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Straight from the Source: Perceptions of Students with Visual Impairments about Graphic Use

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Structured abstract: *Introduction:* This study analyzed the responses of a survey of students with visual impairments in Canada and the United States about their use of tactile and print graphics. Demographic, Likert scale, and open-ended questions focused on perceptions of quality, preferences, instruction, and strategies. *Methods:* Percentages of agreement for tactile and print graphic users are reported. Comparisons were made between the two groups. *Results:* Students felt positive about the quality of the graphics, but density and complexity were identified as challenges. Students varied as to whether they felt graphics supported their understanding of concepts. Both groups indicated that written descriptions were helpful. Students in this survey were positive about knowing how to use strategies that help them access graphics. *Discussion:* Tactile graphics appear to play an additional role in inclusion for some students. Attention to instructional needs should not overlook students with visual impairments who use print graphics. Additional inclusion of quality written descriptions may support understanding of graphical information. *Implications for practitioners:* Conceptual understanding would be supported by helping students recognize where graphics and descriptions are useful. Timeliness of access to graphics in the classroom and attention to quality graphics that reduce complexity and clutter remain important.

Visual displays of quantitative data are commonplace in our technological society (Postigo & Pozo, 2004). Increasing demand for the skills and knowledge to efficiently access these data correspond with the emergence of statistics and data management as key elements in school mathematics curricula (Friel, Curcio, & Bright, 2001; National Council of Teachers of Mathematics, 2000). Reflected in these curricula is the goal that students develop the "ability to interpret and produce graphical representations" (Yeh & McTigue, 2009, p. 435). This skill set is referred to generally as "graphicacy." (Åberg-Bengtsson & Ottosson, 2006). For students with visual impairments, data encoded in visual graphics pose an

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intuitive challenge, particularly for those studying in the areas of science, technology, engineering, and mathamatics (STEM; Beck-Winchatz & Riccobono, 2008; Smith & Smothers, 2012). In order to mitigate the impact of vision loss on access to graphical data, teachers of students with visual impairments provide specialized materials and instruction (Rosenblum & Smith, 2012).

Practices and perceptions regarding graphics use by students with visual impairments are primarily understood via research with samples of teachers of students with visual impairments (for instance, Sheppard & Aldrich, 2001) or university programs preparing teachers of students with visual impairments (for instance, Rosenblum & Smith, 2012). Zebehazy and Wilton (2014a) examined practioners' perspectives via an online survey of 306 teachers of students with visual impairments in Canada and the United States. The survey probed their preferences, practices, and beliefs relating to graphics use by students with visual impairments in the areas of quality, instructional practices, and importance of graphics to student learning. Overall, responses emphasized the importance of both tactile graphics and print graphics to learning outcomes for students with visual impairments. In terms of the quality of the graphics, there was a significant difference in how teachers of students with visual impairments rated the appropriateness of adaptations on state or provincial assessments. Participants were more likely to agree that print graphics on large-scale assessments were more appropriately adapted than tactile graphics, but agreement was limited for both formats (less than 50%; Zebehazy & Wilton, 2014a).

This finding is particularly worrisome given the high graphical content of many standardized assessments. Yeh and McTigue (2009) reviewed late elementary and middle school standardized science assessments from 14 U.S. states administered from 2003 through 2007. Results indicated that, of graphical representations found across states and grade levels, nearly 80% were essential to arriving at a correct answer for a given test item (Yeh & McTigue, 2009). Since teachers of students with visual impairments did not enthusiastically endorse the quality of test item adaptations for graphics in both tactile graphic and print graphic formats, students with visual impairments may be at an inherent disadvantage on standardized assessments.

In terms of their own practice related to graphicacy, teachers of students with visual impairments emphasized the importance of providing direct instruction to both tactile graphic and print graphic users beyond what is delivered in the general classroom. However, they were not likely to agree that they instructed students in how to generate their own graphics. Given that graphicacy encompasses both the ability to understand and to create graphics, some students with visual impairments may be missing essential skills for efficient use of graphics at school (Aldrich, Sheppard, & Hindle, 2003).

