DigiPal: Cross-Cultural & Interlingual Mobile Interaction for Children

By

Dev Raj Lamichhane

A thesis submitted in partial fulfilment for the requirements of the degree of Doctor of Philosophy at the University of Central Lancashire

May 2022

Student Declaration

Type of Award Doctor of Philosophy

School School of Psychology and Computing

Concurrent registration for two or more academic awards

I declare that while registered as a candidate for the research degree, I have not been a registered candidate or enrolled student for another award of the University or other academic or professional institution.

Material submitted for another award

I declare that no material contained in the thesis has been used in any other submission for an academic award and is solely my own work.

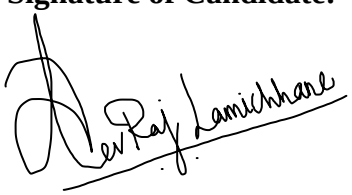
Collaboration

I declare that the research contained in this thesis, unless otherwise formally indicated within the text, is my original work.

Use of a Proof-reader

No proof-reading service was used in the compilation of this thesis.

Signature of Candidate:



DEV RAJ LAMICHHANE

Acknowledgement

I would like to take this opportunity to thank all the people who supported me during this exciting journey directly and indirectly, but probably they won't all fit in this section.

First and foremost, I would like to express my sincere and deep gratitude to my research supervisor, Prof. Janet Read, for giving me the opportunity and providing invaluable guidance and support. Her vision, sincerity, dynamism and motivation have deeply inspired me. I am extremely grateful to her for providing a different viewpoint and pushing me further. I would also like to thank her for her empathy, great sense of humor which definitely helped to cheer me up during the hard times.

Along with my supervisor, I would also like to thank Prof. Effie Lai-Chong Law, Dr. Elisa Rubegni and Dr. Misbahu Zubair for agreeing to be my examiner, Dr. Antonios Kelarakis, my Research Degree Tutor, for helping me to manage my research journey, Dr. Peggy Gregory, for being a referee and helping during my RPA and PhD Transfer, Dr. Dan Fitton, my second supervisor and Dr. Gavin Sim for asking those critical and challenging questions to make the Thesis better, Prof. Scott MacKenzie, York University, for his amazing ideas, Dr. Raid AlQaisi for the motivation, ideas and guidance and all my colleagues from Department of Computing.

This endeavour wouldn't be possible without my amazing and lovely participants. I can't thank enough for their enthusiasm, creativity, ideas, feedback and contribution for the success of this work. I would like to sincerely thank their parents for the consent, their schools and the Headteachers for letting me do the experiments. I would also like to extend my thanks to my brothers Navaraj and Manish for travelling hours to the rural villages in Nepal and assisting me and volunteering during the studies.

Finally, but the most importantly, I would like to thank my family for constant support and love and my wife, Manisha who not only supported me emotionally and mentally but also financially during this period as a student and at last, my little princess, Devisha for coming into our lives and showering us with the happiness and joy that provided the strength, confidence and extra motivation to accomplish this goal.

Abstract

This thesis contributes research and analysis towards, and the design and development of, a Digital Pen pal application (DigiPal) for children from two different countries and languages. Children from a developed and a developing country came together and participated in multiple studies for the design of the app with their ideas and input both matching and differing. Feedback and thoughts provided by them contributed to the design of the app and towards a generalised model for similar applications.

DigiPal required a translation system to be integrated into the App so that the children could talk in their own language which not only makes sure they can talk confidently, but also contributes to preserve local languages. Google translate was the option which was used in this case following a study that assured its effectiveness. Accuracy was relatively low but higher levels of Understandability gave some hope to advocate the possibility of use of Google translate as a translator and most importantly as a facilitator of cross-cultural chat.

A real time letter exchange activity, with children from Nepal and England was conducted. In a deep analysis of text entry errors and their impact on translation, and on other translation errors and their possible causes, findings show why and where Google translate struggled. However, children's reaction to the translated letters, as well as analysis that shows how improving text entry correctness can support the translation software, shows that regardless of some error children could communicate and they enjoyed the activity overall.

This work also contributes insights for design that are needed beyond translation to create an engaging and culturally level experience. Two separate studies were conducted to gather some culturally influenced attributes from the children. In one, children drew pictures to introduce themselves whereas in the second one they drew pictures of games they would like to have in an application like DigiPal.

The thesis concludes with a generalisable model that can be used by other app developers to consider how to create culturally level products for children from different countries and with different languages.

Publications

1. Investigating Children's Passwords using a Game-based Survey

Authors: Dev Lamichhane, Janet C Read
Conference name: IDC '17: Proceedings of the 2017 Conference on Interaction Design and Children, June 2017
Pages: 617–622
Publisher: Association for Computing Machinery, New York, NY, United States
Publication date: 27 June 2017
Digital Link: https://doi.org/10.1145/3078072.3084333

2. Beneath the Himalayas — Exploring Design for Cultural Evenness with Nepalese Children

Authors: Dev Lamichhane, Janet C Read, Daniel Fitton
Conference name: Proceedings of the 32nd International BCS Human Computer Interaction Conference (HCI), July 2018
Conference theme: Human Computer Interaction Conference
Pages: 1-5
Publisher: BCS-Chartered Institute for IT
Publication date: July 2018
Digital Link: https://www.scienceopen.com/hosteddocument?doi=10.14236/ewic/HCI2018.149

3. Make Me Messenger: Critiquing Children as Design Informants

Authors: Dev Lamichhane, Janet C Read
Conference name: International Conference on Human Interaction and Emerging Technologies, April 2020
Pages: 225-231
Publisher: Springer, Cham
Publication date: 23/4/2020
Digital Link: https://link.springer.com/chapter/10.1007/978-3-030-44267-5_34

4. Play It My Way: Participatory Mobile Game Design with Children in Rural Nepal

Authors: Dev Raj Lamichhane, Janet C Read
Conference name: International Conference on Human-Computer Interaction
Pages: 325-336
Publisher: Springer, Cham
Publication date: 19/07/2020
Digital Link: https://link.springer.com/chapter/10.1007/978-3-030-49788-0_24

5. Maybe I Can Help? Google as a Translator and Facilitator for an Inter-lingual Children's Chat Application

Authors: Dev Raj Lamichhane, Janet C. Read, Zixi You
Conference name: International Conference on Human-Computer Interaction, HCII 2021
Pages: 208-215
Publisher: Springer, Cham
Publication date: 03 July 2021
Digital Link: https://link.springer.com/chapter/10.1007/978-3-030-78635-9_29

Table of Contents

Student Declaration **2**

Acknowledgement **3**

Abstract **4**

Publications **5**

Table of Contents **6**

List of Figures **12**

List of Tables **14**

List of Charts **16**

List of Equations **17**

List of Abbreviations **18**

Chapter 1. Introduction **20**

1.1 Research Motivation 20

1.2 Research Aims 22

1.3 Research Questions 23

1.4 Methodology 24

1.4.1 Participants 24
1.4.2 Study Locations 24
1.4.3 Technology 24

1.5 Structure of Thesis 25

1.5.1 Introductory Chapters 25
1.5.2 Research Chapters 26
1.5.3 Concluding Chapters and Appendices 27

Chapter 2. Literature Review **29**

2.1 Culture and Conversation 29

2.1.1 How is Culture Understood 29
2.1.2 Designing Cross Cultural Products 30
2.1.3 Interculturality and Technology 31
2.1.4 Communication and Written Exchanges 33
2.1.5 Children Communicating by Writing 34

2.1.6 Keyboard Design and Alphabets 35
2.1.7 Challenges for Digital Pen Pal Exchanges 36
2.1.8 Conclusions on Culture and Conversation 37
2.2 Child Centred design 37
2.2.1 Importance of Child Centred Design and Working With Children 37
2.2.2 Drawings to Gather Insights – Studies and Challenges 39
2.2.3 Asking Children for Ideas and Feedback 40
2.2.4 Designing across Cultures 41
2.2.5 Conclusions on Child Centred Design 42
2.3 Translation Interfaces 42
2.3.1 Translation Introduction 42
2.3.2 History of Machine Translation 44
2.3.3 Google Translate 45
2.3.4 Uses of Translation with Non-Latin Languages 46
2.3.5 Accuracy of Translation 47
2.3.6 Machine Translation with Children 48
2.3.7 Conclusions on Translation Interfaces 49
2.4 Conclusions 50
Chapter 3. Design and Development of the Digital Pen Pal Application 51
3.1 Introduction 51
3.2 Development of DigiPal Version 1 51
3.2.1 Interfaces/Pages in the DigiPal Version 1 52
3.3 Study 1: Using DigiPal V1 as a Technology Probe 53
3.3.1 Method: 53
3.3.2 Results and Discussion: 55
3.3.3 Contribution/Insights for Follow on Work 56
3.4 Development of DigiPal Version 2 56
3.4.1 Interfaces/Pages in the DigiPal Version 2 56
3.4.2 How the Letter Sending Works 59
3.5 Study 2: Children Chatting and Acting as Design Informants 62
3.5.1 Method 62
3.5.2 Procedure 66
3.5.3 Results and Discussion 66
3.6 Discussion 78
3.6.1 Informing the Design of the DigiPal App - Version 3 78
3.6.2 Children as Informants 81
3.6.3 Cultural Evenness 82
3.6.4 Contribution/Insights for follow on work 82
3.7 Summary of the Chapter 83

Chapter 4. Translation Possibilities and Challenges 84

4.1 Introduction 84

4.2 Available Translation Tools 85

4.3 Measuring Accuracy of Translation 85

4.3.1 Choosing Edit Distance 87
4.3.2 Application Example 88

4.4 Defining Understandability of Translation 89

4.4.1 A New Understandability Metric 91
4.4.2 Application Example 92

4.5 Study 3: Calculations of Accuracy and Understandability of Children's Letters Translated by Google Translate. 93

4.5.1 Stage 1. Gathering and Processing the Texts to Analyse 93
4.5.2 Stage 2. Development of Edit Distance (Minimum String Distance) Calculation Tool 94
4.5.3 Accuracy of Google Translation of Nepalese Letters 96
4.5.4 Understandability of Google Translation of Nepalese Letters 97
4.5.5 Accuracy of Google Translation of English Letters 105
4.5.6 Understandability of Google Translation of English Letters 106
4.5.7 Discussion – Understandability and Accuracy 110
4.5.8 Comparing Accuracy and Understandability 113

4.6 Improving Text Entry and Translation by Checking Input Errors 115

4.6.1 Accuracy of Google Translation of Corrected Nepalese Letters (GTNCs) 115
4.6.2 Understandability of Google Translation of Corrected Nepalese Letters (GTNCs) 117
4.6.3 Accuracy of Google translation of Corrected English Letters (GTECs) 122
4.6.4 Understandability of Google translation of Corrected English Letters (GTECs) 124
4.6.5 Comparing Accuracy and Understandability of Corrected Letters 128

4.7 Discussion 130

4.7.1 Informing Design of the DigiPal App – Version 4 130
4.7.2 Cultural Evenness. 133
4.7.3 Contribution/Insights for Follow on Work 134

4.8 Summary of the Chapter 135

Chapter 5. Study 4: Realtime DigiPal Letters Exchange 136

5.1 Introduction 136

5.2 Participants and Location 137

5.3 Apparatus – DigiPal Version 4 137

5.4 Procedure 138

5.5 Results 141

5.5.1 Structure of Letters 142

5.5.2 Things Shared by Children in Their Letter Exchanges 143
5.5.3 Participants' Reaction 144
5.5.4 Entry Errors 145
5.5.5 Analysing Entry Errors 148
5.5.6 Translation Errors 161
5.5.7 Inconsistency in Translation: 170
5.5.8 Untranslated Words 171
5.5.9 Children's Reaction to the Translated Text and Understandability 174
5.6 Discussion 179
5.6.1 Informing Design of the DigiPal App 180
5.6.2 Contribution/Insights for Follow on Work 182
5.7 Summary of the Chapter 182
Chapter 6. Design for Cultural Evenness 183
6.1 Introduction 183
6.2 Study 5: Exploring Meanings using Drawings 184
6.2.1 Participants 185
6.2.2 Method 185
6.2.3 Results 185
6.2.4 Capturing Culture 194
6.2.5 Contribution/Insights for Follow on Work 194
6.3 Study 6: Designing Engagement 195
6.3.1 Location and Participants 196
6.3.2 Tools and Procedure 196
6.3.3 Results 197
6.3.4 Method: Game Design by Children across Cultures 200
6.4 Discussion 201
6.4.1 Informing Design of the DigiPal App 201
6.4.2 Children as Informants 201
6.4.3 Cultural Evenness 201
6.5 Development of DigiPal Version 5 203
6.6 Design for Cultural Evenness – A model 208
6.6.1 Layer 1 – Presentation Layer 209
6.6.2 Layer 2 – Interaction Layer 209
6.6.3 Layer 3 – Translation Layer 210
6.6.4 Layer 4 – Engagement Layer 210
6.6.5 Layer 5 – Ethic and Security Layer 211
Chapter 7. Looking Back and Planning Further 212
7.1 Summary of Research 212
7.2 Answers to Research Questions 213
7.3 Originality 214

7.4 Contributions of the Research 215

7.5 Reflection on Children's Experience of Participation 216

7.6 Limitations and Future Directions 217

7.6.1 Children's Contributions Towards Design 217
7.6.2 Choice of Accuracy and Understandability 217
7.6.3 Inclusion of Broader Population 217
7.6.4 Children's Perception of Other Children's Lives 218
7.6.5 Engagement and Ethic / Security 218

7.7 Closing Remarks 219

Bibliography 220

Appendices 235

Appendix 1. Ethics and documents 235

Appendix 1.2 Approval from the Head Teacher of School from Khotang 236

Appendix 1.3 Ethical Approval from the School from Khotang 237

Appendix 1.4 Study information 238

Appendix 1.5 Study information Nepalese Translation 239

Appendix 1.6 Participants consent form 240

Appendix 1.7 Participants consent form Nepalese Translation 241

Appendix 1.8 Guardian consent form Nepalese Translation 242

Appendix 1.9 Guardian consent form Nepalese Translation 243

Appendix 2. Participatory Design 244

Appendix 2.1 University Mess Day Example Tuesday 25/06/2019 244

Appendix 3. Technical stuff 245

Appendix 3.1 Edit distance algorithm Code used in Edit Distance calculation tool 245

Appendix 3.2 Language and Locale 246

Appendix 3.3 Google Translation API Implementation 248

Appendix 4. Translation 249

Appendix 4.1 Funny translations 249

Appendix 5. Miscellanies.....250

Appendix 5.1 3MT Poster presentation 250

List of Figures

Figure 1. Children playing with sophisticated technologies *20*
Figure 2. Children collecting flowers *20*
Figure 3. DigiPal Version 1 First page *52*
Figure 4. DigiPal Version 1 Second page top section *52*
Figure 5. DigiPal Version 1 Second page bottom section *53*
Figure 6. DigiPal Version 1 Third page *53*
Figure 7. DigiPal Version 1 English letter *54*
Figure 8. DigiPal Version 1 Phonetically typed Nepalese letter *54*
Figure 9. DigiPal Version 2 home page *57*
Figure 10. DigiPal Version 2 Login page *58*
Figure 11. DigiPal Version 2 Registration Page *58*
Figure 12. DigiPal Version 2 User page *58*
Figure 13. DigiPal Version 2 Letters page *58*
Figure 14. Letters demo: First user typing their letter *60*
Figure 15. Letters demo: First user sent the letter *60*
Figure 16. Letters demo: Second user logged into the app. *60*
Figure 17. Letters demo: Second user receiving a letter *60*
Figure 18. Letters demo: Second user replying to the letter *61*
Figure 19. Letters demo: Second user sending the letter *61*
Figure 20: Letters demo: First user receiving the reply. *61*
Figure 21. DigiPal Version 2 Chat: Welcome page *63*
Figure 22. DigiPal Version 2 chat: Registration page *64*
Figure 23. DigiPal Version 2 chat: Login page *64*
Figure 24. DigiPal Version 2 usability form page 1 English *65*
Figure 25. DigiPal Version 2 usability form page 2 English *65*
Figure 26. DigiPal Version 2 usability test form page 1 Nepalese *65*
Figure 27. DigiPal Version 2 usability test form page 2 Nepalese *65*
Figure 28. Response sample from one of the English participants *67*
Figure 29. Response sample from one of the Nepalese participants *67*
Figure 30. Frequency of different lengths of chat responses from English and Nepalese children *74*
Figure 31. Pics of DigiPal Version 3: The welcome page with flags *79*
Figure 32. DigiPal Version 3, Home page Nepalese *80*
Figure 33. DigiPal Version 3. Register page Nepalese *80*
Figure 34. DigiPal Version 3, Login page Nepalese *80*
Figure 35. DigiPal Version 3. User page Nepalese *80*
Figure 36. DigiPal Version 3, Letters page Nepalese *81*
Figure 37. DigiPal Version 3, Letters page phonetic typing Nepalese *81*
Figure 38. Proposed presentation and interaction layer for DigiPal *82*
Figure 39. Edit Distance Calculation Tool calculating Error rate of translation of Nepalese letters *95*
Figure 40. Edit Distance Calculation Tool calculating Error rate of translation of English letters *95*
Figure 41. DigiPal Understandability: Welcome page *98*
Figure 42. DigiPal Understandability: Example page. *98*
Figure 43. DigiPal Understandability: Code page *99*
Figure 44. DigiPal Understandability: Retelling page *99*
Figure 45. Example of the record sheet for participants from England *100*
Figure 46. DigiPal Understandability: Welcome page in Nepalese *107*
Figure 47. DigiPal Understandability: Example page in Nepalese *107*
Figure 48. DigiPal Understandability: Code page Nepalese *108*
Figure 49. DigiPal Understandability: Retelling Page Nepalese *108*
Figure 50. Using Google Cloud Translation API for the app *130*
Figure 51. Proposed translation layer for DigiPal *133*
Figure 52. DigiPal Version 4 Home page *138*

Figure 53. Children in England and Nepal chatting with each other same time *139*
Figure 54. Keyboard add-ins for phonetic to Nepalese conversion *140*
Figure 55. Phonetic typing with Nepalese suggestive text *140*
Figure 56. Letters seen by Nepalese child part 1 ..... *141*
Figure 57. Letters seen by English child part 1 ..... *141*
Figure 58. Letters seen by Nepalese child part 2 ..... *141*
Figure 59. Letters seen by English child part 2 ..... *141*
Figure 60. Phonetic input - Nepalese output *146*
Figure 61. Proposed Ethic Layer for DigiPal *181*
Figure 62. Landscape drawing from a Nepalese Participant *191*
Figure 63. List drawing from a Nepalese Participant *191*
Figure 64. Landscape drawing by an English Participant *192*
Figure 65. List drawing by an English Participant *192*
Figure 66. UK and Nepal Time difference (Source: https://www.mapsofworld.com) *195*
Figure 67. Game design from a Nepalese child *197*
Figure 68. Game design from an English child *197*
Figure 69. Proposed Presentation and Interaction layer for DigiPal *202*
Figure 70. Proposed Engagement layer for DigiPal *202*
Figure 71. DigiPal Version 5 Welcome page *203*
Figure 72. DigiPal Version 5 showing the drawings from the children *203*
Figure 73. Game option added to the User Page English *204*
Figure 74. Game option added into the User Page Nepalese *204*
Figure 75. DigiPal Quiz English Homepage *205*
Figure 76. DigiPal Quiz Nepalese Homepage *205*
Figure 77. DigiPal Quiz English Information Page *205*
Figure 78. DigiPal Quiz Nepalese Information Page *205*
Figure 79. DigiPal Quiz English Question Page *206*
Figure 80. DigiPal Quiz Nepalese Question Page *206*
Figure 81. DigiPal Quiz English correct Answer page *206*
Figure 82. DigiPal Quiz Nepalese correct Answer page *206*
Figure 83. DigiPal Quiz English Wrong Answer page *207*
Figure 84. DigiPal Quiz English Wrong Answer page *207*
Figure 85. DigiPal Quiz English completed page *208*
Figure 86. DigiPal Quiz Nepalese completed page *208*
Figure 87. 5 Layered design model for DigiPal like application *208*

List of Tables

Table 1. Different versions of DigiPal App and their functionalities *28*
Table 2. List of studies, tools used and outcomes *28*
Table 3. Total number of letters and words typed by the children *55*
Table 4. Changes in the DigiPal version 2 for Children as design informants' study *63*
Table 5. Scores given by the Participants *68*
Table 6. Distribution of ratings from each group *69*
Table 7. Distribution of number of ideas given *69*
Table 8. Most popular ideas (top 10) given by the Children *70*
Table 9. List of Common ideas *71*
Table 10. English children's chat analysis *72*
Table 11. Nepalese Children's chat analysis *73*
Table 12. Example of two English children chatting *75*
Table 13. Example of two Nepalese children chatting *76*
Table 14. Nepalese children using English words in phonetic Nepalese text *77*
Table 15. Ideas implemented in DigiPal Version 3 ..... *78*
Table 16. Different translation tools and their possibilities *85*
Table 17. Edit distance, Error rate and Accuracy of Google Translation of Nepalese letters *97*
Table 18. Number of items of meaningful information conveyed (NMIO), translated (NMIT) and understood (NMIU) *103*
Table 19. Understandability calculation for Individual Letter *104*
Table 20. Understandabilities on original and translated letters *104*
Table 21. Edit distance, Error rate and Accuracy of Google Translation of English letters *105*
Table 22. Number of items of meaningful information present in original and translated English letters and corresponding understandability *109*
Table 23. Accuracy and understandability comparison for Nepalese to English translation *110*
Table 24. Accuracy and Understandability comparison for Google translated English letters *112*
Table 25. Comparing Accuracy and Understandability of Translation of Nepalese and English texts *114*
Table 26. Table. Edit distance, Error rate and Accuracy of Google Translation of Corrected Nepalese letters *116*
Table 27. Comparison between the translations of Nepalese letters before and after the checks *117*
Table 28. Number of meaningful information and Understandability of Corrected Nepalese Letters *118*
Table 29. Understandability comparison on the translated letters before and after error checking *119*
Table 30. Comparison of number of information retained by the translated Nepalese letters before and after error checking. *120*
Table 31. Guesses in the translated Nepalese texts before and after error checks *121*
Table 32. Edit distance, Error rate and Accuracy of Google Translation of Corrected English letters *122*
Table 33. Accuracy comparison between the translations of English letters before and after the checks *123*
Table 34. Understandability of translation of corrected English letters *124*
Table 35. Understandability comparison on the translated letters before and after error checking *126*
Table 36. Comparison of number of information retained by the translated English letters before and after error checking. *127*
Table 37. Comparison of number of information children guessed on the translated English letters before and after the error check *128*
Table 38. Comparing Accuracy and Understandability of Translation of Corrected Nepalese and English texts *129*
Table 39. User Table from Database *130*
Table 40. Letters Table from Database *131*
Table 41. Users Pair Tables from Database *131*
Table 42. Example UserPairs *131*
Table 43. Example of user pair letters *132*
Table 44. English user's screen *132*
Table 45. Nepalese user's Screen *132*
Table 46. Common things involved in the chat from both English and Nepalese Participants *143*
Table 47. Simple cultural difference seen in the letters *144*

Table 48. Character level spelling mistakes *148*
Table 49. Effect of Punctuation Errors on Translation of Nepalese texts *158*
Table 50. Effect of Punctuation errors in Google Translation of Nepalese letters *159*
Table 51. Effect of Punctuation Errors on Google Translation of English Letters *159*
Table 52. Effect of Punctuation Error on Google Translation of English Text *159*
Table 53. Letters with perfect input but imperfect translation *161*
Table 54. Word MOMO translated several ways *164*
Table 55. Phonetic conversion ambiguity *180*
Table 56. Number of Items and Elements represented in the drawings *186*
Table 57. Thematic Analysis of the Drawings *187*
Table 58. The frequencies of common items in Nepalese and English drawings (Top 10) *190*
Table 59. Frequency of Nepalese children's repetitive game ideas. *198*
Table 60. Frequency of English children's repetitive game ideas. *198*

List of Charts

Chart 1. Accuracy and understandability comparison for Nepalese to English translation *111*
Chart 2. Comparison chart for Google translation of English letters *113*

List of Equations

Equation 1. Equation for Error rate calculation *87*
Equation 2. Modified Error rate calculation Equation *87*
Equation 3. Equation for Accuracy calculation *87*
Equation 4. Proposed Equation for Understandability calculation *92*

List of Abbreviations

Abbreviations	Meaning
A	Accuracy
ACM	Association for Computing Machinery
AI	Artificial Intelligence
API	Application Programming Interface
BLEU	Bilingual Evaluation Understudy
CAT	Computer Assisted Translation
CCI	Child Computer Interaction
CER	Character Error Rate
CT	Correct Translation
CTE	Correct Translate of English Text
CTN	Correct Translate of Nepalese Text
EC	English Corrected Text
ER	Error Rate
ERC	Error Rate of Translation of Corrected Text
ET	English Text
GIF	Graphics Interchange Format
GMT	Greenwich Mean Time
GT	Google Translated Text
GTE	Google Translate of English Text
GTEC	Google Translation of Corrected English Text
GTN	Google Translate of Nepalese Text
GTNC	Google Translation of Corrected Nepalese Text
HCI	Human Computer Interaction
HCI4D	Human-Computer Interaction for Development
ICT	Information and Communications Technology
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
KS2	Key Stage 2
MSD	Minimum String Distance
MT	Machine Translation
NC	Nepalese Corrected Text
NMIC	Number of items of meaningful information conveyed
NMIO	Number of items of meaningful information in original text
NMIT	Number of items of meaningful information in translated text
NMITC	Number of items of meaningful information in the translation of the corrected Text
NMIU	Number of items of meaningful information understood

NT	Nepalese Text
OT	Original Text
RQ	Research Question
SRQ	Sub Research Question
UCLan	University of Central Lancashire
UNESCO	United Nations Educational, Scientific and Cultural Organization
UO	Understandability based on Original Text
UOC	Understandability on Original of Corrected Text
UT	Understandability based on Google Translated Text
UTC	Understandability on Translation of corrected Text
WER	Word Error Rate

Chapter 1. Introduction

This thesis contributes to the field of Child Computer Interaction and explores how to develop an application that is culturally appropriate to children from two quite different countries. The app being considered is a Digital pen pal application (DigiPal) where children from different parts of the world can come together, make friends, talk to each other, and understand each other's life. The research specifically considers the use of translation software to facilitate cross language communication. The research also offers insights on how children can participate in development by offering design insights and ideas alongside empirical explorations. Design guidelines for such applications, and a prototype application are outcomes from the work.

