RESEARCH ARTICLE

Visual acuity demands of different language mediums in modern primary school classrooms in Malaysia [version 1; peer review: awaiting peer review]

Izzah Azreena Azizan, Eg Yue Qi, Sharanjeet Kaur, Sumithira Narayanasamy
Optometry & Vision Sciences Programme, National University of Malaysia, Kuala Lumpur, Kuala Lumpur, 50300, Malaysia

Abstract

Background: Good visual acuity is important for children’s learning but the actual visual acuity (VA) demands of classrooms are not well defined.

Methods: In total, 61 classrooms from eight primary schools were included in this study. Classrooms were divided into lower and upper primary which reflect different stages of learning. Three types of national schools were included in the study, which were National, National Types Chinese (C) and Tamil (T). Each type of school utilizes different language as the medium of teaching. The measurements conducted in each classroom were: dimensions, maximum distance a student is seated and vertical height of the distance and near target. Near working distance of 28cm was assumed. Distance and near visual acuity demands (VA) were then calculated.

Results: The distance and near VA demands were 0.11 ± 0.26 logMAR and 0.24 ± 0.10 logMAR for lower primary, and 0.09 ± 0.20 logMAR and 0.24 ± 0.09 logMAR for upper primary classrooms respectively. Distance and near VA demands between both stages were not significantly different (p>0.05). The distance and near VA demands for National schools were 0.24 ± 0.17 logMAR and 0.31 ± 0.04 logMAR, National Type (C) were 0.16 ± 0.11 logMAR and 0.13 ± 0.03 logMAR, National Type (T) were 0.09 ± 0.10 logMAR and 0.12 ± 0.03 logMAR respectively. There were significant differences for both distance and near VA demands between types of schools, F(2, 58) 42.19, p = 0.00; F (2, 58) 208.35, p = 0.00 respectively.

Conclusions: High levels of visual acuity for distance and near are required to meet the demands of modern classroom environments. Both National Types schools require higher VA demand compared to National schools. These findings suggest current vision screening protocols and cut off points for schools might require revision.

Keywords

visual acuity, demand, classroom
Corresponding author: Sumithira Narayanasamy (sumithira@ukm.edu.my)

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Good vision has always been integral to proper education development in children\(^1\). In Malaysia, students are required to spend at least 752 hours per year in school\(^1\). Varying visual tasks such as viewing whiteboards, near work (reading and writing), copying from a whiteboard to workbook, and computer based classes present varying visual demands on the visual system of a student. Eye screenings are often conducted in primary schools to detect students with visual problems, however, these screenings mainly measure distance visual acuity only\(^6\). Students with uncorrected refractive errors are then referred to an eye care specialist for further assessment and management\(^15\). However, there is a paucity of information and guidelines for referrals. Eye screenings often do not adhere to any official guidelines\(^8\). Most current vision screening protocols and reference criteria use 0.20 logMAR as the cut-off point for distance visual acuity\(^6,19\). This could possibly lead to other visual issues being overlooked, such as hyperopia. Hyperopia causes symptoms such as difficulty in maintaining clear and comfortable vision when viewing at near distance, as well as headaches and visual fatigue following sustained near work\(^16\). As children usually have high accommodation\(^8\), they do not face difficulties when it comes to distance visual acuity. Hence, measuring distance visual acuity will not be sufficient in identifying refractive error\(^17,38\). Therefore, there is an urgent need to properly understand the visual demands in classrooms, especially for primary school students. It has been reported that reduced vision impacts students negatively in terms of social skills, struggling with school tasks demands, and economic survival\(^1,12\). Vision disorders in childhood may be carried into adulthood, thus affecting future education\(^13\). Guidelines for proper screening protocols needs to be set in place to reduce the number of students with visual problems being overlooked as early detection will reduce the chances of the students’ visual acuity impacting their educational success.

A literature search found that only 3 studies evaluating the visual demands in primary school students have been conducted. Table 1 illustrates the distance and near VA demand for each country included in these studies.

The Malaysian education system (Ministry of Education — MOE) for primary schools provides 3 different types of primary schools, which are MOE National Primary Schools, Private Institutions Primary Schools and Primary Schools in Institutions under Other Government Agencies. MOE National Primary Schools are chosen for this study as it has the highest level of enrolment compared to the other 2 institutions\(^13\), with 2,693,318 students enrolling in MOE National Primary Schools in 2018\(^16\). For the purpose of this study, the 3 schools chosen were the National (Sekolah Kebangsaan), National Type (Chinese) (Sekolah Kebangsaan Cina) and National Type (Tamil) (Sekolah Kebangsaan Tamil) as these 3 schools are the top 3 nationwide in terms of enrolment. These schools use different languages for teaching; National schools use Malay as their primary language, which uses Latin letters as the medium of language, while National Type (C) uses Chinese (Mandarin) and National Type (T) uses Tamil\(^14\).

