructional coaches and technologists, librarians, and subject-specific teachers, to improve instructional practices via collaborative discussion, identification of potential solutions, adjustment of practices, and reflection (Darling-Hammond & Richardson, 2009). This may also include peer observation and coaching, study groups, and action research within classrooms.

These strategies may begin to develop more awareness of digital (in)equity in schools and subject areas. We hope this awareness can lead to revitalized, digitally-supported curriculum that is interest-driven, active and hands-on, and academically rigorous. Such curriculum may equally prepare young citizens to develop digital literacy and competencies for their futures.

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