1.1 Research Motivation

Not all the children in this world have the same kind of experience of, and access to, technology. Children from developed countries like the UK, USA, Germany, and Japan etc. probably experience all the sophisticated technologies that are developed for children, whereas those from developing countries like Nepal, especially from the rural parts, have fewer and more limited opportunities. Children in less developed countries may have no, or limited access, to the latest technologies (Caspary and O'Connor, 2003). Children from developed countries typically spend large amounts of time playing with mobile phones, tablets, and video games (Chaudron, 2015) while those from less developed areas spend more time playing with physical things, and playing outdoors with toys made with old clothes, and pieces of wood etc (Lewis, 2000).

Figure 1. Children playing with sophisticated technologies

Figure 2. Children collecting flowers

Children not only have different lives, but they also have different knowledge about the things they grow up with. Children from rural areas can see, feel and play with the forest, rivers and flowers whereas children from urban areas might only see these things on pictures, TVs or mobile phones (Lee, 2001) (see **Figure 1 & Figure 2**). It can be romantic to think that a simpler childhood is better than a technological one, but to argue that one childhood is better than the other makes no sense as a child is happy in his or her own childhood (Bok, 2010) . The only thing we can argue is that there are inequalities across childhoods in terms of difference in access to technologies, there are different opportunities in different childhoods, and the way children grow up and experience the world is quite dissimilar in different places.

It is very important that children understand inequalities because bringing understanding of inequalities and differences into childhood and child play is perceived to be a strong possibility for global integration and for peaceful co-existence on our planet (Schimmel, 2009). Let's argue this in a different way; the world is a place that is full of tensions and conflicts, but media and technology can intersect in positive ways to bring communities and people together where they can learn from one another and where a tolerance of differences can be fostered.

An example of such a technology intervention is seen in (Barksdale et al., 2007) where children exchanged letters that not only influenced their literacy, as the language of communication was English, but also helped them to value and learn about cultural differences. This work allowed children to learn about maps, geography, denominations of different currencies, maths, seasonal and meteorological differences and causes, science, and about the different kinds of animals living in different climates and continents. During an analysis of the letters, it became apparent that the children were sharing pictures, and gifts, and showing care and compassion to one another. A similar observation was made by (Farley, 1994) on how children from Russia and America shared thoughts, ideas, pictures, and friendships in letters criss-crossing the two continents. Using technology and mobile game play as a tool to facilitate this understanding is effective with and for children because children love to use technology and are known to be able to pick up new things quite quickly (Plowman et al., 2008)**.** Having pen pals used to be very popular in the past where people exchanged letters to strangers to learn about each other and become friends. Fewer people do this nowadays due to the advancement of technological platforms and social media although there are sites like ePals (https://www.epals.com) where teachers can locate email pen pals for children in their classes, but these are designed primarily for education and for the learning of English as opposed to simply cross lingual chatter.

The technology imagined and explored through this thesis is a mobile application where children can reach out to other children from different countries, talk to them in their own languages, in order to share life stories and learn about each other.

1.2 Research Aims

This project investigates possibilities for a digital pen pal application for children through the development of a working prototype and a series of empirical and design studies. The main motivation is to explore how such an interface can be designed to both engage children from different cultures, and to not bias one language over another. This combination of constraints is referred to as 'cultural evenness'. Building on previous work by (Sim et al., 2015) on the use of serious games technology and child centred technology design, this thesis explores the design of a chat experience that brings children from quite dissimilar locations together in an environment where each appreciates, and gets a glimpse into, the other's life. The overall aim is to: **Inform the design of culturally even technology to improve children's interactions between different countries.**

To provide an instance of this, a digital pen pal platform for children (DigiPal) is developed using iterative design, informant studies and participatory design methods, that includes elements that both attract the children to use the technology and retain local cultural ideologies and icons. This app is used as a research tool throughout the thesis. The main technical challenge for the design of the chatting app is the translation of language, from Nepalese to English and vice versa. **The study of the effectiveness of translation, and the identification of the constraints** is a major challenge for the work and one that delivers **the primary research contribution**. Other research contributions include insights on the participation of children across cultures in the work and on the design of engagement into the app.

Bringing children together from different cultures, without favouring one culture over another, is not well studied. Research exists that has shown how pen pal activity in different cultures can help children to share but such systems classically encourage the development of English (or other main language) skills. *With translation software, we should be able to ensure that children can communicate each in their own languages.*

This thesis is situated in the field of Child Computer Interaction (CCI) and takes its methods from there and from HCI. Most of the research in the field of designing for children from different cultures is focused on areas like: development of technology keeping different children in mind (Alper et al., 2012; Markopoulos et al., 2021; Mazzone et al., 2008a) and the involvement of children from developing countries in design processes (Druin, 1999; Ferreira et al., 2016; Hussain, 2010); there is still work to be done on adapting methods to work across contexts. *There is still much to be learned by using CCI methods across cultures*

With traditional pen pals, there was a problem of maintaining of engagement over different time zones and different places, this was less of a problem in the olden days when we were used to waiting for (snail) mail, but nowadays everyone wants instant results. This is another area of focus for this research. *It is important to consider how to create an engaging interface that keeps children interested.*

The Pen Pal app is iterated during the research which examines the effectiveness and necessary design of the lens between the two cultures and informs **a model for level, as opposed to uneven, cross cultural and cross language child communication – this is the primary theoretical contribution.**

1.3 Research Questions

RQ: To what extent, and how best, can a chat application be designed to encourage children from different cultures to talk with one another in their own languages?

Sub research questions are:

> *SRQ1. To what extent, and with what limitations and consequences, does automatic translation work with children's chat?*
>
> *SRQ2. To what extent can children, from two different cultures, equally participate in the design of a single application?*
>
> *SRQ3. In what ways can a design ensure cultural evenness whilst also being engaging for children?*

1.4 Methodology

Predominantly the research is adopting a HCI methodology with ‘quasi- experimental work’ interspersed with design and build, prototype evaluation and with research studies. Diverse data is collected and analysed throughout the work. Some of this is used to develop the application for another stage of the study, other data answer the research questions about the effectiveness of translation software and potential add-ons in the app. Participatory sessions were conducted with children to get ideas and useful data to make the app much more child friendly and culturally levelled. The data gave some indication on how easily children are chatting to each other, and on the effectiveness of translation.

1.4.1 Participants

Most of the participants in the studies were children aged 8 – 12 from Nepal and England. The research started with field work in Nepal and England with different cultures thereby working closely with schools, teachers, and children. Ethical clearance was gathered for the work and children worked with teachers in both locations.

1.4.2 Study Locations

The countries chosen for the research were the United Kingdom and Nepal. The UK, and specifically England, is one of the most developed countries in the world with a great deal of child involvement in technologies; Nepal is a poor South Asian country which is developing slowly. The urban areas of Nepal are significantly more developed than the rural parts where children hardly get access to high-level technologies – work was done with children in both urban and rural locations. Studies in the project took place in schools in Nepal and in schools, and in the university, in England.

1.4.3 Technology

Through the study – in line with common HCI practice – there is an application being developed both as a research instrument but also as a prototype that has potential to be developed outside the PhD. This is built for Android based mobile devices. Other equipment used included papers, pens, pencils, erasers, sharpeners for the game design sessions.

1.5 Structure of Thesis

1.5.1 Introductory Chapters

Chapter 1 – Introduction

This is where the motivation, context and research questions are presented.

Chapter 2 - Literature Review:

The works starts with a literature search on the related fields. This includes Culture and Conversation, Child Centred Design and Translation Interfaces.

Under the Culture and Conversation heading of the Literature review, research relating to the definition of culture in terms of children, the design of cross-cultural products, and the implementation of cultural insights into technology is researched. As children are actively involved in the conversation, children's communication in terms of letter exchanges like pen pal and other digital platforms already used and the challenges of text input, including keyboards layouts involved are other key fields in this part of the review.

As children will be involved in the design process of the DigiPal app, the importance of Child Centred Design, designing for children from different cultures, and approaches to include children voices are covered. Capturing drawings during the design process is one of the methods used in the thesis so the literature also reviewed studies and challenges around drawing as a design tool.

The final section of literature looked at the history of machine translation, reviewing available translation tools for DigiPal app to analyse the issues and solutions involved. Challenges with the translation of children's text input and the studies around that are also be looked at.

1.5.2 Research Chapters

The four chapters after the literature review inform the technology design and work towards a multi-layered design model for cross cultural design whilst also answering the research questions.

Chapter 3 - Design and Development of the Digital Pen Pal Application

This chapter contributes towards answering the sub research question: *SRQ2. To what extent can children, from two different cultures, equally participate in the design of a single application?* This chapter also contributes towards the **design of a digital app**. The chapter describes the first ideas for an app that came from the researcher and then describes two informant studies with children. At the end of this chapter there are reflections on the inclusion of children from the two cultures as well as design insights. Methods used in the chapter include informant design with the app used as a technology probe, and quasi experimental work.

Chapter 4 - Translation Possibilities and Challenges

A main aim for the work was to explore ways that children could send/receive the letters in their own language. In this chapter, Google translate is explored for its efficacy with children's text. This chapter contributes towards answering the sub research question: *SRQ1. To what extent, and with what limitations and consequences, does automatic translation work with children's chat?* This chapter also contributes towards the **design of the digital app** in terms of its main findings which are that the translation is good enough for children to understand and that with cleaning of the text as it goes into translation, understanding can be improved.

Chapter 5 – Realtime Digital Letter Exchange: A Study

With translation integrated into the app, the new version is tested with children from Nepal and England where they take part in a real time letter sending activity. This chapter contributes towards answering the sub research question: *SRQ1. To what extent, and with what limitations and consequences, does automatic translation work with children's chat?* by demonstrating that children could carry on conversations even with sub-optimal translation. It also provides some insights as to the sub research question: *SRQ2. To what extent can children, from two different cultures, equally participate in the design of a single application?* and it contributes insights towards the **design of the digital app** as well as towards a general model for design

for **cultural evenness** as it demonstrates that there does need to be some attention to security and the need for engagement.

Chapter 6 – Design for Cultural Evenness

This chapter mainly focusses on design and considers the elements that are needed beyond translation to create an engaging and culturally appropriate experience. The focus is on SRQ3. *In what ways can a design ensure cultural evenness whilst also being engaging for children? which is explored with two informant design studies, with children from both Nepal and England.* The effectiveness of these studies additionally informs SRQ2. *To what extent can children, from two different cultures, equally participate in the design of a single application?* with insights on how to carry out drawing methods. This chapter delivers additional insights, from children's design inputs, for the design of the digital app and informs a general model for design for cultural evenness which is presented at the end of this chapter.

1.5.3 Concluding Chapters and Appendices

The work is concluded in **Chapter 7** where the research questions are revisited, the contributions re-stated and where the limitations, and future directions of the work are discussed. A set of appendices that support the research work is included at the end.

Table 1 & Table 2 below list the different versions of the app with their functionalities and uses in studies and summarize the studies conducted, the tools used in each, and the outcomes towards informing design and cultural evenness.

Table 1. Different versions of DigiPal App and their functionalities

DigiPal Version	V1	V2/V2+	V3	V4	V5
Input / Informed by / Developed from	Researcher	Study 1	Study 2	Study 3	Study 5 & 6
Functionalities	Letter typing, Username, password	Letter sending, User account	Typing experience, App in Nepalese	Translation integration	Images and Game

Table 2. List of studies, tools used and outcomes

Studies	Study 1	Study 2	Study 3	Study 4	Study 5	Study 6
Chapters	3	3	4	5	6	6
Tools used	DigiPal V1	Modified DigiPal V2 (V2+)	Edit distance calculation tool, DigiPal understandability	DigiPal V4	Drawings	Drawings
Output	Observational data gathered	Feedback from children: ideas, improvement, and critique	Accuracy and Understandability analysis	Real time chat analysis, Letters analysis, Observation of children reaction	Introduction	Games ideas
Informing Design	DigiPal V2	DigiPal V3	DigiPal V4	Digipal V5	DigiPal V5	Digipal V5
Cultural Evenness	Presentation Interaction	Presentation Interaction	Translation	Translation Interaction	Presentation Security	Engagement

Chapter 2. Literature Review

The literature review is structured in three parts. In the first section culture, intercultural awareness and tools and ideas around culture are described before looking at how communication – via writing – can support these ideas. In part two, child computer interaction and children as designers and evaluators is discussed. The last section looks at translation. Literature was gathered in a narrative fashion and much of this was sought as papers were developed and studies were being planned. Use was made of Google Scholar, the IEEE and ACM Digital libraries and the journal search facilities at UCLan. In line with other HCI theses, some of the literature specifically about the individual studies in the chapters that follow is placed in the introduction to those chapters.

2.1 Culture and Conversation

In this section literature on culture is presented and an introduction to language as it applies to both different locations of culture and to childhood, is covered.

2.1.1 How is Culture Understood

The main motivation for the work in this thesis came from the author's own experience of moving from one culture to another. As a child growing up in Nepal, and then as an adult living in England, it was not possible to not be interested in the differences and similarities across these two cultures.

Culture is a hotly contested term with many interpretations from communication, sociology and beyond. The anthropologist Alan P. Fiske writes that: "A culture is a socially transmitted or socially constructed constellation consisting of such things as practices, competencies, ideas, schemas, symbols, values, norms, institutions, goals, constitutive rules, artifacts, and modifications of the physical environment" (Fiske, 2002), UNESCO endorsed the definition of culture "as the set of distinctive spiritual, material, intellectual and emotional features of society or a social group, [encompassing], in addition to art and literature, lifestyles, ways of living together, value systems, traditions and beliefs" (UNESCO, 2002). These definitions both show that culture is a many faceted thing. We can refer to a culture in a singular way or to the

cultures of childhood for example. Local culture includes broad socio-cultural factors from national and ethnic cultures as well as subgroup cultures – like the cultures of childhood (Valentine, 2017) and also to culture as it associates with countries (Gellner, 2001). Gellner's reflection on Nepalese culture closes with the interesting observation that "Whichever solutions are attempted, it is clear that Nepalis face a predicament that is common in many other places. At the very time when many minor cultural differences are being eroded and when it makes sense to speak of an emerging global culture, other cultural differences are being politicized as never before."

This points to the complication of 'protecting' local culture and differences (diversity) whilst also promoting cultural awareness and understanding. According to UNESCO's Universal Declaration on Cultural Diversity (UNESCO, 2002), cultural diversity should be considered the common heritage of humanity and, should, therefore, be respected as requirement for an ethical society where individual differences need to be treated with dignity. (Feenberg, 2012) writes how when cultural diversity is valued, this assists in democracy rather than having a homogenous product that obliterates geography and subverts traditional values.

2.1.2 Designing Cross Cultural Products

Cross cultural design is defined as being concerned with globalization, internationalization, and localization (LISAQA, 2007). For a product to be useful on a global scale, it needs to be both internationalized and localized. This requires isolating and extracting cultural context from a product (Taylor, 2012) and then infusing cultural context into the product specific to where it is being used. This infusion covers categories including linguistic issues, physical issues, business issues and technical issues (LISAQA, 2007). There are many criticisms of simply adding a flag to an interface to make it culturally appropriate although there continue to be simple apps that are very specific to local cultures. One example of localization is an app which teaches children about Filipino culture (Paragas et al., 2021). It does this with simple games and activities and it positions the culture of the country as something to be learned. Another localized app is from (Ali et al., 2021) which seeks to teach children Arabic vocabulary in an app which was described as 'Understanding my world'. Interestingly this study encountered difficulties with translation that will be visited in more detail in part 3 of this literature review. (Hoft, 1995) proposes that issues of translation, colour, page layout etc. are

just the tip of an iceberg with many cultural layers' unseen. He takes the view that shallow adaptations to interfaces – like adding a flower – are not enough.

The more complicated aspects of culture have been described in many ways – although there are critiques, Hofstede's cultural dimensions – power distance, uncertainty avoidance, individualism and collectivism, masculinity, and femininity and long versus short term orientation are often used to think about the 'distances' between cultures (Hofstede, 2011). In 2002, in a review of Info sys cross cultural research – 24 out of 36 studies had used Hofstede's dimensions (Myers and Tan, 2002). The same paper criticizes this approach however in saying that such analysis misses 'the actual practice of social activity'. This social activity is included to some extent in Barber and Bader's paper from (1998) in which they coined the term Culturability – the merging of culture and usability (Barber and Badre, 1998). (Tarkka and Tikka, 2001) proposed cultural usability as being a thing that situates the practices of technology within cultural and social contexts. Cultural differences certainly play into usability; people from different cultural backgrounds think differently so designing for that population might raise some issues which need to be addressed (Plocher et al., 2021). (Winschiers-Theophilus, 2009) writes how contextual connotations can affect evaluation as well as design; this is an important point to consider as too often we only think about design. Modelling users (Jagne and Smith-Atakan, 2006) and modelling designs and design processes has been shown to assist in designing for different cultures.

2.1.3 Interculturality and Technology

There have been many approaches to promote interculturality and the widespread use of digital technology has helped in this. One example is from (Sarangapani et al., 2016) in which Cross cultural learning possibilities with the help of videos and smartphones are described. Others include analysis of cross-cultural learning with the help of a fully online intercultural collaborative learning environment and discussion on how the cultural background has an influence on it (Law and Nguyen-Ngoc, 2008), and analysing mobile application usage behaviour depending on different cultural contexts while discussing design and implementation for context-aware mobile services (Qin et al., 2018).

One of the most used approaches to study intercultural awareness is through the use of Byram's model (Byram, 2021, p.131) which contains the following elements:

- "Attitudes of curiosity and openness, readiness to suspend disbelief about other cultures and belief about one's own"
- "Knowledge of social groups and their products and practices in one's own and in one's interlocutor's country, and of the general process of societal and individual interaction"
- "Skills of interpreting and relating: ability to interpret a document or event from another culture, to explain it and relate it to documents from one's own"
- "Skills of discovery and interaction: ability to acquire new knowledge of a culture and cultural practices and the ability to operate knowledge, attitudes and skills under the constraints of real time communication and interaction"
- "Critical cultural awareness/political education: an ability to evaluate critically and on the basis of explicit criteria perspectives, practices and products in one's own and other cultures and countries"

Whilst this was not written with young children in mind, it does help focus on the important aspects of intercultural awareness that include the possibility to question, to interpret and to discover – all elements that will be included in the DigiPal experience. An early example of work to promote intercultural awareness with children was by (Hutchinson et al., 2005) who built a children's digital library in 100 languages with input from children. Challenges in this work included selecting books to include, handling different character sets and fonts, and addressing differences in cultural, religious, social, and political interpretation. Importantly in this work, the research team ensured they spoke to children from many countries and spaces – which will be revisited in part 2 of this literature review. Other papers (Africano et al., 2004) have shown how, when children design for other cultures, they also learn about those other children's lives. Engagement of all children in design and evaluation, and ensuring learning are both positive ways to improve intercultural awareness.

2.1.4 Communication and Written Exchanges

Before digital technology existed, children were encouraged to improve their cross cultural understanding while writing and reading in 'foreign' languages as pen pals (Liaw and Johnson, 2001). The aim of having pen pals was to glimpse into others' lives. (Shulman et al., 1994) reported on how many school-initiated pen pal relationships continued into adolescence and how many of these relationships were considered safe, close, and open. Since digital technology has become commonplace, the use of email and other systems has been promoted to mimic the old pen pal activity. Most studies that are reported promote the English language as a dominant expressive form as they are situated in the context of 'other language learning'. (Mahfouz, 2010) studied email exchanges with 110 university students learning English, and (Yang and Chen, 2007) in a study in Taiwan with 44 10th grade students found that a technology enhanced pen pal helped them learn and improve their English letter writing skills. In Indonesia, the ePals platform (https://www.epals.com/#/connections) was used to train children in English. (Puspa et al., 2022) describe a similar study with Korean children, and (Shandomo, 2009) with children between Zambia and America and found similar kinds of communication patterns. There have also been apps that simply allow children to chat one with another without the language concern. One such app is from (BITAR et al., 2022) who included chatting into an app for children with diabetes.

Several papers touch on what children learn from pen pal exchanges with children from other places. (Barksdale et al., 2007; Lemkuhl, 2002) conducted pen pal letter exchange activities where children shared about themselves, the area around them, their culture, weather, and their favourite things. (Durost and Hutchinson, 1997) highlighted how having pen pals (Keypals) built friendships and (Santiago and Dias, 2018) specifically referred to the extent to which having a pen pal exchange fitted into the government internationalization programme in Brazil. This paper is an example of the willingness to use writing to promote intercultural thinking with children. It resonates with the good practice described in (Montgomery, 2001) which talks about how to make culturally responsive classrooms. She writes in this article that "Through the Internet, second-language learners may communicate in their native language with children from similar cultural and linguistic backgrounds.": This is a core aim for the DigiPal experience. The next section of literature will briefly look at children's writing in order to provide some background to the research work.