There are 2 stages of learning for MOE National Primary Schools, Stage 1 (Tahap 1) are for year 1, 2 and 3 (7 to 9 year olds), and Stage 2 (Tahap 2) are for year 4, 5 and 6\(^10\) (10 to 12 year olds). It is known that Stage 1 students spend fewer hours at school as compared to Stage 2 students, 752 hours and 800 hours each respectively\(^17\). While there is a difference in hours spent in school, MOE National Schools use the same textbooks for all subjects\(^8\). Although the same syllabuses are used, different languages are used for National Type schools, which are Mandarin and Tamil\(^13\). As previous studies only focused on Latin letters, this multicultural setting of using differing mediums of language for education could lead to differing VA demands.

Mandarin is used as the official medium of teaching for National Type (C) schools\(^14\). It is known to be a non-alphabetical language\(^8\). Chinese characters are either pictographs (single-body) or compounds of pictographs\(^30\). Therefore, these do not always have the regularities of Latin letters\(^21\). A character may consist of 1 stroke, will others involve more than 60 strokes, leading to wide spatial complexities\(^27\).

Tamil is used as the official medium of teaching for National Type (T) schools\(^35\). Tamil is one of the commonly spoken South Indian languages. Tamil script is syllabic, not alphabetic, thus are comprised of a variety of strokes, curves and dot patterns unlike Latin alphabets\(^24\). Current Tamil script consists of 12 vowels, 18 consonants and one special character, the āyātam.

The aim of this study was to (1) determine the distance and near visual acuity demands of Malaysian national primary school classrooms, (2) compare the visual acuity demands between Stage 1 and Stage 2 and (3) compare between different types of national schools.

**Methods**

This was a cross-sectional study conducted at schools located within Klang Valley from the month of January 2019 till April 2019. Three types of national schools were selected, namely the National, National Type (C) and National Type (T). A list of all

<table>
<thead>
<tr>
<th>Study</th>
<th>Distance VA demand (LogMAR)</th>
<th>Near VA demand (LogMAR)</th>
<th>Age range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Langford &amp; Hug(^12)</td>
<td>0.35 ± 0.10 (6/13)</td>
<td>0.96 ± 0.34</td>
<td>5 – 11 years old</td>
</tr>
<tr>
<td>Narayanasamy et al.(^11)</td>
<td>0.33 ± 0.13 (6/12)</td>
<td>0.72 ± 0.09</td>
<td>11 and 12 years old</td>
</tr>
<tr>
<td>Neglioni et al.(^12)</td>
<td>0.31 ± 0.17 (6/12)</td>
<td>0.83 ± 0.14</td>
<td>9 – 17 years old</td>
</tr>
</tbody>
</table>
the national schools located in Klang Valley was obtained from the Ministry of Education directory. Eight different schools were then selected from the list using the RANDBETWEEN function in Microsoft Excel 2010. Classes representing each year were also selected within each school using the RANDBETWEEN function in Excel from the list of all classrooms within each school. Year 6 student classrooms were excluded from this study as they usually stayed longer than other years. This is due to the preparation for the Primary School Achievement Test, which is a national examination taken by all students in Malaysia at the end of their sixth year in primary school before they leave for secondary school. All data was collected right after school ends. The study was approved by the Malaysian Ministry of Education (Kementerian Pendidikan Malaysia) [reference: KPM.600-3/2/3-eras(2429)], the Education Department of the Federal Territory of Kuala Lumpur (Jabatan Pendidikan Wilayah Persekutuan Kuala Lumpur) [reference: JPNWP. 900-6/1/7 Jdl 21(42)], and the UKM Ethics Committee (UKM PPI/111/8/JEP-2019-209). Written informed consent was obtained from each of the school principal prior to the study. As data collection was done after classes, there was no contact with the students. Hence, consent from students & parents were not required.

