# Designing a Data Visualization Dashboard for Pre-Screening Hong Kong Students with Specific Learning Disabilities

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## ABSTRACT

Students with specific learning disabilities (SLDs) often experience reading, writing, attention, and physical movement coordination difficulties. However, in Hong Kong, it takes years for special education needs coordinators (SENCOs) and special-ed teachers to pre-screen and diagnose students with SLDs. Therefore, many students with SLDs missed the golden time for special interventions (i.e., before six years old). In addition, although there are screening tools for students with SLDs in Chinese and Indo-European languages (e.g., English and Spanish), they did not provide a student data visualization dashboard that could help teachers speed up the pre-screening process. Therefore, we designed a new visualization dashboard for Hong Kong SENCOs and special-ed teachers to assist them in pre-screening students with SLDs. Our formative study showed that our current design met teachers' need to quickly identify a student's specific under-performing tasks and effectively collect evidence about how the student was affected by SLDs. Future work will further test the efficacy of our design in real life.

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## 1 INTRODUCTION AND BACKGROUND

Specific learning disabilities (SLDs) affect how people process and learn language-based information [21], but they do not affect people's intelligence quotient [20]. As a result, SLDs can significantly impact learning skills and the acquisition of literacy skills [30, 33]. SLDs are used to cover a range of frequently co-occurring learning difficulties, most commonly known as dyslexia (reading), dysgraphia (writing), and dyspraxia (physical co-ordination) [2]. Research [6] suggested that students with SLDs who receive special interventions during the golden time (i.e., before six years old) can develop better learning skills as they grow up.

To help special education students, including those with SLDs, Hong Kong Education Bureau has recruited special education needs coordinators (SENCOs) and special-ed teachers for public schools since 2017 [4]. However, because of the limited number of SENCOs and special-ed teachers, one special-ed faculty has to support nearly one thousand students. In this case, many students with SLDs in Hong Kong have to wait over 2 to 3 years to finish their assessment [9, 22].

To help the Hong Kong special-ed faculty speed up assessing their students, Fung et al. [10] developed an automatic pre-screening tool for dyslexia in Chinese, dysgraphia in Chinese, and dyspraxia. Fung et al.'s pre-screening tool collected valuable student data, including correctness rate, answer time, handwriting process, and the video of the student interacting with the touchscreen. Teachers can analyze the data to understand why the student's performance is below average and what difficulties the student encountered. However, it is still quite time-consuming for special-ed teachers to analyze the raw data.

Currently, the student data dashboards of existing pre-screening tools [3, 8, 12, 29] only provide student performance statistics. For example, the dashboard of Dyscreen Dyslexia Screener [29] only provides individual student performance scores and scores compared with the student's related age group. If we were to adopt the existing student data dashboard designs, teachers would have faced

the same problem: They cannot efficiently analyze and understand students' performance with SLDs.

Therefore, our work aims to design a new student data visualization dashboard that processes the raw data collected by Fung et al.'s pre-screening tool [10]. Without collecting the raw data of handwriting and videos, special-ed teachers cannot discover how exactly the student's performance was affected by SLDs. Therefore, although our dashboard visualizes the raw data provided by Fung et al.'s tool, it is potentially helpful for any pre-screening tools designed to meet special-ed teachers' needs. Our tool allows special-ed teachers to quickly narrow down the list of students who might have SLDs in Chinese from thousands of student records and efficiently gather evidence that indicates how the students were affected by SLDs. To verify whether our design meets our goals and improves our design, we conducted a formative study with two SENCOs, one special-ed teacher, and one special-ed student-teacher. The study showed that our current design met special-ed teachers' need to quickly identify a student's specific under-performing tasks and effectively collect evidence about how the student was affected by SLDs. Our future work will test the efficacy of our dashboard design in special-ed teachers' daily jobs. We will also explore how our design may benefit SLDs pre-screening for other languages (e.g., Indo-European languages such as English).

## 2 DASHBOARD DESIGN

The design of our tool consists of 4 panels (as shown in Figure 1): (1) an overview of all students' tests performance (Panel 1) for the teacher to quickly narrow down the list of students who might have SLDs; (2) overview of a selected student's test performance (Panel 2) for the teacher to identify the specific under-performing tests quickly; (3) performance statistics of individual questions in a test (Panel 3) for the teacher to identify which question to look into; (4) student performance when the student answered the question (Panel 4) for the teacher to investigate how the student was affected by SLDs. Each one of the panels is designed based on a design requirement by our target users. In the following paragraphs, we will elaborate on each design requirement.