2.1.5 Children Communicating by Writing

Children's first communication is oral, and their babble develops into words, typically between the ages of one and two. As they approach pre-school, they start to explore the equivalences of spoken and written language, and then, as they improve their ability to manage pens and writing tools and start to make some sense of spelling, they start to explore the symbolic properties of spoken and written language (Dyson, 1991). Once in KS2 (aged 9 – 11), children's speaking and writing become quite differentiated with written texts lengthening, and with the structure, and rules of writing encouraging planning of written texts and conformance to rules (Daiute, 2010).

Writing is a complex task that requires motoric mastery, knowledge of the symbols used, language construction and grammatical rules (Bereiter and Scardamalia, 1983). It has been observed that children might change their intention in writing when they, for example, feel they cannot spell a word (Read, 2001); this would not be the same when a child was speaking as a child's spoken vocabulary is considerably ahead. Whether writing with a pen, or with a keyboard, spelling is a main challenge for children when using written language systems (Druin et al., 2009).

Nepalese is the spoken language of Nepal and for written texts it adopts the Devanagari script, one of several scripts derived from Brahmi script, which is one of the most known Indic scripts. As early as the 11th century, it became the default script for writing Sanskrit (Daniels and Bright, 1996). Brahmic scripts developed over 2300 years ago and fall into the general category of being Abugida scripts, characterised as being semi alphabetic as they have consonants that follow an arithmetic style but vowels that are positioned before, above and around consonant collections in a syllabic style. This arrangement of the script makes it poorly suited to discrete limited character keyboards and so many people in Nepal type on Latin keyboards using the sounds of the words in a process referred to as phonetic input which is described in the next section. For English text entry, it is possible to talk about spelling errors as the children are writing in a language with spelling rules (Cooper, 2012) although there can be ambiguities. It is important to note that without knowing a child's intention, it is really impossible to know if an error is a slip at the keyboard or a spelling error (Kano and Read, 2009a). With phonetic text entry, spelling errors have no reality.

2.1.6 Keyboard Design and Alphabets

Text entry (text input) is the phrase given to the process of entering text into a computer system in such a way that it can be encoded (usually using Unicode) and then stored, manipulated or presented (Scott MacKenzie and William Soukoreff, 2002). Originally this was done with 'hard' keyboards only but nowadays there are a range of methods including reduced keyboards as found on early mobile phones, soft keyboards as found on smartphones, and recognition based methods like speech and handwritten input; in all cases, the performance of the individual doing the text entry varies with experience (MacKenzie and Zhang, 2001). Whilst keyboard text entry is commonplace, many keyboards only support alphabetic scripts, especially Latin scripts (QWERTY). Non-alphabetic scripts like logographic (e.g., Chinese), abjad (e.g., Hebrew) and Abugida (e.g., Hindu) are poorly suited to standard keyboards as they have very many symbols and complex construction. Soft keyboards, with the potential for layering of menus and prediction, provide an option for such languages and have been explored within HCI (Bi et al., 2012; Malsattar et al., 2014; Tanaka-Ishii and Gupta, 2010). There have been specific research efforts in HCI and elsewhere to build text input systems for Indic scripts, (Joshi et al., 2014; Malsattar et al., 2014); one alternative is to integrate some pen based input as seen in (Qgurlg et al., 2019), but with so many different scripts and many more associated languages, many users of non-alphabetic writing systems have resorted to phonetic writing systems which use the alphabetic (and in most cases Latin) script to enter the 'sound' of a word which is then saved, either as the 'spelt out' sound – relying on the reader to simply know the sounds of the Latin alphabet - or as native written text having been 'translated' by the software into a full local script representation of the word.

Whilst some languages have standardized phonetic equivalents (e.g. Chinese Mandarin PinYin which is even used in their infant language learning (McBride-Chang et al., 2010)), most phonetic text entry is not bound by rules in the same way as many 'native' scripts are, and is very much a transliteration of spoken language – bringing with it all the variations of written language that existed in most languages before written standards were imposed (Aronoff, 1994). Phonetic text entry is fine as long as both writer and reader essentially see the same thing. An example from English might be where a phonetic typist might write 'We wer out' which could be interpreted as 'We wear out' or 'We were out'.

When children without English as a first language are writing phonetically at a keyboard, there is an additional scope for errors of interpretation as they will be less skilled at representing sounds with Latin alphabet symbols than adults will be.

2.1.7 Challenges for Digital Pen Pal Exchanges

In early studies on pen pal exchanges, letters moved slowly across the globe. (Barksdale et al., 2007) conducted a letter exchange activity with children between Malawi and America where the researcher had to travel back and forth with the letters; the children exchanged 7 letters which took around 3 years. Early prototypes showed that mobile technology was a good choice for pen pals; e.g. (Piernot et al., 1995) designed a tablet like prototype for children aged 4-5 that let them search images in the internet and send them along with the sounds. A challenge of always on technology is that children expect instant responses. According to (Yarosh et al., 2010), communication in different place and time is complex; there are delays and lags in the communication. In Yarosh's work, children from different locations were video conferencing to engage them in social free play. Though they hesitated and were self-conscious initially, later they were enjoying, interacting and reacting to each other's activities and being creative as well. This gives an idea on how children can interact with each other and can have a playful experience even when they are not present in the same place. The children were successful in this interaction but still faced some challenges like visibility, attention and intersubjectivity that are present in face-to-face play. In one study, two wireless dolls were designed and placed in two different places where the local doll copied the remote doll but this was not engaging enough; co-play only occurred if the children were given an additional synchronous audio connection (Bonanni et al., 2006). Another investigation, where the participants were playing a social game over video conferencing, found that there are some challenges like social distance, signalling to remote partners and managing attention (Batcheller et al., 2007).

2.1.8 Conclusions on Culture and Conversation

In this section of the literature review, what is culture, and why it needs to be protected, is discussed. These lead to the importance of having cross cultural products. Research around this included designing apps and games. Culturability, interculturality and technology are other fields that are also looked at for cultural usability and intercultural awareness.

Intercultural awareness could be achieved with the help of intercultural communication. Pen pal exchange and email exchange are examples that have been researched. While it is acknowledged that children could communicate with video, photos and sketching e.g., (Rutta et al., 2019) the aim for this PhD work is to explore text conversation and so this is a limitation proposed in order to bound the work. Children communicating using those methods need to use writing or typing, with typing being the most preferable method with the advancement of technology. Spelling mistakes and language immaturity are likely to be the key issues with children writing which will need critical attention and consideration.

Children from different countries and cultures often have different first languages with different alphabets and different types of keyboards. Sometimes the keyboards are complex to accommodate all the alphabets and signs present in the script, so users use a phonetic writing system for simplicity. One issue with phonetic writing is that these don't follow any rules and may vary person by person which means understanding a piece of text will mainly depend on the context. Spelling mistakes, along with inconsistency in writing, will put a challenge on the success of Digital pen pal exchanges. Other challenges that might occur are translation complexities that arise because of the issues mentioned above.

2.2 Child Centred design

In this section, literature on child centred design is presented that covers why children need to be included in this work, outlines work that has informed the choices made in this thesis and details some of the methods used.

2.2.1 Importance of Child Centred Design and Working With Children

In the field of system and software development, the user’s voice is always heard. Software development companies always care about what the users want or like and spend quite a lot of

resources to make sure to understand the user's need. Afterall, user satisfaction is the key to their success. The participation of end users in the design or evaluation of products is core to HCI and is considered an activity worth doing and worth reporting on. The inclusion of children in the design and evaluation of their technologies is considered especially valuable as they bring insights into product design and development that is from their own experiences, their own contexts and expressed in their languages, however their inclusion has to be considered carefully (Bekker et al., 2018). Children think differently than adults as they are still learning about different aspects of the things around them. They are not only curious and inclined towards learning about the everyday world but also have critical cognitive skills involving scientific reasoning (van der Graaf et al., 2015). Due to this reason, child perspective research has increased in recent decades with an interest of listening to children's experiences and views with children being considered as the social actors in their own lives rather than the passive result of socialization. (Honkanen et al., 2018) argues how children can act as an active producers of research data which cannot be obtained by examining only adults. Others also debate that children have their own specialties, characteristics and peculiarities as historically, socially and geographically situated (Prout, 2004). That is why research should be for and with children rather than on or about them (Punch, 2002).

Participatory methods with children became popular after the paradigm shift in the social study of children. According to (Cahill, 2004), participatory methods generate better knowledge than other techniques. Previously, children were taken as subordinates of adults, considered as incompetent, developing, and wanting (Lee, 2001); the so-called paradigm shift situated children as competent social actors. (Holloway and Valentine, 2000; John and Susie, 2003) strongly argue that children should be included in a research as active social actors by themselves rather than as a pre-adult (waiting to be competent). It is widely reported in the literature that including children in the design of interactive products is beneficial (Markopoulos et al., 2021).

There are many papers that describe work with children as informants to research and design work. These typically describe either a new way to work with children, (Barendregt et al., 2016; Yip et al., 2017) be it in design or in evaluation, or they describe how children actually contributed to the ideation or creation of a product or system by narrating how ideas come from children either during evaluation or design (Gennari et al., 2017; Pantsar-Syväniemi et al., 2015). Many papers especially reflect on the inclusion of children from marginalized or non-

typical groups (Benton and Johnson, 2015), (Garzotto et al., 2016). Sometimes, researchers use children as co-researchers to clarify an existing idea or theory or to discover the children's perspective. For example (Honkanen et al., 2018) worked with children to research on the subjective well-being in residential areas.

2.2.2 Drawings to Gather Insights – Studies and Challenges

Drawing is a method often used in experiments to engage with children. It has the advantage that it is largely language free, is easy for children to do and it needs no special equipment. When we capture a drawing from a child, we might be looking at their story of an event, their idea for a technology, their interpretation of an experience or their understanding of their world (Punch, 2002). According to (Salmon and Lucas, 2011), art-based methods are very suitable for children because children find it hard to express things orally. Children naturally start to draw as soon as they can hold a drawing utensil. This is their first representational way to express and communicate with the world which is why drawing is a great way for children to express the views and interpretations of their experiences and also their hopes and fears (Farokhi and Hashemi, 2011).

For any drawing activity with children, it is important that they draw freely without constraints. On the study by (Villarroel et al., 2018), children were asked to draw pictures of plants where they were given instructions before the drawing activity on what was expected but once it started, they were left with full freedom on what they wanted to draw. The authors found remarkable results on how much children can express themselves. (Kullman, 2012) also found, in his photo and video taking study, that if children are left free to do whatever they want, they will try new things, be more creative, and even find new ways of using the materials provided.

In drawing research, it is important to be clear what is being asked for as at the end the researcher is the one who does the analysis of the data. Interpretation is a major problem with using drawings in research. As (Buckingham, 2009) explained in his paper, drawings do not give the researcher privilege to get access to what people really think or feel but they have been used effectively within HCI as windows into children's lives and ideas. Interpreting drawings is always easier if the researcher has extra context, like many other papers, (Honkanen et al., 2018) used audio and drawings to gain rich insights. (Villarroel et al., 2018) asked children to draw pictures freely but then sat with them and noted the meanings of the picture that they expressed. This approach really helps to make the drawings much clearer. (Einarsdottir et al.,

2009) found in their research that the combination of both drawing and narrative is proven to be a powerful way of expressing rather than just the drawings. When considering children's drawings of animals, for example, (Profice, 2018) asked the children to say what they had drawn. Interpretation depends on the cultural and linguistic closeness that a researcher has to the children, as an example in (Lamichhane et al., 2018), a Nepalese child drew some small round pieces. This could be anything, but the child labelled it as Momo which is a very popular Nepalese dish, but also something that would have made no sense to a non-Nepalese interpreter.

2.2.3 Asking Children for Ideas and Feedback

Taking a fairly direct approach (e.g., asking for ideas and designs) to involving children in the design of a system being developed for them is beneficiary (Read et al., 1999), (Holloway and Valentine, 2000), (John and Susie, 2003). It is unlikely that an effective game or app can be entirely designed by children, but their input can certainly improve it. It is generally assumed that children's ideas must be integrated in some way with expert technology design. In (Chatain et al., 2019), researchers integrated game ideas from the participants aged 8-16 and collected diverse game designs. In (Read et al., 2016), a study showed that from many game designs only a small number were unique hence it is important to be realistic when including children's ideas. When they are interpreted, do the researchers see only the image or can they abstract more? This is a critical question to consider. Typically input from children is affected by the people they live with, the environment where the study is done and the people around while doing the study. These are other things to be closely monitored while analysing. Social pressure and the adult controlled study session also has some effect on the responses of the children (Punch, 2002).

In working with children in research, children are often acting as evaluators of technology and in so doing are expressing value judgements (MacDonald and Atwood, 2013). Just as there must be a layer of interpretation placed on designs from children of different cultures, so there also has to be care taken when using evaluation methods and philosophies from Western cultures with children from different places. One example where an adaptation has to be made is in relation to the Thumbs up Scale from (Kano et al., 2010). This scale uses thumbs in red and green to help children choose whether they agree with something or not. Culturally this has been highlighted as being non universal (Tipton, 2008). Whilst some papers have explicitly

looked at adapting evaluation methods for (Sim et al., 2015), and doing evaluations with children in different countries (Anokwa et al., 2009), there seem to be no papers that have carried out a matched value based evaluation activity with children across two quite different countries. This, together with designing with two different populations, is an aim of this thesis work.

2.2.4 Designing across Cultures

Children can be encouraged or supported to 'design for others' but this is complicated and is generally less productive than having them design for themselves. Approaches can include the use of personas to describe a population (Metatla et al., 2020) or, as in (Mazzone et al., 2008b), the use of scenarios of 'others' to design a game; the use of others in this case was to mask the fact that the game being designed was to correct their behaviour – they thought they were designing for other children, but actually they were designing for themselves. A useful approach is to intersperse expert design (from an informed adult) with child feedback and insights in a similar way to that described in (Kelly et al., 2006). This approach can speed up the time to product and, especially when children are hard to reach as they may be in different countries, can be cost effective.

There is always a risk that products are designed that do not take account of local contexts but also result in products that are biased considerably in favour of Western ideals and Western content (Ho et al., 2009). This argues for the inclusion of many authentic voices in design; that is to say working with children from the places where the app will be used. Typically this can be both expensive and difficult; (Fisher et al., 2016) worked with children in refugee camps in Jordan to understand Jordanian and refugee culture, (Oyugi et al., 2014) did similar work in sub Saharan Africa. When participatory design work is done with children in cultures that are removed from the Western cultures where techniques were developed, there have to be adjustments made and the event has to be carefully orchestrated to ensure the children stay engaged. Childhood researchers focus on numerous children friendly experiments that make the research fun and relevant to children (John and Susie, 2003; Punch, 2002). These include mapping exercises, child-led tours, role play exercises, photography, model making, story-telling, printing, electronic publishing, drama, puppetry, music, dance, writing skills, diaries, story writing, drawing, mobile app design and so on (Einarsdottir et al., 2009; Kullman, 2012; Profice, 2018; Salmon and Lucas, 2011). This focus on the child's experience helps counter

the argument that participatory methods are largely managed by the researchers not the participants. (Gallacher and Gallagher, 2008) are concerned that participatory methods are in danger of being seen as a 'fool-proof' technology: *'we have not been arguing against participatory methods as such- we have no particular issue with researchers asking children to draw, dance or build – we are simply concerned that such methods are not used naively.'* With children the researcher influences the children due to the power imbalance to participate in a certain way. That is why in any research, it is important to give the full power to the children on how they want to do the task given to them. Proper consideration and planning are needed to determine to what extent decision making can be given to children whilst not to deviate from the aim of the research.

2.2.5 Conclusions on Child Centred Design

Participation of end users, in this case the children, during the design and evaluation process is important. They do see the world differently than adults and can contribute to the research with their special views as an active participant. The challenge is to figure out how their voices can be collected and included. There is always a power imbalance between the researcher and the children as participants which may directly affect the outcome of the study. Giving freedom during studies helps children to be more explorative, creative and makes the activity more fun but too much freedom can harm the research. There needs to be a balance between power and freedom. Drawing is a simple and common method to collect data from children as they can express their views easily on drawings which they would struggle orally. Evaluations need to be planned to ensure that any instruments suit both populations.

2.3 Translation Interfaces

In this section the history and process of translation is described and studies that have examined translation with children's interfaces are introduced.

2.3.1 Translation Introduction

Whilst there are around 195 countries in the world, there are over 7000 languages. In some countries there are many languages, and of course some languages, like English, Spanish and Portuguese are used in geographically distant places in more than one country. More than country barriers however, language identifies a culture. Many mature countries have acknowledged this and have distinct language cultures – take Belgium and Switzerland – where

the language spoken in different areas can almost predict the behaviours of those who live in those regions. It is no surprise that this is the case as different languages come from historical traditions that were carved out in earlier times when people settled in place. Language is so important to identity that many cultures are working hard to preserve and even re-introduce languages which in return preserves the culture itself (Amery, 2001; Mazari, A. & Derraz, 2015).

Unfortunately, languages create barriers to communication and cooperation. Two people who speak two different languages require a bridge that helps them to understand each other. One solution is for one of them to learn a new language (bilingualism), a second option is for both of them to learn a third language, and third solution is to get, and rely on, an interpreter; a third party who takes the spoken words from one person and presents it to the other in the second person's language (Alshamsi et al., 2020).

When interpretation is applied to written language, the word 'translation' is typically used. The advantage of translation over the other two bridges to communication (bilingualism and foreign (third) language) is that the effort is moved from the communicating partners to an external party who has extensive knowledge (Yamashita and Ishida, 2006). The disadvantage of translation is that it has traditionally been an expensive task taking considerable time and effort. Indeed, the cost of translation, amidst globalization, has encouraged the rise of International English as a third language for communication but opponents of this point to its own cultural past and see its growth as a form of cultural imperialism which erodes local identities and imposes a particular view on the populations using it (Wiggins and Carnoy, 1975). A second significant problem with English as a foreign (third) language is that it naturally causes an imbalance towards those having English as a first language which can have the effect of making the non-native English speaker feel disempowered or even disregarded (Bradac, 1992).

Cross cultural communication benefits from being language free where possible. This can be facilitated with the help of language translation techniques. (O'Haggan and Ashworth, 2002) explained how translation - mediated communication is becoming popular and argue that all languages should be preserved by the help of language translation. Cross cultural communication is always difficult when the two cultures do not share a common language (Ho et al., 2009). Classic solution to this is to remove language barriers by either using International English and translation technologies or by using image-based interfaces. Whilst these fixes go some way towards making interfaces useful across cultures, they only account for cultural

variety on a surface level and do little to mitigate away from a deep-seated Western paradigm of interface design. Most technology products fail to include cross cultural equity (Piernot et al., 1995).

Language translation is especially difficult when the intended users of the technology are children. Children will typically be much less proficient with a second language and the errors and mistakes they make in their own languages will make any automatic translation more error prone (Read et al., 2002). On top of that children tend to make many mistakes while typing as seen in (Lamichhane and Read, 2017), where an experiment with fifteen 7- 8 year children resulted in a total of 18 spelling mistakes, which is considerably high.

2.3.2 History of Machine Translation

The phrase 'Machine Translation (MT) of language' refers to the process by which a machine can take a word or phrase from one language and can 'convert' it into another language whilst retaining the meaning. It was first suggested in the early 1930s; at that time systems were mechanical and not computational, and progress was slow (Hutchins, 2005). In the early days of MT, there was a belief that translation could be fully automated and always deliver 100% accuracy - but even with modern technology, this has not been possible to achieve although great strides have been made.

Early translation software worked on a word by word basis and then later with a phrase by phrase approach with most translation being between languages with Latin scripts and with the main engine of translation being statistical modelling which presented 'best guess' results (Zens et al., 2002). Statistical modelling presented the 'most likely' candidate word for a word and so was reliant on having a corpus of text from both languages in order to 'make that guess'. Once it was understood that the context of a sentence added hints as to what a word should translate to, advances towards phrase level translation were seen. For example (Nakamura et al., 2006) looked at the translation of English to Japanese or Chinese using 600000 travel related sentences. They achieved high accuracy by splitting long sentences into multiple sentences and translating them back. (Koehn et al., 2003; Zens et al., 2002; Zhou et al., 2011) all found that the phrase-based translation was more accurate than word based. They used English, German, French, Finnish, Swedish and Chinese languages to do their analysis. They concluded that phrase-based translation was better able to capture contextual information and thus translate accordingly (Zhou et al., 2011).

At that time, translation was still struggling with non-Latin alphabets and languages. One example was when researchers were trying to translate from English to Persian (Komeili et al., 2011). In this work, the researchers had to incorporate human intervention in the translation to make it more appropriate. It was during this time that the translation community scrapped the unrealistic idea of having a fully automatic translation system that would completely replace human translators. The idea of computer assisted translation (CAT) (van Rensburg et al., 2012) was touted.

Neural networks gave additional power to translation. (Sato and Nagao, 1990) proposed an idea of memory-based translation where expressions were matched to combinations of fragments of translation examples. The system selected the best translation on the basis of scores given to each translation based on the matching expression. (Cho et al., 2015; Kalchbrenner and Blunsom, 2013; Sutskever et al., 2014) have all published on neural networked MT based on an encoder-decoder system for each language pair. Whilst accuracy was improved, they still struggled with unknown and rare words (we can say newly evolved words as language is constantly evolving).

2.3.3 Google Translate

With the advent of AI, translation software has been able to become highly available and adaptive. Google translate (GT) is the most used translation engine in the world; first introduced in 2006, it is a web-based machine translation service which currently translates between over 100 different languages. The translation is at a sentence level meaning that when words are translated that do not make sense in a stream, one or more may be altered in order to create a sentence that makes sense; this makes it ideal for ‘faithful’, as opposed to ‘literal’ translation (Newmark, 1988). In 2016 Google enhanced its product by adding neural machine translation, (Bahdanau et al., 2015), which uses deep learning techniques and example-based machine translation to translate the whole sentence with better accuracy with the help of end to end artificial neural networks. For every translation, Google looks for patterns in millions of examples and decides which words to choose and how to arrange them. Since GT learns from millions of examples, it becomes more accurate day by day. To improve the translation, Google has implemented an interactive feature where the user can amend the translation which is then saved in the database for future reference. GT has been evaluated in a range of academic papers, but these have primarily been with adult text. Examples that have included non-Latin text

translation include evaluations of the effectiveness of GT for English into Bahasa (Nadhianti, 2016), and from English into Arabic (Jabak, 2019). Machine translation has reduced the cost of translation and is now very accessible due in part to the efforts of Google, Facebook and others who have established inclusive and easy to use systems. For example, Google translates over 150 billion words each day and is widely used for business and leisure with clear benefits in real time translation like in healthcare settings where it has enabled communication between individuals with no shared language (Kapoor et al., 2020). When children are trying to communicate, given they will be unlikely to be proficient in several languages, machine translation offers interesting possibilities.

2.3.4 Uses of Translation with Non-Latin Languages

Translation is not without complexities. It is widely reported that machine translation has difficulties with accurately translating meanings – especially with unstructured or poorly constructed text and with minority languages (Anggaira, 2017), and critics of machine translation point to its biases towards English language structures and its potential for misuse (Yanisky-Ravid and Martens, 2019), however it has revolutionized the way adults manage unknown languages with menu translation (Fuentes-Luque, 2017), social media translation (Coretti and Pica, 2019) and website translation (Jiménez-Crespo, 2013) all being widely used.