The distance VA demand in logMAR was calculated using the smallest vertical height of the teachers' writing on the whiteboard (measured using a millimetre scale) in each classroom and its furthest viewing distance (furthest student table from the whiteboard). Smartboards were not included as majority of the schools did not have such teaching tools. Due to the variability of the handwriting on the whiteboards, a minimum of 10 samples was measured in each classroom and the average was used for the demand calculation. As letter optotypes usually have a stroke width that is one fifth of the letter height, the critical detail of the smallest vertical height of the target was arbitrarily taken as one fifth of the target height\(^6\). This means that the value of the vertical height of the target will be one fifth of its original height. An example is illustrated below:

A 10mm letter is viewed at a distance of 5m. The critical detail on a letter is arbitrarily taken as \(1/5\) of the letter height, which will be 2mm in this example\(^6\) (Figure 1).

\[
\begin{align*}
\text{Tan}\theta &= 2/5000 \\
\theta &= 0.0229\ \text{degrees} \\
\text{Minimum angle of resolution (MAR)} &= \text{degrees} \times 60 \\
&= 0.0229 \times 60 \\
&= 1.375\ \text{minutes of arc} \\
&= 0.14\ \text{logMAR}
\end{align*}
\]

Therefore, a 10mm target viewed at a distance of 5m corresponds to a threshold acuity demand of 0.14 logMAR.

The same method was adopted and used by Hug \textit{et al.}\(^{10}\), Narayanasamy \textit{et al.}\(^{11}\) and Negiloni \textit{et al.}\(^{12}\). This calculation method was also used for the calculation of near visual acuity demand. For National schools, only the height of the smallest lowercase letter was measured, excluding the ascenders and descenders. For National Type (C), the height of the smallest stroke was measured as Chinese optotypes consists of variable numbers of strokes\(^9\). As for National Type (T), the smallest height for dots, curves or lines were measured as Tamil script consist of a mixture of these three attributes\(^34\).

Similar method was used for calculating the near VA demand, using the smallest vertical height of near learning materials and their viewing distance. As ethical restrictions prevented direct interaction with the children in the school classroom, a fixed near working distance of 28cm was used. This was obtained from a pilot study that was conducted on 30 students, aged 7 to 11 years old. Each student was given reading material of N5.0 in size and their viewing distance was measured. The mean viewing distance was calculated and used as a standard distance for near VA demand calculation in this study. Previous studies have reported that in children with normal vision, the near acuity reserve varies between 2.5:1 and 8:1\(^11\).\(^{42}\). Visual acuity reserve, which is the ratio between habitual best corrected visual acuity and the acuity demand of the visual task\(^41\) is important in enabling comfortable and fluent reading especially during sustained near tasks\(^35\). Hence, a child’s habitual near visual acuity needs to be needs to be at least 2.5 times greater than the minimum required demand for comfortable sustained performance. Using this guideline, the near VA demand values were then converted to actual near VA demands, which means that the value in logMAR will be even less.

**Statistical analysis**

All data was entered in Excel (Microsoft Office 2010) and statistical analysis was done using IBM \textit{Statistical Package for Social Sciences} (SPSS) version 25. Descriptive analysis was performed for the distance and near visual acuity demand. Comparisons of visual acuity demands between Stage 1 and Stage 2 students and between types of schools were performed using Independent t-tests and One Way ANOVA respectively. A p-value of less than 0.05 was considered as statistically significant.

**Results**

A total of 61 classrooms from 8 schools were included in the study. All classrooms were rectangular in shape, using only whiteboards. There was great variation in terms of students’
desk arrangement in each classroom. The mean, standard deviation (SD) and range for the classroom dimensions (length x width), furthest table away from the whiteboard, smallest distant and near material size, distance and near VA demands for all the classrooms are presented in Table 2 (see underlying data\(^4\) for values for each classroom).

One-Sample T-Test was conducted to compare VA demands between Stage 1 and Stage 2 students. Comparisons of VA demands between stages of learning are presented in Table 3. There was no significant difference between Stage 1 (M = 0.11, SD = 0.26; M = 0.24, SD = 0.10) and Stage 2 (M = 0.09, SD = 0.21; M = 0.25, SD = 0.09) for both distance and near VA demands; t (59) = 0.34, p = 0.74 and t (59) = -0.33, p = 0.75.