The literature reviewed thus far has examined the quality and utility of graphics

for students with visual impairments from the teacher's perspective. There is a dearth of perception-based research with samples of those school-aged students. Of the few existing studies, Aldrich and Sheppard (2001) utilized focus groups of students with visual impairments aged 9 to 19 years at specialzed schools. The researchers recorded students' perceptions of the quality and utility of tactile graphics. Aldrich and Sheppard (2001) noted that younger students were more likely to favor the use of tactile graphics than were older students. Younger students in particular enjoyed the process of creating their own tactile graphics. In terms of effective display of information in tactile graphics, students felt at a disadvantage to their sighted peers. Based on students' responses, Aldrich and Sheppard (2001) concluded that many tactile graphics were "too derivitive and 'sightist'" and called for tactile graphics that do not simply "translate" the visual graphic (p. 72). Although the variable quality of tactile graphics detracted from students' positive perceptions, participants noted that direct instruction by teachers in the use of tactile graphics and teachers previewing them were significant determinants of effectiveness when engaging with graphical information.

The current study contributes to the extant research by documenting and analyzing the perceptions of students with visual impairments with visual access to graphics, in addition to those of students who access graphical information via touch. The goal of the study was to represent students' voices in the educational literature devoted to tactile graphic and print graphic use, and to contrast these perspectives with those of teachers of students with visual impairments. The authors posit that students can be keen observers of school life and of teachers' instructional practices (Busher, 2012). Therefore, students in the current sample were uniquely positioned to comment on the quality of the graphics they use and on the effectiveness of teachers of students with visual impairments' instruction in accessing and analyzing graphical information.

Method

Instrument

In order to gain a firsthand perspective from users of graphics, the researchers designed an online survey for students with visual impairments about their perceptions and practices using graphics. The survey contained demographic, Likert scale, and open-ended questions. Most of the Likert scale questions were rated on a 5-point scale: strongly agree, agree, neutral, disagree, and strongly disagree. Four statements asking students to rate their skill level used a different scale: very well, well, neutral, somewhat, and not at all. For all statements, the respondents could also select, "I don't know." Tactile graphic and print graphic students responded to parallel statements, which were worded to refer to their respective medium. A few questions were unique to one medium.

Dissemination and analysis

In November 2011 the researchers disseminated the student survey at the same time as the graphics survey for teachers of students with visual impairments (Zebehazy & Wilton, 2014a). An e-mail invitation sent to teachers of students with visual impairments across Canada and the United States included the link to the

Table 1
Within-group percentages for demographic characteristics.

Characteristic	TG users	PG users
Grade level		
4–6	16% (*n* = 10)	15% (*n* = 5)
7–9	32% (*n* = 20)	24% (*n* = 8)
10–12	52% (*n* = 33)	61% (*n* = 20)
School placement		
School for the blind	25% (*n* = 16)	39% (*n* = 13)
School for the blind and local school	2% (*n* = 1)	6% (*n* = 2)
Public school (full-time classroom)	16% (*n* = 10)	27% (*n* = 9)
Public school and resource room	30% (*n* = 19)	27% (*n* = 9)
Other (not specified)	28% (*n* = 18)	0% (*n* = 0)
Frequency of graphic use		
3 or more times/week	45% (*n* = 28)	52% (*n* = 17)
1–2 times/week	24% (*n* = 15)	21% (*n* = 7)
A few times a month	24% (*n* = 15)	24% (*n* = 8)
Almost never	6% (*n* = 4)	3% (*n* = 1)
Use of graphics by content area		
Math	91% (*n* = 58)	88% (*n* = 29)
Science	86% (*n* = 55)	88% (*n* = 29)
Social studies	70% (*n* = 45)	88% (*n* = 29)
Health	23% (*n* = 15)	42% (*n* = 14)
Language arts	19% (*n* = 12)	39% (*n* = 13)
Art	19% (*n* = 12)	24% (*n* = 8)
Music	8% (*n* = 5)	21% (*n* = 7)
Gym	3% (*n* = 2)	18% (*n* = 6)

PG = print graphic; TG = tactile graphic.

student survey and an e-mail for parents, with a request to pass the link on to students with visual impairments in grades 4 through 12 who might be interested in participating. The survey remained open for approximately six months, with a reminder e-mail sent halfway through. The authors' university ethics board approved the study, including the manner of dissemination and informed consent. Results are reported descriptively using percentages based on the total number of respondents who answered that particular question. Within-group percentages (tactile graphic users and print graphic users) are used when comparing responses between the two mediums.

