MIDDLE AND HIGH SCHOOL MATH TEACHERS' NARRATION OF TI-NAVIGATOR USE AS A FORMATIVE ASSESSMENT TOOL

By

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CERTIFICATION OF PROJECT WORK

We, the undersigned, certify that this project entitled Middle and High School Math Teachers' Narration of TI-Navigator Use as a Formative Assessment Tool by Michelle L. Swackhammer, Candidate for the Degree of Master of Science in Education, Curriculum and Instruction, is acceptable in form and content and demonstrates a satisfactory knowledge of the field covered by this project.

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Abstract

The present study was designed to examine how middle and high school math teachers narrate their uses of TI-Navigator and describe sources of external school support for using this technology. A three-part, written survey was sent to 35 math teachers in three school districts across two counties in Western New York. Fourteen useable surveys were returned (i.e., 40% response rate) that indicated that: (a) graphic calculators were more accessible and used more often than TI-Navigator, (b) there was a reported under-utilization of the technology and specific program features, and (c) professional development and support appeared to be equally minimal. Those teachers who did use TI-Navigator regularly noted some additional time demands from its use but that pupils responded favorably to the technology. Implications for future research and practice are described.

Table of Contents

Page

Introduction

This master's project addressed two basic questions: (a) How do middle and high school math teachers narrate their use of TI-Navigator? and (b) what levels of external school support are provided to assist in implementing this technology? There has been a recent influx in technology use in public school classrooms. This technology has the ability to capture student attention and imagination, and build on their prior knowledge in new and different ways. TI-Navigator in particular is one intriguing instructional tool that was highly recommended by mathematics professionals. The investigator was also interested in finding out if and how professional development or encouragement in implementing technology influenced actual classroom use of TI-Navigator.

This project involved a survey of mathematics teachers in two counties in New York State, one mainly rural and the other a more urban county. Districts were chosen because they reportedly purchased at least one class set of TI-Navigator. Math teachers in the target schools were selected to explore some important questions and hypotheses. For example, how does having only one set of TI-Navigator in a district affect teacher access to and use of TI-Navigator? This is an important question because any innovative practice will be of little value to children if it is not implemented accurately or at all. A secondary research question regarded the perceived satisfaction among those who did use the TI-Navigator system. The change of terms from district to school building is to allow for school districts with more than one school building, as opposed to school districts which may contain grades K-12 in one building.

The number of classroom technology sets that are provided to schools depends on financial support of the district and the level and amount of individual or group advocacy for TI-Navigator. Therefore, it would be useful to research which individuals or groups who were

driving forces in the districts. This may be reflected in teacher responses to survey questions regarding implementation supporters of TI-Navigator.

There are increasing numbers of schools and students, who possess Texas Instruments (TI) graphing calculators. TI-Navigator, however, only works with specific TI graphing calculators. For schools to own TI-Navigator they must also use TI calculators in the classroom. As stated by Roschelle (2003), there is an ability to market to classrooms with TI graphing calculators due to their prevalence within schools in the United States.

> One possibility is that a single platform could become dominant. For example, presently in high school in the United States, Texas Instruments graphing calculators are nearly ubiquitous, which enables textbooks, teacher professional development and application developers all to target this platform. (p. 269)

Another article that mentioned the prevalence of graphing calculators commented on students owning these calculators. "Sixty percent of high school seniors, for instance, currently own a TI-83 series. The TI-83 series of graphing calculators is manufactured by Texas Instruments" (Branch, 2001, paragraph 7).

The present study is important because it may better inform districts who are implementing new forms of technology. This study deals specifically with TI-Navigator, but there may be generalizations to other technologies and to shed some light on what forms of professional development and support are preferred by teachers who use the technologies. Examining teacher preferences for professional development may assist in subsequent dissemination of the same technology to other teachers and other technologies to new teachers. The study used a written survey format that assessed teacher understanding and use of TI-

Navigator technology, as well as perceptions of professional development and support and technology effectiveness.

