Dy-poThon: A Bangla Sentence-Learning System for Children with Dyslexia

Dipshikha Podder[a], **Manjira Sinha**[b*], **Tirthankar Dasgupta**[b], **Anupam Basu**[c*]
[a]Indian Institute of Technology Kharagpur, India,
[b]TCS Innovation Lav, India,
[c]Jadavpur University, India
dipshi.podder@gmail.com,
manjira.sinha@cet.iitkgp.ac.in, dasgupta.tirthankar@tcs.com, anupambas@gmail.com

Abstract

The number of assistive technologies available for dyslexia in Bangla is low and most of them do not use multisensory teaching methods. As a solution, a computer-based audio-visual system Dy-poThon is proposed to teach sentence reading in Bangla. It incorporates the multisensory teaching method through three activities, listening, reading, and writing, checks the reading and writing ability of the user and tracks the response time. A criteria-based evaluation was conducted with 28 special educators to evaluate Dy-poThon. Content, efficiency, ease of use and aesthetics are evaluated using a standardised questionnaire. The result suggests that Dy-poThon is useful for teaching Bangla sentence-reading.

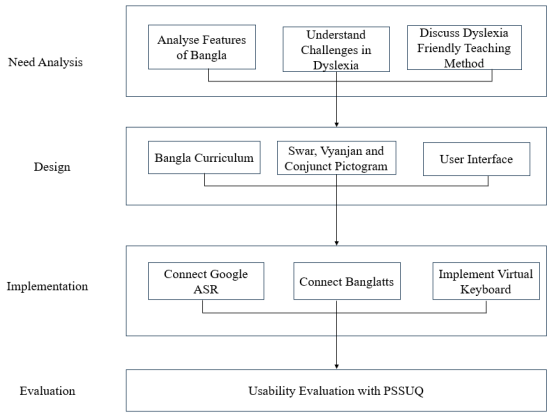

Figure 1: Schematic diagram of workflow including till evaluation

1 Introduction

Bangla is the seventh most spoken language in the world with nearly 234 million native speakers and 39 million second-language speakers. It has many unique features including alphasyllabic script, vowel modifiers or diacritics(Alam et al., 2021)(Sircar and Nag, 2019) which are not present in English. These get added to the consonant in the upper, lower, left or right position. Bangla follows a different type of articulacy sequencing compared to English, in some cases, the vowel presents itself earlier in the writing form but while speaking, it comes later(Narendra et al., 2011). These characteristics increase the difficulty for the readers(Gupta, 2004). Another unique characteristic of Bangla is that, a lot of time the consonants change their forms completely when written as consonant clusters or *'yuktaksars'*(Adak et al., 2018)(Khan and Bajre, 2018). Dyslexia is a language-based learning disability(Bruck, 1993) where the person has trouble with reading, letter or word identification, phonological awareness, spelling skills etc.(Roitsch and Watson, 2019). Being a language-based difficulty, dyslexia can be manifested in any language, hence it is important to conduct research on Bangla dyslexia.

Looking into the sentences, the structure of sentences in Bangla and English also different, English follows a subject-verb-object structure and Bangla follows subject-object-verb structure(Haque and Hasan, 2018). Bangla has some more characteristics which is not present in English. Bangla verbs have causative and honorifics(Sultana, 2010). Along with the discussed difficulties, Bangla has an advantage over English. It has a highly transparent orthography which is easy for learners (Sircar and Nag, 2019)(Bhide, 2018).

2 Literature Review

The most effective way to teach children with dyslexia is to teach through the multisensory

*the work was done during the authors' tenure at IIT Kharagpur

teaching method(MTM)(Stevens et al., 2021). It incorporates multiple senses through different activities which helps to train their weak working memory. Moreover, computer-based audio-visual feedback increases the effectiveness of any lesson(Hosseinkhanzadeh et al., 2017). However, the number of work incorporating these methods are countable. The number of research work available in Bangla for dyslexia, dysgraphia and dyscalculia are also very less and most of them were conducted in Bangladesh. Dyslexia-focused sentence learning systems (Podder et al., 2021)(Podder et al., 2022) offers multisensory computer-assisted learning environment. Apart from them, some speech-to-text(Mubassıra and Das, 2021)(Islam et al., 2019) and text-to-speech(Naser et al., 2010) converting systems are available in Bangla which are considered to be helpful in dyslexia though they are not dyslexia focused. Some android-based educational applications and games are available for alphabet and word reading and some of them offer a multisensory teaching environment. For sentence level, the only available technology is the AAC Avaz [1] Bangla which was targeted to help children in communication. Beside this, some Bangla pictogram(Nandy, 2019), word predictor(Hamarashid et al., 2022), spelling corrector(Hládek et al., 2020) are available in Bangla to help in dyslexia. But it is important to teach sentence-reading by grouping words together (Robichon et al., 2002) as it helps in developing reading comprehension(Casalis et al., 2013) which was not addressed by any research work.