For non-Latin languages, it is not clear which translation tools are the best. (Fitria, 2021) conducted a review of machine translation tool considering Google Translate (GT), Collin Translator (CT), Bing Translator (BT), Yandex Translator (YT), Systran Translate (ST), and IBM Translator (IT) where the researchers fed Indonesian text into each translator and reported similarities and differences. They were unable to recommend one translator over the others on the basis of their work. This is not surprising as the nuances of different translation tools mean that where one might provide a very satisfactory translation of one piece of text, it may poorly translate a second piece of text. Having said that, a systematic review of 27 papers by (Rivera-Trigueros, 2021) concluded that Google Translate was the most used tool (over 50% of the papers reported using that), with translators and products offered by Microsoft, and specifically trained systems, accounting for a further 25% of the analysed works. Given it being most used, one can hypothesise that Google Translate may also be learning at a faster rate than other translation tools. Google Translate has been used by medical doctors while dealing with

patients who speak different languages due to its ease of use, the fact that it is free to use, and the flexibility it offers (Moberly, 2018).

2.3.5 Accuracy of Translation

One setback for MT is that it is often not accurate and can sometimes be misleading as well. Terms can be translated into new meanings and this can result in a whole sentence being changed. (Evans, 2004) did a study on translation errors that showed that full equivalence of translations between languages is very rare. Especially when technical terms are translated, there is a high risk of mistranslation and misunderstanding. The writers used accounting terminologies to illustrate these points. The accuracy of Google Translate is questionable. In examining translation accuracy, methods include back translation (where a phrase is converted into and out of the other language and matched), as well as comparisons with human translation. (Douglas and Craig, 2007) found issues with back translation in terms of the comprehension and meaning to the respondents. In another study, (Groves and Mundt, 2015) recruited some students whose first language is not English and asked to complete their assignment in their first language which was later translated to English using Google translate engine; they found that the translated English text had many grammatical errors. (van Rensburg et al., 2012) translated 6 different texts from Afrikaans to English and vice-versa using Google translate and concluded that the translation system needs a lot of improvements in their quality. Researchers also looked at the translation between English and Arabic. (Abdel Azim ElShiekh, 2012) analysed the results from the translation and found out the translation had errors such as identifying Arabic vowels, struggling with long and complex sentences etc. Translation of text is a mechanical process and so is not directly altered whether or not the writers or recipients are children. Papers that have examined the effectiveness of Google Translate in communication tend to focus on the errors; for example highlighting ‘defective translation’ (Rodríguez-Castro et al., 2018), and translation being gibberish (Stapleton and Leung Ka Kin, 2019).

2.3.6 Machine Translation with Children

Machine translation has not been extensively studied with children's writing but studies of children's use of recognition systems, which can cause errors in 'translation', do suggest that children may be very sympathetic and forgiving of the errors and not too upset (Read et al., 2003, 2002). This is probably a good thing as studies in text entry work on children have shown that children make many errors, which would have an impact on any translation task (Kano and Read, 2009b, 2009a). A positive side to machine translation for children, who might be involved in a real time chat, is that what might be considered an error of translation may in fact create a space for invention and may keep a conversation going on account of its ambiguity (Kohl and Ouyang, 2020; Reynolds et al., 2020). In a multicultural workshop with children, where they were using machine translation, researchers found that the children were using alternative translation, hand gestures and internet browsing to find pictures for mistranslated texts or sentences or objects (Pituxcoosuvarn et al., 2018). As alluded to earlier, the way text is entered at a keyboard will have implications for translation. If phonetic input is being used there can be a layer of complexity introduced where children may be slightly unfamiliar with the sounds represented by the Latin keyboard. One example is (Matsuda and Kitamura, 2009) where due to complexity in the native language (Kanji), Japanese children typed in Hiragana (simplified keyboard) which was then converted to Kanji and then to English. Problem occurs when children use different / abbreviated spellings while chatting as described in (Bushnell et al., 2011). Another difficulty with translation when the users are children is that the end-user won't know whether the translation is accurate or not unless the user also understands the grammatical accuracy or acceptability of the target language (Williams, 2006).

Studies of the effectiveness of Google Translate with children are rare; one study that looked at GT to translate language in the classroom evaluated it from the point of view of its usefulness (Dagenais et al., 2017). Usefulness is an interesting concept to apply to translation. In creating a cross cultural interface, this is perhaps more important than accuracy, after all, in communication it simply has to communicate the essentials (Nagro, 2019), so when there are no essentials it can become a tool for creativity and play. Literary experimentation is one playful approach where text is put into a translation tool with no expectation of anything that resembles correctness (Małecka and Marecki, 2018). Prismatic translation, (Reynolds et al., 2020), is a term given to the process by which translation opens rather than closes and in which what might ordinarily have been considered errors are simply part of a creative experience. The

basic idea behind Prismatic Translation is that translation works differently with different languages and is inherently creative especially where speaking and writing interact in non-European ways (as in Nepalese). It assumes that whilst translation can be right or wrong – that is to say a piece of text can have a meaning that can be conveyed - translation also generates change, and the significance of a translation is generated only in collaboration with the reader (recipient) of that text who makes approximations and adjustments.

In this study, while exploring cross cultural chat with children, facilitated by Machine translation, it is considered that there will be ambiguity and uncertainty around automatic translation as something to work with rather than work against. With the uncertainty in a message for example, the interest is focused on how that might provoke a reply and keep the dialogue going. This work seeks to instantiate machine translation in a pen pal application for real time translated chat (Crawford and Kirby, 2008; Flowers, 2015).

2.3.7 Conclusions on Translation Interfaces

Translation software is getting better and better every day with new approaches and technology, but it is still struggling to do the job without error. Even Google Translate which uses the most sophisticated translation phenomena experiences mistranslation that leads to misunderstandings and can be dangerously misleading.

Translating children's text is an even more complex issue as they tend to make several grammatical and spelling errors while typing which has a direct impact on the accuracy. There have been very few studies done that have explored the accuracy of MT with children's text. Some researchers argue a valid point that it's not always about the accuracy, if the translation includes the essentials and is understandable then that's a win as the goal – which is to communicate – has been met. Studies exploring the understandability of children's translated text have not yet been published.

2.4 Conclusions

Research has shown that there are questions that need to be explored in relation to designing a cross cultural chat interface for children. These questions hinge around the extent to which children can equally contribute from two quite different countries and the extent to which translation can be useful.

The Digital pen pal app that is being built for children should reflect and include the children's views; this will be achieved by involving them during the design process. The research and evaluation studies will be conducted in a way that the children get maximum freedom so that they can express their views without hesitation. To make sure that contributions are captured clearly and completely, narrative approaches will be implemented in the studies where the participants can explain their views. Drawing studies will be conducted to gather children's design ideas.

Translation functionality will be implemented within the App so the children can talk to each other in their own language. The most favourable translation software needs to be chosen and analysed to see if it does the job needed for this project. This includes looking at the accuracy of translation and the understandability.

Chapter 3. Design and Development of the Digital Pen Pal Application

3.1 Introduction

This chapter contributes towards answering *SRQ2. To what extent can children, from two different cultures, equally participate in the design of a single application?* This chapter also contributes towards the **design of a digital app**. The chapter describes the first ideas for an app that came from the researcher and then describes two informant studies with children. At the end of this chapter there are reflections on the inclusion of children from the two cultures as well as design insights. Methods used in the chapter include informant design with the app used as a technology probe, and quasi experimental work.

Some of the work from this chapter is published in the following paper:

Make Me Messenger: Critiquing Children as Design Informants

Authors: Dev Lamichhane, Janet C Read
Conference name: International Conference on Human Interaction and Emerging Technologies, April 2020
Pages: 225-231
Publisher: Springer, Cham
Publication date: 23/4/2020
Digital Link: https://link.springer.com/chapter/10.1007/978-3-030-44267-5_34

3.2 Development of DigiPal Version 1

DigiPal Version 1. was developed both to be a design contribution but also as a technical probe for data collection. A first version of the app was therefore developed without the participation of the children in design process. The app was designed to run on an Android phone and developed using Android studio. There was no particular reason behind selecting the platform (iOS/android or any other) or type of app (native/web) aside from the author's skill available. A decision was made for the first version to include an alphabetic keyboard as Nepalese children are familiar with using such a keyboard which they use to input their own language phonetically.

3.2.1 Interfaces/Pages in the DigiPal Version 1

DigiPal Version 1 was made up of three pages.

Page 1. When the App started, the page shown in **Figure 3** opened up which acted as a landing page. It had a small instruction saying "Click here to Start" which on click would take the user to page 2.

Page 2. This was the letter typing/sending interface **Figure 4 & Figure 5**. The user could type their letter on the top section of the page. After finishing typing, the page could be scrolled down to where they would put their name/username, create a password, confirm the password and click send to send the letter. The app would then go direct to page 3.

Page 3. After the letter was sent, the user would get the 'letter sent' notification. The NEXT STUDENT Button on the middle of the screen (**Figure 6**) indicated that it was now the turn for the next participant. When the button was clicked, page 1 opened up again for the next participant.

Figure 3. DigiPal Version 1 First page

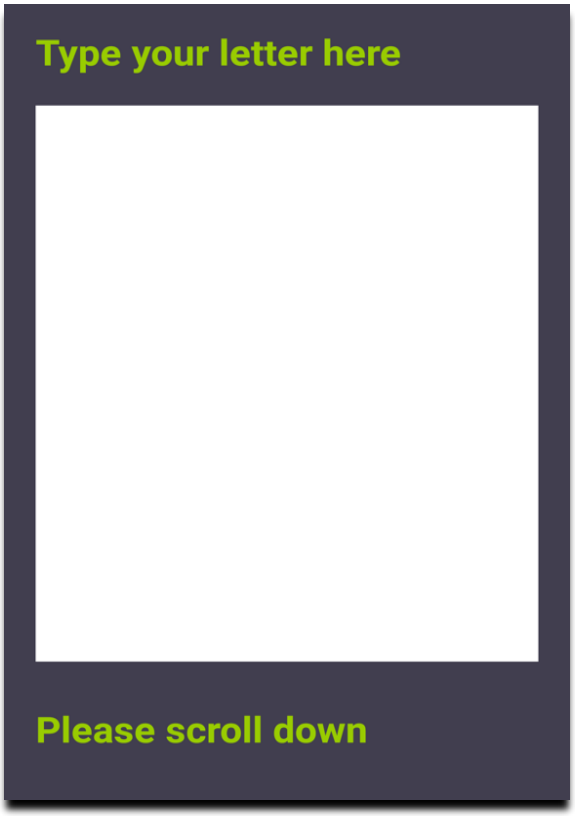


Figure 4. DigiPal Version 1 Second page top section

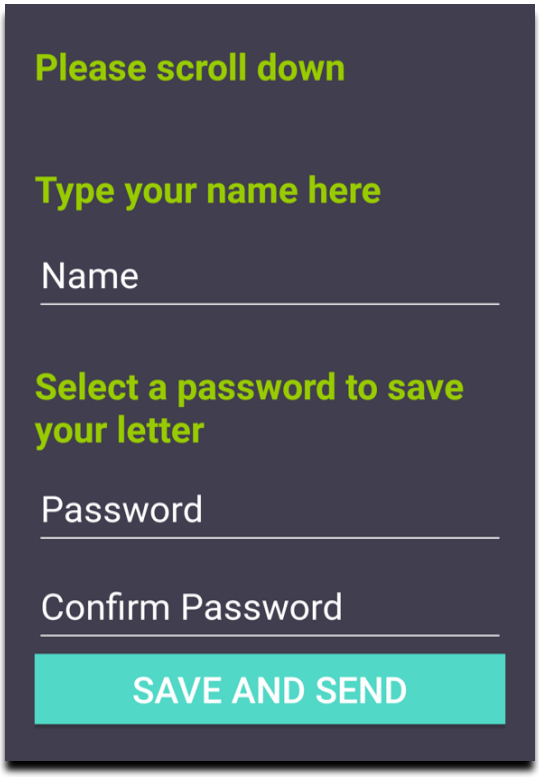


Figure 5. DigiPal Version 1 Second page bottom section

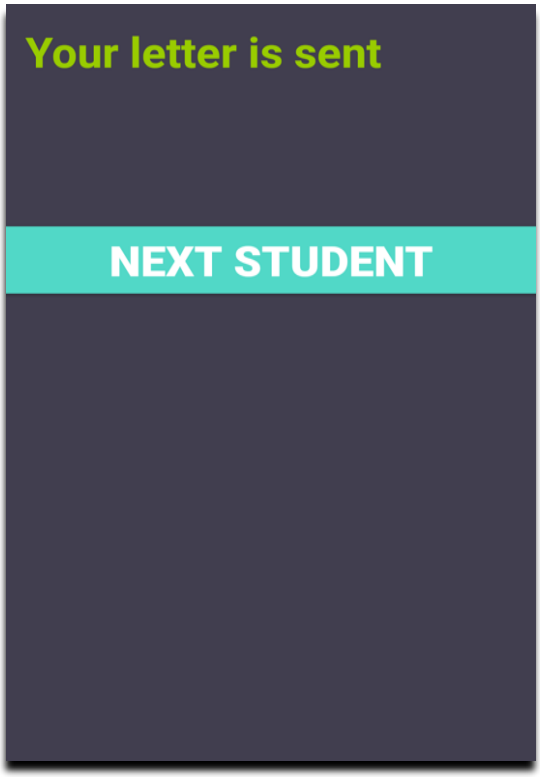


Figure 6. DigiPal Version 1 Third page

A simple database with a table was created to store the letters for future use. Neither the usernames nor the passwords were stored in the database.

3.3 Study 1: Using DigiPal V1 as a Technology Probe

This activity was run to see how comfortably children typed and to explore the language and words they used. Android mobile phones (Make: Cubot Magic, Screensize:5”), equipped with the DigiPal Version 1, were used for this activity.

3.3.1 Method:

Thirty-one Nepalese children from a school in Khotang, a rural village in Nepal, and 27 English children from a school in Preston, a city in England, participated in this study. Consent and ethics were cleared with the respective bodies, the schools and the parents prior to the study in both cases. All the participants were aged between 8-12. On the day of the study, the Nepalese children were put into a classroom of their school to join a series of activities. In the case of the English children, they were invited to the university to take part in several activities in

which one of them was this study. Note that these two studies were asynchronous activities and took place on different days – the author of the thesis was at both.

Due to there being a limited number of Android devices available, only 6 participants at one time did the activity while the other participants were involved in other activities. For the activity, each child used a mobile device with the DigiPal app installed and running. Both sets of participants (English and Nepalese) were asked to type a letter to an imaginary friend introducing themselves. They were given 20 minutes each to complete this activity. After they completed typing their letters, they entered their name and a password to send the letter.

Once the child got the letter sent notification (page 3), the device was passed to the researcher and then handed to the next child. The sent letters were stored in the database table created on a secure server.

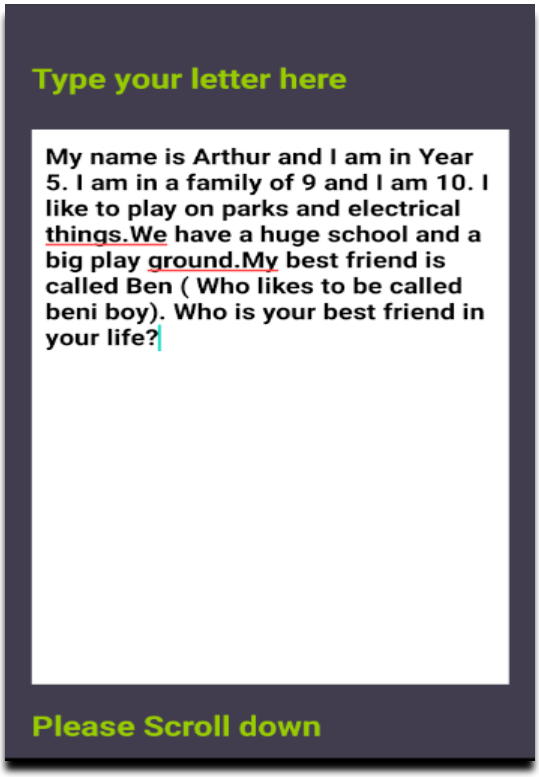


Figure 7. DigiPal Version 1 English letter

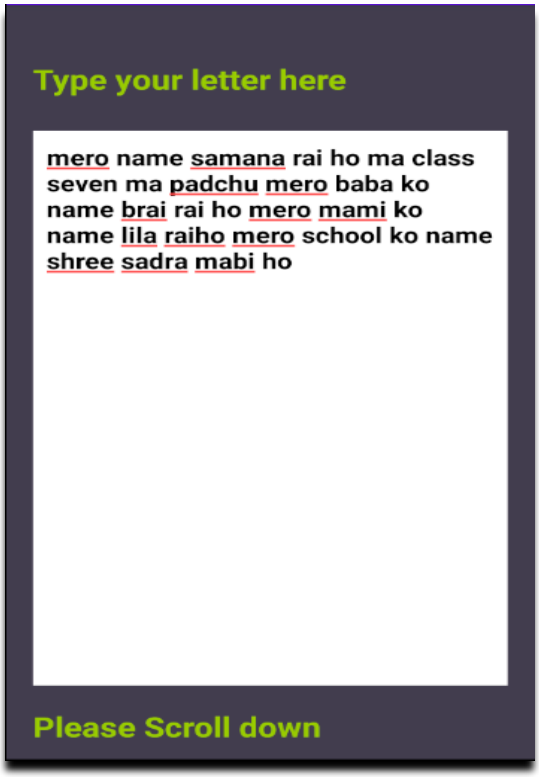


Figure 8. DigiPal Version 1 Phonetically typed Nepalese letter

3.3.2 Results and Discussion:

From observation, everyone enjoyed the activity, and no one seemed to struggle typing and they all finished writing their letters before the allocated time. Some English children were asking for the spelling of some of the words.

The Nepalese children typed phonetically so spelling wasn't a thing – phonetic typing is normal in Nepal due to the complexity of managing a Nepalese keyboard. **Figure 7 & Figure 8** show examples of typing.

The Nepalese children didn't ask if they needed to type in English or Nepalese. They just used phonetic because this is what they use and it's kind of habitual to them. The short letter typing activity informed that the children in Nepal were happy to type using such a keyboard, albeit not very speedily.

Table 3 shows the number of characters and words present in the letters that both Nepalese and English children typed. For the same amount of time (20 minutes) given to each group of participants, the English children wrote longer letters compared to the Nepalese ones.

Table 3. Total number of letters and words typed by the children

	Nepalese letters				**English letters**			
	Total	**Average**	**Max**	**Min**	**Total**	**Average**	**Max**	**Min**
Number of Characters	3854	124.3	570	30	7444	275.7	524	94
Number of Words	686	22.1	91	6	1504	55.7	110	20

Design implications:

- The Nepalese children were typing phonetically rather than in Nepali script. This gave a clear idea that phonetic typing can be an appropriate input method for these children which could then be converted to Nepalese and then translated to English in real time letter sharing. In the case of English children, they obviously typed in standard English and the translation will need to be from English to Nepalese.
- The app will need translation functionality integrated which will be discussed in coming chapters.

- After looking at some of the letters from the English children, it was clear that there were several spelling and grammatical mistakes, which is quite normal in the case of children. These may have some effects on any translation - this will also be looked at in upcoming chapters.
- The password typing field seemed to make sense to all the participants. This assured the children that the letters could only be seen by the sender and the receiver. The children seemed to be okay with user accounts in the app which implies that this can be incorporated in the live app to provide some security.

3.3.3 Contribution/Insights for Follow on Work

In this study, both sets of participants were writing letters to an imaginary friend introducing themselves. There was no two-way conversation. It was clear that the participants could write using the app and the study gave us insights into the amount of time needed to write a multi-sentence paragraph. This informed the design of future studies. How they would read, comprehend, and reply to a letter was not covered in this study which informed the design of the next study for a two-way conversation.

3.4 Development of DigiPal Version 2

Based on the observations gathered during that small pilot study, a second edition of DigiPal was developed. Child friendliness and simplicity was maintained in this version; this version of the App included the following interfaces (pages):

3.4.1 Interfaces/Pages in the DigiPal Version 2

Home Page. When the app starts, the page shown in **Figure 9** opens. This has the name on the top, a picture with two coloured envelopes indicating letters and a set of different coloured hands representing children from all around the world with different cultures and languages. It consists of two buttons one for login and another one for registering; these lead to respective pages.

Login Page. Here, shown in **Figure 10**, the users can insert their username and password to log in. The correct credentials take the user to the user page after the submit button is clicked.

New users can click on the Register link, the second option below the button, to go to the registration page.

Registration Page. Users can register themselves in this page (**Figure 11**). They just need to enter the username and password and confirm it to register. After submitting the details and successfully registering, the user is redirected to the login page again for the signing in process.

User Page. After successfully logging in, users are directed to the user page (**Figure 12**) which contains a button that allows the user to read and reply to the letter – which goes to the main letter sending and receiving page and a sign-out button to sign out from the account.

Letters Page. This is the main page to send and receive letters (**Figure 13**). In the top section, all the conversation can be seen. The button on the bottom section can be used to write or reply to a letter.