The mean of the distance and near demands for each type of school were compared and presented in Table 4. One way ANOVA showed significant difference for both distance (F (2, 58) = 42.19, p = 0.00) and near (F (2, 58) = 208.35, p = 0.00) VA demands between schools. A Games-Howell post hoc test revealed that there was significant difference for distance VA demand between National (0.24 ± 0.17 logMAR, p = 0.00) and National Type (C) (-0.16 ± 0.11 logMAR, p = 0.00) schools, and between National and National Type (T) (-0.09 ± 0.10 logMAR, p = 0.00) schools. However, there was no significant difference in distance VA demand between National Type (C) and National Type (T) schools (p = 0.353). Similar results were reported for near VA demand. Post hoc test revealed there was a significant difference between National (0.31 ± 0.04 logMAR, p = 0.00) and National Type (C) (0.13 ± 0.03 logMAR, p = 0.00) schools, and between National and National Type (T) (0.12 ± 0.10 logMAR, p = 0.00) schools. No significant difference was reported between National Type (C) and National Type (T) schools (p = 0.411).

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Table 2. Summary of the descriptive analysis for the dimensions, working distance, VA demands for distance and near.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom dimension: Length (cm)</td>
<td>864.02</td>
<td>50.30</td>
<td>630.00 – 933.80</td>
</tr>
<tr>
<td>Classroom dimension: Width (cm)</td>
<td>737.06</td>
<td>21.46</td>
<td>650.00 – 761.30</td>
</tr>
<tr>
<td>Furthest table from whiteboard (cm)</td>
<td>675.77</td>
<td>8.53</td>
<td>400.00 – 762.70</td>
</tr>
<tr>
<td>Smallest distant material size (cm)</td>
<td>1.42</td>
<td>0.08</td>
<td>0.50 – 3.00</td>
</tr>
<tr>
<td>Smallest near material size (cm)</td>
<td>0.22</td>
<td>0.01</td>
<td>0.10 – 0.50</td>
</tr>
<tr>
<td>Distance VA demand (logMAR)</td>
<td>0.10</td>
<td>0.03</td>
<td>-0.56 – 0.52</td>
</tr>
<tr>
<td>Near VA demand (logMAR)</td>
<td>0.24</td>
<td>0.01</td>
<td>0.09 – 0.44</td>
</tr>
</tbody>
</table>

Table 3. Comparison of visual acuity demands for distance and near between stages of learning.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean (SD)</th>
<th>Range</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance VA demand (logMAR)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage 1</td>
<td>0.11 (0.26)</td>
<td>-0.56 – 0.52</td>
<td>0.74</td>
</tr>
<tr>
<td>Stage 2</td>
<td>0.09 (0.21)</td>
<td>-0.29 – 0.42</td>
<td></td>
</tr>
<tr>
<td>Near VA demand (logMAR)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage 1</td>
<td>0.24 (0.10)</td>
<td>0.09 – 0.34</td>
<td>0.75</td>
</tr>
<tr>
<td>Stage 2</td>
<td>0.25 (0.09)</td>
<td>0.09 – 0.44</td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Comparison of distance and near visual acuity demands between types of schools.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean (SD)</th>
<th>Range</th>
<th>F (2, 58)</th>
<th>p (values)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance VA demand (logMAR)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National</td>
<td>0.24 ± 0.17</td>
<td>-0.56 – 0.52</td>
<td>42.19 (0.00)</td>
<td></td>
</tr>
<tr>
<td>National Type (C)</td>
<td>-0.16 ± 0.11</td>
<td>-0.30 – 0.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Type (T)</td>
<td>-0.09 ± 0.10</td>
<td>-0.26 – 0.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Near VA demand (logMAR)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National</td>
<td>0.31 ± 0.04</td>
<td>0.22 – 0.44</td>
<td>208.35 (0.00)</td>
<td></td>
</tr>
<tr>
<td>National Type (C)</td>
<td>0.13 ± 0.03</td>
<td>0.09 – 0.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Type (T)</td>
<td>0.12 ± 0.10</td>
<td>0.09 – 0.16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Discussion

This study may be the first of its kind to be done in Malaysia that evaluated the distance and near visual acuity demand for different types of national primary schools. According to the International Bureau of Education, Malaysian primary school students spend around 80.00% to 81.25% of their weekly education in school that involves visually based tasks (education of core subjects).