Results

Participants

Ninety-seven students took the survey in whole or in part. Sixty-four of the students (66%) were tactile graphic users and 33 (34%) were print graphic users. The students represented two Canadian provinces ($n = 13$; 14%) and 23 states ($n = 82$; 86%). For print graphic users, 30% ($n = 10$) reported viewing regular print graphics with no enlargement, 36% ($n = 12$) reported viewing enlarged versions of graphics, and 27% ($n = 9$) reported using a low vision device to view graphics most of the time. Table 1 lists the within-group percentages for grade level, school

Table 2
Percentages of agreement regarding quality in graphics use.

Quality-related statements	Graphic type	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	I don't know
Graphics on assessments or tests are the same format as what I use during classroom instruction.	PG (*n* = 33)	9	52	12	15	3	12
	TG (*n* = 59)	20	44	10	10	3	1
Most of the graphics I use are good quality.	PG (*n* = 33)	18	46	15	15	6	0
	TG (*n* = 59)	27	36	22	9	3	3
In class I always have a graphic to use when my peers are also using graphics.	PG (*n* = 30)	37	50	7	3	3	0
	TG (*n* = 59)	17	27	17	31	5	3
Color is helpful for me to see and understand graphics.	PG (*n* = 29))	45	21	17	14	3	0
	TG	NA	NA	NA	NA	NA	NA
I frequently use the tactile graphic supplements to my textbooks.	PG	NA	NA	NA	NA	NA	NA
	TG (*n* = 59)	17	27	19	24	5	9

PG = print graphic; TG = tactile graphic.

placement, frequency of graphic use, and content areas where graphics were used.

Perceptions of quality

One set of statements focused on quality. Two statements were presented to only one group: a statement about the usefulness of color for print graphic users and a statement about use of a tactile supplement to textbooks for tactile graphic users. In general, the majority of students felt that graphics were of good quality, although print graphic and tactile graphic users answered differently regarding the availability of graphics at the same time as their peers. Table 2 shows the specific percentages of agreement for each statement about quality.

Preferences of graphic users

Another set of statements focused on preferences. One statement about the use of descriptions in place of tactile graphics was only asked of tactile graphic users. Tactile graphic users, in general, were more likely to agree or strongly agree that they liked and wanted more access to graphics, while print graphic users tended to be more neutral. However, neither group strongly indicated (less than 50% agreeing or strongly agreeing) that graphics helped them to understand concepts better than text alone. Greater than 50% of the respondents in each group also indicated that descriptions paired with graphics were helpful. Tactile graphic users, in particular, agreed or strongly agreed with this statement (92%). Although enthusiastic about wanting access to graphics, tactile graphic users were also more likely to agree or strongly agree (50%) that 3-D models were preferred over graphics, as compared to print graphic respondents (33%). Neither print graphic nor tactile graphic users tended to make their own graphics to understand information. Table 3 shows the specific percentages of agreement for each statement related to preferences.

Perceptions of skills and instruction

Two sets of statements focused on the skills, instruction, and support needed for

Table 3
Percentages of agreement regarding preferences in graphics use.

Preference-related statements	Graphic type	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	I don't know
I like it when I have graphics to look at or access.	PG (*n* = 33)	12	30	42	6	3	6
	TG (*n* = 60)	42	42	8	2	3	3
I wish I had more access to graphics.	PG (*n* = 30)	13	17	40	10	7	13
	TG (*n* = 59)	25	27	25	17	2	3
I find it helpful to have a description along with the graphics.	PG (*n* = 33)	27	30	15	9	12	6
	TG (*n* = 59)	56	36	7	2	0	0
I prefer to have descriptions in place of tactile graphics.	PG	NA	NA	NA	NA	NA	NA
	TG (*n* = 59)	22	15	27	17	14	5
Graphics help me to understand concepts better than text or descriptions alone.	PG (*n* = 30)	13	20	37	13	13	3
	TG (*n* = 59)	17	25	25	20	7	5
I prefer models or objects instead of visual or tactile graphics.	PG (*n* = 30)	10	23	43	20	3	0
	TG (*n* = 58)	24	26	35	14	0	2
I make my own graphics to help me understand material.	PG (*n* = 29)	3	24	21	45	3	3
	TG (*n* = 59)	5	15	10	49	19	2

