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Numeracy Programming at Major Canadian Urban Libraries: An Exploratory Study
La programmation en numératie dans les bibliothèques urbaines canadiennes importantes: une étude exploratoire

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Résumé de l'article

Le gouvernement du Canada considère que la numératie est une compétence fondamentale pour le travail, l'apprentissage et la vie. Les bibliothèques ont toujours été championnes de l'alphabétisation; toutefois, le rôle des bibliothèques dans le développement des compétences en numératie est peu étudié. Plus précisément, il y a une lacune importante dans l'étude des programmes de numératie offerts par les bibliothèques publiques. Cette étude exploratoire porte sur l'état des programmes de numératie dans cinq grandes bibliothèques publiques urbaines au Canada (Calgary Public Library, Edmonton Public Library, Bibliothèques de Montréal, Bibliothèque publique d'Ottawa et Toronto Public Library) afin de comprendre les types et la variété des programmes de numératie qu'elles offrent. Cet article porte sur la fréquence des programmes, le public cible et le contenu des programmes. Cette recherche a examiné 1,166 descriptions de programme provenant des sites Web des bibliothèques susmentionnées. Les données ont été recueillies la deuxième semaine de décembre 2015 et ne s'appuient que sur les descriptions de programmes disponibles publiquement en ligne. Dans l'ensemble, un total de 65 programmes (5,6% du total des programmes offerts) portaient sur des compétences en numératie. Les possibilités d'apprendre des concepts liés à la numératie sont très limitées dans toutes les bibliothèques de l'échantillon. Calgary a offert le plus de programmes de numératie destinés aux enfants, tandis que Toronto a offert le plus de programmes destinés aux adultes. Le terme « mathématiques » était le plus souvent utilisé pour décrire les programmes de numératie. Cette étude exploratoire souligne le besoin d'explorer davantage les programmes de numératie offerts par les bibliothèques publiques.

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Numeracy Programming at Major Canadian Urban Libraries: An Exploratory Study

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Abstract

The Government of Canada identifies numeracy as a foundational skill for work, learning, and life. Libraries have historically been champions of literacy; however, the

role of libraries in developing numeracy skills is understudied. Specifically, there is a critical gap in studying numeracy programs offered by public libraries. This exploratory study examines the state of numeracy programming at five major urban public libraries in Canada (Calgary Public Library, Edmonton Public Library, Bibliothèques de Montréal, Ottawa Public Library, and Toronto Public Library) to understand the types and varieties of numeracy programs that they offer. The frequency of programs, the intended age range, and the program content are the main foci of this paper. The researchers examined 1166 program listings by scraping programming information from the five libraries' websites. The data was collected for the second week of December 2015 and relied on programming descriptions from libraries' websites. Results showed that a total of 65 programs (5.6% of total programs) covered numeracy related skills. Overall, the options to learn about numeracy concepts were very limited at all of the libraries in the sample. Calgary offered the highest number of children-focused numeracy programs, while Toronto offered the greatest number of adult-focused numeracy programs. "Math/mathematics" was the most common term used to describe numeracy-related programs. This exploratory study underscores the need for greater investigation of numeracy programming in public libraries.

Keywords

numeracy; public library; children; mathematics; programming

Introduction

From being able to count to 10 to preparing a tax return or maintaining a household budget, numeracy is an unavoidable and vital component of modern life. The Government of Canada (2015) identifies numeracy as one of nine essential skills that form the foundation for learning other skills and that are foundational to work, learning, and life. Similarly, the Organisation for Economic Cooperation and Development (OECD, 2016) underscores numeracy, literacy, and problem solving skills as the three skills essential for full participation in 21st century life and work. The OECD's keen interest in numeracy is reflected through its efforts, in partnership with governments around the world, to measure numeracy in adults through its Programme for the International Assessment of Adult Competencies (PIAAC). While Canada performs slightly above average with regard to adult numeracy scores, a moderate decrease in national performance has been noted (OECD, 2016). Unsurprisingly, concerns over Canada's national and provincial numeracy performance are subjects of both media interest (CBC News, 2013a, 2013b; Friesen, 2018; Southwick, 2018) and think tank recommendations for enhancing national competitiveness (Conference Board of Canada, 2019; Lane & Murray, 2019; MacLeod & Emes, 2018; Stokke, 2015). Improving individual and collective numeracy is clearly an important objective, and it is one in which public libraries can and should play a role.

While primary and secondary education form the cornerstone for numeracy instruction in Canada, numeracy education need not be focused so narrowly. Library programming in numeracy can fill gaps in school numeracy instruction by reaching preschool-aged children and adults. Numeracy programming for school-aged children can serve as a

valuable supplement and complement to in-class instruction. Furthermore, public libraries have continually served as champions of literacy, and while numeracy is distinct from literacy, the two are closely aligned. Championing numeracy and providing numeracy programming would therefore align with one of the foundational values of libraries. There is a growing national emphasis on developing science, technology, engineering and math (STEM) skills as the Government of Canada (2018) highlights a range of STEM initiatives it is eager to advance. All of these factors underscore the crucial role libraries can play in supporting numeracy. The key question is not whether libraries should be involved in numeracy programming, but to what degree are libraries involved in numeracy education?

This exploratory study aims to address this research question through an analysis of one week of public library programming in five major Canadian urban library systems. The analysis of programming in the second week of December 2015 from the Toronto, Montreal, Ottawa, Calgary, and Edmonton public library systems reveals a mixed picture of the state of library programming. While some numeracy programs were found, there is opportunity for additional programming in this area.

This paper begins with a review of the literature followed by a discussion of methodological considerations. Out of the 1166 programs analyzed, the authors focus on numeracy programming and examine the targeted ages, duration, and timing, as well as differences in programming across the five systems. The analysis from this exploratory study aims to provide a basis for evaluating and improving public libraries' role in promoting numeracy.

Literature Review

As noted in the introduction, numeracy is distinct from literacy. However, they are often discussed together in literature, particularly when highlighting the importance of these skills in overall quality of life. The Canadian Library Association (as quoted in Sawyer 1996, p. 17) noted that "[b]asic literacy includes numeracy and information literacy," and these skills play an important role in various economic, social, and political facets of life. From an economic perspective, these skills are "essential steps on the pathway out of poverty" (Thompson, 2012, p. 190), and from a social perspective, they are important for active community participation (Department of Education and Skills, 2004).