There have been previous studies that investigated the use of TI-Navigator as a formative assessment tool. Owens, Pape, Irving, Sanalan, Boscardin, and Abrahamson (2008), for example, touched upon the four main features of TI-Navigator that can be used in a classroom: (a) Quick Poll, (b) Learning Check, (c) Screen Capture, and (d) Activity Center. Quick poll can be used to have all students respond to single questions, while learning check can ask multiple questions of students. Screen capture, on the other hand, allows the teacher to display an image of a calculator screen; this can then be used to generate discussion. Activity center can be used to have students graph over an image, such as a grid, that teachers had prepared. Owens et al. (2008) described general uses for these four features as follows: "Activity Center is typically used to develop conceptual knowledge. Quick Poll and Learning Check are typically used as tools for formative assessment and Screen Capture may be used for either of these purposes" (The Connected Classroom, paragraph 1).

Literature Review

Definitions

The study's primary research questions were: (a) How do middle and high school math teachers narrate their use of TI-Navigator? and (b) what levels of external school support are provided to assist in implementing this technology? To address these questions, some common definitions are offered. Some important definitions include *formative assessment tool*, and *external school support*. The working definition of a formative assessment tool used by Black and Wiliam (1998) is stated here as, "assessment becomes formative assessment when the evidence is actually used to adapt the teaching to meet student needs" (p. 140). As such, the TI-

Navigator should help teachers receive and provide feedback on pupil performance and monitor their relative levels of success. *External school support* refers to service provided in support of teacher instruction such as professional colleagues, administrators, and technology managers

The illustrative literature focused on five primary topics: (a) formative assessment, (b) Texas Instruments claims on TI-Navigator technology, (c) other class wide response system technologies, (d) teacher perceptions and survey research, and (e) external school supports.

Formative Assessment

Formative assessment refers to the frequent and direct evaluation of pupil performance on important educational measures and the use of this information to make better instructional decisions and improve student outcomes. This formative assessment perspective was shared by more than just Black and Wiliam (1998; 2004). Heritage, Kim, Vendlinski, and Herman (2009), for example, expanded upon this thought by stressing that assessment should be continuous and the feedback should be available to students by mid-lesson. Paschal (2002) shared the view that formative assessment and feedback are important components of the learning process. Each of these authors stressed the importance of an assessment-student feedback cycle where feedback to students was important to reassure or redirect student comprehension.

All three studies intimated that formative assessment creates opportunities to identify student misconceptions and provide immediate corrective feedback to improve student understanding. Paschal (2002) used a Personal Response System (PRS) in a college level course where graded homework, would not be returned to students until a week after they handed it in. This week without feedback left students who were making mistakes with additional opportunities to practice incorrect conceptualizations and methods which, in turn, are embedded in their memories.

Heritage et al. (2009) suggested that it was important for teachers to identify expected performance on formative assessments prior to using them so that they could monitor the progression of learning. This knowledge may be useful when encountering student responses that illustrate poor understanding of concepts; teachers might, for example, adjust their teaching methods in response to pupils' rates of progress. Heritage et al. (2009) stated that formative assessments should be linked to the short term goals the teachers hold for student achievement. With the knowledge gained through these assessments, teachers are able to judge if they need to move back a few steps or if they can to progress as planned.

Bokhove (2010) included a categorical list that was developed by NyQuist (2003) to examine the effects of feedback "levels" on pupil performance. This list was comprised of five levels: (a) weaker feedback only, (b) feedback only, (c) weak formative assessment, (d) moderate formative assessment, and (e) strong formative assessment. Feedback only conditions involved giving students numerical grades with minimal feedback and perhaps correct answers. Formative assessment conditions, on the other hand, also provided students with detailed explanations to supplement correct answers. Bokhove (2010) suggested that educators must provide the highest levels, "strong formative assessment": detailed information about correct answers, explanations, and specific activities to improve pupil understanding.

Like Paschal (2002), Hivon, Pean, and Trouche (2008) explored the use of instructional technology, in this case the TI-Navigator, in a secondary school setting. Both research groups argued that the use of their respective technologies would increase active student participation in the classroom. The PRS system used by in Paschal (2002), for example, ensured 100% in-class participation under most conditions. On the other hand, Hivon et al. (2008) reported that the TI-Navigator system caused, "pupils [to] have no difficulty sending their results when they have not

yet been checked by the teacher" (p. 14). These are important points in formative assessment because for teachers to correctly direct instruction for multiple pupils simultaneously it is important for the majority, if not entirety, of the class to participate in the assessment. Both studies found high degrees of active student participation.