*Design Requirement 1: The system should help teachers narrow down the list of students who might have SLDs in Chinese.* SENCOs and special-ed teachers in Hong Kong need to care for around a thousand students. They need an assistive tool to quickly narrow down the list of students who might have SLDs. Many pre-screening tools [1, 7, 12, 18, 19, 32] provide information about which students potentially face mild, moderate, or severe learning difficulties. Therefore, we designed Panel 1, which allows teachers to filter the student records by choosing the options of four learning difficulty levels: acceptable, mild, moderate, and severe. We also added a red line that denotes the average score of all students so that teachers can explicitly compare how much a student lags behind the average student performance.

*Design Requirement 2: The system should help teachers identify the specific under-performing tasks.* After the teacher decides which student profile to look into, they want to determine which testing tasks are under-performing. The existing SLDs pre-screening tools [11, 14, 15, 17, 27, 28] provide information about the performance of each task in three testing categories: word recognition, reading, and writing. Therefore, we designed Panel 2, which presents all one student's task scores. Panel 2 also provides information about how much a student lags behind the average student performance in each task. Reviewing Panel 2 allows teachers to decide which testing tasks to investigate quickly.

*Design Requirement 3: The system should help teachers decide which sub-question to investigate.* In many SLDs pre-screening tools [13, 24–26, 31], students need to answer multiple sub-questions to complete one task. As a result, students potentially affected by SLDs may spend too much time on one sub-question (even though they might answer it correctly). Therefore, teachers need a convenient way to determine whether the student was in the above situation and further investigate how the student answered this sub-question.

We designed Panel 3 to meet the teachers' needs. Panel 3 presents the following student data for each sub-question: the correctness rate (including correct, incorrect, and no answer), the time spent on a sub-question, the average time spent on all sub-questions of the same task, and the average time that all students spend on the same sub-question. In addition, we designed a new feature for handwriting tasks - animating the playback of the entire handwriting process. Previous work for pre-screening dysgraphia in English only provided the final screenshot of a student's handwriting [23]. However, research [10] suggested that analyzing the Chinese character stroke sequence to pre-screen dysgraphia in Chinese is essential. Furthermore, it is also critical to pre-screen dyspraxia in Chinese by identifying slow and curly handwriting process [36]. Therefore, our handwriting animation (as shown in Figure 1, 3.1) helps teachers to pre-screen dysgraphia and dyspraxia in Chinese.

*Design Requirement 4: The system should help teachers investigate how the student was affected by SLDs.* Fung et al.'s pre-screening tool [10] collected more student data than many pre-screening tools for SLDs in an Indo-European language (e.g., English, Spanish) [3, 8, 12, 29, 34]: screenshots of every handwriting Chinese character stroke and videos of the student interacting with the pre-screening tool. As with any disability, no two individuals experience the same difficulties, and some may exhibit signs of more than one SLD. Therefore, this information is helpful for teachers to collect explicit evidence about the common characteristics of SLDs (i.e., short attention span and inadequate memory retrieval). That being said, it is time-consuming for teachers to go through all the videos, especially for Hong Kong special-ed teachers, because they have to manage many student cases.

Special-ed teachers care most about students' specific spatial movement patterns (e.g., starting to look around the room). However, because the temporal information is rich, we faced a design challenge to break down all the temporal information to reduce visual clutter and avoid visual occlusion.

Inspired by previous timeline designs [16, 35] for analyzing temporal evolution of body movement we broke down the student movement information into three dimensions (i.e., limbs, heads, and body movements) as shown in Figure 1, 4.1. We also visualized the average student movement range and put it alongside the individual student's movement visualization, as shown in Figure 1, 4.2. The special-ed teachers can then capture the signals in the timeline