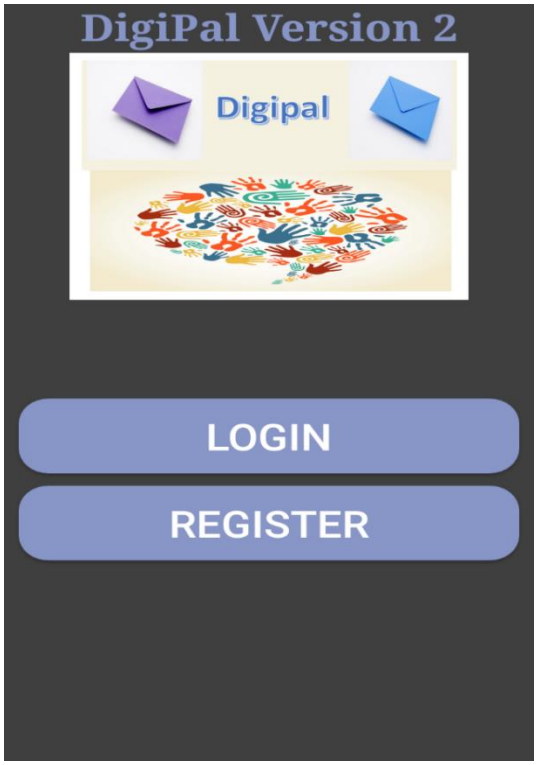


Figure 9. DigiPal Version 2 home page

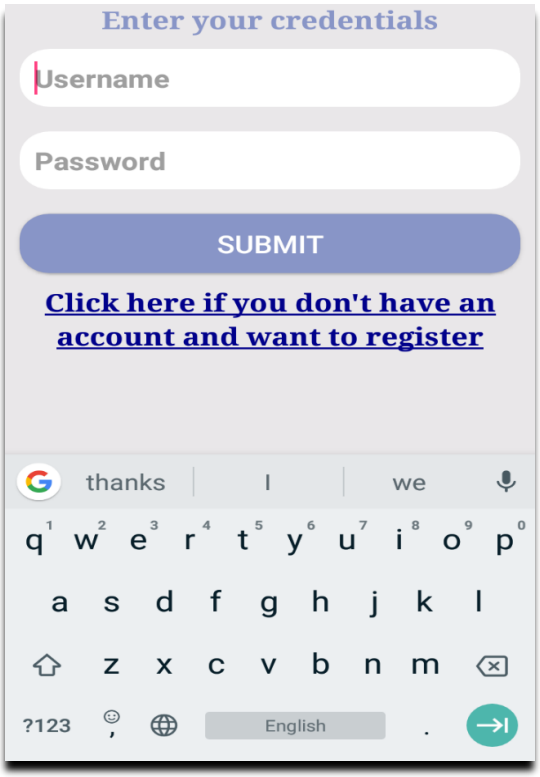


Figure 10. DigiPal Version 2 Login page

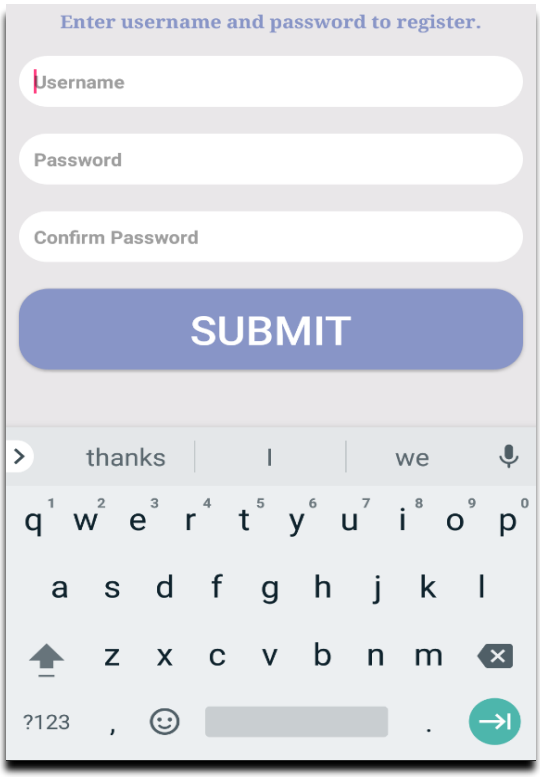


Figure 11. DigiPal Version 2 Registration Page

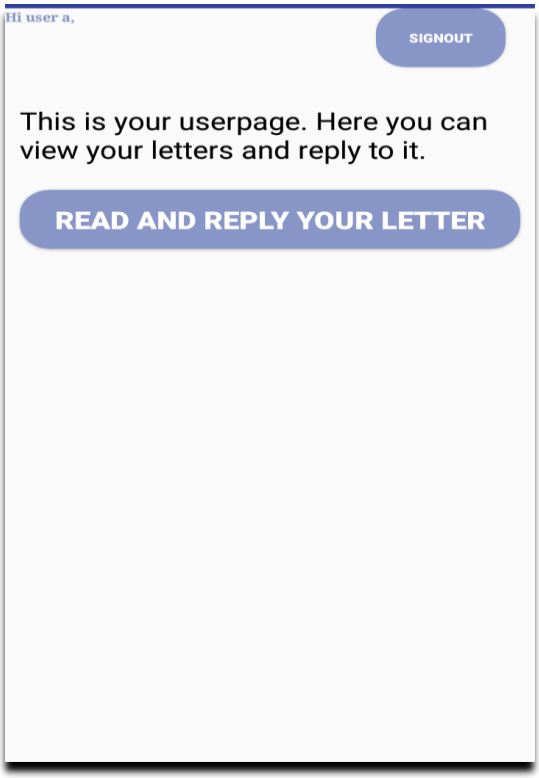


Figure 12. DigiPal Version 2 User page

Figure 13. DigiPal Version 2 Letters page

3.4.2 How the Letter Sending Works

If there are two registered children (user A and user B) talking to each other, the following steps and pictures demonstrate how they send, receive, and reply to their letters.

- User A logs into the app and lands on the user page.
- User A clicks on the ‘Read and reply your letter’ button to write a letter to his partner user B. The letter page opens, which is empty at the moment.
- User A clicks on the ‘Click here to reply to the letter’ button and starts typing (**Figure 14**).
- User A clicks on the arrow button to send the letter once finished typing. The sent letter can be seen on the letters field above it (**Figure 15**). Now user A waits for the reply.
- User B logs into the app (**Figure 16**).
- User B clicks on the ‘Read and reply your letter’ button. Once into the letters page can see a letter from user A (**Figure 17**).
- User B clicks on the reply button and starts to write the reply (**Figure 18**).
- User B sends the letter by clicking on the arrow button and can see the letter gone on the letters field (**Figure 19**).
- User A logs back in and go to the letters page to see if he got the reply and sees it’s there (**Figure 20**).

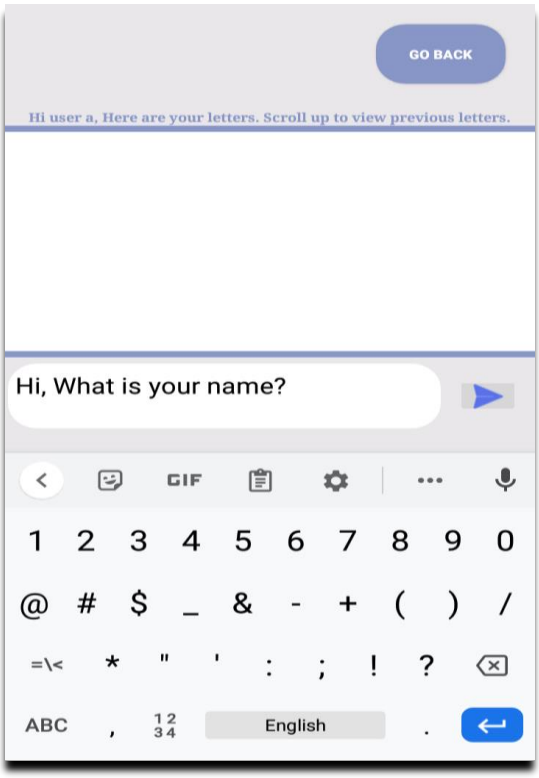


Figure 14. Letters demo: First user typing their letter

Figure 15. Letters demo: First user sent the letter

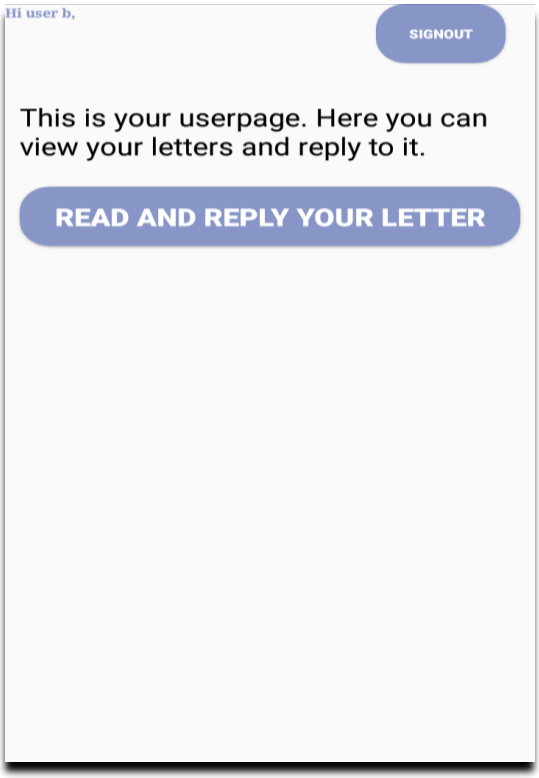


Figure 16. Letters demo: Second user logged into the app.

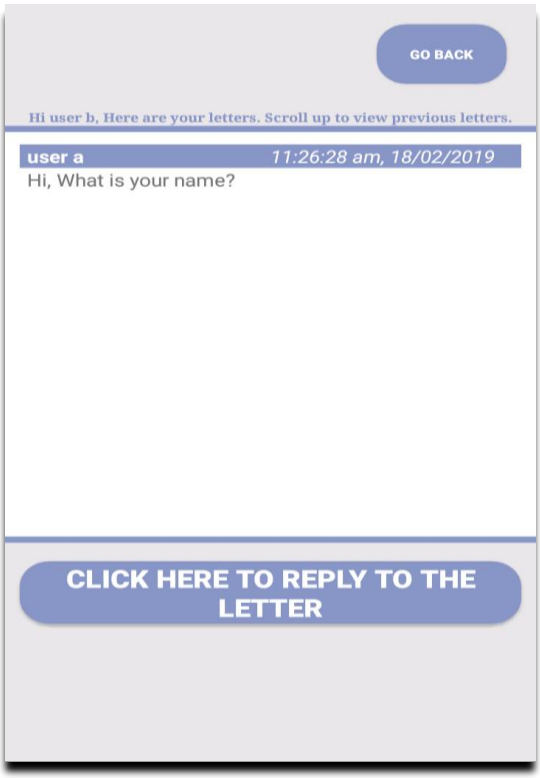


Figure 17. Letters demo: Second user receiving a letter

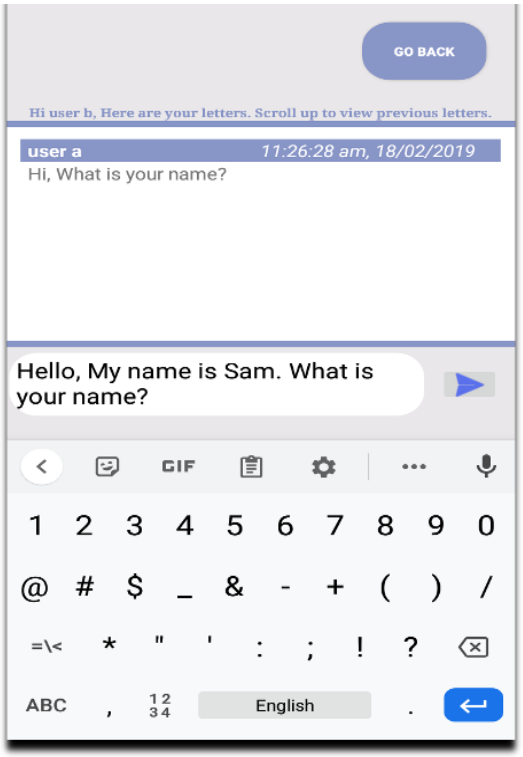


Figure 18. Letters demo: Second user replying to the letter

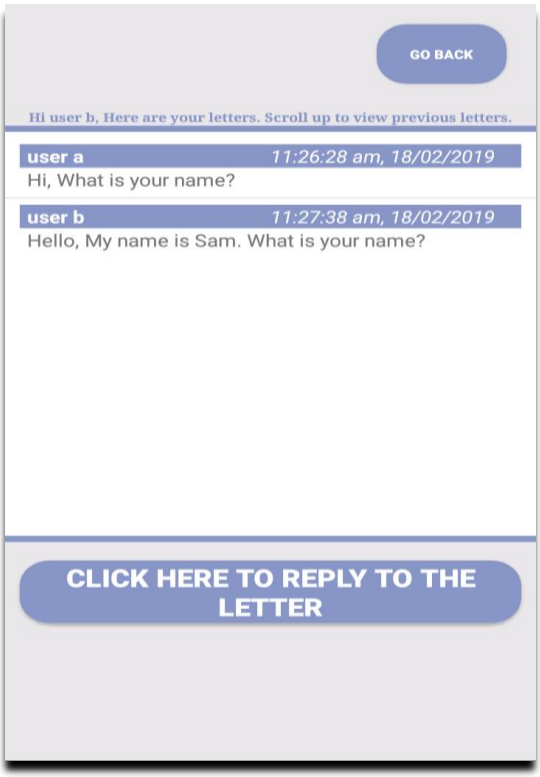


Figure 19. Letters demo: Second user sending the letter

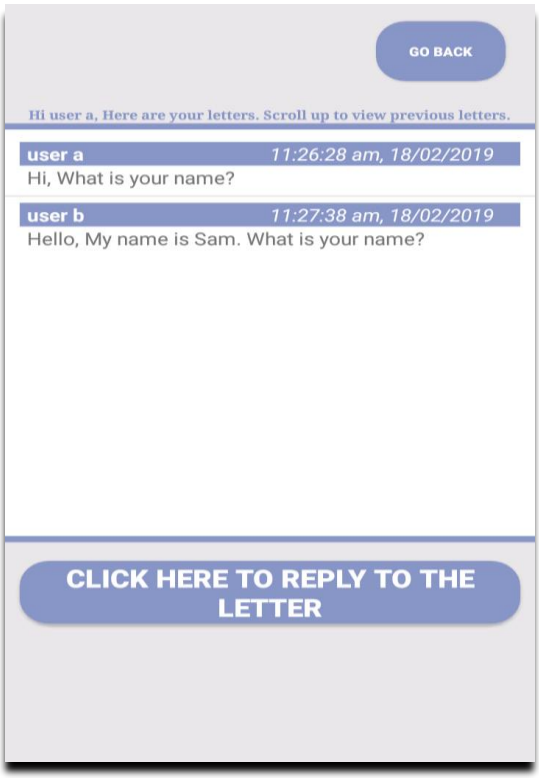


Figure 20: Letters demo: First user receiving the reply.

This version of the app was a simple letter sending and receiving interface with a simple user account functionality. Now the next step was to get feedback from the target user in terms of the design and functionality.

3.5 Study 2: Children Chatting and Acting as Design Informants

In child centred design, it is important to get children's ideas during the design process and listen to their views. One way to do this is to involve the children actively and ask them what they think about the design (Druin et al., 1998). Once DigiPal Version 2 was developed, it was important that children used it and gave some feedback so that it could be updated accordingly.

The aim of this study was therefore to gather feedback on the partly designed app to contribute design ideas and to add child friendly aspects into the App. Two studies, one with the English children and other with Nepalese children, were conducted on two different dates and times but each used the same version of the app so that the ideas given by the children could be compared and consolidated.

3.5.1 Method

In England, the study took place in the Child Computer Interaction Lab of the University over two days where 44 children aged 9 - 11 participated. In Nepal, 36 similar age-grouped children from a school from a suburb area of a small town called Banepa came along to participate in the study which was ran in their own school classroom. The work had been approved by the University ethics committee, and the respective schools, and the children consented, as did their parents, to participate in the study. The children in both activities were told before and after participation that they could personally also withdraw their consent and their data. No children took this option.

Two products were used – Mobile phones (Make: Cubot Magic, Screensize:5") equipped with the DigiPal Version 2 and a data collection form. DigiPal Version 2 was temporarily modified (see **Table 4** below) to work as a chatting app to facilitate the study so that children would chat through the app rather than sending letters. All the other functionality and designs remained the same.

Table 4. Changes in the DigiPal version 2 for Children as design informants' study

Page	Details
Welcome page (**Figure 21**)	Just the Label for the app name changed to add chat.
Registration page (**Figure 22**)	Just a username needed to register
Login page (**Figure 23**)	Just a username needed to login
User page	Remained the same
Letter Page	Remained the same visually but data refreshes every second so that the letter can be seen instantly just like a chat interface.

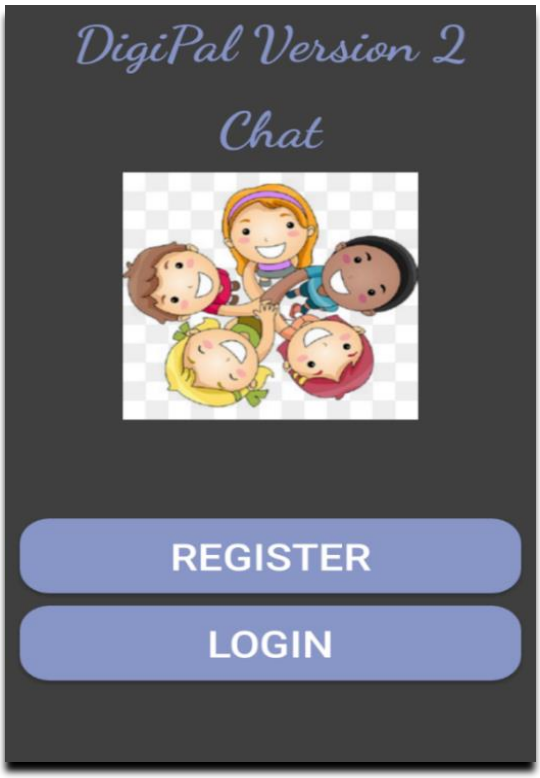


Figure 21. DigiPal Version 2 Chat: Welcome page

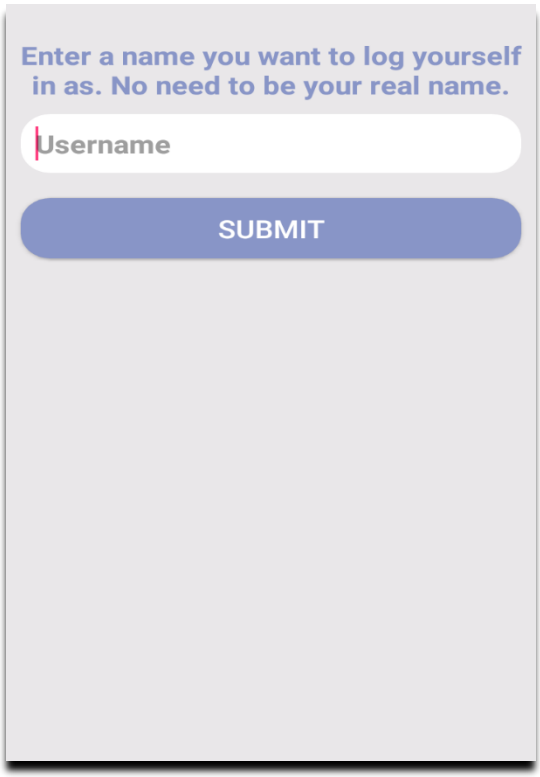


Figure 22. DigiPal Version 2 chat: Registration page

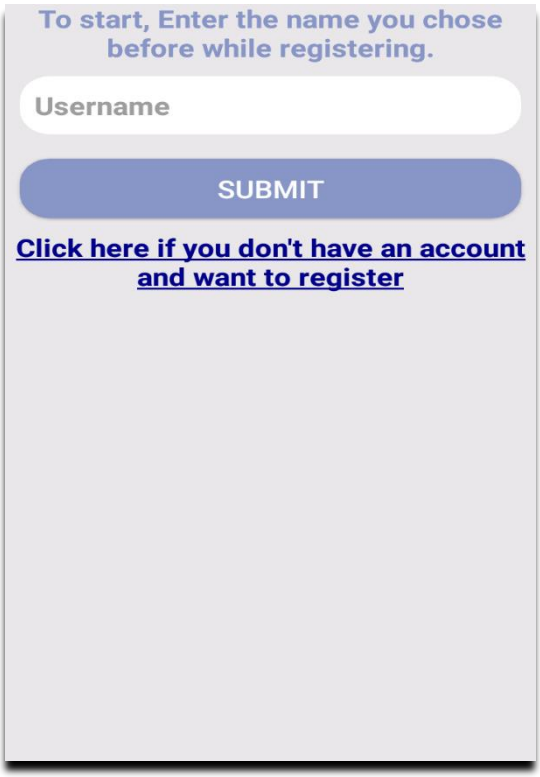


Figure 23. DigiPal Version 2 chat: Login page

A two-page data collection form was used made up of two surveys; one of these was a Smileyometer, inspired by the work of (Read and MacFarlane, 2006). There was also a space for feedback. The pages of the form were therefore as follows:

- Page 1: Before using the app, rate how good the chatting app would be? (**Figure 24**)
- Page 2: After using the app, rate it again on the modified form of the Smileyometer and add ideas to make it better (**Figure 25).**
- In the case of Nepalese children, this form was translated into Nepalese so that they could fill it in Nepalese (**Figure 26 & Figure 27**).

Figure 24. DigiPal Version 2 usability form page 1 English

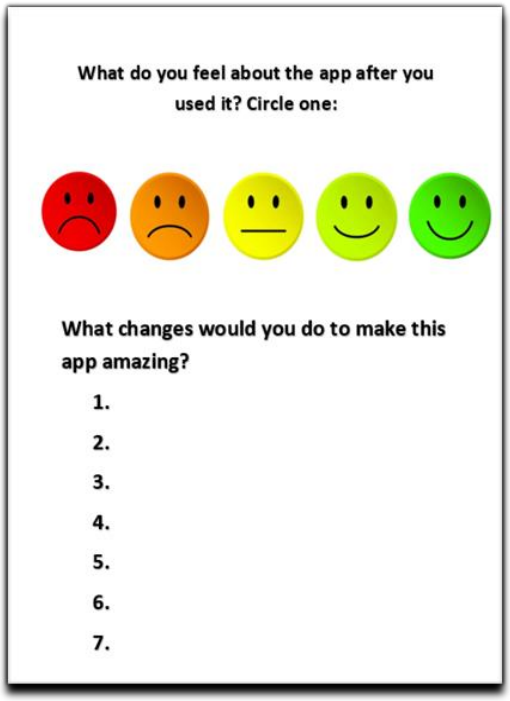


Figure 25. DigiPal Version 2 usability form page 2 English

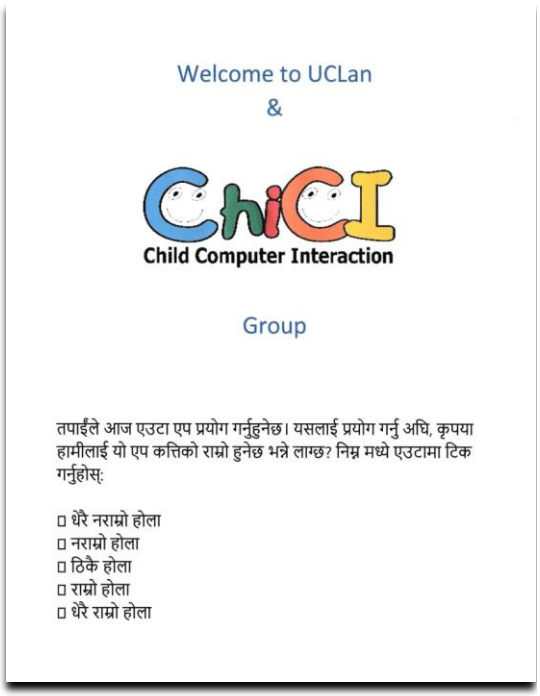


Figure 26. DigiPal Version 2 usability test form page 1 Nepalese

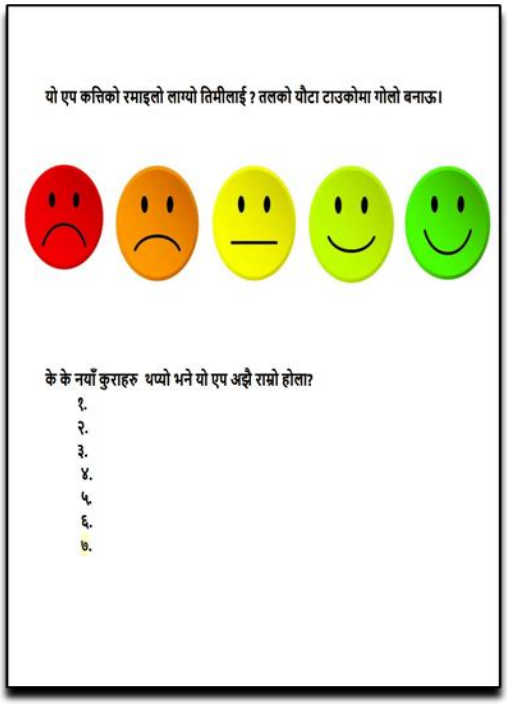


Figure 27. DigiPal Version 2 usability test form page 2 Nepalese

3.5.2 Procedure

A similar procedure was applied to both studies. The children came to the study in teacher constructed groups of 6 at a time due to the limited number of devices (Make: Cubot Magic, Screensize:5") available. The researcher explained the activity to the children and explained what their role would be in this study. To ensure the children were comfortable doing the activity and were familiar with how chat apps worked, the researcher had an informal chat with the group about the Apps they knew about or had used. After ensuring the children were comfortable, each child was given the first page of the data sheet to complete where they were asked to predict how good the app, that they were about to use, would be. After every child had filled this in, each was given an identical mobile phone, with the chat app installed, and was asked to register (they could use any name they want). Having registered, each then chose another child to pair up with and began to use the phone interface, in the room, to chat with one another, so this was a synchronous chat activity. The children were given 10 minutes of time to chat and were encouraged to write about anything (no theme provided). After 10 mins of chat, they came back to the paper and filled out page 2, where they reported their experience and design ideas. If there was any time left after they had completed the sheets, they could return to the app and continue chatting. As each group left the room, the researcher signed them out of the app and got the room ready for the next group.