Texas Instruments Claims on TI-Navigator Technology

The TI-Navigator, a product of Texas Instruments, was designed to create *connected classrooms* where students communicate wirelessly with their teachers regarding questions posed to the class (Hivon et al., 2008; Paschal, 2002). The TI-Navigator system allows for up to 32 calculators to be connected in groupings of four by wires to 'hubs' that "communicate via wireless with a router box (Access point) which is linked by cable to a computer on which the software applications are loaded. The computer is connected to a video projector!" (Hivon et al., 2008, p. 3). Through this system teachers can create files and ask students to respond on their connected calculators. There are four main features to the TI-Navigator: (a) Quick Poll, (b) Learning Check, (c) Screen Capture, and (d) Activity Center. As students connect their calculators their names appear and indicate which groups had responded (Hivon et al., 2008). Group responses can be displayed without identifying individual students. For example, the teacher might display the number of students who thought that an assignment was challenging using Quick Poll, or the percentage of students who answered a challenge question accurately during Learning Check without revealing how any individual pupil responded. As Hardy (2008) noted, there is ability for the teacher "to display student-generated work…while protecting the student-author's identity" (p. 232). Student work displays can occur almost immediately after work was submitted, and can prompt discussions about daily results. Anonymity and ability for

immediate discussion may influence students to have fewer reservations about submitting answers electronically without first being certain they are correct (Hivon et al., 2008).

A purported strength of TI-Navigator was its potential as a formative assessment tool. Paschal (2002) also noted some positive outcomes associated with the use of a Personal Response System (PRS). A PRS is a wireless communication system with which an instructor can receive responses from students and form the instruction based on the responses. In Paschal (2002) the PRS was used for quizzes based on assigned readings. Paschal (2002) found that there was evidence that the use of a wireless communication system with feedback and instruction adaptation was just as effective, and possibly more effective, than homework and lecture class. What this means with regard to TI-Navigator is that the instant feedback available has potential to positively impact student learning. Paschal (2002) also found that PRS implementation increased all students' levels of participation in the classroom.

Additional Class Wide Response System Technologies

Personal Response System is a class wide response system that was described and evaluated by Paschal (2002). Other class wide response systems included *Class-talk*, *Classroom Performance System (CPS)*, *TI-Navigator*, and *Interactive Presenter*. Each program was created by different companies to facilitate communication among teachers and students and CPS, PRS, and TI-Navigator are wireless (Paschal, 2002). Regarding these wireless systems, Paschal stated:

> These classroom communication systems offer many advantages. The ability of these systems to rapidly collect a large volume of responses via signals not visible to the human eye gets every student to respond to every question without being inhibited by the fear of "looking stupid" to their peers (p. 300).

Pierce and Ball (2009) investigated some other technologies used commonly by teachers to assist in the instruction of mathematics. Some forms of technology that were explored were scientific and graphing calculators. Pierce and Ball (2009) stated that another study had "investigated teachers' perceptions of the use of graphic calculators in secondary schools. Overall, most of these teachers believed that the graphics calculator would improve students' mathematical understanding and make a positive contribution to student learning (p. 302)." Being that TI-Navigator uses graphing calculators it is important to note teacher perceptions regarding the use of these classroom calculators.

Teacher Perceptions and Surveys

Two areas of prominent research on teacher perceptions regarding technology include: (a) perceived confidence levels with using technology and (b) perceived usefulness of technology to student learning. Survey methodology was quite prominent in these domains. This particular study focused on teacher perceptions of technology use in the classroom.