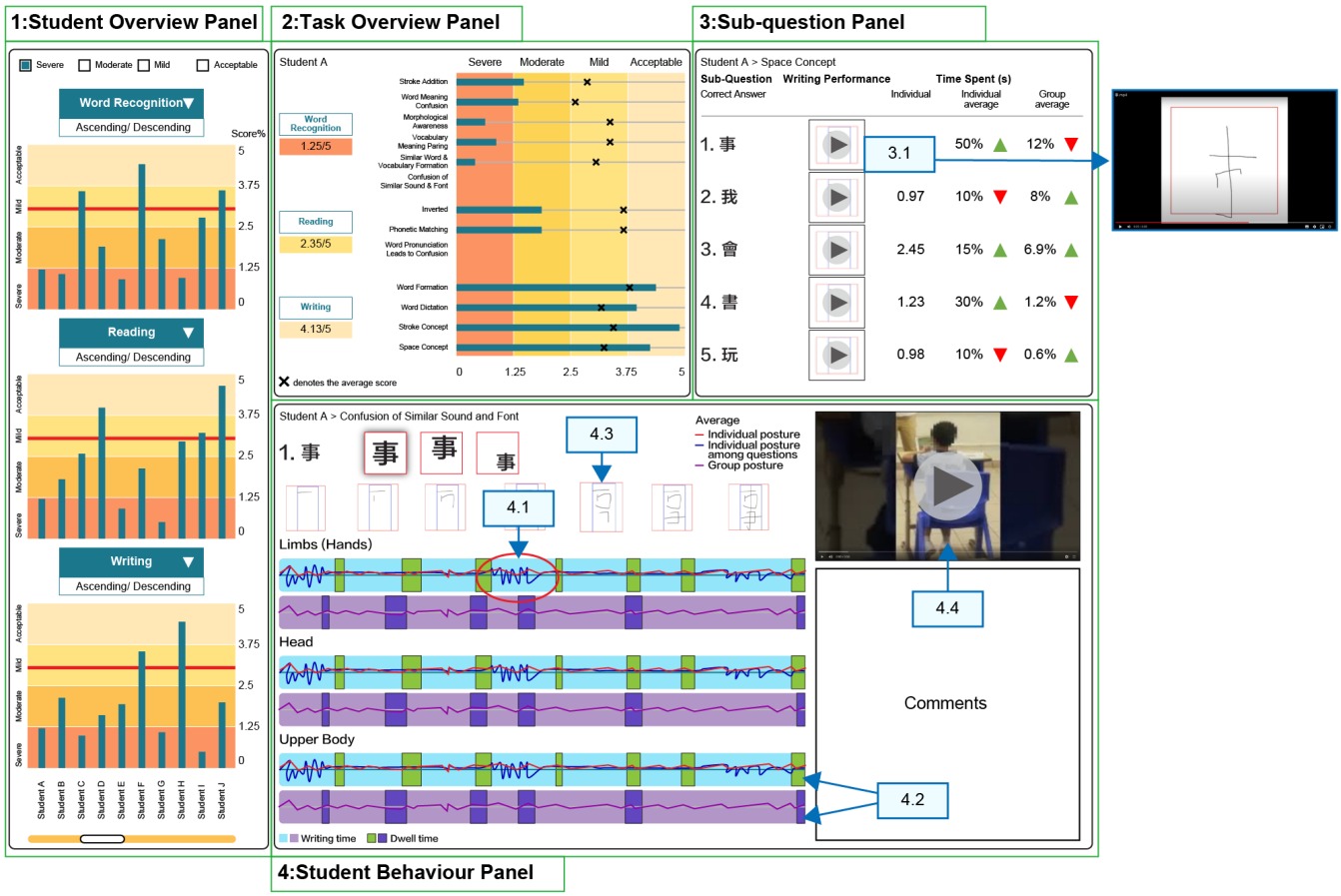


**Figure 1: Student Data Visualization Dashboard. Panel 1 shows the overview of student performance. Panel 2 shows the overview of one student's testing tasks. Panel 3 shows the student data in answering all sub-questions in one task. Panel 3.1 shows the playback of the handwriting recording. Finally, panel 4 shows the visualization of the movement data (Panel 4.1), the comparison between individual and average movements (Panel 4.2), each stroke of the Chinese character in the writing tasks (Panel 4.3), and the video recording of the student movement (Panel 4.4).**

visualization that indicate a student might have a short attention span compared with general education students.

Panel 4 also visualizes when and how the student wrote each Chinese character stroke in the writing tasks (as shown in Figure 1, 4.3). This visualization can highlight the situation when a student spent a significant amount of time finishing one Chinese character stroke, which informs the teacher that the student might experience inadequate memory retrieval. The teacher can then go to the corresponding video playback time (as shown in Figure 1, 4.4) to watch how exactly the student behaved.