3 Curriculum Design

Dy-poThon aims to teach sentence-reading in a way which is helpful in dyslexia and before implementation the sentences were selected to use in the system. While selecting the sentences for the curriculum, four features were considered, i.e., spelling rule, length of word in sentence, length of sentence, and presence of concrete word in each sentence. The grouping of spelling rules is illustrated in the table shown in appendix A, for each spelling rule different lessons were created. Consonant clusters obtained by adding two consonants, known as diphthongs, are grouped together; some of these clusters which are known as transparent conjuncts(Adak et al., 2018), change their form after the conversion, are grouped separately. Triphthongs, created by adding three consonants together, are grouped separately. The most used Bangla textbook *"Varnaparichay"* was used for sentence selection and grouping of spelling rules. As it is important to show pictures to familiarize or remind the sound of letters, a Bangla pictogram is developed to provide as hint, one frame of the pictogram is shown in figure 2. Figure 2 also illustrates how the sentences will be taught in form of word package. Figure 1 shows all the developmental stages of the system.

4 Implementating Different Components and Assemble Them

For developing reading skills, Dy-poThon uses three approaches, MTM, reading and writing mistakes count, and the generation of performance reports. The purpose of the performance report is to provide documentation for each performance so that the special educators or the parents will be able to assess the performance of the students.

4.1 Implementation of Multisensory Teaching Method

As instructed by Orton and Gillingham, three activities are used to implement MTM, listening, reading and writing. All the activities are performed parallelly which will help to retain the maximum of a lesson. Every lesson contains five sentences and for every sentence. The activity diagram, shown in figure 4, shows the stage where MTM is implemented. For the listening activity, python banglatts[2] is used that generate realtime audio output. The system has virtual keyboards which contain vowels, vowel modifiers, consonants, diphthongs and triphthongs, and all of them are grouped separately. Figure 3 shows the keyboard.

4.2 Evaluation of wrong attempts

Dy-poThon checks the number of reading and writing errors, Figure 6 illustrates the pro-

[1] https://www.avazapp.com/products/avaz-aac-app/

[2] https://sourceforge.net/projects/bangla-tts/

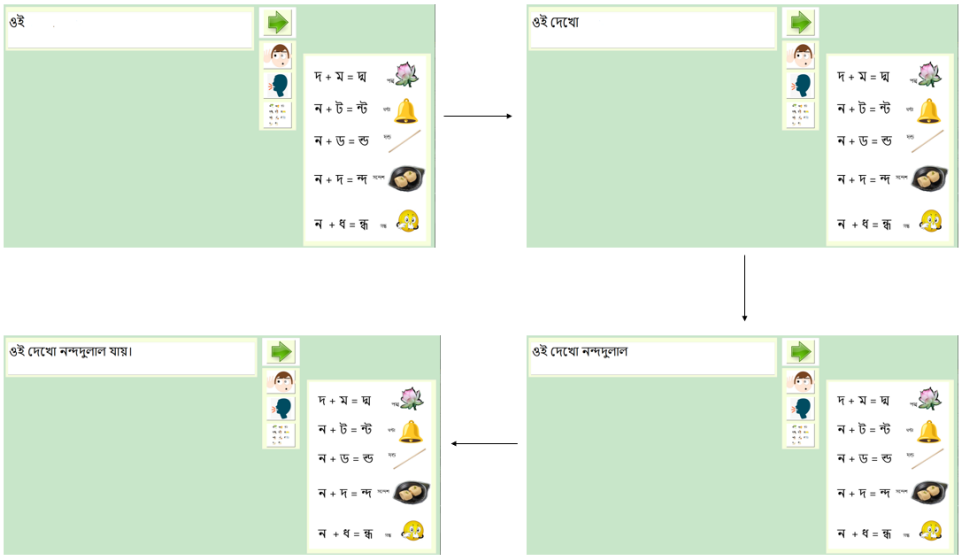

Figure 2: Screenshot of the system to display the use of word package in teaching sentence reading