The field of numeracy has greatly evolved throughout the last century: there has been a shift from "trying to find what children can do to trying to reveal what they can do" (Baroody, 2000, p. 61). The memorization and drill approach to numeracy has become increasingly outmoded and replaced with a constructivist view of education developed by Piaget, who believed in children's natural curiosity as exemplified by their "inherent desire to find patterns and resolve problems, the essence of mathematics" (Baroody, 2000, p. 61). Findings from several studies have demonstrated that young children and infants, including those with disabilities, have potential to learn numeracy skills before entering school (Hannula & Lehtinen, 2005; Notari-Syverson & Sadler, 2008; Starkey & Cooper, 1980; Whyte & Bull, 2008). Before being exposed to any numeracy, infants "have some biologically primary quantitative abilities, which encompass their implicit

understanding of numerosity, ordinality, counting, and simple arithmetic, and thus form the basis for later mathematical development" (Hannula & Lehtinen, 2005, p. 238). Certain numeracy skills, such as subitizing, which is defined as the "process of seeing the number in a set without counting" (Jung, 2011, p. 552), are present in infants before they start talking (Starkey & Cooper, 1980). There are many advantages of early numeracy for children. In general, an emphasis on early numeracy better readies children for future formal education by allowing them to better understand mathematical concepts (Notari-Syverson & Sadler, 2008). Certain advantages are more skills-specific. For example, those with a solid understanding of number relationships develop a "more sophisticated understanding of number and quantity" (Jung, 2011, p. 551). The benefits of early numeracy are not only limited to hard skills, but also include improved attitudes towards mathematics (Kliman, Jaumot-Pascual, & Martin, 2013).

Early numeracy is not without its challenges. In comparison with early literacy, there is a lack of early numeracy documentation, and it is often criticised as being less developed (LeFevre et al., 2009). There is also less consensus in the numeracy rhetoric as to the relative importance of numeracy compared with literacy, despite its equal status as an essential skill assigned by a variety of government bodies (Dion, 2014). The lack of consensus may also be attributed to the fact that "researchers have not distinguished amongst different types of home numeracy experiences" (LeFevre et al., 2009, p. 56). Another particular challenge is that, in Canadian education, numeracy tends to be isolated to the STEM fields, whereas literacy tends to have an overarching interdisciplinary presence (Dion, 2014). Furthermore, there is no significant number of other opportunities to develop numeracy skills presented by libraries or other para-scholastic organizations. Compared with literacy-based programs, libraries offer limited numeracy-focused programs for children (Dynarski et al., 2003), and "mathematics offerings are typically limited to homework help" (Kliman et al., 2013, p. 10).

Numeracy is multifaceted and includes skills such as oral counting, estimation, and number relationship, which play an important role in the development of overall numeracy-related competencies in individuals. Oral counting is an important skill in children: it not only contributes to other types of numeracy skills, but also "precedes both effective object counting and numeral identification" (Gould, 2012, p. 109). Estimation is another critical numeracy skill, which must be developed to complete more complicated mathematical functions "such as approximating answers to arithmetic problems, estimating the number of objects in an array, or locating numerical magnitudes along a number line" (Whyte & Bull, 2008, p. 588). Another crucial numeracy skill is the understanding of number relationships, which is broken down into three types: subitizing, more-less relationships, and parts-whole relationships (Jung, 2011).

An interesting element of numeracy that bridges the divide of numeracy and early literacy is the acquisition of number words. In order for children to learn number words, they must accomplish "the task of identifying the dimension of experience denoted by all number words (i.e., the dimension of numerosity) and the task of learning the specific meaning of each individual number word" (Slusser & Sarnecka, 2011, p. 39). These tasks are a meaningful step, because studies have shown that they bring "profound

changes to children's understanding of number" (Slusser & Sarnecka, 2011, p. 50). The achievement of learning number words is not the only link to literacy. At least one study has shown that merging numeracy and literacy development activities "may be the best way to stimulate early numeracy skills" (Kleemans, Peeters, Segers, & Verhoeven, 2012, p. 476); these results indicate an advantage for interdisciplinary learning.

Library numeracy programming primarily falls under STEM programming (Anderton, 2012). The big push for STEM programming in the United States took place in 2011, when the U.S. federal government reauthorized a law that focused on STEM education. This change greatly increased STEM support from businesses and organizations such as the American Library Association (Braun, 2011; Hopwood, 2012). The new law also increased government and public support and created a ripe environment for libraries to devise STEM opportunities. STEM programming is a compelling way for libraries to "gain support as part of educational initiatives, as well as to increase community partnerships" (Hopwood, 2012, p. 53). This support can be in the form of funding, because STEM can easily demonstrate educational value to library stakeholders (Hopwood, 2012, p. 53). Community partnerships for STEM programs offer libraries numerous benefits, which may take the form of "financial support, resources, or even volunteers at events" (Hopwood, 2012, p. 54). Additionally, partnerships can benefit library patrons, because libraries are in the position to "create an atmosphere of creativity, exploration, and excitement about STEM topics by tapping into local networks, mining information online, and exchanging ideas with colleagues at conferences" (Spencer & Huss, 2013, p. 45). STEM library programs also benefit patrons in that they are often presented by a non-expert, and as such introduce concepts in a way that is simple and easy to understand (Hopwood, 2012).

However, challenges exist with using non-experts in STEM fields to deliver such programs. As mentioned, many adults tend to shy away from numeracy if they were unsuccessful at mathematics, and they may perpetuate a negative attitude towards mathematics (Dion, 2014; Intel, 2009; Kliman et al., 2013). Another serious challenge is that STEM material becomes outdated relatively quickly and thus requires significant work to ensure that library materials and staff resources remain relevant and accurate (Anderton, 2012).

Despite the challenges, there are instances of STEM library programs with a numeracy focus. Sometimes a program's ties to numeracy are implicit rather than explicit, but a certain working knowledge and mathematical logic are necessary and may be developed further, as with the coding-focused LEGO MINDSTORMS and Scratch programs (Romero, 2010). Other programs have mathematical themes and explicitly state that numeracy is included. This is the case for the "What's the Big Idea?" program developed by librarian Sally Anderson, executive director of the Vermont Center for the Book/Mother Goose Programs. This program "aims to provide librarians with techniques and tools for introducing preschool and kindergarten children to science and math through literature" (Rupp, 2009, p. 27). Numeracy programs in libraries often include a partnership or collaboration with other community organizations. The Queens Borough Public Library, for example, "invited the education staff from the New York Hall of Science to demonstrate one of their early childhood programs" (Cerny, 2004, p. 12).