## 3 FORMATIVE STUDY: TEACHER FEEDBACK

To form our design, we conducted a formative study with two SENCOs, one special-ed teacher, and one special-ed student-teacher for students with SLDs (3 females, 1 male, between 3 to 30 years of experience in teaching students with SLDs from primary school students to undergraduates, aged from 20 to 55 years old). They have either an education certificate or a bachelor degree in special education. We started by interviewing the participants because they are the key users of the learning analytic visualization tool and have experience in using relevant systems to pre-screen SLDs students. We anticipated that the participants would be able to use their SLDs pre-screening experience to offer valuable insights into our current design. During the study, we demonstrated our prototype to the participants. Our participants' working languages are Chinese and English, so the system language of our prototype supports these two languages.

The data presented in our dashboard prototype are real data collected by Fung et al. [10] when they invited students to play a game for pre-screening SLDs in Chinese. We post-processed the

video recordings of student actions using the OpenPose AI model [5] to highlight the students' heads, arms, and hands. We also wrote a script to visualize how a student writes each stroke of a Chinese character by processing the handwriting data (i.e., the coordinates of screen touching).

As we showed the dashboard prototype to our study participants, we asked them to give feedback on the design of the data visualization dashboard to help them pre-screen SLDs. We screen-recorded and then transcribed all interviews. We coded the transcriptions and found two design highlights and one design improvement summarized from the teacher feedback.

All SENCOs and special-ed teachers mentioned that the student data visualization dashboard could facilitate their pre-screening job. In addition, they appreciated the design of Panel 3 for analyzing dysgraphia and dyspraxia in Chinese and the design of Panel 4 for analyzing the issues of short attention span or inadequate memory retrieval. One special-ed teacher explained why animating the order of handwriting strokes helps, "The stroke order is a characteristic of reading and writing [Chinese words]. We can [use it to] analyze the student's sense of spacing. It can provide more evidence for teachers to judge students' reading and writing problems." Another special-ed teacher shared a similar opinion, "Children with SLDs might not be aware of the writing grid. [So] their handwriting is sometimes big or small."

One special-ed and one SENCO pointed out that Panel 4 helped them quickly and explicitly collect the evidence of students having SLDs because "it can record students' problematic situations like easily distracted, and sitting awkwardly" according to the special-ed teacher. All participants agreed that the time range of a student interacting with the touchscreen (as shown in Figure 1, 4.2) in Panel 4 helped them understand the student thinking process. One special-ed teacher explained, "If the student thinks for a long time but can write a word correctly. The teacher will wonder if the question is too difficult, or the student cannot extract the word because of inadequate memory retrieval."

According to one SENCO and one special-ed teacher, we can improve our tool to help them better analyze the student behaviours when the student looks left and right while halfway finishing the writing task. Noticing that our tool provides both handwriting animation (as shown in Figure 1, 3.1) and video recording (as shown in Figure 1, 4.4), they suggested we synchronously display these two types of playback side by side in Panel 4.

## 4 CONCLUSION AND FUTURE WORK

We presented a new design of a student data visualization dashboard for SLDs pre-screening. Our design aims to assist Hong Kong SENCOs and special-ed teachers with their SLDs pre-screening job so their students can receive SLDs assessment and special interventions in time. We invited two SENCOs, one special-ed teacher, and one special-ed student-teacher for a formative study. Our design met their needs for quick pre-screening of students with SLDs in Chinese, especially our designs that fulfill their design requirements of identifying a student's specific under-performing tasks quickly and collecting evidence about how the student was affected by SLDs. The study participants also suggested a minor design improvement of the visualization dashboard.

In the future, we will recruit more SENCOs and special-ed teachers to test the efficacy of our dashboard in their daily job. We will also explore how our dashboard design may benefit SLDs pre-screening for other languages (including Indo-European languages). Finally, our work will inspire educational technology designers and developers to leverage our design to provide a better student data visualization dashboard for teachers of students with SLDs.

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## REFERENCES

[1] GL Assessment. 2022. Dyslexia and Dyscalculia Screeners Digital. (2022). https://support.gl-assessment.co.uk/media/1764/gla176-dyslexia-and-dyscalculia-screener-sample-report.pdf

[2] The Dyslexia Association. [n.d.]. *Specific Learning Difficulties (SpLDs).* https://www.dyslexia.uk.net/specific-learning-difficulties/

[3] Nathanael Bucher, Mirjam Voegeli, and Rebecca Gretler. [n.d.]. *Welcome to Dybuster Calcularis.* https://dybuster.com/wp-content/uploads/2018/12/WorkingCards_Calcularis_2018.pdf