Figure 3: Sreenshot of the UI while the diphthong was written using the keyboard

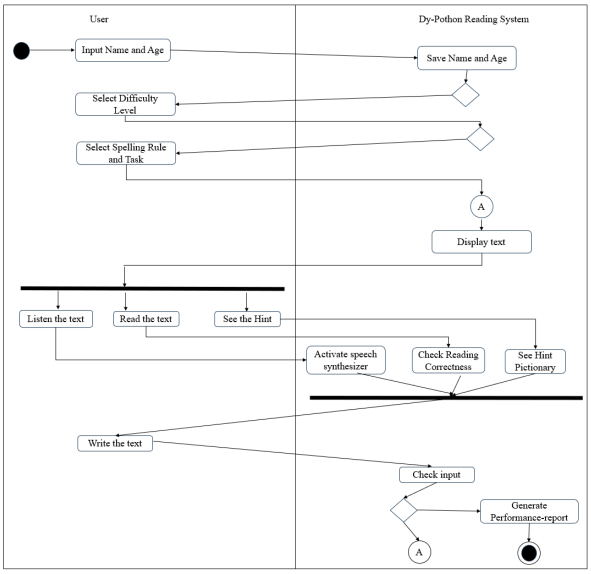

Figure 4: Activity Diagram of the system

cess of error check. Python in-built Google speech recognizer converts the speech input and through string matching it checks if the user read correctly. Through emoji and audio feedback, the system instructs the user for the next activity, i.e., if she can proceed to the next text or need to repeat. Emoji feedback displayed after writing is shown in figure 5. Writing error is also checked using string matching.

4.3 Generation of performance-report

The performance report contains response time for each word package, number of reading and writing mistakes and how many times the audio and visual assistance are taken. The system does not save the performance report, all measures are kept stored till the end of the lesson and if the user does not download the report, the stored data gets deleted immediately. A sample performance report is shown in figure 7.

5 Evaluation of The System

A usability evaluation is conducted with 28 special educators to evaluate the system in terms of four criteria, content, student involvement, ease of use and aesthetics. Questionnaire(Kara, 2007), specifically designed for teachers to evaluate an educational system, is used. The questionnaire has ten questions under each of the criteria and uses a five-pointer Likert scale. All of the educators work with

(a) Feedback for correct input

(b) Feedback for wrong input

Figure 5: Screenshot of the system after the generation of visual feedback at the end of a writing task

dyslexia and all of them teach language. The evaluation is conducted in a one-to-one setup where all of the educators are given a demonstration of the system and have the opportunity to use it. After that, the questionnaire is given to them where point 5 indicates strongly agree and point 1 indicates strongly disagree.

6 Results

After collecting the data, the overall score given by each educator for all four criteria is calculated, as there are 40 questions with five points, the total score is 200 on which everyone marked the system. Total scores obtained by each educator are given in table 1. The calculated percentile score from this obtained score and the standard percentile scores(Kara, 2007) are shown in table 2. The 25th percentile of the total score comes as 159 which is comparably more than the standard which is 125. The 75th percentile of the total score comes as 184, which is again more than the standard score which is 157. From this score it can be concluded that the usability evaluation of the system is conducted properly and it is useful in teaching sentence-reading.

Educator	Total Score	Educator	Total Score
E1	134	E15	183
E2	159	E16	137
E3	176	E17	179
E4	184	E18	180
E5	158	E19	180
E6	164	E20	194
E7	164	E21	158
E8	147	E22	174
E9	194	E23	189
E10	192	E24	168
E11	184	E25	164
E12	164	E26	187
E13	166	E25	164
E14	149	E28	165

Table 1: Total score given by each educator out of 200

Values	Participant Number	25th	75th
Standard	32	125	157
Obtained	28	158	184

Table 2: A comparison between the standard and obtained score

7 Future Work

Experts evaluate the content and usability of a system better(Tokmak et al., 2012), however, the design and aesthetics should be evaluated by the user group. In future, the system will be evaluated by the children with dyslexia and their parents with PSSUQ(Lewis, 1992). An experiment will also be conducted to evaluate the efficiency.

8 Conclusion

This study aims to develop and evaluate a Bangla sentence-reading system that is focused on the dyslexia-friendly teaching method. The available systems, except (Podder et al., 2022) do not target sentence reading in Bangla. All the dyslexia-focused systems help in word reading as they assume that sentence-reading is developed naturally. However, Dy-poThon focuses solely on sentence-reading ability. It will be useful for any age group with dyslexia.