Certain libraries address numeracy directly but may not include it in a formal program title. Multnomah County Library's 2002 "Go Figure!" initiative features a mathematical interactive exhibit, which "brings the exciting world of math and its everyday uses to children two- to seven-years-old with representations from many well-known children's books" (Arnold, 2002, p. 25). Examinations of numeracy programming in a Canadian public library context are less common. Poremba (2011) noted numerous means by which mathematics can be integrated into library programming, but there remains a gap in the literature in assessing the extent of numeracy programming.

The library literature has specific recommendations for incorporating STEM into library programs. One successful method has been to "infuse mathematics into what they already do successfully and confidently, rather than create a separate, standalone mathematics program" (Kliman et al., 2013, p. 11). This recommendation could require less time and energy from library staff than creating a completely new program. Another recommendation is to include STEM opportunities in library spaces, such as by "creating space for a hands-on learning environment, where patrons can use the latest technology devices, conducting labs with a science librarian, and bringing in exhibits from local science museums" (Spencer & Huss, 2013, p. 42).

While there is a growing focus on STEM skills for children, numeracy continues to play an important role in the lives of adults. A report by the U.K. Department of Education and Skills (2004) noted that limited literacy and numeracy skills are likely to lead to income loss, lower productivity, limited training options, and higher health risks. Thus, numeracy skill is equally important for adults as for children. A number of studies have focused on numeracy and various facets of adult life, such as employment and health. For example, Parsons and Bynner (1997) conducted research in the area of numeracy and employment. They argued that the demand for numeracy skills is increasing in different jobs (e.g., sales jobs), and they concluded that "the poor labour market experience is associated even more strongly with poor numeracy, even when accompanied by good literacy skills" (p. 11). They also noted that people with limited numeracy skills are likely to experience job loss in their career. In general, people with lower numeracy skills will experience challenges in finding a job, keeping it, and advancing in their career. Other researchers have examined the importance of literacy and numeracy skills in different facets of health management (Estrada, Martin-Hryniewicz, Collins, Byrd, & Peek, 2004; Huizinga, Beech, Cavanaugh, Elasy, & Rothman, 2008; Marden et al., 2011). For example, Estrada et al. (2004) suggested that both literacy and numeracy skills are important to understand "medication instructions and the risks and benefits of clinical information" (p. 88). Huizinga et al. (2008) found that there is "a significant association between low numeracy skills and higher BMI [Body Mass Index] in adult primary care patients" (p. 1966). Similarly, Marden et al. (2011) concluded that "low numeracy skills were adversely associated with diabetes control" (p. 662).

A number of countries (e.g., the OECD countries) "have lifelong learning policies which recognise that literacy is an ongoing endeavour developed through many contexts over the lifetime including through nonformal and informal means" (Thompson, 2012, p. 191). Such focus on "informal lifelong learning and literacy" brings attention to public libraries

(Thompson, 2012, p. 191). Authors such as Sawyer (1996), Liu (2004), and Bourke (2007) have noted that public libraries play an important role in developing and honing patrons' (e.g., children's and adults') various skillsets, including literacy and numeracy skills. For example, Liu (2004) argued that public libraries, through their education-focused initiatives, contribute in improving various skills including language and numeracy.

Methodology

This exploratory study purposively selected five major urban library systems for analysis. Calgary Public Library (CPL), Edmonton Public Library (EPL), Bibliothèques de Montréal (MPL), Ottawa Public Library (OPL), and Toronto Public Library (TPL) were chosen for several reasons. Foremost, these five systems are the Canadian public library systems serving the largest populations, as identified by Canadian Urban Library Council's public library statistics for 2013 and 2014 (Marriott, n.d.-a, n.d.-b). This study focused on large systems because of their greater capacity to deliver a range of programming, due in part to greater resources and having more branches. These five library systems also provided a degree of geographic diversity, with two from Alberta, two from Ontario, and one from Quebec.

In order to generate a sample of programs for analysis, the researchers decided to capture all programming within a specific week: the second week of December 2015 (December 9 to 15). Website scraping to analyze library programming is an increasingly common methodological approach and resonates with the data collection methodology used by Luo (2018) and Goulding and Crump (2017). The selection of the second week of December was primarily driven by the sequencing of the research project. An initial scraping of websites occurred in October 2015; however, the researchers observed some problems with the data scraping. A new data collection phase was conducted in December, which coincided with the end of the fall semester and therefore allowed greater time for data collection by Graduate Research Assistants. The October data was not used in the analysis. The researchers acknowledge that the week chosen is not representative of library programming throughout the year, particularly summer weeks when there may be greater programming to serve out-of-school children. The second week of December also included some programming unique to the holiday season. Despite these limitations, the scraping of 1175 programs across five major library systems still serves as a valuable snapshot of numeracy programming; however, as noted below, the actual sample of programs was 1166 because of problems with records for nine programs.

Program information was captured by scraping the websites of the five systems. Each program listing was saved as a PDF, which was then given a unique identifier (e.g., CPL-0001) based on the library system and the chronological order of the programs. 1175 programs were recorded for this time period from all five library systems. The number of programs each library scheduled can be seen in Table 1.

Table 1
Total number of programs held at each library system

Library System	Number of Programs
CPL	235
EPL	248
MPL	100
OPL	180
TPL	412

PDFs were transcribed into a master spreadsheet in order to facilitate analysis. From the PDFs, the researchers recorded:

- Library system
- Which branch hosted the program
- Date
- Time of day
- Length of program (in hours and minutes)
- Whether registration was required
- Listed age range (both the descriptive range and the range in years)
- Maximum number of spots for participants
- Speaker or facilitator
- Cost
- Program description

Unfortunately, not all program listings provided all of this information. When the information was missing, it was noted in the master spreadsheet.