Teacher perceptions on technology use are quite varied. Some teachers strongly support the use of technology, although many do not necessarily use it in their own classrooms (Hardy, 2008). Such outcomes may emanate from some identified barriers to implementation. Pierce and Ball (2009) found, for example, that many teachers support the use of technology but barriers such as "instructor inexperience using wireless communication systems for classroom instruction," (p. 307) often interfere with implementation. Phelps and Graham (2008) reported as well that, "Overall, teachers reported low levels of confidence for independent learning…they were more confident learning with maximum direction," (p. 127). This report supports the concept that teachers require support from external sources in order for their use of technology to be most productive.

External School Support

As mentioned earlier, external school support refers to the support that teachers using TI-Navigator receive in implementing the technology from other individuals or groups within the school. Numerous studies highlighted the use of either professional development or short training sessions as a good way to introduce new technologies into classrooms (Bruce & Reynolds, 2009; Hardy, 2008; Phelps & Graham, 2008; Pierce & Ball, 2009; Sinclair, 2008; Tan, Hedberg, Koh, & Seah, 2006). Phelps and Graham (2008) described other implementation methods such as Companion Mentors (CM), goal setting meetings, and formal mentoring and support to facilitate training and use. They reported that many, "schools allocated regular time in the first 5-20 minutes of staff meetings to focus on reflection, discussion and celebration" (p. 127). Time in staff meetings can provide a forum for discussion of successes and challenges in the use of new classroom technologies. Companion Mentoring would consist of teams of teachers, with varying experience levels in technology, grouped to support other teachers.

Tan, Hedberg, Koh, and Seah (2006) described some potential benefits of CM's. Their study tracked teachers who relocated in and out of the district. This movement of teachers in and out of the system resulted in uneven professional development opportunities. Having regularly-scheduled training sessions would create more equity from which teachers could build their technology competence. Tan et al. (2006) noted that many less experienced teachers also missed previous professional development sessions and may be at a disadvantage. In support of regular technology training sessions, Hardy (2008) noted that it, "takes an extended period of time…for teachers to infuse technology into their pedagogy" (p. 226).

The support of school staff, other than the teachers, is important for implementation of new technologies such as TI-Navigator. Pierce & Ball (2009) investigated teacher perceptions

regarding instructional technologies. Teachers expressed that they may alter their use of technology based on how building leaders promoted their use. They also noted that, "in more metropolitan schools, there was a perception that school leadership expected technology to be used," (p. 312). This demonstrates that perhaps larger school districts may be more likely to implement expensive technologies such as TI-Navigator. Bruce and Reynolds (2009) cautioned, however, that even though high costs may be found in large, more urban school districts, "new technologies are increasingly affordable and could potentially migrate differences in wealth," (p. 561-562). These findings suggest that more schools and more students may have access to more recent educational technologies.

Other forms of professional development and external support were mentioned in the literature. "In the Docklands schools, principals are working to develop coordinated strategies for planning, support and training which address their school technology needs!" (Bruce & Reynolds, 2009, p. 573). These authors also mentioned other work experiences that teachers can pursue outside of school to increase their comfort and use of technology in the classroom. Tan et al. (2006) described the use of training provided by external companies, explicitly by technology vendors and stressed that teacher collaboration, teachers having possession of instructional manuals, and designated technical support staff would greatly enhance teacher use of technology. Sinclair (2008) used technology assistants who helped teachers in applying different methods and offered advice for solving technological difficulties. This study also provided a *technical support line*. The author found, however, that, "although the TI technical support line was available, teachers did not take advantage of it," (p. 6). There may be ways of aiding in use of technology that are successful in some districts and not as successful in other districts.

Collectively, the literature review suggests that new instructional technologies have appeared and that many may promote pupil learning. The literature suggests as well, however, that there are numerous barriers to the successful use of these potentially valuable technologies as well as promising practices for improving their use and dissemination. The present study was designed to gather more information about teachers' use of one form of technology, TI-Navigator system. The two primary research questions were: (a) How do middle and high school math teachers narrate their use of TI-Navigator? and (b) what levels of external school support are provided to assist in implementing this technology?

Method

Participants and Settings

Participants were a convenience sample of middle and high school math teachers from three school districts in Western New York. It was reported that all potential respondents had previous exposure to the TI-Navigator program. Thirty-five surveys were sent to secondary math teachers across the three districts and 14 individuals (10 F, 4M) completed and returned useable forms. This represents a 40% response rate which is not overly high, but quite common in social science and education survey research (Creswell, 2002).Participants ranged in age from 27 to 56 years old with the largest percentages coming from the 27 to 32 and 33 to 40 age ranges.