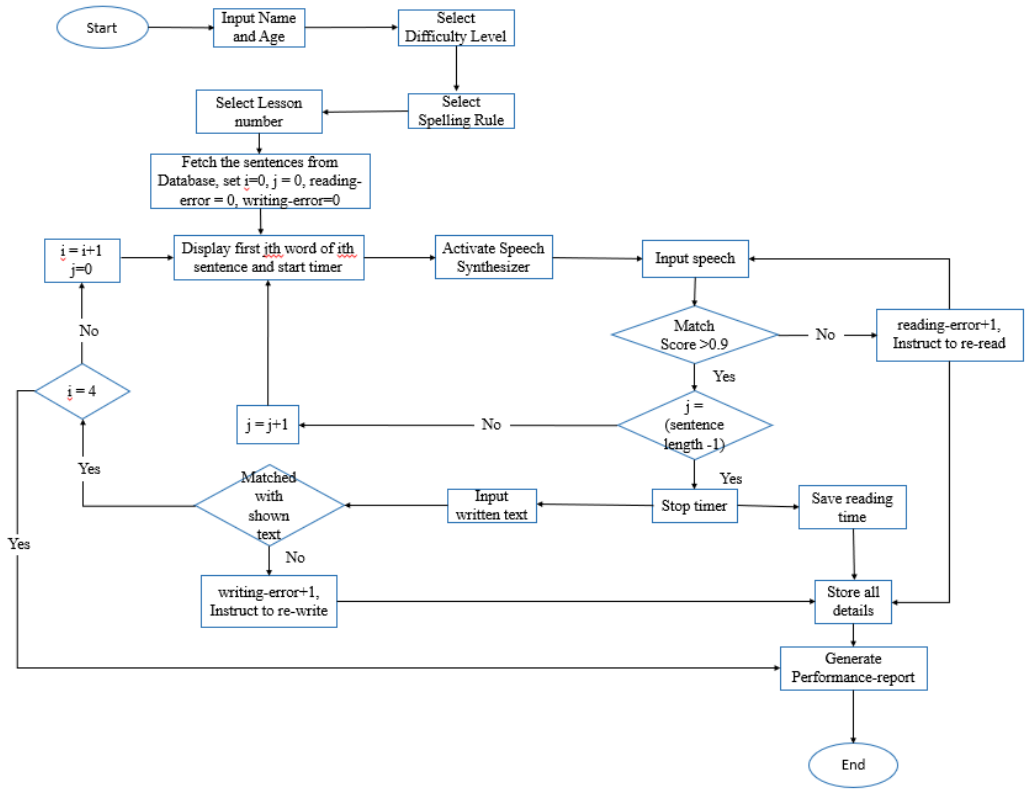

Figure 6: Flowchart of the working principle

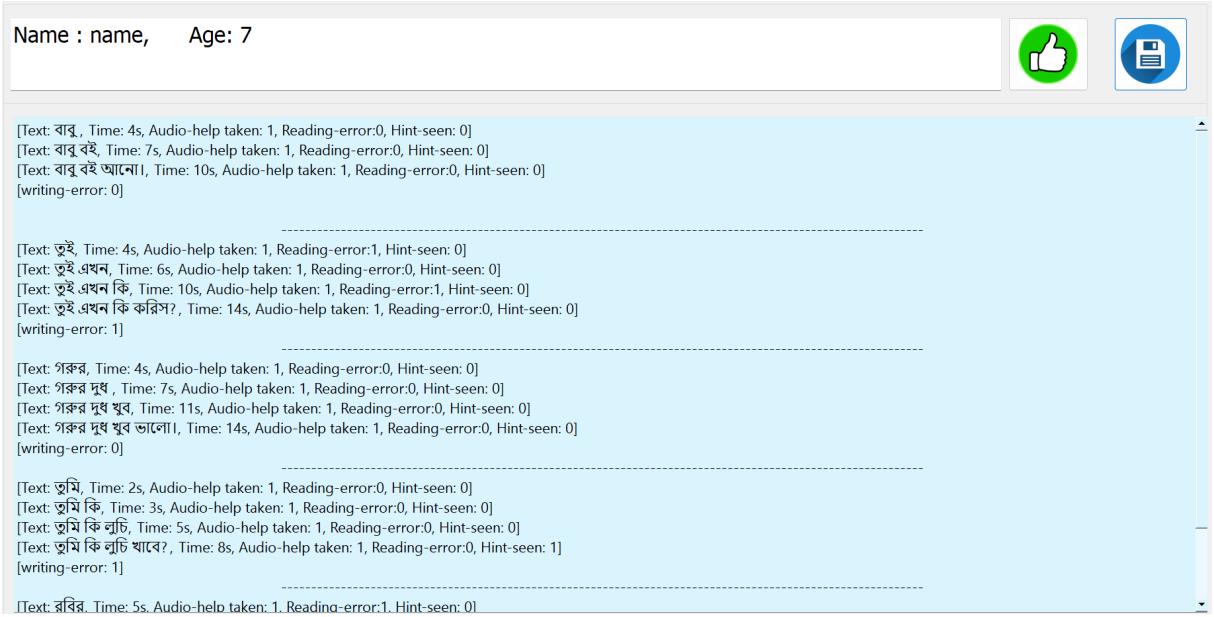

Figure 7: Report generated after completion of a lesson

References

Chandranath Adak, Bidyut B Chaudhuri, and Michael Blumenstein. 2018. Cognitive analysis for reading and writing of bengali conjuncts. In *2018 International Joint Conference on Neural Networks (IJCNN)*, pages 1–7. IEEE.

Samiul Alam, Tahsin Reasat, Asif Shahriyar Sushmit, Sadi Mohammad Siddique, Fuad Rahman, Mahady Hasan, and Ahmed Imtiaz Humayun. 2021. A large multi-target dataset of common bengali handwritten graphemes. In *International Conference on Document Analysis and Recognition*, pages 383–398. Springer.

Adeetee Bhide. 2018. Copying helps novice learners build orthographic knowledge: Methods for teaching devanagari akshara. *Reading and Writing*, 31(1):1–33.

Maggie Bruck. 1993. Word recognition and component phonological processing skills of adults with childhood diagnosis of dyslexia. *Developmental Review*, 13(3):258–268.

Séverine Casalis, Christel Leuwers, and Heather Hilton. 2013. Syntactic comprehension in reading and listening: A study with french children with dyslexia. *Journal of learning disabilities*, 46(3):210–219.

Ashum Gupta. 2004. Reading difficulties of hindi-speaking children with developmental dyslexia. *Reading and writing*, 17:79–99.

Hozan K Hamarashid, Soran A Saeed, and Tarik A Rashid. 2022. A comprehensive review and evaluation on text predictive and entertainment systems. *Soft Computing*, pages 1–22.

Mozammel Haque and Mahmudul Hasan. 2018. English to bengali machine translation: An analysis of semantically appropriate verbs. In *2018 International Conference on Innovations in Science, Engineering and Technology (ICISET)*, pages 217–221. IEEE.