Because the data initially entered into the master spreadsheet did not include program titles, the researchers decided to return to the PDF files in June 2016 and rectify this oversight. During this second round of transcription, the researchers discovered that important information had been cut off in the process of saving the Bibliothèques de Montréal program listings to PDFs. Fortunately, most of the Bibliothèques de Montréal program listings were still available online. At this time, the researchers decided to return to the original Bibliothèques de Montréal program listings and re-save the program listings as PDFs, ensuring that all of the information was included. During the creation of these new PDFs, there were nine program listings that could not be found again. Since the information about these programs was incomplete, the researchers ultimately did not include these nine programs in the analysis. This left 91 Bibliothèques de Montréal programs and a total of 1166 programs to examine. Once the new

Bibliothèques de Montréal PDFs were saved, the information from these PDFs was also transcribed into the master spreadsheet.

Bibliothèques de Montréal Programs

When the information from the Bibliothèques de Montréal PDFs was transcribed, it was also translated into English. Bibliothèques de Montréal provided translations for some of the programs, which were used whenever possible. Where Bibliothèques de Montréal did not provide a translation, a completely accurate translation could only be made if the translator understood the entire context of the text. While familiarity with the public library environment provided a well-rounded context for translation, there was still a need to make assumptions to enable an accurate translation, rather than a word-for-word translation. At times, translation led to awkward phrases in English but provided a clearer understanding of the programs. Table 2 shows a few examples of these translations.

Table 2.
A few key translations

Original French Word	**English Translation Used**
Touts petits OR les petits	Little ones
Jeunes	Youth
Comptines	Rhymes
Contes	Stories
Informatiques	Technology
Animation	Animation
Brico OR bricolage	Crafty OR Crafts

Using Voyant Tools

As a final step, Voyant Tools was used to complete text analysis (Sinclair & Rockwell, 2018). This is a suite of text analysis tools intended to assist users in reading and interpreting texts. Voyant Tools was used in order to supplement the analysis and help determine patterns among the numeracy programs across the five library systems. In order to simplify the analysis, the researchers separated the programs into five different files: one for each library system. Only the titles and descriptions of the programs were included in these files.

Using Voyant Tools, the researchers searched for the terms "math*" and "numeracy|numbers" to find any major differences between the different library systems. With this approach, any terms beginning with “math” were counted as one term and "numeracy" and "numbers" were counted together. “Math” was chosen since it refers to mathematical concepts in both French and English. There were no instances of other appropriate French terms, such as nombre or calcul, and as a result, only the conjunction of “numeracy” and “numbers” was used. The researchers determined that these terms would best capture instances of numeracy-related programming.

A wildcard search for “numbers” (i.e., "num*”) was not used due to libraries advertising a “limited number” of some object or feature in program descriptions, whether that be seats or books, unrelated to numeracy learning. Similarly, "count*" was not used due to “country” creating false positives. The researchers wanted to avoid these false positives, so they used the affordances of Voyant to distinguish between them.

Limitations of the Study

As indicated by the methodology, the study has several limitations. It only examines programming from five urban library systems, and as such cannot be generalized to represent all urban libraries in Canada. Furthermore, the data provides no insights into how rural and remote, or even small- or medium-sized library systems undertake numeracy programming. The analysis also focuses on a single week, which is not representative of programming throughout the course of a year. Programs that run irregularly or only during a specific time of year may not be included in the study. Programming is only one means of delivering numeracy content. This type of data does not reveal interactive library exhibits, online resources (e.g., instructional videos), or collections related to math and numeracy.

Another limitation of the study is relying simply on publicly available programming descriptions from the libraries’ websites. In some cases, the person running the storytime program may touch on numeracy concepts, but if they are not mentioned in the program description, the researchers have no knowledge of them. For example, EPL’s “Sing, Sign, Laugh and Learn” program, which ran a total of 70 times across all the EPL branches during the selected week, describes its focus as “signing, rhyming and singing” and states the program will “enhance their child’s communication and development through repetition, visuals and movement.” Given this description, the program was not included as involving numeracy; however, the authors knew that counting was an aspect of the program, because one author had previously worked at EPL and had delivered the program. There were also some inconsistencies within the publicly available information on programs. For some EPL programs, for example, the descriptive terms for age and the age range in years conflicted. There were programs that were labeled for preschool children but listed the appropriate age range as 6-12 years of age. In these cases, the authors decided to use the descriptive term rather than the age range.

Findings

From the 1166 programs that the researchers examined during the week of December 9 to 15, 2015, the analysis revealed a total of sixty-five programs (5.6% of total programs) offered that taught numeracy-related skills in some form. More specifically, the analysis also revealed that EPL did not offer any programs that touched on numeracy concepts. As a result, EPL is excluded from the following graphs.

Numeracy Programming by Age

The target audience age was an important aspect of the analysis, because numeracy programming for young children is markedly different from numeracy programming for adults. Each numeracy program was advertised to be for a certain age group. The descriptive age ranges for numeracy programs included adults, children, school age, preschool, and a category for both adults and children. Examining the appropriate age ranges for the numeracy programs gives insight into which age groups are most supported and, perhaps more importantly, which audiences are not the focus. There is approximately an equal number of numeracy programs for adults and for children. However, each of the library systems is quite distinctive in regards to which audience they favour. This distinction can be seen in Figure 1.

In Figure 1, “Children” and “Adults” are exclusive categories: “Children” refers to programs that were described as being for children, school age or preschool; “Adults” refers to programs that were described as being for adults. “Both” refers to programs that were listed as being for adults and children. These programs often required an adult to register alongside a child.