PG = print graphic; TG = tactile graphic.

reading and understanding graphics. The majority of both groups indicated that they were taught how to use graphics. Tactile graphic users were less likely (47% agreeing or strongly agreeing) than print graphic users (66%) to indicate that they could keep up with their peers when using graphics. Greater than 50% of both groups indicated that it is helpful to have someone preview graphics with them (59% of print graphic and 75% of tactile graphic users agreeing or strongly agreeing); however, print graphic users were less likely (38%) than tactile graphic users (56%) to agree or strongly agree that previewing actually occurs. Table 4 lists the specific statements and percentages of agreement.

In addition to the general statements in Table 4, respondents were also provided with a set of four specific statements about skills related to reading and understanding graphics. Table 5 displays the specific statements and the percentages of agreement. In general, 50% or greater of the respondents in each group agreed or strongly agreed they could perform the skills indicated in each statement.

Qualitative responses

Participants were also asked the following four open-ended questions:

1. In what ways do you find graphics helpful in your classes?
2. In what ways do you find graphics challenging?
3. What would help you use graphics better?
4. What strategies do you use to read graphics that are unfamiliar?

Table 4
Percentages of agreement regarding skills and instruction in graphics use.

Instruction-related statements	Graphic type	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	I don't know
I was taught how to use graphics.	PG (*n* = 33)	39	49	3	3	3	3
	TG (*n* = 59)	48	36	5	9	0	3
If I don't understand a graphic, I know what to do to figure it out.	PG (n = 30)	27	40	13	13	3	3
	TG (n = 59)	19	36	19	17	3	7
I am able to keep up with my peers when using graphics during assignments or instruction.	PG (*n* = 30)	23	43	10	23	0	0
	TG (*n* = 59)	15	32	19	25	3	5
My teacher (or other person) previews graphics with me before I need to use them in class.	PG (*n* = 29)	14	24	7	31	14	10
	TG (*n* = 59)	20	36	15	17	9	3
I find it useful when someone previews or orients me to a graphic.	PG (*n* = 29)	21	38	7	17	10	7
	TG (*n* = 59)	44	31	14	9	2	2
It is easy to read graphics.	PG (*n* = 29)	28	24	31	10	7	0
	TG (*n* = 59)	14	31	25	20	9	2

PG = print graphic; TG = tactile graphic.

The response rate for each question ranged from 24 to 50 respondents. Both researchers coded the data for the most common responses made by print graphic and tactile graphic users. The researchers then compared codes and came to full consensus on any discrepancies through discussion and referring back to the data. Table 6 lists the prevalent responses for print graphic and tactile graphic users for each question. In addition to the general strategies given by tactile graphic users, some

Table 5
Percentages of agreement on specific skill statements for reading graphics.

Skill-related statements	Graphic type	Very well	Well	Neutral	Somewhat	Not at all	I don't know
I know how to systematically explore or use good hand movements to explore a graphic.	PG (*n* = 28)	21	29	18	14	7	11
	TG (*n* = 55)	31	33	16	18	0	2
I know how to use descriptions paired with graphics.	PG (*n* = 28)	29	36	14	7	4	11
	TG (*n* = 55)	35	38	9	15	2	2
I know what kinds of questions to ask to gain information about graphics.	PG (*n* = 28)	25	40	11	11	11	4
	TG (*n* = 55)	35	27	13	20	0	6
I understand common parts of graphics that I look for when exploring a new graphic or picture.	PG (*n* = 28)	39	43	7	7	4	0
	TG (*n* = 55)	33	40	9	15	4	0

PG = print graphic; TG = tactile graphic.

Table 6
Prevalent responses to open-ended questions.