Daniel Hládek, Ján Staš, and Matúš Pleva. 2020. Survey of automatic spelling correction. *Electronics*, 9(10):1670.

Abasali Hosseinkhanzadeh, Mona Latif Zanjani, and Mahboobe Taher. 2017. Efficacy of computer-assisted cognitive remediation (cacr) on improvement executive functions and reading performance of students with dyslexia. *Neuropsychology*, 2(7):27–46.

Jahirul Islam, Masiath Mubassira, Md Rakibul Islam, and Amit Kumar Das. 2019. A speech recognition system for bengali language using recurrent neural network. In *2019 IEEE 4th international conference on computer and communication systems (ICCCS)*, pages 73–76. IEEE.

Yilmaz Kara. 2007. Educational software evaluation form for teachers. *Online Submission*.

Azizuddin Khan and Purnima Bajre. 2018. Reading alphasyllabic hindi: contributions from phonological and orthographic domains. *Psychology of Language and Communication*, 22(1):492–515.

James R Lewis. 1992. Psychometric evaluation of the post-study system usability questionnaire: The pssuq. In *Proceedings of the human factors society annual meeting*, volume 36, pages 1259–1260. Sage Publications Sage CA: Los Angeles, CA.

Masiath Mubassıra and Amit Kumar Das. 2021. Implementation of recurrent neural network with language model for automatic articulation identification system in bangla. *International Journal of Advanced Networking and Applications*, 12(6):4800–4808.

Ankita Nandy. 2019. Beyond words: Pictograms for indian languages. *International Journal of Research in Science and Technology*, 9(1):19–25.

NP Narendra, K Sreenivasa Rao, Krishnendu Ghosh, Ramu Reddy Vempada, and Sudhamay Maity. 2011. Development of syllable-based text to speech synthesis system in bengali. *International journal of speech technology*, 14:167–181.