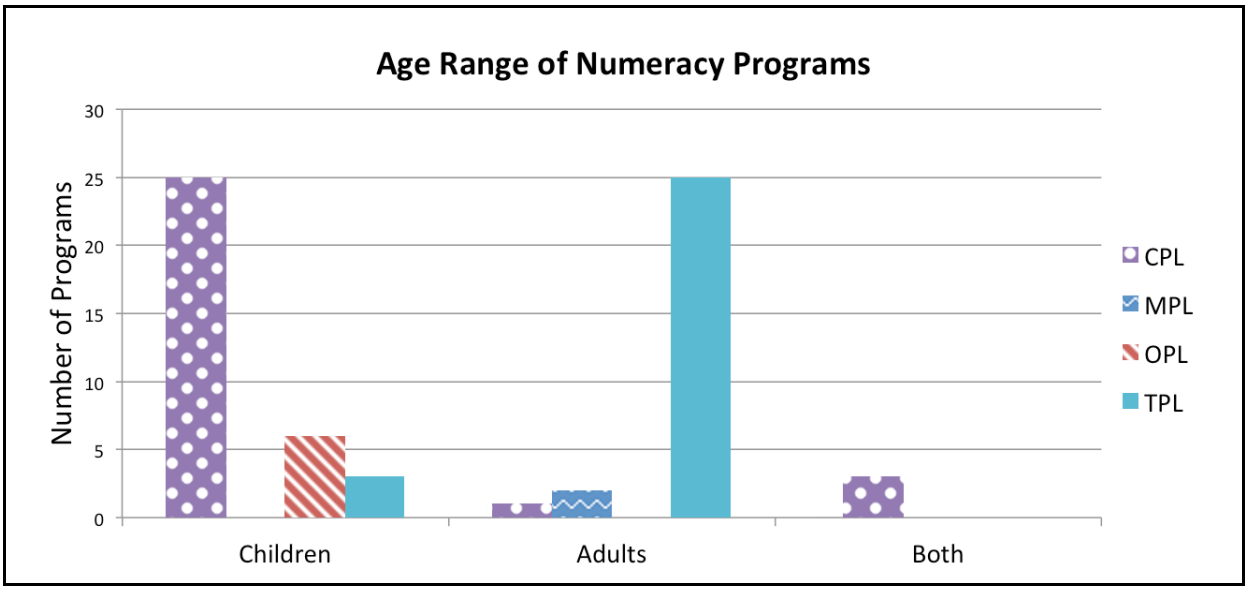

Figure 1. The number of numeracy programs offered for each age bracket by library system.

Each of the library systems focuses on a different audience when it comes to numeracy programs. The majority of CPL's numeracy programming is for children and for adults with a child. CPL only offers one program that is solely for adults, which is a financial planning program. TPL offers the majority of their numeracy programs for adults and a small number for children. OPL only offers numeracy programs for children, and MPL only offers numeracy programs for adults.

Numeracy Programming by Time

The duration of a program and when it takes place are both important aspects for the library and for the patron. The library needs to know when certain rooms or areas of the library will be in use, and patrons who wish to attend need to know when to fit a program into their schedule. More importantly, for higher-level numeracy programming, such as programs aimed at teens or adults, sufficiently numerate staff would be required to facilitate such programming. The length of time taken by a program and when the program occurs are important for scheduling, but also are contingent on the target audience. Both time of day and duration will have an effect on who can and will attend.

Duration of Numeracy Programs

The researchers expected that the duration of a numeracy program would reflect the intended audience. Results show that 82.5% of programs solely for adults were over an hour long, compared with only 24.8% of programs that included children. The researchers presumed that the distribution of program duration would match the distribution of program age ranges in Figure 1, particularly when looking at the library systems separately.

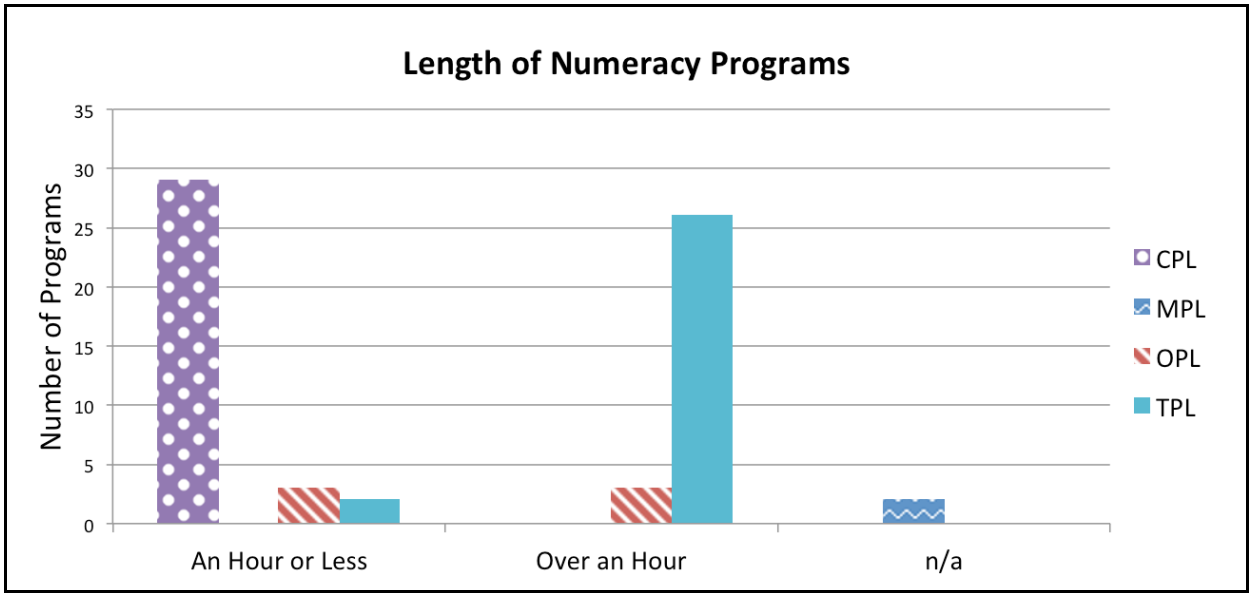

Figure 2. The number of numeracy programs by time duration in each library system.

Figure 2 shows how many numeracy programs in each system are over an hour and how many are an hour or less. As expected, the distribution is similar to Figure 1, particularly at CPL and TPL. Understandably, all of the CPL programs were an hour or less in length, because the majority of their programs target children. Conversely, the majority of the TPL programs were over an hour, with only a few being an hour or less, which reflects the fact that their numeracy programs generally target an older audience. For example, TPL's general assistance programs for adults listed an eight-hour window of time during which someone could register for a minimum two-hour time slot. Both of these durations are significantly longer than all CPL programs. The OPL programs were evenly divided between an hour or less and over an hour. Unfortunately, none of the MPL numeracy programs had a duration listed, resulting in the MPL programs being classified as "N/A."

When Numeracy Programs Began

Start times for numeracy programs were divided into three categories in order to simplify the analysis. Programs that began before noon were defined as morning programs, programs starting after noon were defined as afternoon programs, and any program that started after 5:00pm was defined as an evening program.