3.5.3 Results and Discussion

3.5.3.1 Children's Opinions

The opinions of the children, of the app, were gathered by collecting before and after data (see **Figure 28** & **Figure 29**) which allows some analysis as to whether children were disappointed, satisfied or impressed. Applying a score from 1 to 5, with 1 being the least fun, the ratings from both sets of children were gathered (see **Table 5**) and analysed.

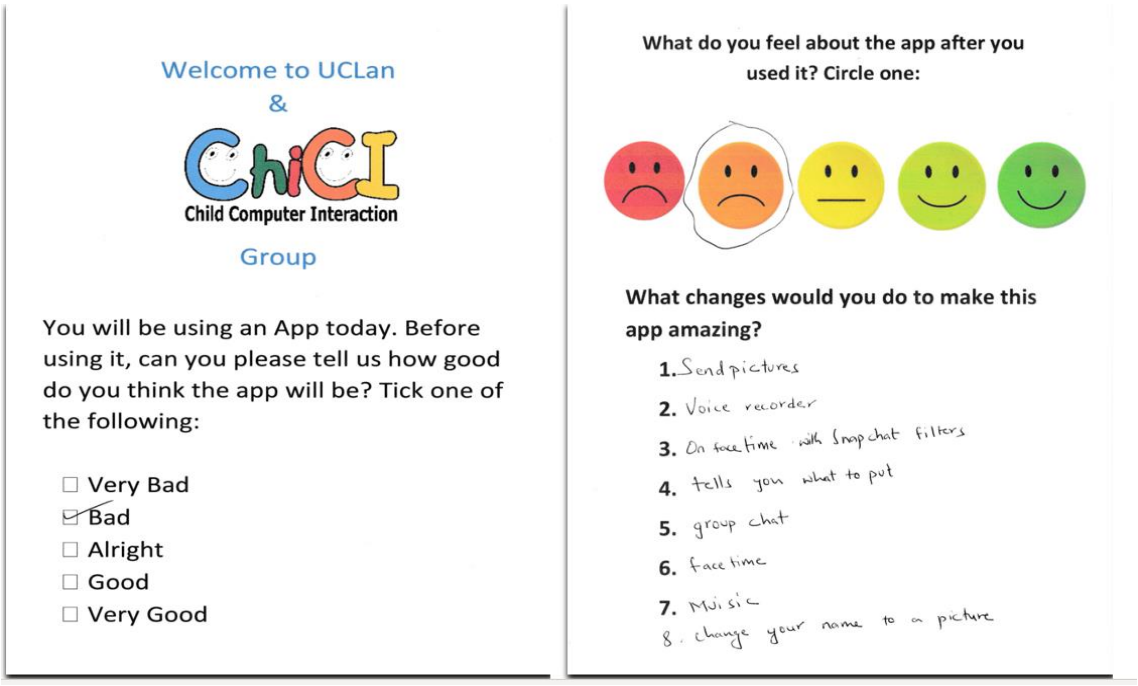


Figure 28. Response sample from one of the English participants

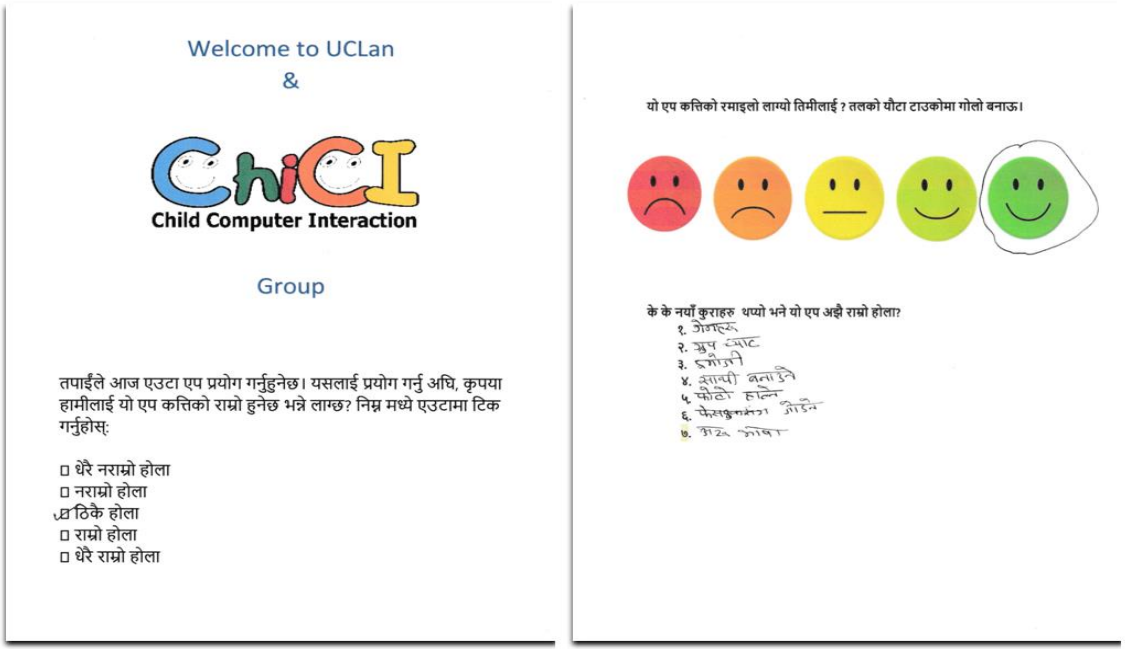


Figure 29. Response sample from one of the Nepalese participants

Table 5. Scores given by the Participants

English Participants				Nepalese Participants			
Participant Number	**Scores**			**Participant Number**	**Scores**		
	Before	**After**	**Change**		**Before**	**After**	**Change**
1	2	5	3	**1**	4	5	1
2	4	5	1	**2**	4	5	1
3	1	5	4	**3**	4	5	1
4	5	5	0	**4**	5	5	0
5	5	5	0	**5**	5	5	0
6	5	5	0	**6**	4	5	1
7	5	5	0	**7**	5	5	0
8	5	5	0	**8**	4	5	1
9	5	4	-1	**9**	5	5	0
10	5	5	0	**10**	4	5	1
11	5	5	0	**11**	4	5	1
12	4	5	1	**12**	5	5	0
13	5	5	0	**13**	5	5	0
14	5	5	0	**14**	3	5	2
15	2	5	3	**15**	5	5	0
16	2	5	3	**16**	4	5	1
17	4	5	1	**17**	3	5	2
18	4	5	1	**18**	4	5	1
19	3	5	2	**19**	3	5	2
20	2	5	3	**20**	4	5	1
21	3	3	0	**21**	3	4	1
22	3	2	-1	**22**	5	5	0
23	2	5	3	**23**	4	5	1
24	3	5	2	**24**	3	5	2
25	3	5	2	**25**	5	5	0
26	2	5	3	**26**	4	5	1
27	2	5	3	**27**	5	4	-1
28	2	5	3	**28**	3	5	2
29	2	2	0	**29**	4	5	1
30	2	2	0	**30**	4	4	0
31	5	5	0	**31**	3	5	2
32	5	5	0	**32**	3	5	2
33	5	5	0	**33**	3	5	2
34	5	5	0	**34**	4	5	1
35	2	5	3	**35**	3	5	2
36	3	5	2	**36**	4	5	1
37	4	5	1				
38	4	5	1				
39	3	5	2				
40	4	4	0				
41	4	5	1				
42	5	5	0				
43	5	5	0				
44	3	5	2				
Average	**3.61**	**4.70**	**1.09**		**4**	**4.92**	**0.92**

The average rating given by the English Children (E) for the app before using it was 3.61 and after was 4.70, (U (44) = 484.5, z = -4.04, $p < .00001$), for the Nepalese Children (N) these were 4 and 4.92, (U (36) = 219, z = -4.83, $p < .00001$) respectively which shows that overall, both the sets of the children found the app better than they expected. As shown in **Table 6**, 38

(86%) of the English children and 33 (92%) of the Nepalese children rated the app 5 out of 5 after using it. This indicates that they really enjoyed the activity and thought that the app was good.

Table 6. Distribution of ratings from each group

English Children			Nepalese Children		
Score	**Frequency**	**Frequency**	**Score**	**Frequency**	**Frequency**
5	16	38	5	10	33
4	8	2	4	16	3
3	8	1	3	10	0
2	11	3	2	0	0
1	1	0	1	0	0

3.5.3.2 Ideas for Improvement

The data sheet given to the children prompted them for seven ideas for improvement (**Figure 28 & Figure 29**). Most of the English children gave between 2 and 3 ideas, two gave more than the sheet asked for, and six gave none. In the case of the Nepalese children, most of the children gave 5 ideas, one gave more than seven and no one gave none.

Table 7. Distribution of number of ideas given

Number of ideas	**Number of Participants**	
	English	**Nepalese**
0	6	0
1	1	0
2	12	0
3	10	2
4	7	5
5	3	19
6	2	8
7	1	1
8	1	1
9	1	0

Concerning the ideas given by the children a total of 134 ideas were noted from the English children and 184 ideas were noted from the Nepalese children. Within these totals there were 41 and 28 unique ideas respectively. Of the ideas that were given by more than one child, the most mentioned, by both English and Nepalese children, was for the inclusion of emojis. Other popular choices are shown in **Table 8** below:

Table 8. Most popular ideas (top 10) given by the Children

English Children			**Nepalese Children**		
Ideas	**Frequency**	**Percentage**	**Ideas**	**Frequency**	**Percentage**
Include emojis	38	86	**Emoji**	24	67
Include picture	12	27	Games	22	61
Group chat	8	18	**Video Calls**	21	58
Phone calls	7	16	**Send Pictures**	15	42
Video calls	6	14	**Group Chat**	15	42
Voice messages	5	11	Make Friends	10	28
Send videos	4	9	**Send Videos**	8	22
Fix errors	4	9	**Send Music**	8	22
Send Music	4	9	**Voice Messages**	8	22
Profile picture	3	7	Post Photo	7	19

The frequency columns above show the number of children who noted that idea; thus 86% of the English and 67% of the Nepalese children mentioned they wanted emojis in the app. It is very interesting that both groups of children were thinking similarly in terms of technology enhancements (see emboldened items which were popular from both sets of children). **Table 9** lists the common ideas along with other ideas given by each group of children.

All the common ideas given by the children from both countries were the ones which a normal chatting application would have. The English children gave some ideas like face filters and snap chat which are normally present in apps popular in England. The Nepalese children included ideas like post photo, select games to play like Messenger, connect with Facebook, and comment using Facebook which shows that children are aware with the applications like Facebook and Messenger. The addition of features like these are discussed again in coming chapters of the thesis when the consideration of layering on a cultural interface is discussed in more detail.

Table 9. List of Common ideas

Common ideas
Emojis Pictures group chat audio calls, voice messages, video calls, send videos, send pictures, send music, games, add friends, take photo, stickers, send gifs
Only by English children
No errors, profile pictures, face filters, rainbow writing, different sounds, unicorn colour, change the font, snap chat, read other people, speakers, delete messages, rate a message, change font colour
Only by Nepalese children
Post photo, talk in different languages including Nepalese, App in Nepalese group call, play games using emojis, select games to play like messenger, watch videos, clip art, share games, connect with Facebook, graphic, free games, email, multiplayer games, free chatting, comment using Facebook

3.5.3.3 Children's Chat

Table 10 and **Table 11** show the number of chat posts between pairs of children for both English and Nepalese children. On average the English children made more posts (17.3 to 11.7) but they were typically shorter (17.9 to 23.9) although the length did vary across the different pairs. In some cases, but only with the English children, one of the pair wrote twice as many posts as their partner (marked with an *) – this was most often seen with pairs who posted low characters per post or where one of the pair wrote lengthy posts.

Table 10. English children's chat analysis

	First Child (English)			Second Child (English)		
	sent	**characters**	**characters/post**	**sent**	**characters**	**characters/post**
	19	349	18	16	317	20
	15	158	11	14	162	12
	14	1194	85	32*	933	29
	22	493	22	14	268	19
	10	169	17	10	141	14
	19	220	12	12	157	13
	19	542	29	32	716	22
	26	217	8	24	277	12
	14	215	15	26	269	10
	31*	325	10	14	621	44
	19	168	9	32	215	7
	18*	165	9	9	200	22
	8	70	9	10	81	8
	26	275	11	16	161	10
	10	36	4	9	124	14
	11*	167	15	5	97	19
	25*	251	10	11	108	10
	17	183	11	16	192	12
	17	219	13	14	257	18
	10*	96	10	5	28	6
	16	312	20	21	210	10
	31	1049	34	23	799	35
Mean	**18.0**	**312.4**	**17.3**	**16.6**	**287.9**	**16.6**

Table 11. Nepalese Children's chat analysis

	First Child (Nepalese)			Second Child (Nepalese)		
	sent	**characters**	**characters /post**	**sent**	**characters**	**characters /post**
	9	310	34	14	185	13
	15	289	19	20	313	16
	12	456	38	14	228	16
	14	283	20	9	399	44
	11	311	28	12	273	23
	10	365	37	17	335	20
	8	145	18	8	193	24
	9	198	22	8	209	26
	13	234	18	19	340	18
	14	172	12	10	286	29
	9	133	15	7	283	40
	10	194	19	13	283	22
	14	206	15	14	427	31
	12	198	17	10	230	23
	18	245	14	14	370	26
	6	72	12	6	222	37
	8	125	16	6	286	48
	13	241	19	15	503	34
Mean	**11.4**	**232.1**	**20.7**	**12.0**	**298.1**	**27.2**

Figure 30 shows the frequency of the different lengths of chat responses for the two groups. This shows many very short chat entries from the English children. If we were to dismiss the chats of ten characters or less (approximately 2 – 3 words) it appears that the lengths of the more meaningful chat comments were quite similar across the two groups.

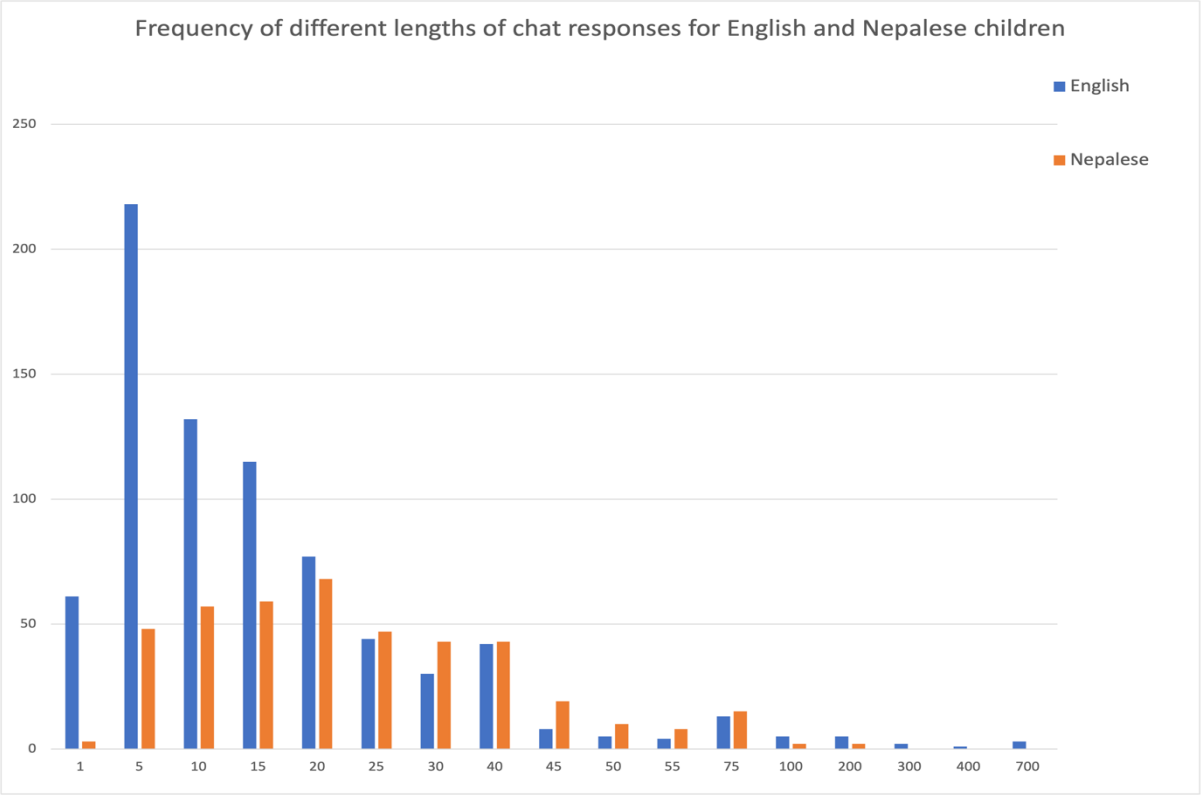


Figure 30. Frequency of different lengths of chat responses from English and Nepalese children

The content of the chat varied according to the effectiveness of the dialogue. With three of the English pairs, the dialogue was very limited, and nothing was found out between the two children, just 'silly' talk (this is discussed a little bit in the next section). Where there was meaningful chat, it generally followed a question answer approach.

Examples of an English pair chatting (Hanna and Natasa), and a Nepalese (Abhi and Yung) pair chatting are shown here:

Table 12. Example of two English children chatting

Hanna	Natasa
hi	
	hi how are you
Whats your favorite sport you	
	running and racing ????
I like them as well	
	cool ????????
What is your favorite food from Poland	
	polish soup
sounds nice ooops	
	yeah
silly	
	haha
do you like any o TJ er	
	what is your favourite colour
do you like any other food from Poland	
	yes
cool ideas I can see what do you like ???? are you there	
	yes
your interesting to me	
	I also like this cake with strawberrys inside delicious bye
is it Polish	
no	
	yep
five more minutes	

Table 13. Example of two Nepalese children chatting

Abhi	Yung
Hello **(Hello)**	
	Hello **(Hello)** Helo **(Hello)**
k Cha k? **(What's up?)**	
	thik xa **(Alright)** tero ni **(What about you?)**
Mero thik cha **(I am alright)** cricket khelne hoina yo sanibar? **(Play cricket this Saturday?)**	
	khelau khelau **(Lets play. Lets play)** kaati bhayo nakhekeo **(been long not played)**
la confirm hai ta.arulai no vannu parcha **(okay confirmed. Need to tell others too.)**	
	pratik pani janxa re **(Pratik said he will go too)**
la la thikcha. ball chai kinnu parne Cha so sabaile 10 rupya uthaunu parcha **(Okay good. Need to buy a ball so lets collect Rs. 10 each.)**	
	ma sanga xa ta yauta **(I have got one.)**
ye ho ra **(Is it?)** literally aaija na ta . Ani kinnai pardaina **(Bring it then. No need to buy.)**	
	la la **(Okay okay)**
school ko pachadi ko ground ma hai ta khelne **(Lets play on the ground behind the school)**	
	ma first batting hai ta **(I will bat first)**
ka tyasari huncha. tyo ta team banayera khelne ho. **(It doesn't work like that. Need to make a team)**	
	Mero team le Garza ni ta batting **(My team will bat first then)** nabhaye lyaudina ball **(Otherwise won't bring the ball)**

As can be seen from the summary data, the English children wrote more chats and typically these were shorter than those written by the Nepalese children. In the English chat, there were many (>70) instances when it was clear that one of the two was waiting to hear from the other. There were many comments in the like of 'Are you there?" as well as many "????" comments. The other interesting thing from the English children's chat was that there were quite a few 'risky' although not outright 'rude' comments. "Poo" featured in many comments, including just the word itself but also "poo head" and "you are a poo", there were also many mentions of "bums", "butts" and so on with terms like "butt face" and "big but" being seen. These comments were mainly restricted to three of the pairs, but it does highlight the need, going forward, to look at what children are writing.

Many of the Nepalese chats included English words, there were several uses of hello, haha and bye, used singly, but most times these words were embedded in sentences where the rest was in Nepalese. In the following table, the situations that lead to English words being in the Nepalese chat are summarised:

Table 14. Nepalese children using English words in phonetic Nepalese text

Category/Reason	English words
Greetings/communication	Hello, hi, okay, ok, bye, welcome
Sports	Cricket, football, goal, volleyball, goal, ball, ground
School	School, break, class, math, sir, extracurricular activity, subject, exam
Colours	Blue, red, colour, black, white
Numerals	First, third, three
Other	Best, friend, favourite, bore, popcorn, half, uncle
Corresponding Nepalese word is not frequently used	Bench, tiffin, canteen, team, doll house, gift, username, total, bag, doctor, police, copy, school, class, sir, phone, film, homework
Do not have corresponding Nepalese word	Chocolate, Samsung, ticket

Examples included:

"ye tyo black and white wala"

"Suresh le 3 goal hanyo"

"ko ni best friend"

And

"timro best friend baag ho"

3.6 Discussion

3.6.1 Informing the Design of the DigiPal App - Version 3

In terms of ideas worth implementing in the app, it was clear from this study that children might like the functionality of a fully-fledged product with all the unusual add on features but there would be a tension in providing this as the aim of the project was to primarily enable, and study, text-based communication. Facilitating emojis by using the keyboard was in line with the overall aims and so was implemented in later versions of the app; and the use of the standard keyboard was planned to enable 'in typing' error correction. Some Nepalese children mentioned that they wanted the app interface and the message sending in a different language. One or two clearly mentioned it to be in Nepalese. The app will be developed in Nepalese for these children. Based on ideas and feedback provided by the children, the next version of the DigiPal application, DigiPal Version 3, was developed. The following were the design ideas which were addressed in the iteration:

Table 15. Ideas implemented in DigiPal Version 3

Participants	Ideas
Both	Emojis
English	Fix errors, type infinite
Nepalese	Use app in Nepalese

Emoji:

In DigiPal Version 2, emoji sending didn't work. The emojis wouldn't be received fine on the receiver side. As seen above, most of the children from both countries wanted this functionality to work. Including a separate emoji button and list of emojis to select would be ideal but again keeping deadlines in mind that was not developed. However, the emojis bug was fixed so that the children can select emojis from the keyboard depending on whatever phone they use.

Fix error/infinite typing:

Both these were connected to each other. Due to some coding flaws, any text having an apostrophe (') in it was impossible to send. This error was fixed in this iteration because use of apostrophes is quite frequent in English text. The children thought they were having an error

because they were typing long strings of characters, but the actual error was to do with the apostrophe.

Use App in Nepalese:

For Nepalese children, the App should run in the Nepalese language as the project wants to protect all languages. The app was modified in a way that the pages in the app would be in both English and Nepalese. All they need do was to select an appropriate flag on the first page of the app which was newly added to the page. The English flag opens the page in English and the Nepalese flag in Nepalese. This is facilitated using Locale class (**Appendix 3.2 Language and Locale**). The locale remains the same unless the app is completely closed or restarted. Therefore, the following changes were made on DigiPal Version 2 to get to DigiPal Version 3:

Welcome page. The existing welcome page was replaced with this one which consisted of the country flags mentioned above. When a flag is selected, locale is set up accordingly and redirects to the page for corresponding country and language.