[4] The Hong Kong Education Bureau. 2017.08. 關愛基金《向普通學校撥款以安排特殊教育需要統籌主任》試驗計劃成效檢討報告 (Report on the Effectiveness Review of the Community Care Fund's Pilot Scheme on "Appropriation of Funds to Ordinary Schools to Arrange Special Educational Needs Coordinators"). (2017.08). https://sense.edb.gov.hk/uploads/page/professional-support/special-educational-needs-coordinator/Evaluation_LegCo_Chi.pdf

[5] Zhe Cao, Gines Hidalgo, Tomas Simon, Shih-En Wei, and Yaser Sheikh. 2021. OpenPose: Realtime Multi-Person 2D Pose Estimation Using Part Affinity Fields. *IEEE Transactions on Pattern Analysis & Machine Intelligence* 43, 01 (2021), 172–186.

[6] Helen Arkell Dyslexia Charity. [n.d.]. *When should a Child be Assessed for Dyslexia?* https://www.helenarkell.org.uk/about-dyslexia/parents/faq-for-parents.php#:~:text=Dyslexia%20can%20be%20identified%20by,symptoms%20are%20not%20always%20obvious.

[7] The Psychological Corporation. 2008. DAS-II Sample Report - Pearson Clinical. (2008). https://www.pearsonclinical.com.au/files/DASII_Sample_Report(1).pdf

[8] Houston Independent School District. [n.d.]. *Dyslexia Universal Screener 2021-2022.* https://www.houstonisd.org/Page/178674

[9] The Hong Kong Society for Community Organization. 2018. 《學前有特殊教育需要兒童過渡至學齡階段的服務需要》質性研究調查報告 (A Qualitative Research Report on the Service Needs of Preschool Children with Special Educational Needs in Transition to School Age). (2018). https://www.legco.gov.hk/yr17-18/chinese/panels/ed/papers/ed20180302cb4-679-1-c.pdf

[10] Ka Yan Fung, Fung Kwong Chiu, Chan Aidan, and Yu Yi Ching. 2021. A Digital Tool to Provide Pre-Screening to Dyslexia in Hong Kong. In *Proceedings of the 2021 IEEE International Conference on Engineering, Technology & Education.* IEEE, 755–761.

[11] Louise Ho. 2000. Hong Kong Writing and Writing Hong Kong. *World Englishes* 19, 3 (2000), 381–386.

[12] Children's Learning Institute. [n.d.]. *Dyslexia Screeners on CLI Engage.* https://public.cliengage.org/tools/assessment/dyslexia-screener/

[13] Ruchira Kariyawasam, Madhuka Nadeeshani, Tuan Hamid, Inisha Subasinghe, Pradeepa Samarasinghe, and Pasangi Ratnayake. 2019. Pubudu: Deep Learning based Screening and Intervention of Dyslexia, Dysgraphia and Dyscalculia. In *Proceedings of the 2019 14th Conference on Industrial and Information Systems.* IEEE, 476–481.

[14] Catherine Lam. 2018. Children Assessment Service Epidemiology and Research Bulletin. (2018). https://www.dhcas.gov.hk/file/caser/CASER15.pdf

[15] Che Kan Leong, Pui Wan Cheng, and Li Hai Tan. 2005. The Role of Sensitivity to Rhymes, Phonemes and Tones in Reading English and Chinese Pseudowords. *Reading and Writing* 18, 1 (2005), 1–26.

[16] Haotian Li, Min Xu, Yong Wang, Huan Wei, and Huamin Qu. 2021. A Visual Analytics Approach to Facilitate the Proctoring of Online Exams. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems.* 1–17.

[17] Catherine McBride-Chang, Fanny Lam, Catherine Lam, Sylvia Doo, Simpson WL Wong, and Yvonne YY Chow. 2008. Word Recognition and Cognitive Profiles of Chinese Pre-school Children at Risk for Dyslexia through Language Delay or Familial History of Dyslexia. *Journal of Child Psychology and Psychiatry* 49, 2 (2008), 211–218.