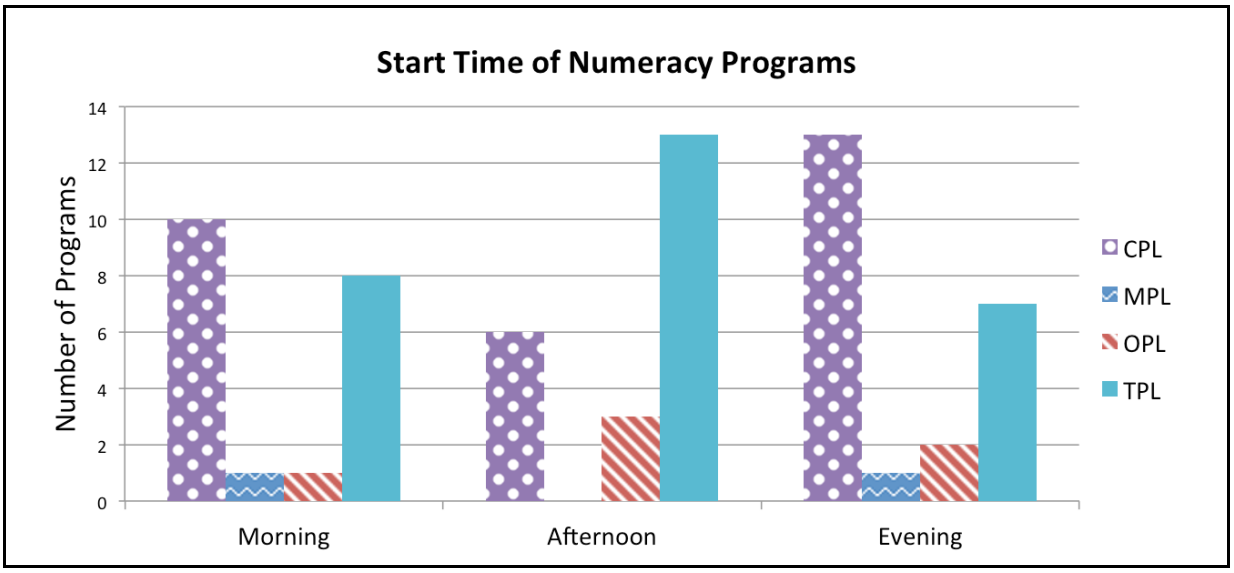

Figure 3. Number of numeracy programs that began during each time of day in each library system.

Figure 3 shows that TPL and CPL programs happened throughout the day, with the most CPL programs starting in the evening and the most TPL programs starting in the afternoon. No MPL programs began in the afternoon, and an equal amount started in the morning and evening. Most of the OPL programs began in the afternoon, with a few in the evening and one in the morning. Overall, program start times were distributed throughout the day, with no substantive differences among them. There were not enough programs to draw larger conclusions on the timing of numeracy programs. It is also important to note that mid-December, which would be a regular school/work week,

may not reflect increased programming during weeks in which children are out of school and adults may be more likely to take holidays.

Text Analysis

A more complex story emerges from text analysis that examines the frequency of numeracy words used in relation to which library system hosted the program. Analysis in Voyant revealed that there were 139 instances of "math*" and twenty-six instances of "numeracy" or "numbers" being mentioned in program titles and descriptions. Figure 4 shows the relative frequency of these terms, giving an overview of how often these terms were used relative to the size of the corpus. In this case, the size of the corpus is determined by the number of programs offered by the library system. It is important to note that the frequencies do not indicate the number of programs offered, but the number of times the terms were used. Results show that CPL programs mentioned numeracy-related terms at a much higher frequency than other library systems.

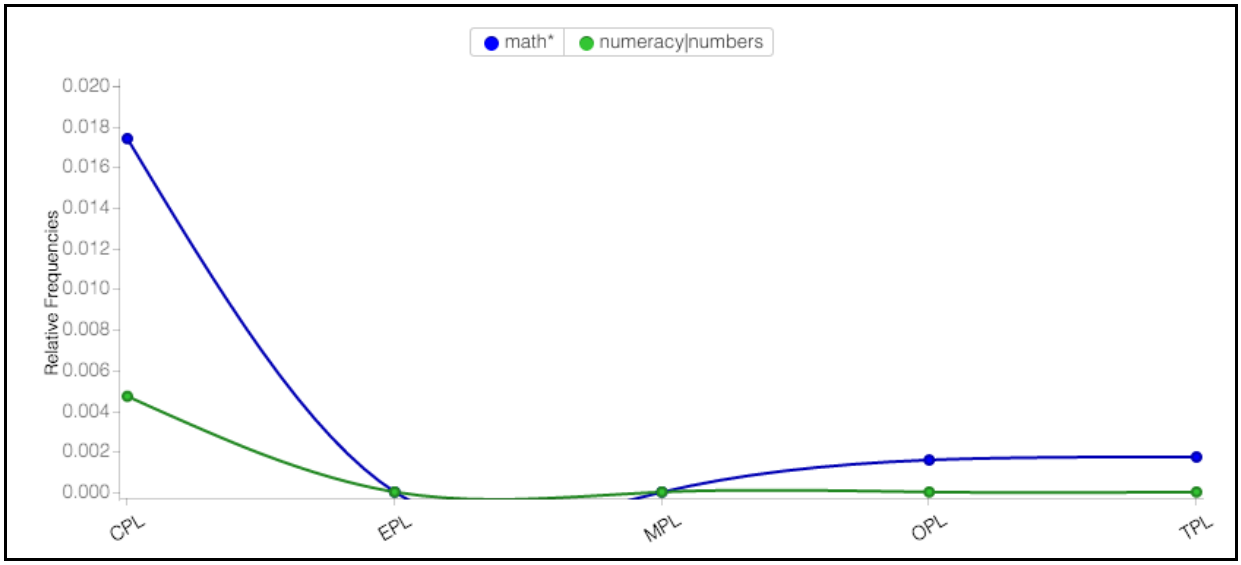

Figure 4. Relative frequencies of “math*” and “numeracy” or “numbers” mentioned in program descriptions at each library system.