Previous studies in the US reported an increase in distance VA demand with increasing grade level, from 0.70 to 1.18 logMAR for grades Kindergarten (5 years old) to 2 (7 years old), and 0.48 to 0.70 logMAR for grade 3 (8 years old) to 5 (10 years old)\(^1\). A similar study conducted in Australia showed that grade 5 and 6 students require 0.33 logMAR of distance VA demand\(^1\). While another study in India reported distance VA demand of 0.35 logMAR for grades 4 to 8 and 0.24 logMAR for grades 9 to 12\(^2\). However, there was no significant difference in distance VA demand between Stage 1 and Stage 2 students for this study, 0.11 ± 0.26 and 0.09 ± 0.21 logMAR respectively. This could be due to the teachers’ handwriting on the board being similar in size regardless of grade level. As whiteboards were the most widespread teaching medium in national schools, teachers possibly adopted similar writing sizes to reduce any visual discomfort while the students viewed the whiteboard.

The distance VA demand for this study was 0.10 ± 0.03 logMAR. This showed that the VA demand for Malaysian primary school students to be slightly higher compared to other previous studies. This could be due to the fact that this study included Chinese and Tamil schools, both using their respective mother tongue as the language medium for teaching, while other studies focused on Latin characters\(^10–13\). As previously mentioned, Chinese and Tamil characters tend to be more complex in nature as compared to Latin characters\(^10–13\). For Chinese characters, the dot is one type of stroke that makes up a single body character. This character could be a single body character or a compound character that is made up of multiple parts\(^11\). As for Indian characters, the aspect ratio is more than Latin characters\(^10–13\). This is due to Tamil characters having more curves, number of strokes, holes and sliding characters\(^29\). Currently, no complete hand written text recognition is available for Tamil due to the large character set, presence of vowel modifiers and compound character\(^29\). Hence, the smallest vertical height measured for both languages included the dots and strokes. This could possibly lead to the higher distance VA demand for such schools.

Near VA demand for this study was reported to be 0.24 ± 0.01 logMAR. Previous studies in the US, Australia and India reported 0.96 ± 0.34 logMAR, 0.72 ± 0.09 logMAR, and 0.83 ± 0.14 logMAR each respectively for near VA demand. Again, this study showed higher near VA demand compared to other studies and could be due to the inclusion of National Type (C) and National Type (T) schools. The smallest vertical stroke measured was as small as 0.10cm, with a mean of 0.22cm. This resulted in a higher near VA demand compared to previous studies. For comparison between stages of education, both Stage 1 and Stage 2 students had demands of 0.24 ± 0.10 logMAR and 0.25 ± 0.09 logMAR and no significant difference (p = 0.75) were found between both stages. This could be due to similar writing sizes in students’ workbook writings and printing as all schools use the same textbooks but with different languages\(^10\).

However, there is a significant difference when it comes to the comparison between National and National Type (C) schools and between National and National Type (T) schools. Differences in the smallest stroke size in their workbook could lead to the significant difference. As previously stated, both Chinese and Tamil characters are more complex compared to Latin character, consisting of dots, strokes and curves. Hence the smallest print size for National Type (C) schools were 0.10cm, with a mean of 0.13cm, for National Type (T) schools, it was also 0.10cm, with a mean of 0.16cm, National schools measured at 0.15cm, but with a mean of 0.26cm, which produced a lower near VA demand compared to the other 2 schools. But between National Type (C) and (T), there were no significant differences (p = 0.411) in terms of near VA demand. This could possibly be due to similar print size as stated previously.

This study is limited to only schools in urban areas, future studies should expand into suburban areas to observe the VA demand as compared to this study. Private institutions should also be included as different syllabus are taught in these schools, namely the British, American, Australian, Canadian and International Baccalaureate\(^14\).

Conclusion

The distance and near VA demands for this study was reported to be 0.10 ± 0.03 logMAR and 0.24 ± 0.01 logMAR respectively. There was no significant difference of VA demands between stages of learning. However, National Type (C) and National Type (T) schools had significantly higher VA demands compared to National schools. However, there was no significant difference between National Type (C) and National Type (T) schools. Current vision screening protocols and reference criteria of using 0.20 logMAR as the cut-off point\(^10,27\) should be revised and updated. This is to ensure that children with possible refractive errors that may impact on their school performance are not excluded for further reference to primary eye care professionals.

Data availability

Underlying data

Harvard Dataverse: Visual acuity demands of different language medium modern primary school classrooms in Malaysia. https://doi.org/10.7910/DVN/BDXS8ZU\(^14\)

This project contains the following underlying data:

- Research Data – F1000 final.tab (Collected data from classrooms and visual acuity demand)

Data are available under the terms of the Creative Commons Zero “No rights reserved” data waiver (CC0 1.0 Public domain dedication).

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References


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