Question	PG Users	TG Users
Ways graphics are helpful	Help visualize situations and text; help understand some concepts (for instance, quantities)	Helpful in math and science; helps to know what is happening in class (for instance, on board, what teacher is talking about, etc.); helps enforce certain concepts (for instance, visual concepts)
Ways graphics are challenging	Too small or too detailed; enlargement issues; difficulty following lines	Spacing too cluttered, complex, or symbols too close; textures not distinct enough; 3-D shapes presented as 2-D graphics; not enough labels or description
What would help in using graphics better	Improved quality of color, labels, less clutter	Descriptions provided with graphics; preview with teacher and time to preview; better texture, spacing, and less complexity
Strategies used to read unfamiliar graphics	Ask a teacher or friend; use text or description around them; look at titles or headings	Ask teacher or friend or paraprofessional for help or description; locate key read descriptions if available; read title and labels; feel one piece at a time, locate general shapes and textures; use the problem or questions

PG = print graphic; TG = tactile graphic.

respondents also noted specific strategies related to hand movements. These included: using a left-to-right strategy; going around the perimeter first; using a top-to-bottom, right-to-left strategy; scanning the graphic and determining a point of reference; asking the teacher to read the graphic as the student scans landmarks she or he recognizes; starting at the left side and moving down the graphic in a column-like fashion; and following the lines to try to figure it out.

Discussion

Overall, this group of respondents seemed to have received effective insruction in graphics, given that the majority indicated that they had been taught how to use graphics and that tactile graphic users were confident in their skills for reading graphics. Within the data set, a number of interesting contrasts between tactile graphic and print graphic users emerged that are worth discussing.

Usefulness and usability of graphics

Tactile graphic users had a stronger preference for graphics than print graphic users. This is perhaps because print graphic users were more likely to report that they had graphics at the same time as their peers compared to tactile graphic users (87% agreed or strongly agreed as compared to 44%). Neither group, however, strongly connected with the idea that graphics helped them to understand concepts better than with text alone or via another method (for instance, 3-D models). Although students indicated that graphics helped in math and science, more specific qualitative responses indicated that the complexity of some graphics (for instance, 3-D images, maps, too many details) inhibited their usefulness for understanding concepts. This finding mirrors that of Aldrich and Sheppard (2001), where students highlighted several issues related to the production of tactile graphics as barriers to usefulness.

Data in the study presented here suggest that tactile graphic users' enthusiasm for graphics may, in part, be related to feelings of inclusion. Even though less than half of the tactile graphic users felt that they could keep up with peers when using graphics, one of the main qualitative findings from tactile graphic users was the indication that having graphics helped them to understand and feel connected to what was going on in the classroom.

The usefulness and accessibility of graphics for print graphic users also cannot be overlooked. Print graphic users did not strongly endorse several statements related to the usefulness of print graphics. For example, only 23% of print graphic users strongly agreed that they could keep up with peers in the classroom when using graphics to complete classwork. The overall neutrality of print graphic users regarding graphics also highlights a need to further examine print graphic user needs as they relate to effectively using graphics.

Descriptions

In terms of overall utility of print graphics and tactile graphics, both groups displayed a strong inclination toward written descriptions. Fifty-seven percent of print graphic users and 92% of tactile graphic users felt that having written descriptions with a graphic was better than the graphic alone. Qualitative responses by tactile graphic and print graphic users also indicated that graphics were improved when written descriptions or more textual support (for instance, labels or captions) were included. Previewing of graphics by a teacher or other adult is a related support. Both groups valued this support but were less likely to indicate that it was available. In the qualitative responses, a popular strategy common to both groups was to seek a description or explanation from a teacher, friend, or paraprofessional.

Provision of quality written descriptions in the classroom has the potential for supporting students in understanding concepts in graphics and their access to assessment material. Given the onset of more computer-based testing, descriptions will be important for access. In a study of the use of image description on assessments, Carver et al. (2012) found students to have a strong preference for image descriptions and also found braille-reading students to be more likely to answer questions correctly even when there were image descriptions without tactile graphics. In the current survey, only 37% of the tactile graphic users expressed agreement or strong agreement for descriptions in place of graphics, but another 27% were neutral. Context and experience should be considered when helping students to understand their accommodation preferences and needs as well as which combinations are useful in different situations.