Figure 31. Pics of DigiPal Version 3: The welcome page with flags

Other pages. All the pages from DigiPal Version 2 remained the same for all the English users because all the pages were already in English. For the Nepalese users, all the pages from DigiPal Version 2 are shown in Nepalese with the help of Locale and corresponding Nepalese display as shown in the pictures below:

Figure 32. DigiPal Version 3, Home page Nepalese

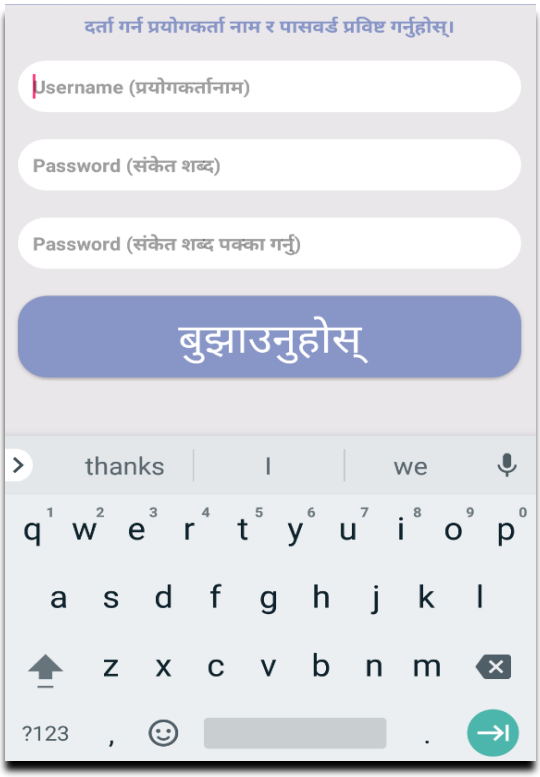


Figure 33. DigiPal Version 3. Register page Nepalese

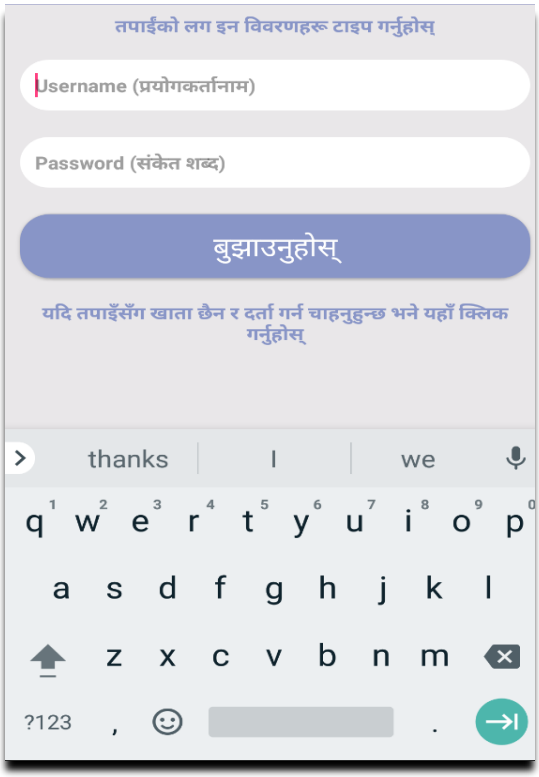


Figure 34. DigiPal Version 3, Login page Nepalese

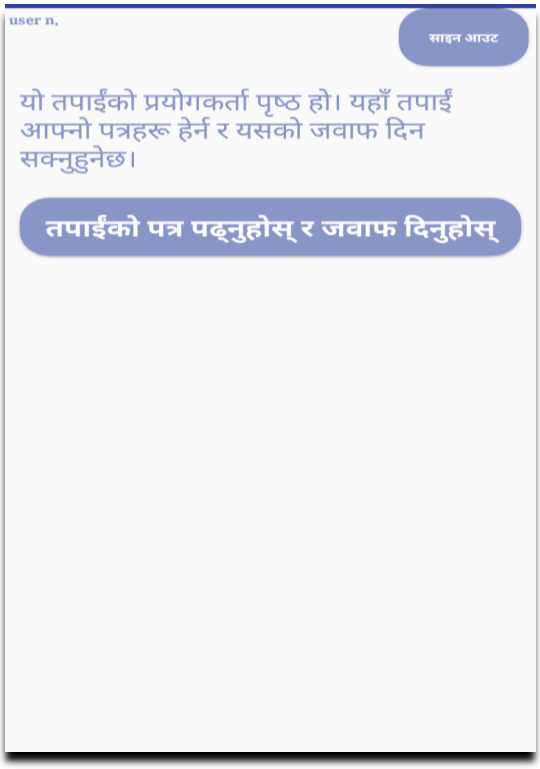


Figure 35. DigiPal Version 3. User page Nepalese

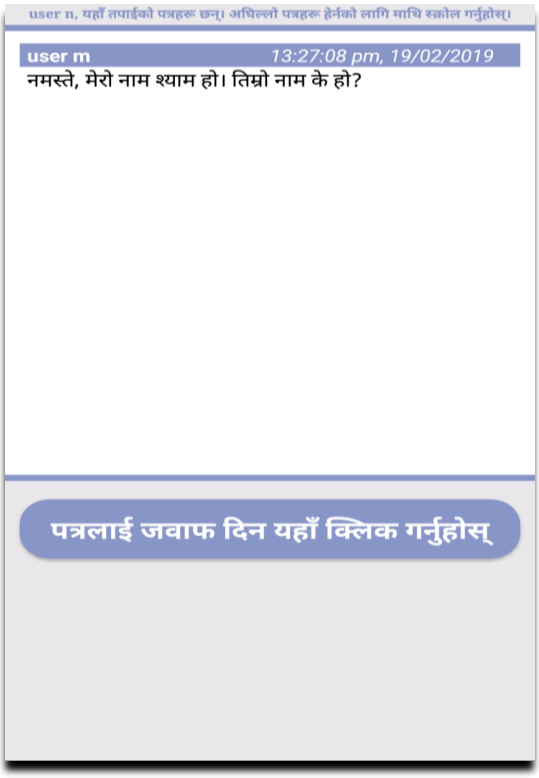


Figure 36. DigiPal Version 3, Letters page Nepalese

Figure 37. DigiPal Version 3, Letters page phonetic typing Nepalese

3.6.2 Children as Informants

From the analysis above, it is clear that children can provide feedback and critique on the software developed for them as active contributors as explained in (Lee, 2001; Prout, 2004). They were also able to suggest some useful ideas to improve the app and make it suitable for them. This shows how children can act as actors of this research being informants for the design of the app as seen in (Read et al., 1999, 2017). Most of the ideas the children contributed were motivated from other applications. Children were able to give some critical feedback too. For example, when the emoji sending didn't work, they clearly mentioned that it should be fixed. And due to some coding but, when the text with apostrophe was not being sent, the children critiqued about that too. It appeared, but was not explicitly tested, that the English children wanted more advanced additional design features than Nepalese children – this might be expected as there is typically a lag in technology getting to rural areas.

3.6.3 Cultural Evenness

The findings from this chapter shape the first and second layers of the Model, The Presentation and Interaction layer respectively. The presentation layer is about the normal look and feel of the App including its visual components. The children are able to select the language of the app by selecting their country flag, and then see all the components in their own language.

The letter sending interface falls into the Interaction layer. Children need to be enabled to be able to read the letters and reply back in their own language and this is the main focus for this layer. Ability to type in phonetically by Nepalese children, errorless letter sending and use of emojis are also the integral parts of this layer as informed by the children.

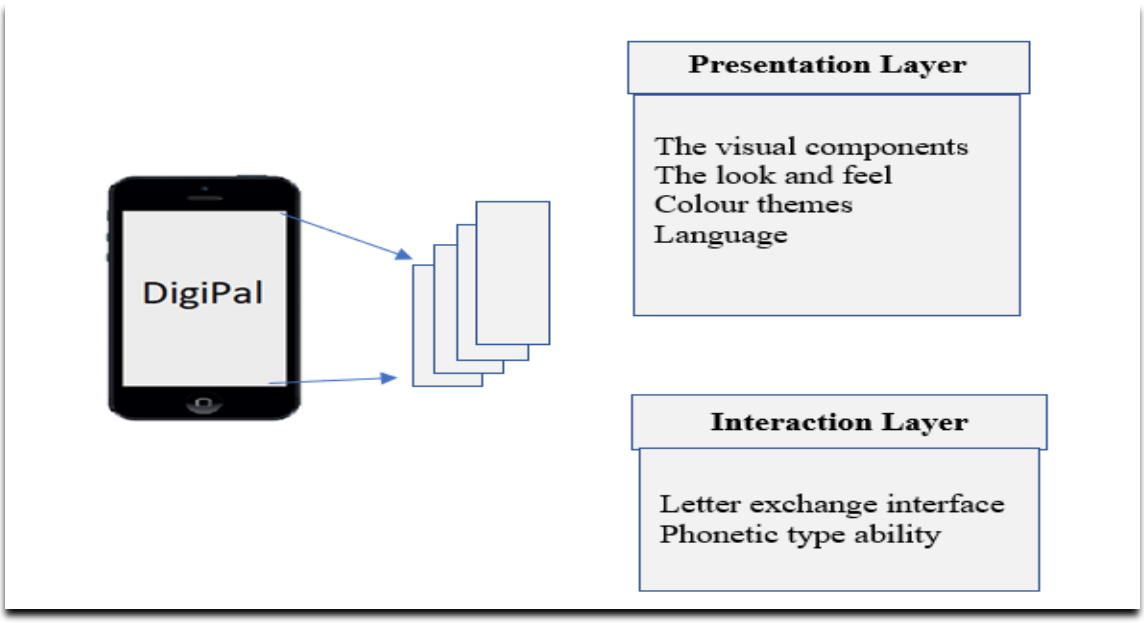


Figure 38. Proposed presentation and interaction layer for DigiPal

3.6.4 Contribution/Insights for follow on work

This study showed how the app could facilitate a two-way communication; it demonstrated that the app was usable for this and gave indications of the amount of chatting that could take place. It did highlight that in this design, children would use short chat segments which were not especially grammatically correct. The study also highlighted some of the issues, that are returned to later, in regard to 'bad' language use. In terms of ideas for the app it was clear that

children were influenced by apps they had already used. To test out translation possibilities it was probably better to have longer segments of writing as found in Study 1. For the follow-on work, testing translation, it was considered important to have chat that was more than a few words. The follow on was to identify a possible translation tool and then study accuracy and effectiveness on 'pre-collected' children's chat. The ideas for additional elements were not immediately followed up but are returned to at the end of the thesis as elements for further work.

3.7 Summary of the Chapter

This chapter describes how the DigiPal app was iteratively designed with observational analysis and the input from children. It was clear from these studies that children were enthusiastic to use the app and were able to use the simple interface. Looking at how the children carried out chat 'within country' it was clear that this could be sustained with simple questioning and with humour. The next chapter explores the possibilities for building translation into the app to facilitate 'beyond country' communication.

Chapter 4. Translation Possibilities and Challenges

4.1 Introduction

A main aim for the work was to explore ways that children could send/receive the letters in their own language. In this chapter, Google translate is explored for its efficacy with children's text. This chapter contributes towards answering the sub research question: *SRQ1. To what extent, and with what limitations and consequences, does automatic translation work with children's chat?* This chapter also contributes towards the **design of the digital app** in terms of its main findings which are that the translation is good enough for children to understand and that with cleaning of the text as it goes into translation, understanding can be improved.

The children who have contributed to this thesis have two different first languages, English and Nepali. Nepalese children do study English in school but are obviously not at the same level as English children. In addition, using only English language during communication was against the aims of the overall work and would have been divisive (Bradac, 1992; McArthur and McArthur, 2003). Giving equal importance to different languages also helps to preserve them which is a sound rationale for building translation into the DigiPal system. This chapter discusses the process by which decisions were made, and the outcomes, regarding the choice of a translation tool and the choices for evaluating translated text in the context of children chatting in the DigiPal tool.

This chapter begins by analysing available translation tools **Section 4.2** and then(**Sections 4.3 & 4.4**) by considering how the accuracy and understandability of translation can be measured with a new method for measuring understandability being introduced. The remainder of the chapter (**Sections 4.5, 4.6, 4.7 & 4.8**) describes four studies where the metrics are applied with children's text that has been translated using Google translate. The chapter ends (**Section 4.8**) with insights for translation of children's text as well as with design ideas.

4.2 Available Translation Tools

The important prerequisites for a translator tool to be used in this project were that it was not costly, that it could easily integrate into a mobile app and that it could translate English to Nepalese and vice-versa. Several tools were examined against these criteria in order to make a choice. A summary of the main tools considered, and their features is shown here in **Table 16.**

Table 16. Different translation tools and their possibilities

Translator tool	Remarks
Bing	• None of these translate between English and Nepalese. • Most just translate Arabic, Chinese, French, Spanish, German, Portuguese etc. • Some of them check grammar and spelling mistakes.
Worldlingo_translator	
Online-translator	
Translate.com	
Collins dictionary translator	
Deepl	
Reverso translation	
Google translate	• Free • Can use Google Cloud Translation API for integration • Can translate many languages including English to Nepalese • Grammar and punctuation checking is not available.
http://www.easynepalityping.com	• Free • Can translate between English and Nepalese • Use the Google API for the translation • Integration can be tricky as these are layered on top of GT
http://www.easyhindityping.com	
https://www.stars21.com/translator	
http://tamilcube.com/nepali	
https://www.englishnepalidictionary.com	

From this analysis, Google Translate seemed to be best option for this project. It had an easy to integrate API, was free and could deal with the language limitations. In the next sections, the feasibility and effectivity of Google translate are investigated.

4.3 Measuring Accuracy of Translation

Translation can be regarded as accurate when a text from a source language translates to the target language without any error. Accuracy can be reported as a percentage based on the extent to which a translated text maps to the 'intended text'. Accuracy of translation can be measured by hand, where meanings and semantics can be judged, or by use of automated systems. This latter method is preferred as it not only saves time but also allows for replicable comparison across different studies. Automated metrics, in general, compare the output of a machine

translated system with one or more reference translations which may have been done by humans (Castilho et al., 2018; Han, 2016).

The most popular current metric for accuracy of translation is the Bilingual Evaluation Understudy (BLEU). This is a precision measurement carried out at the level of n-grams rather than words (note – an n-gram is simply a collection of words in sequence – e.g., 'the cat' is an n-gram and more specifically it is a 2-gram or bigram). The primary programming task for a BLEU implementor is to compare n-grams of the candidate (machine translated text) with the n-grams of the reference translation and count the number of matches. These matches are position independent.

e.g., Candidate: The cat is eating by the dog
Reference: The dog is eating the cat
The n gram matches are 'the cat', 'is eating', 'the dog'

The more the matches, the better the candidate translation is and the lengthier the n grams the better. The BLEU metric employs a modified precision that takes into account the maximum number of each n-gram appearance in the reference translation and applies a brevity penalty that is added to the measurement calculation (Papineni et al., 2002). This measurement became very popular as it showed good correlations with human evaluations and its usage extended amongst different MT evaluation workshops (Castilho et al., 2018).

BLEU is however best suited to lengthy text, and it has certainly not been shown to be used with children's text. In Computer Science, it is common to use an Edit Distance algorithm when considering short pieces of text (often referred to as text strings) like those anticipated in the DigiPal app. For this, any two text strings can be lined up and compared with a Minimum String Distance (MSD) algorithm. Levenshtein was the first person to come up with this idea in his paper (Levenshtein, 1966) where he defined Edit Distance as the weighted operation, or number of insertions, deletions or replacements needed to transform one string to another. The edit distance algorithm is typically computed on characters where it results in a Character Error Rate (CER). There are other applications of the Edit Distance that look at the Word Error Rate which uses a similar process to consider insertions, deletions and replacements (Ney, 2007). To apply this automatically, the words used must be spelt properly for matches to be noticed.

Whilst often used, there are limitations to using CER and WER calculations as they do not deal well with some linguistic variations. For example, they do not admit reordering of words, e.g.,

'the cat's cradle' and 'the cradle of the cat', and they treat substitutions, deletions, and insertions of equal importance. Alternatives like the PER (Position-Independent Word Error Rate by (Tillmann et al., 1997) and TER (Translation Error Rate) metrics by (Snover et al., 2006) attempt to solve the reordering problem but they are complex to apply and are currently not in widespread use.

4.3.1 Choosing Edit Distance

(William Soukoreff and Scott MacKenzie, 2001) used the edit distance statistic proposed by Levenshtein to find the accuracy of text entry. They proposed a formula for error rate for two strings A (Presented text) and B (Entered Text).

$$Error\ rate = \left(\frac{MSD(A,B)}{\max(|A|,|B|)}\right) * 100\%$$

Equation 1. Equation for Error rate calculation

MSD = minimum string distance (Edit distance to transform A to B)
|A|= length of string A
|B| = length of string B

The denominator of this calculation is therefore the larger of the two string sizes.

This formula can be used to find the error rate of Google translated text with small modifications where Entered Text is replaced by Google Translated text (GT) and Presented Text is replaced with the correct text (CT). Additionally, rather than taking the larger of CT and GT for the denominator, only CT is taken because correct translation was the one that was aimed for and so error rate should be assessed on that basis only.

Hence the equation that will be used will be:

$$Error\ Rate\ (ER) = \left(\frac{MSD(GT,CT)}{|CT|}\right) x100\%$$

Equation 2. Modified Error rate calculation Equation

Therefore,

$$Accuracy(A)\ =\ (100 - ER)\%$$

Equation 3. Equation for Accuracy calculation

MSD (GT, CT) is the number of edit distances needed to convert GT into CT.
|CT| = Number of characters in CT

4.3.2 Application Example

Let's look at an example when a Nepalese sentence (original text, OT) is translated using Google translate to GT and then compared to the human interpreted meaning of the original text (CT).

OT= प्रिय साथी, नमस्ते , मलाई यहाँ सांचै छ।
GT= Dear friend, Hello, I am really here.
CT=Dear friend, Hello, I am fine here.
|GT|= 37
|CT| = 35

The only difference between GT and CT are the words 'really' and 'fine'.
To convert GT into CT, 'really' has to be converted to 'fine'.
Following are the minimum steps to be taken to do so:

1. replace 'r' with 'f' =>feally
2. delete 'a' => felly
3. delete 'l' =>fely
4. delete 'l' => fey
5. delete 'y' = fe
6. add 'i' after f => fie
7. add 'n' after I => fine

The string distance here is 7 as it took 7 steps for the conversion. In the following example, a more effective conversion is shown:

1. replace 'r' with 'f' =>feally
2. replace 'e' with 'I' => fially
3. replace 'a' with 'n' => finlly
4. replace 'l' with 'e' => finely
5. delete 'l' => finey
6. delete 'y' => fine

The string distance here is 6 as it took only 6 steps for the conversion.

That is why MSD (GT, CT) = 6.

Now, Error Rate (ER) = ((MSD (GT, CT)/|CT|) x100% = (6/35) x100% = 17.14%

Therefore Accuracy (A) = 100 - ER = 100 -17.14 = 82.86%

The given Google translation can be said to be 82.86% accurate.

Whilst Levenshtein's Edit Distance is the most used, there are several other algorithms that have been used to compute edit distances and to solve similar problems like error correcting (Wagner and Lowrance, 1975), pattern recognition (Sellers, 1980), string matching (Hall and Dowling, 1980), spelling correction (Masek and Paterson, 1980), choosing mutually distant key words (Waterman, 1985), finding longest subsequence of characters common to two strings in the design of a programming language (Wang and Pavlidis, 1990) and so on. The main advantage of using the Levenshtein Edit Distance to measure accuracy of translation in this thesis is that a) it is easy to compute and can be done using an algorithm, b) it does not have difficulties with poor spelling (which can be a problem for BLEU and other word-based methods and c) it is suitable for small pieces of text. Hence a Levenshtein CER method was chosen.

4.4 Defining Understandability of Translation

Whilst text entry measures can tell us about accuracy, even with mistakes in a piece of text, individuals can make allowances and still make sense of text, and sometimes even learn from that process of decoding ambiguity (Kintsch, 1994). For this reason, it is important to consider the meaning of text that has been translated as well as the accuracy of translation. The meaning of a piece of text is associated with the extent to which it can be read and understood. Readability is a fairly well understood metric that can be applied to a piece of text as a predictor of the information within it being successfully conveyed to a larger population when people are trying to access it (Ojha et al., 2021). Readability is often seen as a proxy for understandability, but readability is independent of the human reader, it is a predictive measure applied to writing, and there are many well understood metrics, e.g. Flesch, that can be used to derive readability scores (Kincaid et al., 1975).

It is fair to say that a piece of text can be read but may still not be understood. In their paper looking at understanding accounting texts, (Jones and Smith, 2014) write that "Readability measures the textual difficulty of a passage; while understandability measures the ability of a reader to gain knowledge from a text, and is contingent not only on syntactical difficulty, but also on reader characteristics such as the reader's background, prior knowledge, interest and

general reading ability". (Doruk et al., 2020) evaluated 26 websites and scored understandability using PEMAT Auto Scoring Form which is designed for AV material. (Rello and Baeza-Yates, 2012) used lexical quality which equated to a count of the number of spelling and grammar errors to determine understandability as it related in that case to accessibility. Neither of these methods seem well suited to children's text.

Comprehension can be used as a proxy for understandability. There are metrics that are commonly used to determine comprehension, but these too have critics. One technique is the cloze technique where a text is read and then a reader 'fills in' missing words to show understanding of the text that has been read, relying on contextual factors that exist in the text (Taylor, 1953). It has been suggested that this may more possibly be measuring some sort of intelligence related to guessing missing words. One version of this, the C-test was first developed in 1981 as a test of general language proficiency, and has been used mainly with children learning their first or second language, or with adults learning a foreign language (Grotjahn, 2002)– this, and the related SVT test, (Royer et al., 1996)– based on meaning of a sentence – requires readers to read a passage and then decide whether presented sentences have the same meaning as a sentence in the story they had just heard or read. With short pieces of text these tests are untested.

Retelling a story from text is another method used to measure understanding (Roberts et al., 2005), Critiques of retell highlight that as a measure of comprehension it suffers, as the student has to recall information, organize it and then possibly draw conclusions – with shorter texts retell does not suffer from these limitations (Klingner, 2004). From (Reed and Vaughn, 2012) survey of the use of retell it is clearly often used as a method. In that paper, of interest was not only why they used the method but also the way different individuals quantified the method. The most used approach was to count idea units that were recalled. In many cases, the counts were converted into a proportion of idea units recalled e.g., (Miller and Keenan, 2009; van den Broek et al., 2001; Zinar, 1990), the authors noted that little guidance was provided for making conclusions about what a desirable percentage of recalled idea units might be, or what percentage might indicate comprehension difficulty.

With translated text, there have been few studies on understandability – in (Hassani, 2017) work, the choice was to ask the readers to 'rate' the understandability of each piece using things like 'slightly understandable' etc. (Rossetti, 2019) used standard readability scores as well as

retelling – without penalty for synonyms – to measure understandability of machine translated text with 18/19-year-olds.

In this thesis, the hypothesis is that accuracy will affect understandability. (Nilsson, 1997) writes how in pedagogy and communication theory, **understandability** of a **text** is often defined as the ability of the **text** to communicate; that is to transmit, a certain message. The theory being that the more errors there would be in a text the more difficult it would be to understand.