[18] A Jockey Club Learning Support Network. 2010. The Hong Kong Behaviour Checklist of Specific Learning Difficulties in Reading and Writing for Primary

School Students (Second Edition) Manual (BCL-P(II)). (2010). https://hksld.eduhk.hk/%E8%B3%87%E6%BA%90/%E8%AD%98%E5%88%A5%E5%B7%A5%E5%85%B7

[19] NWEA. 2022. Dyslexia Screener Matrix Report. (2022). https://teach.mapnwea.org/impl/maphelp/Content/ReadFluency/Reports/DyslexiaScreenerMatrix.htm

[20] Learning Disabilities Association of America (LDA). [n.d.]. *Types of Learning Disabilities.* https://ldaamerica.org/types-of-learning-disabilities/

[21] University of Kent. [n.d.]. *What are Specific Learning Difficulties?* https://www.kent.ac.uk/teaching/networks/ltn/documents/2014-15/18-Sept-2014-SpLD-handout-L-Regan.pdf

[22] Legislative Council of the Hong Kong Special Administrative Region. 2014. 立法會十題：教育心理學家 (LCQ10: Educational psychologists). (2014). https://www.info.gov.hk/gia/general/201405/14/P201405140403.htm

[23] Md Abdur Rahman, Elham Hassanain, Md Mamunur Rashid, Stuart J Barnes, and M Shamim Hossain. 2018. Spatial Blockchain-based Secure Mass Screening Framework for Children with Dyslexia. *IEEE Access* 6 (2018), 61876–61885.

[24] Maria Rauschenberger, Christian Lins, Noelle Rousselle, Andreas Hein, and Sebastian Fudickar. 2019. Designing a New Puzzle App to Target Dyslexia Screening in Pre-readers. In *Proceedings of the 5th EAI International Conference on Smart Objects and Technologies for Social Good*. 155–159.

[25] Luz Rello, Ricardo Baeza-Yates, Abdullah Ali, Jeffrey P Bigham, and Miquel Serra. 2020. Predicting Risk of Dyslexia with an Online Gamified Test. *Plos One* 15, 12 (2020), e0241687.

[26] Luz Rello, Miguel Ballesteros, Abdullah X Ali, Miquel Serra, Daniela Alarcón Sánchez, and Jeffrey P Bigham. 2016. Dytective: Diagnosing Risk of Dyslexia with a Game. In *Pervasive Health*. 89–96.

[27] Luz Rello, Clara Bayarri, and Azuki Gorriz. 2012. What is Wrong with this Word? Dyseggxia: a Game for Children with Dyslexia. In *Proceedings of the 14th International ACM SIGACCESS Conference on Computers and Accessibility*. 219–220.

[28] Luz Rello, Clara Bayarri, Yolanda Otal, and Martin Pielot. 2014. A Computer-based Method to Improve the Spelling of Children with Dyslexia. In *Proceedings of the 16th International ACM SIGACCESS Conference on Computers & Accessibility*. 153–160.

[29] Dyscreen Dyslexia Screener. [n.d.]. *Reading Assessment & Progress Monitoring, Simplified.* https://dystech.com.au/

[30] Hong Kong EP Services. [n.d.]. *Specific Learning Difficulties (SLD).* https://www.hkep.org/specific-learning-difficulties-sld/

[31] Abdul Samad Shibghatullah. 2017. Dleksia Game: A Mobile Dyslexia Screening Test Game to Screen Dyslexia using Malay Language Instruction. *Asian Journal of Information Technology* 16, 1 (2017), 1–6.

[32] Hong Kong Specific Learning Difficulties Research Team. 2015. The Hong Kong Reading Ability Teacher Observation Checklist for Preschool Children(TOC-K). (2015). https://hksld.eduhk.hk/

[33] Zikai Alex Wen, Erica Silverstein, Yuhang Zhao, Anjelika Lynne Amog, Katherine Garnett, and Shiri Azenkot. 2020. Teacher Views of Math E-learning Tools for Students with Specific Learning Disabilities. In *Proceedings of the 22nd International ACM SIGACCESS Conference on Computers and Accessibility*. 1–13.

[34] Zikai Alex Wen, Yuhang Zhao, Erica Silverstein, and Shiri Azenkot. 2021. An Intelligent Math E-Tutoring System for Students with Specific Learning Disabilities. In *Proceedings of the 23rd International ACM SIGACCESS Conference on Computers and Accessibility*. 1–4.

[35] Haipeng Zeng, Xingbo Wang, Yong Wang, Aoyu Wu, Ting-Chuen Pong, and Huamin Qu. 2022. GestureLens: Visual Analysis of Gestures in Presentation Videos. *IEEE Transactions on Visualization and Computer Graphics* (2022).

[36] 李瑩玓. 2004. 寫字困難學生寫字特徵之分析 (An Analysis of the Writing Characteristics of Students with Writing Difficulties). 師大學報: 教育類 (2004).