The 14 respondents taught in middle and senior high school in two neighboring counties in New York State. One county was quite rural while the other was urban. The two school districts in the urban county owned a classroom set of TI-Navigator and one district participated in the survey. Most respondents taught multiple grade levels ranging from 7^{th} through 12^{th} grade with most instruction being provided to freshmen through seniors. Average class size across the 14 respondents ranged from 15 to 25 pupils with an average class size of about 20.

Survey Development

The Texas Instruments (TI)'s Mathematical Technology Survey was developed by the investigator from three earlier measures on teacher use of instructional technology (Gray, Thomas, & Lewis, 2010; Hardy, 2008; Sinclair, 2008). Items from these scales were then adapted and included in the present survey (see Appendix A). The survey consists of three primary sections: (a) demographic information, (b) technology use in the classroom, and (c) open-ended questions about current usages and perceptions. Demographic information was elicited for age, gender, and class size. Questions from the second part of the survey asked teachers to respond to the relative availability, uses, and perceived satisfaction with different TI-Navigator features (e. g., Graphing Calculators, Quick Poll, Learning Check, Screen Capture, and Activity Center). Open-ended questions in the third section asked respondents to comment further on how TI-Navigator features were used, who was responsible for providing professional development, what challenges were encountered, and what impact the technology had on pupil understanding of mathematics.

Thirty-five survey packets were sent out through the mail to secondary teachers in school districts where the investigator was told that they use TI-Navigator. Each survey packet included: (a) a cover letter explaining the survey purpose and how results will be used, (b) directions for completing and returning survey materials, (c) an informed consent form, and (d) a copy of the survey. Participants were notified that consent forms would be stored separately from surveys to maintain privacy, and they were asked to return surveys within four weeks.

Research Design and Procedures

The present investigation was a descriptive study using a mailed survey methodology (Creswell, 2002). Potential participants were located initially using data from the Director of

Technology Services at a local instructional support center in New York State (i.e., BOCES). The director provided information regarding which districts in these two counties had acquired TI-Navigator technology. Survey packets were sent to individual mathematics teachers in participating schools where at least one class used TI-Navigator. Survey responses were aggregated and are described in detail in the results section. Section two responses were aggregated to reflect the relative availability and use of various technological features and to assess respondents' perceived levels of efficacy and satisfaction. Open-ended responses were categorized into common themes or topics and are described qualitatively.

In addition to survey results, one respondent invited the investigator to observe his 12th grade class using TI-Navigator. This observation took place in a rural school with eight students present. The 40-minute lesson included students using the graphing functions to create functions based on descriptions, as well as the Screen Capture and Quick Poll functions. Pupil comments appeared to be quite supportive of the use of TI-Navigator.

Results

Survey responses regarding the availability and reported usage of the TI-Navigator and graphing calculators can be seen in Table 1. As depicted, graphing calculators were widely available and used daily in almost all teachers' classrooms. Only one math teacher indicated that s/he did not use graphing calculators. In contrast, TI-Navigator was not even available for half of survey respondents and only three teachers (21%) reported having it in the classroom for daily use. No teachers reported using it "often" and 11 (78%) said that they never used TI-Navigator. Of those teachers who reported using TI-Navigator, additional information was sought regarding the specific instructional features that they used in class. These data are depicted in Table 2. As seen, the four high school math teachers that used TI-Navigator implemented a variety of

features. It appears that one respondent, used all four features (Quick Poll, Learning Check, Screen Capture, and Activity Center), while two others reported using Quick Poll and Screen Capture. Two respondents also indicated that they never used Learning Check and Screen Capture.