CPL Numeracy Programs

The researchers used TF-IDF (term frequency–inverse document frequency) to determine that "math" and "numeracy" were distinctive terms in the CPL program descriptions. This indicates higher usage of numeracy-related terms in the CPL program descriptions than the other library systems’ program descriptions. These results are similar to what was found through the initial analysis. Twenty-nine of the sixty-five programs that relate to math concepts were run by CPL, resulting in CPL hosting the highest proportion (45%) of the math-related programs. A total of 12% of all programs offered by CPL were math-focused, which is the largest percentage across all library systems. The vast majority of these were programs focused on children ages five to 12. Three of the programs were repeated instances of “1-2-3: Count with Me!,” which was

for preschool-aged children. The preliminary analysis of the program descriptions revealed that CPL also offered one adult-focused finance program.

EPL Numeracy Programs

According to the Voyant analysis, EPL had no programs that offered math-based learning. This conclusion matches with the results of the initial investigation of program descriptions: no programs were found that mentioned math or numeracy concepts.

MPL Numeracy Programs

Figure 4 suggests that MPL offered no programs with math-based learning; however, preliminary analysis revealed that there were two programs (2% of MPL programs) focused on financial help for adults. Neither of these programs mentioned math, numbers, or numeracy, nor calcul or nombres.

OPL and TPL Numeracy Programs

Based on Figure 4, OPL and TPL appear to be similar in their usage of words beginning with “math,” relative to the number of programs offered. However a deeper examination of the text analysis showed that these two library systems are rather different.

Only 3% of OPL programs related to math in some way. OPL offered four instances of a general homework help program for students ages 6 to 15 in French and English. Because the program description is bilingual, “math*” is mentioned twice in each program description and counted twice by Voyant (“Come join our homework club and get help with reading, math … Joins-toi à notre club d’aide aux devoirs, pour recevoir de l’aide avec : la lecture, les maths ...”). This homework help program comprises most of the math-related programs that OPL offers. However, the researchers were primarily interested in programs that introduce math concepts rather than generally assist with homework. The other two times that OPL used “math” in the program descriptions were in two instances of a program for 7- to 10-year-olds that encourage the development of math skills through knitting. This program exemplifies what the researchers wanted to find.

Although it is hard to discern from Figure 4, TPL actually had a slightly higher relative frequency of “math*” mentions than OPL, placing it second, behind CPL. The text analysis showed that TPL offered 28 programs that focused on math or numeracy in some way; this number represents 7% of their total programs. However, unlike CPL, the majority of programs that TPL offered focused on adult literacy. Twenty-four of the 28 TPL math and numeracy programs offered general assistance to adults. These programs are similar to the OPL homework help programs in that they offer general mathematics help alongside other topics. Of the other four programs, there was an instance of a finance program for small business owners, a chess club for school-aged children, an escape-room-type program with math problems for school-aged children, and a program for preschool children and their parents that was intended to foster a positive outlook towards mathematics.

The Resulting Word Cloud from Numeracy Programs

Figure 5 is a word cloud that primarily reflects the programs that were held multiple times over the week the researchers examined. It also reflects the fact that most numeracy programs were advertised using the word “math” and not “numeracy.” The TPL general help program for adults was called “Adult Literacy” and specified that “adult volunteer tutors” would meet with the “English speaking adults.” The CPL programs for school-aged children also mentioned “adult volunteers” and specified that there would be “fun numeracy activities.” Both of these program descriptions referred to the library. All of the words from these phrases are visible in the word cloud.

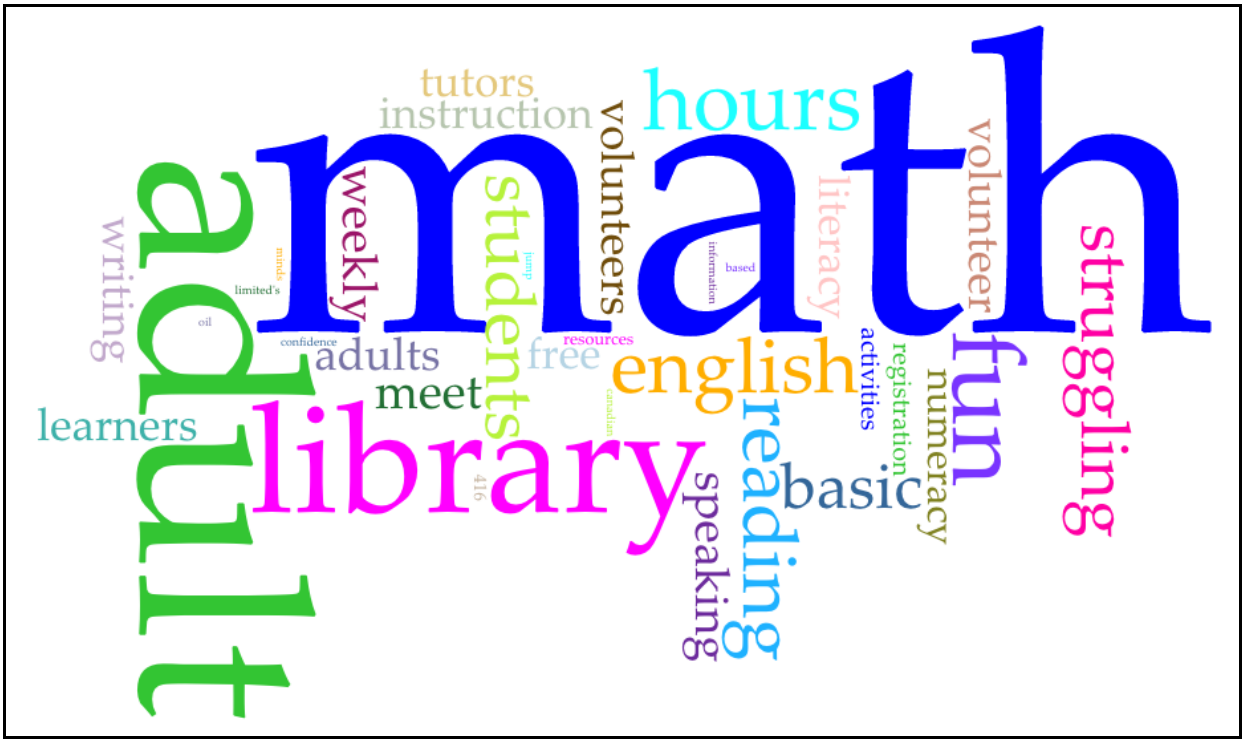

Figure 5. Word cloud of the numeracy program titles and descriptions.