Contrasts with teachers' perceptions

Several similarities and contrasts found between the perceptions of students and those of teachers of students with visual impairments (Zebehazy & Wilton, 2014a, 2014b) regarding graphic use are also worth noting. Teachers of students with visual impairments, similar to students, viewed written descriptions paired with tactile graphics as useful. Although both teachers of students with visual impairments and students were less likely to agree or strongly agree that descriptions in place of graphics were preferable, the percentage of students (37%) who agreed

with this statement was higher than that of teachers of students with visual impairments (11%). Also, tactile graphic users and teachers of students with visual impairments were in agreement about the importance of providing graphics to them at the same time as their peers in the classroom (44% and 54% agreeing or strongly agreeing, respectively; Zebehazy & Wilton, 2014a).

Teachers of students with visual impairments were more optimistic about the potential for graphics (84% print and 72% tactile) to support concept development than the students were in this survey (33% print graphic; 42% tactile graphic). It is important to understand this difference more fully in order to avoid making assumptions about what students are gaining from the use of graphics in the classroom. In the qualitative data for teachers of students with visual impairments (Zebehazy & Wilton, 2014b), the importance of developing concepts through early intervention and exposure to graphics was highlighted. Along with the comments made by students about the complexity of graphics, amount of experience and exposure may also be contributing factors to the perception of the usefulness of graphics for understanding concepts.

An area that warrants further pedagogical consideration is the role of making one's own graphics in helping students to understand graphical data and concepts. Low percentages of students in both groups (27% print graphic; 20% tactile graphic) indicated that they made their own graphics to help them understand materials. Similarly, teachers of students with visual impairments were not likely to teach students how to make graphics (41% print graphic; 36% tactile graphic agreeing or strongly agreeing; Zebehazy & Wilton, 2014a). Yet teachers of students with visual impairments said in the open-ended questions that "successful tactile graphics users" had opportunities to make their own graphics and noted making graphics as a teaching strategy (Zebehazy & Wilton, 2014b). Aldrich and Sheppard's (2001) study upholds these findings, noting that the younger students in their study enjoyed making their own tactile graphics. This contrast between what is considered important and what is being done has implications for both print graphic and tactile graphic users.

Implications for practitioners

The conclusions outlined in the previous sections are of direct relevance to practitioners, since the data are drawn from the students they support. The following list summarizes the implications.

1. Providing systematic instruction in the use of graphics, including opportunities for making graphics, is important for both tactile and print graphic users.
2. Assessing the accessibility needs and skill levels with graphics will help identify instructional areas of need for print graphic users.
3. For print graphics readers, providing enlarged graphics or using low vision devices or assistive technology may not be sufficient to ensure full access and understanding of graphical information.
4. Providing timely print and tactile graphics may affect students' perceptions of belonging and connection to the classroom environment. Tactile graphics may bear a special significance beyond simple access to graphical information.

5. Providing quality written descriptions to accompany graphics may support conceptual development for both tactile and print graphic users. Helping students to make connections between materials used in the classroom and those being assessed may support learning and demonstration of knowledge.

Limitations and future research

Several inherent limitations should be noted in this study. First, as with all perception-based research, the assumption cannot be made that all responses mirror actuality. Second, the distribution achieved by the study cannot be assumed to be representative of all geographical regions of Canada and the United States. For example, students from only two Canadian provinces were represented, and there were also clusters of students that attended the same school (for instance, a school for the blind). Third, conclusions were made on a relatively small sample size, particularly for print graphic users. Finally, because the sample was self-selected, the respondents were potentially those for whom this topic was of interest or were students who had more confidence in their graphic use.

Future research is needed to add to the knowledge base related to graphics instruction and use. Continued research into written descriptions with and without graphics and the contexts in which each combination works best will be important as technology continues to develop and provide new options for testing and instruction. Broader sampling of print graphic users is important to enrich our knowledge of graphic use by students with low vision. In vivo analyses of the strategies used by both tactile and print graphic users to effectively gain information would complement the perception-based data gathered here. Finally, the potential benefits of teaching students to create their own graphics warrants further investigation.

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