Abu Naser, Devojyoti Aich, and Md Ruhul Amin. 2010. Implementation of subachan: Bengali text to speech synthesis software. In *International Conference on Electrical & Computer Engineering (ICECE 2010)*, pages 574–577. IEEE.

Dipshikha Podder, Manjira Sinha, and Anupam Basu. 2021. Sentence learning system for children with dyslexia to learn english as second language. In *2021 IEEE International Conference on Engineering, Technology & Education (TALE)*, pages 1028–1032. IEEE.

Dipshikha Podder, Manjira Sinha, and Anupam Basu. 2022. Teaching sentence in hindi and bangla with an assistive system to the children with dyslexia. In *2022 International Conference on Advanced Learning Technologies (ICALT)*, pages 287–288. IEEE.

Fabrice Robichon, Mireille Besson, and Michel Habib. 2002. An electrophysiological study of dyslexic and control adults in a sentence reading task. *Biological psychology*, 59(1):29–53.

Jane Roitsch and Silvana Watson. 2019. An overview of dyslexia: definition, characteristics, assessment, identification, and intervention. *Science Journal of Education*, 7(4):81–86.

Shruti Sircar and Sonali Nag. 2019. Spelling and reading words in bengali: The role of distributed phonology. *Handbook of literacy in akshara orthography*, pages 161–179.

Elizabeth A Stevens, Christy Austin, Clint Moore, Nancy Scammacca, Alexis N Boucher, and Sharon Vaughn. 2021. Current state of the evidence: Examining the effects of orton-gillingham reading interventions for students with or at risk for word-level reading disabilities. *Exceptional children*, 87(4):397–417.

Asifa Sultana. 2010. Specific language impairment-when only language becomes difficult.

Hatice Sancar Tokmak, Lutfi Incikabi, and Tugba Yanpar Yelken. 2012. Differences in the educational software evaluation process for experts and novice students. *Australasian Journal of Educational Technology*, 28(8).

A Appendix

Bangla Spelling Rule	**Grouping**
Vowel Modifier or Diacritic	অ, আ [*a, A*] ই, ঈ [*i, I*] উ, ঊ [*u, U*] ঋ [*RRi*] এ, ঐ [*e, ai*] ও, ঔ [*o, ou*]
Diphthongs	ক্ট, ক্ক, ক্ম, ক্ল, ক্ষ [*kTa,kba,kma,kla,kSa*] গ্ধ, গ্ন, গ্ব, গ্ম, গ্ল, গ্ঘ [*gda,gna,gba,gma,gla, ghna*] চ্ছ, জ্জ, জ্ঝ, জ্ব [*chchha,jja,jjha,jba*] ট্ট, ট্ঠ, ণ্ট, ণ্ঠ, ণ্ড, ণ্ণ [*TTa,Tba,NTa,NTha, NDa,NNa*] ত্ন, ত্ব, ত্ম, দ্দ, দ্ধ, দ্ব [*tna, tba, tma, dda, ddha, dba*] ন্ট, ন্ড, ন্ত, ন্দ, ন্ধ, ন্ন, ন্ব, ন্স [*nTa,nDa,nta,nda,, ndha,nna,nba,nsa*] প্ট, প্ত, প্প, প্ল, প্ল [*pTa,pta,pna,ppa,pla*] ম্ল, ম্প, ম্ফ, ম্ব, ম্ন [*mla, mpa,mpha,mba, mna*] ল্ক, ল্ট, ল্ড, ল্ব, ল্ল [*lka, lTa, lDa, lba,lla*] শ্চ হ্ব, হ্ল, জ্ঞ, দ্দ [*shcha, hba, hla, bja,bda*] ষ্ক, ষ্ট, ষ্ঠ, ষ্ণ [*Shka, ShTa, ShTha, ShNa*] স্ত, স্ব, হ্ন, হ্ম [*sta, sba, hna,hma*] ক্ত, ক্র, ক্ষ, ঙ্গ ,ঙ্ক [*tka,kra,kSha,Ngga, Ngka*] ত্ত, ত্ব, ত্থ, ত্র [*tta, ttba, ttha,tra*]
Triphthong	ন্ত্ব, ন্ত্র, স্ক্র, স্ত্র [*ntba,ntra,Skra,Stra*] দ্ভ্র, ক্ষ্ম [*dbhra, kShma*]

Table 3: List of Bangla spelling rules and their grouping for the curriculum