The same four respondents were then asked to rate their levels of satisfaction with each TI-Navigator feature that was used in class. These data can be seen in Table 3. As shown, there were a total of four "not satisfied at all", five "somewhat satisfied", and three "very satisfied" responses across the four program features. Interestingly, at least one teacher indicated overall dissatisfaction with each of the Navigator features and at least one reported being somewhat satisfied with each feature. Learning check was the only component that didn't receive a "very satisfied" rating. It is also important to note that at least one teacher indicated that each program feature was not available for their use. Finally, the four teachers were asked to rate the efficiency of each TI-Navigator feature. These data are presented in Table 4. As seen, teachers' perceptions of TI-Navigator's efficiency mirrored their responses for satisfaction. That is, each program feature was rated as "not efficient at all", as well as "somewhat efficient" by at least one math teacher. Once more, the only feature that did not receive a "very efficient" rating was Learning Check.

The final seven survey questions required open-ended responses and yielded varied response rates from respondents. Question #9 asked teachers about the use of TI-Navigator for its formative assessment functions. Four teachers responded to the question; one said that s/he didn't use it for that purpose, another noted using Quick Poll as a "ticket out the door" and a third said that it was used to provide "informal feedback to pupils". A fourth respondent wrote, "I used navigator as informal feedback for students and myself. The students like the

competition. I like viewing all students and their mistakes. It is very difficult to look at each student's individual screen to see if they have entered material correctly". Question #10 asked teachers how the TI-Navigator program was introduced to them. Eight open-ended responses were elicited here. Two teachers noted that TI-Navigator was introduced by school administrators, two others heard about the programs from their departmental leaders, and two others learned about the program from math colleagues. Two teachers also commented, however, that they received insufficient or no formal training after the system was available.

Question #11 asked high school math teachers about the amount and type of professional development that they received to use the TI-Navigator. This item elicited seven diverse responses. Four individuals noted, for example, that they had attended workshops related to the use of TI-Navigator; two others received no training at all, while another was self-trained and also provided in class assistance to other teachers. When asked to comment on whether their training experiences were sufficient (i.e., Question #12), four of five teachers felt that it was while another thought that s/he would benefit from more one-on-one training in the classroom. Question #13 asked teachers to discuss any technological challenges that were encountered when using TI-Navigator. One teacher noted that additional time was required to set up and take down the Navigator and that they present problems when only using it with some classes. A second respondent noted that, "some kids couldn't log in or there were not enough supplies for the entire room". A third teacher wrote, "my district uses MACs and TI tech support does not support MACs (at least they didn't when I started to use Navigator five years ago). I usually have Activity Center crash after students race their cursers for about five minutes".

When asked to comment specifically on "planning challenges" in Question #14, three respondents indicated that the TI-Navigator required additional time for preparation and to set up

systems and activities. The final open-ended question asked teachers to comment on TI-Navigator's impact on pupil learning. Only three teachers responded here. The first noted that it, "greatly increases student engagement! I typically use Navigator when graphing functions. Students have developed deep thinking and reasoning about slope and intercepts when they try to match my graph". A second teacher commented that "students can see if they are correct right away and learn how to fix the errors". A third responded noted that TI-Navigator could be more helpful if additional support was provided.

Discussion

The present study was designed to narrate how middle and high school teachers use the TI-Navigator system to improve their pupils' understanding of mathematics. A total of 35 survey packets were mailed to secondary math teachers in three school districts in Western New York. Fourteen teachers completed and returned surveys for a respectable but insufficient response rate of approximately 40% (Creswell, 2002). A first finding was that graphing calculators were much more visible and utilized than TI-Navigators. Almost all teachers reported daily access and use of graphing calculators. In contrast, TI-Navigator was not even available to most teachers and just over 20% reported using it daily. Of those who used it regularly, only one teacher reported using all applicable features. Clearly, the reported usage of TI-Navigator is too low to assess its impact on teacher practice and/or pupil learning. It should be noted, however, that two of three regular TI-Navigator users felt that the system had a positive impact on their pupils' understanding of mathematics. Three reported users were also "very satisfied" with the TI-Navigator while the majority appeared less than satisfied. Subsequent open-ended responses by primary users of TI-Navigator indicated that only some individuals received formal training in its use, although those who were trained were satisfied with the level of support provided. A few

teachers were using TI-Navigator for formative assessment purposes but there appeared to be uneven and insufficient use of all program features. It reportedly took more planning and set up time to use the technology than more traditional lessons. Collectively, these findings, although limited, paint a rather bleak picture of technology usage in three representative school districts. Although these districts purchased TI-Navigator systems, they appeared to be relatively unavailable to most secondary math teachers in those districts; or at least those who chose to respond to this survey. Of those who did use the system, they did not use most program features. It is highly unlikely that the best technological tools available will be of value to children if their teachers cannot or do not use them.