Discussion

The current study’s findings agree with the majority of the literature: despite their importance, numeracy-focused programs are rare (Dynarski et al., 2003; Kliman et al., 2013). In the OPL and TPL library systems, programs that focus on numeracy were generally outnumbered by programs offering numeracy-related help through generalized programs. These were frequently the only programs provided that included numeracy concepts, replicating the findings that “mathematics offerings are typically limited to homework help” (Kliman et al., 2013, p. 10). Programs offering instruction in multiple literacies, or homework help programs, include numeracy instruction as one possible aspect and do not necessarily include numeracy instruction every time the program is run. When excluding general literacy programs and only examining distinct

opportunities for learning or practicing numeracy, the options are incredibly limited. This rarity is even more pronounced when examining programs by the suggested age of participation. There were very few programs for preschool children that included a focus on numeracy: only four programs in total. This number is far too small for the authors to conclude much about the content of the programs themselves; however, the lack of programs offered is noteworthy. Interestingly, while CPL offered the vast majority of numeracy-focused programs, these programs were mostly for children under 12 and older than five. Similarly, none of the other library systems offered programs for older teens that included numeracy concepts as an area of focus. The only options for older teens were the general homework help programs. While these programs are doubtlessly important, they should exist alongside programs that include numeracy instruction as a point of focus. The lack of numeracy programming for teens raises an important question. While teens generally are disinclined towards mathematics (Woodward, Beswick, & Oates, 2018; Yong, Gates, & Harrison, 2016), another contributing factor may be staff expertise. Teenagers would generally be in need of programming dealing with higher level forms of numeracy (e.g., calculus), and it is possible that there is a gap in staff expertise to deliver such programming. Examining library staff's ability to deliver higher-level numeracy programming is an important recommendation stemming from this research.

Other than the general literacy programs offered by TPL, adult options for numeracy programs were also very limited across the library systems studied. Overall, there were four programs for adults that focused primarily on numeracy concepts. Most of them dealt with taxes and finances. However, one of these programs was designed for helping small business owners with their taxes; this program targeted a very specific audience, rather than assisting the adult population generally. These adult numeracy programs provide important information but, again, there is a very small number of them. The lack of numeracy programs for adults is especially disappointing, because adult perceptions of numeracy are critical to children's attitudes (Dion, 2014). Negative adult perceptions of numeracy concepts may explain the lack of programs that consistently include numeracy instruction, but the lack of options would be frustrating for those looking for numeracy-focused programs for themselves or their children.

Another finding of note is that none of the adult-focused finance programs included any of the key terms that were searched for (math*, numeracy, or numbers) and were only found through examination of the program descriptions. This lack of key terms may create difficulties for those searching for numeracy related programs, depending on what words they use to search for programs.

One of the contributing factors to CPL's extensive numeracy programs for school-aged children is their partnership with Canadian Oil Sands Limited (Calgary Public Library Foundation, n.d.). This initiative, which included a number of other partners and for which Canadian Oil Sands Limited provided financing, intended to improve math skills by focusing on children in kindergarten to grade six (Canadian Oil Sands Limited, 2012). This initiative explains the large number of numeracy programs offered by CPL for this age group. 20 of their 29 numeracy programs are titled "Canadian Oil Sands Limited's Math Minds" and are intended for children aged five to 12. It would be interesting to see

the long-term effects of this partnership and the effect that it has on numeracy programming in Calgary generally. It is worth noting that CPL has nine programs that appear unrelated to this partnership, which is still a large number in relation to the other library systems examined.

To increase numeracy programming, libraries could either adopt a partnership model, as CPL has done, by partnering with outside organizations, or develop new numeracy programs on their own. The interdisciplinary aspects of numeracy should be highlighted, and numeracy concepts should be included in programs that already run regularly. For example, numeracy concepts could be included in general storytime programs, as recommended in the literature (Kliman et al., 2013, p. 11). Numeracy that is integrated into general programs should be identified in the description as a component of these programs, in order not to mask the extent of numeracy programming available in libraries. Treating numeracy as an interdisciplinary skill rather than an isolated one would both increase the number of opportunities to learn it and help improve perceptions of it.

Conclusion and Future Work

Numeracy is a foundational knowledge area for life and work in the 21st century. Libraries have historically been champions of a variety of essential skills such as literacy; however, the role of libraries in developing numeracy skills is understudied. Specifically, there is an acute gap in studying numeracy programs offered by public libraries. This paper has provided an overview of numeracy programming at five major urban library systems through the collection and analysis of programming data during a single week.

Overall, the program options to learn about numeracy concepts were very limited at all of the libraries in the sample. CPL offered the largest number of numeracy programs; however, the vast majority were for school-aged children. Few of the programs were dedicated towards preschool-aged children, teens, or adults. EPL offered no numeracy-related programs, according to the posted program listings; however, as noted earlier, EPL's programming descriptions did mask some of the numeracy-related programming, particularly with respect to preschool-aged children. MPL only offered two numeracy programs that focused on financial help for adults. OPL offered homework help programs that included math help, but only focused on school-aged children. TPL offered multiple numeracy related programs for adults but had relatively scant options for children. Across the five library systems, programs that specifically focus on numeracy instruction and learning were very limited for preschoolers, older teens, and adults.

This exploratory study presents several excellent avenues for future research, including longer-term observation of library program offerings at these five library systems. Longer-term research would provide the opportunity to determine whether there is variation in the numeracy programs offered at different times of year. Additionally, it would allow the researchers to determine whether library systems take recommendations from the literature into account in the planning and advertisement of

their programs. If they did, the researchers would hope to see a gradual introduction of more numeracy concepts into public library programs and see this reflected in the program listings and descriptions with explicit reference to numeracy. Another direction for research could include interviews with librarians and library assistants responsible for developing programs to gain better understanding on the depth of numeracy instruction in libraries. An interview approach may also reveal whether the lack of numeracy programs stems from perceived lack of demand or other factors. Finally, undertaking comparative studies among different types of library systems (e.g., large and small; urban, rural, and remote) could provide insight into similarities and differences in numeracy-focused programming.

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