The present findings, although quite limited, are consistent with previous research on the use of educational technologies like the TI-Navigator system. For example, present findings are consistent with those of Hardy (2008) and Pierce and Ball (2009) who noted the additional time and professional development requirements are associated with the use of such technologies. Similarly, like Roschelle (2003) present results confirmed the wide-spread use of graphing calculators in high school math classes. Finally, present findings are consistent with the broader literature on the diffusion of *any* educational technology. That is, wide-spread and sustained usage is highly unlikely, if not impossible, when insufficient training and support are provided for all service delivery personnel. Before the instructional impact of TI-Navigator can be assessed formally, more representative users of the technology must be recruited and supported.

On the surface, the current results have a few implications for practice. Perhaps first of all is the need to disseminate "purchased" instructional resources more deliberately. The fact that most respondents did not even have access to the technology suggests a gap in implementation. Once access is guaranteed, however, more systematic professional development and support

should be provided. This might include increased levels of in class assistance, particularly with regard to how to use the many important features of the TI-Navigator system (e.g., formative assessment), more peer modeling and coaching, and policies that support technology users and innovators. Finally, once a more substantial number of TI-Navigator users have been identified, more formal evaluation efforts should be conducted to link the impact of this technology to important pupil outcomes in mathematics.

While the present findings are not overly encouraging, one must recognize that they simply establish a "baseline" for current technology usage in the target school districts (Cullen, Brush, Frey, Hinshaw, & Warren, 2006; Watson, 2006; William, Harrison, & Black, 2004). Moreover, current results are quite limited in terms of representativeness, technical adequacy, and specific implications for practice. All conclusions, therefore, must be viewed as tentative at best. Present findings are limited first by small sample size, low response rates and restricted geographic locations. Since more than half of math teachers in these districts did not respond, it is not clear that present findings represent the perceptions of the majority. Similarly, current responses came from a small geographic location in one section of New York State; generalizations to other rural, urban, and/or suburban locations in the state and nation-wide are not supported. A third limitation is related to the survey itself. The TI-Navigator Mathematics Technology Survey assessed teacher perceptions of a very limited range of instructional technologies, included only a few items on reported usage, satisfaction and efficacy, and failed to collect relevant information on the measure's technical adequacy (i.e., reliability and validity). Fourth, survey methodology in and of itself represents an *indirect* measure of how respondents might actually behave with regard to technology use. One cannot assume, therefore, that written responses were representative of overt behavior. Clearly, the survey can be improved in terms of

its technical adequacy; formal studies of reliability and validity would be helpful here. Finally, open-ended survey responses were interpreted and classified by the investigator. As such, one cannot rule out the possibility of experimenter bias. Future research should certainly use independent evaluators and conduct inter-rater reliability checks with regard to classification.

Despite the aforementioned limitations, the present study does provide a nice starting point for examining the potential role of instructional technologies like the TI-Navigator on math teachers' practice and ultimately their students' learning. It is quite clear, however, that much more work must be done in public schools to ensure that the technologies are available and used effectively by classroom teachers. Failure to use potentially valuable instructional resources like TI-Navigator at a time when so many struggle in mathematics cannot be good for the discipline or the profession. Survey results suggest that technologies must become more accessible and more efficient if they are to be used on a daily basis. Until that day comes, it is highly unlikely that they will benefit those they were intended to help; our public school students.

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Table 1. Summary of math teachers' responses on the availability and use of TI-Navigator (N = 14).

	Availability			**Frequency of Use**			
Feature	Not available	Available as needed	In classroom for daily use	Never	Rarely	Sometimes	Often
Graphing Calculator	0	1	13	1	1	0	12
TI-Navigator	7	4	3	11	1	2	0

Table 2. Math teachers' reported use of TI-Navigator features (N = 4).

TI-Navigator Features	Never Use	Sometimes Use	Use Frequently	Not Available
Quick Poll	1	2	1	0
Learning Check	2	1	1	0
Screen Capture	1	2	1	0
Activity Center	2	1	1	0
Total	6	6	4	0

Table 3. Math teachers' perceived satisfaction with TI-Navigator components (N = 4).

TI-Navigator Features	Not Satisfied At All	Somewhat Satisfied	Very Satisfied	Not Available
Quick Poll	1	1	1	1
Learning Check	1	2	0	1
Screen Capture	1	1	1	1
Activity Center	1	1	1	1
Total	4	5	3	4

Table 4. Math teachers' perceived efficiency of TI-Navigator components (N = 4).

TI-Navigator Features	Not Efficient At All	Somewhat Efficient	Very Efficient	Not Available
Quick Poll	1	1	1	1
Learning Check	1	2	0	1
Screen Capture	1	1	1	1
Activity Center	1	1	1	1
Total	4	5	3	4

Appendix A

Mathematics Technology Survey

Directions:

Please complete the survey to the best of your ability. Survey results will be aggregated into group responses and there will be no identifiable information included in the final report. The primary purpose of this survey is to see how TI-Navigator is being used as a formative assessment tool. The survey was sent to you because it was reported that your school district has at least one class set of TI-Navigator. The first two sections ask you to check or circle the appropriate response, while the final section asks you to respond to a series of short-answer questions. Thank you in advance for your willingness to participate.

Section 1: Demographic Information

1. Gender: □ Male □ Female

2. Select the age range that best fits you:

Under 26 27-32 33-40 41-48 49-56 57-64 Over 64

3. Select the term that best represents your district:

Urban Suburban Rural

5. What grade(s) do you currently teach at this school? (Circle all that apply)

PK K 1 2 3 4 5 6 7 8 9 10 11 12 Ungraded

6. On average, how many students do you have in your classroom **at one time** this school year? _____

Section 2: Use of Technology in Classrooms

7. For each technological device listed below, indicate its availability to you (Check the box for the type of availability), and for available devices indicate how frequently they are used for instruction.

	Part 1: Type of Availability			**Part 2: Frequency of use if available**			
Device	Not available	Available as needed	In classroom every day	Never	Rarely	Sometimes	Often
Graphing Calculators							
TI-Navigator							

8. If you currently use or have used TI-Navigator recently, please ***rate*** the four main features of TI-Navigator, according to: (a) frequency of use, (1 = never use; 4 = sometimes; 7 = very frequently), (b) your satisfaction with each feature (1 = not satisfied at all; 4 = somewhat satisfied; 7 = very satisfied) and (c), their efficiency (1 = not efficient at all; 4 = somewhat efficient; 7 = very efficient).

TI –Navigator Features	**Quick Poll**	**Learning Check**	**Screen Capture**	**Activity Center**
How frequently do you use this feature in your classroom?				
How satisfied are you with the use of this feature during lessons?				
How efficient do you feel the use of this feature is during class time?				

Section 3: Open-Ended Responses (Please respond to applicable items).

9. If you currently or recently used TI-Navigator as a **formative assessment tool**, please describe how you did so (e.g., to provide informal feedback to pupils, to provide informal feedback to the teacher, and/or to monitor pupil progress)?

10. How was the TI-Navigator system introduced to you and your school district (e.g., administrative decision, math department recommendation, other math teachers, and/or some other way?

11. Please describe any professional development training that you received prior to using TI-Navigator in the school district? If you received training, how much and what type(s) of training did you receive? (Ex: workshops, one-on-one training, in class assistance).

12. Was professional development sufficient for accurate use of TI-Navigator? If not, what other professional assistance would be useful?

13. What ***technological*** challenges, if any, did you when encounter when using TI-Navigator?

14. What ***planning*** challenges, if any, did you face when using TI-Navigator?

15. What impact do you think TI-Navigator has had on student learning?

Thank you for participating in this study!