4.4.1 A New Understandability Metric

To move forward with this complex idea, the term 'understandability of the translation' is here defined as the extent to which the translated text is understandable to the intended recipient. The context of the text can certainly help even when there may be spelling, grammatical or punctuation errors.

> For example:
> *I rely like pizza.*

Is understandable as: **I really like pizza**, even though it is not accurate. If the accuracy is calculated using the algorithm used in the previous section, this is 90% accurate but it is surely close to 100% understandable.

Based on the retell approach as described above, an understandability method that would deliver 100% understandability to the phrase above, that would be easy to apply and could be consistently used was required. This new approach is described in the next section.

A piece of text can be defined as entirely understandable when each sentence or phrase of that text is understood. Importantly, each text has several items of meaningful information; understanding each of these means we have understood the whole text.

For example:
My name is Laura. I live in England.

In this text, there are two sentences and two pieces of information the writer is sharing. The name and the place. In another example:

My name is Jack. I live in England, and I am 7 years old.

There are two sentences, but three meaningful pieces of information are conveyed: name, place, and age.

I propose a measure of understandability based on the understanding of meaningful (main) information.

$$U = (NMIU/NMIC)x100\%$$ *Equation 4. Proposed Equation for Understandability calculation*

Here,

U=Understandability

NMIU = Number of (pieces of) meaningful information understood.

NMIC = Number of (pieces of) meaningful information conveyed.

4.4.2 Application Example

For example:

The original text in Nepalese: मेरो नामे दिवस भुजेल हो मा क्लास ६ मा पढ्छु तमि कति मा अद शोउ

Correctly Translated text: My name is Diwas Bhujel. I am in class 6. Which one are you in?

This contains three pieces of meaningful information: name, school class and a question.

Translated using Google Translate: My name is Bhujel ho in class 6 how much is it to show?

Now if this text is given to an English child to make meaning out of it.

First information (Name): Even though only the surname is retained by Google, for the child this is understandable, and Bhujel will be associated as the name.

Second information (Class): The sentence is not complete but the phrase 'in class 6' helps the reader to understand that the writer is in class 6.

Third information (The question asked): now that doesn't make sense in the context. That is difficult to understand, and, if the reader had to reply to that text, he / she would skip that or ask back what that means.

So, in this case, only two pieces of information were understood out of 3 conveyed.

The understandability for this piece of Google translated text will be:

U= (NMIU/NMIC) x 100% = (2/3) x 100% = 66.67%

4.5 Study 3: Calculations of Accuracy and Understandability of Children's Letters Translated by Google Translate.

Even though Google translation is not always accurate, it seems to be the best option for the DigiPal app as a translation tool as explained in Machine Translation with Children in **Section 2.3.6.** Hence it is necessary to find out whether it is good enough to use in the case of children's chat conversation. To determine suitability, accuracy and understandability of such text needs to be calculated and analysed. This study will go through number of stages to achieve that. The hypothesis here is *'Even though the translations are not accurate, many will still be understandable'.*

4.5.1 Stage 1. Gathering and Processing the Texts to Analyse

The early letters typed by the Nepalese and English children during the in-class study (as described in **Section 3.3**) were used to evaluate accuracy and understandability. Each letter was initially coded for meaningful information and those that had at least three pieces of meaningful information were chosen for this study. Out of 31 Nepalese and 27 English letters, only 15 of the Nepalese and 22 of the English letters were selected for the study.

For analysis purposes, the chosen Nepalese letters (NLs) were labelled as N1, N2…..and so on to N15 and each was manually translated to English by the author who is a fluent bilingual for both languages. These manually translated letters are taken as the correct translations (CTNs) of NLs and named CTN1, CTN2… and so on to CTN15. In the next step, all the NLs were translated to English using Google translate (https://translate.google.co.uk) to get a Google translation of each of the Nepalese letters (GTNs) GTN1, GTN2 … and so on to GTN15. A similar approach was used for all the English letters (ELs) to get human translated (correct) letters (CTEs) CTE1, CTE2….to CTE22 and Google translated letters (GTEs) GTE1, GTE2…. to GTE22.

4.5.2 Stage 2. Development of Edit Distance (Minimum String Distance) Calculation Tool

The accuracy of the GTNs and GTEs was to be calculated by determining the edit distance and error rate as explained in **Section 4.3**. For each calculation there are number of steps that need to be followed which include:

- Counting the number of characters in the Google translated text (GT)
- Counting the number of characters in the (Human) Correct translation of the text (CT)
- Calculating the Minimum String Distance (MSD) to convert GT into CT
- Calculating Error rate (ER)
- Calculating Accuracy (A)

A simple Java Desktop application was developed using NetBeans IDE to calculate the MSD, Error rate and the Accuracy. This was a one window application where just the Correct Translation and the Google Translation of each letter needed to be inserted as shown in **Figure 39 & Figure 40**. Note that some sections (like Input 3) that are displayed here were NOT used in this analysis that follows in this section but were put in place for later analysis in **Section 4.6**.

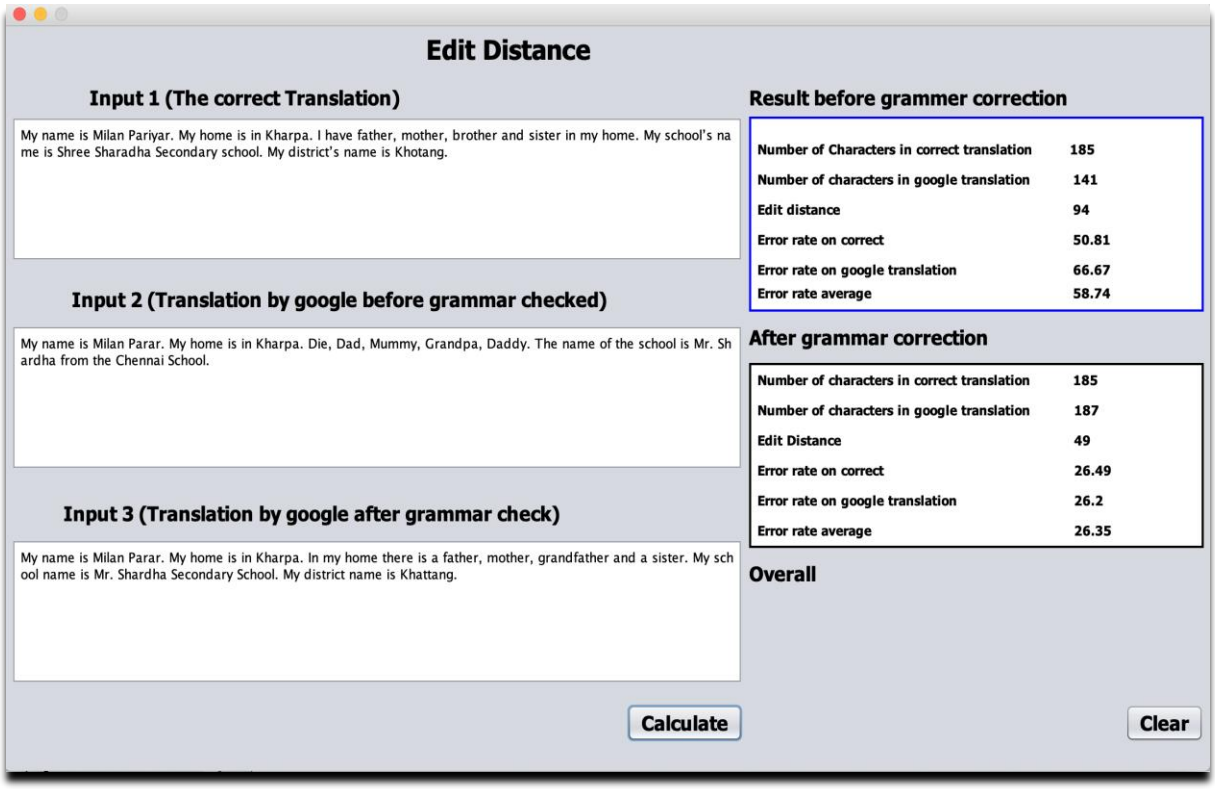


Figure 39. Edit Distance Calculation Tool calculating Error rate of translation of Nepalese letters

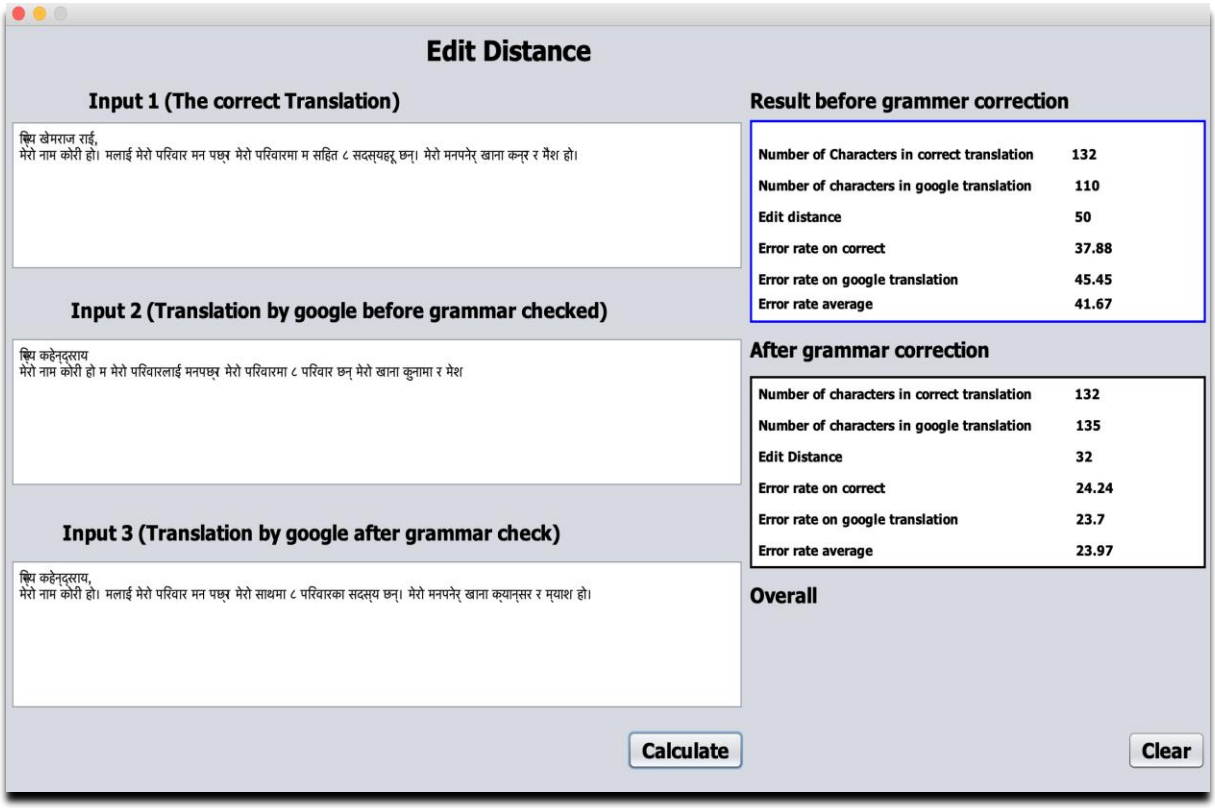


Figure 40. Edit Distance Calculation Tool calculating Error rate of translation of English letters

Handling synonyms. Whilst the calculations here were automated, it is important to note that on entering the data into the app, where a synonym was found, this was manually adjusted prior to the calculation being made.

E.g., If a Nepalese text is translated using the human translator and Google translate as follows:

- *NL: मलाई फिल्म हेर्न मन पर्छ।*
- *CT: I like watching films.*
- *GT: I like watching movies.*

Here both the phrases mean the same thing, but it could be said that the Google translation is inaccurate as an Edit Distance Calculation will give the accuracy as only 77.27%. Taking the same approach as (Papineni et al., 2002), during the accuracy calculation, both GTs and CTs were checked for tight similarities in meanings. Some examples of the synonym words that were found (and resolved) during the calculations were:

- Dad & father
- Mummy & mother
- My school's name & name of my school
- Class & grade
- Home & house
- No. & number

4.5.3 Accuracy of Google Translation of Nepalese Letters

The accuracy of Google translation of the Nepalese letters was calculated using the Edit Distance Calculation tool. The table below shows the full results:

|CTN| = Number of characters in correct translation
|GTN| = Number of characters in google translation
MSD = Minimum string distance
ER = Error Rate
A = Accuracy percentage

Table 17. Edit distance, Error rate and Accuracy of Google Translation of Nepalese letters

Letter Code	|CTN|	|GTN|	MSD	ER	A
N1	186	140	79	42.47	57.53
N2	129	98	43	33.33	66.67
N3	93	108	57	61.29	38.71
N4	155	146	71	45.81	54.19
N5	117	86	73	62.39	37.61
N6	97	103	63	64.95	35.05
N7	116	120	60	51.72	48.28
N8	164	150	82	50	50
N9	220	192	74	33.64	66.36
N10	128	75	68	53.13	46.87
N11	169	171	74	43.79	56.21
N12	174	178	105	60.34	39.66
N13	140	130	44	31.43	68.57
N14	108	98	41	37.96	62.04
N15	490	258	347	70.82	29.18
Average	**165.73**	**136.87**	**85.4**	**49.54**	**50.462**
SD	**96.49**	**48.24**	**74.27**	**12.54**	**12.5**

The accuracy varied from 29.18% to 68.57%. The average was 50.46% but the high standard deviation of 12.5 indicates the data are quite scattered out from the mean. The correlation between CTN and ER is 0.29. This shows a very weak positive relationship meaning that error rate doesn't increase for longer texts.

4.5.4 Understandability of Google Translation of Nepalese Letters

Once the Nepalese letters were translated to English using Google Translate, it was interesting to note the loss of some phrases or sentences during the translation. This meant some meanings were being lost which would have a direct effect on understandability because the reader of the translated text is not able to see the text that is lost. That is why, it is important to record how many pieces of meaningful information are present in translated text i.e., how many Google managed to retain. To measure understandability a study explained below was conducted with children.

4.5.4.1 Participants

The participants for the study of understandability were ninety-two English speaking children from a school from England. The children, who were aged 8 – 12, attended a research activity day in the University where this study was one of several completed on the day. All the children did the activity while accompanied by a teacher and they each consented to take part and had consent from their parents to participate.

4.5.4.2 Tools

Just for the purpose of this study, an adapted research app, DigiPal Understandability, was developed. The children used mobile phones where this app was installed. The app had following pages:

Welcome page. This is the welcome page of the app with simple information about the activity and a button to start (**Figure 41**).

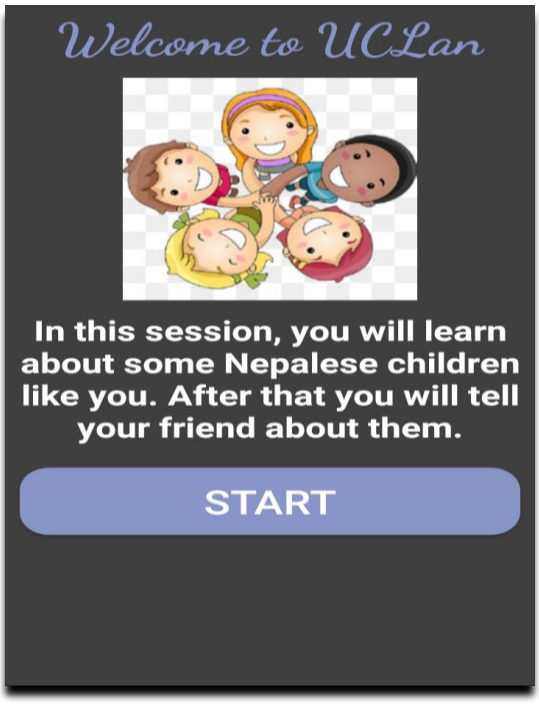


Figure 41. DigiPal Understandability: Welcome page

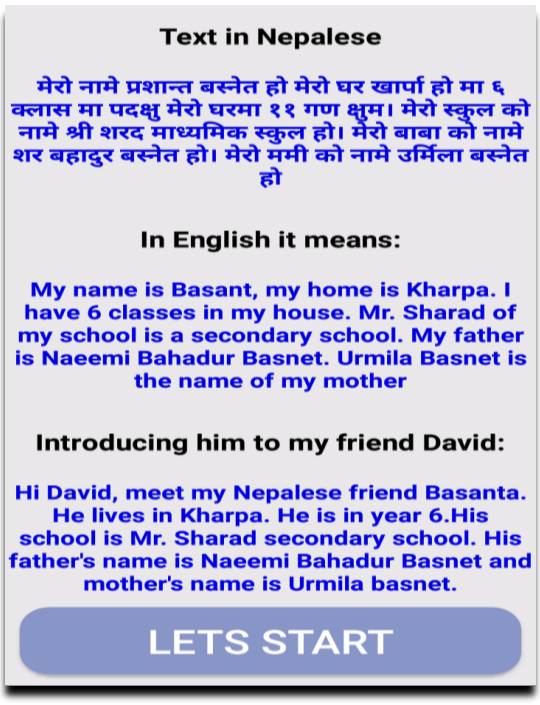


Figure 42. DigiPal Understandability: Example page

Example page. This page contains an example showing how participants will perform the task (**Figure 42**). The instruction page contained a letter in Nepalese at the top, it's translation in English in the middle, and another piece of text at the bottom which is an example of how to

complete the task which was to explain their own understanding of the text to a friend embracing the idea of retelling. At the very bottom the 'Let's start' button takes the child to the next page where they start the activity.

Code page. Participants enter the code (provided by the facilitator) of the translated letter here and submit (**Figure 43**).

Retelling page. The letter, corresponding to the code entered in the Code page, will be visible here. Underneath that there is a text box where the participants can enter what they understood and then submit (**Figure 44**). After submitting, a confirmation alert is received, and the participant is redirected to the Code page where he or she can look at another letter.

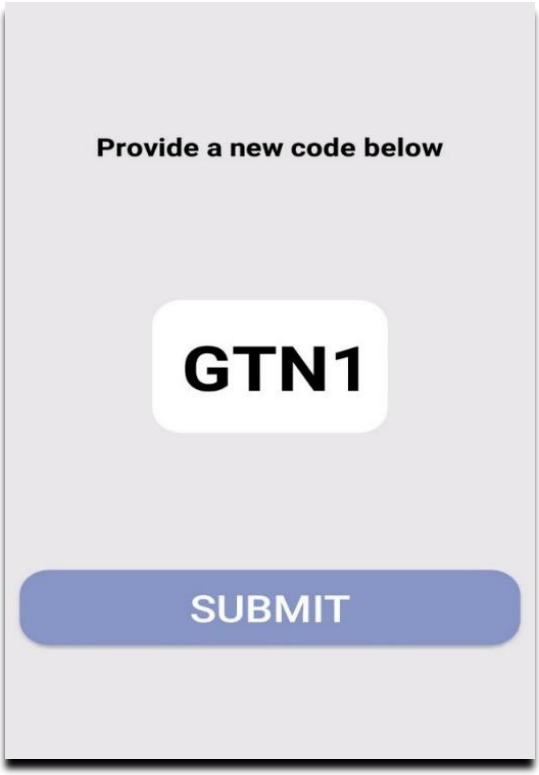


Figure 43. DigiPal Understandability: Code page

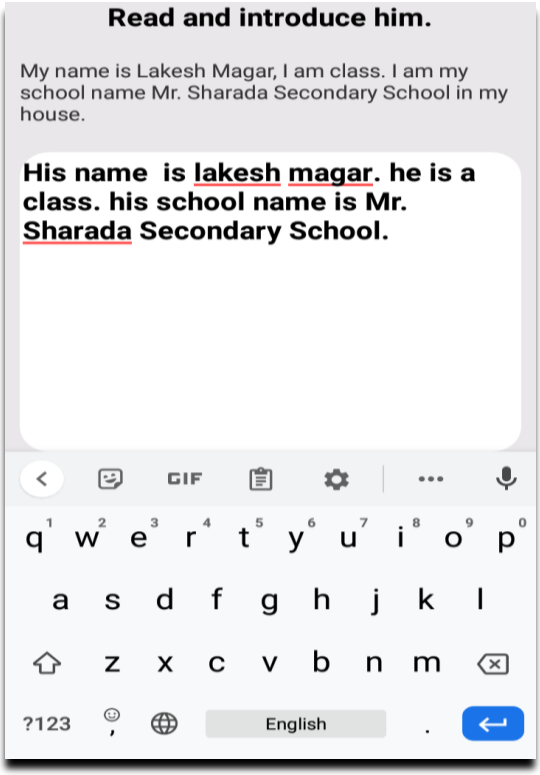


Figure 44. DigiPal Understandability: Retelling page

A document with the translated letter codes was used to record the participants working on each letter (see **Figure 45**). This was used to make sure that the participants did a different letter every time and that in the main, each of the letters was seen an equal number of times. The figure shows how 22 participants E1-E22 read the translation of 15 different Nepalese texts GTN1-GTN15.

Understandability Calculation Participants record sheet

Participants Code/Letter Code	GTN1	GTN2	GTN3	GTN4	GTN5	GTN6	GTN7	GTN8	GTN9	GTN10	GTN11	GTN12	GTN13	GTN14	GTN15
E1	1						1					1			
E2		1			1			1	1					1	
E3			1			1			1		1		1		
E4		1		1				1				1			1
E5			1				1				1			1	
E6		1		1						1			1		1
E7			1			1	1		1			1			
E8	1				1			1							1
E9				1			1						1	1	
E10		1				1			1			1			
E11				1						1			1		1
E12			1			1			1		1				
E13		1			1			1					1	1	
E14			1				1					1			
E15	1				1						1			1	
E16				1					1			1			1
E17		1				1				1			1		
E18				1			1				1				
E19								1				1	1	1	1
E20	1			1						1					
E21					1		1							1	
E22			1					1		1					1

Figure 45. Example of the record sheet for participants from England

4.5.4.3 Procedure

Before the pupils came to the study, all the Google translated letters (GTNs) were gathered and saved in a database with the respective codes given previously GTN1, GTN2 and so on. These codes are also noted down on the chart used for recording the frequencies (**Figure 45**). The children came to the study in a group of 7 or 8 at a time to a room in the University where the study took place. Each was given either an Android mobile phone (Make: Cubot Magic, Screensize:5”), or an Android tablet (Samsung Galaxy Tab E, with 9.6” display) installed with the App. After they were explained what was expected from them, the children started the activity on the mobile device.

After submitting a code into the app, on the next page each child saw the corresponding letter which is the Google translated version of the Nepalese letter retrieved from the database. The task for the children here was to first read the letter which would be about a Nepalese child introducing him/herself and then to type the same letter in a way that they are introducing this child to a third reader, i.e., retelling what they have been told. In this way the aim was to see what the child was able to understand from the translation. Children were briefed on the task, and they also saw an example on the instruction page of the app (**Figure 42**).Once the

participants had finished typing, they submitted their writing which was then saved in the same table of the database next to the original translated text. The participant would get confirmation this was saved, and the screen would then redirect to the code page to enter a new code. While giving the new code, the facilitator made sure that the same child didn't get the same letter again. Code delivery was also manipulated so that over the study, each piece of text was seen at least 5 times. The children were allowed to do as many letters as they could in 10 minutes. The children were asked not to copy the same text and write what they understood instead.

4.5.4.4 Analysis

After the study was finished, the first step was to look at each Google translated letter and compare that with the original Nepalese letter to see the number of items of meaningful information each retained. Out of 15 letters, only 6 retained all the information and 3 retained half or less of the information.

The next stage was to analyse and count the number of those items of meaningful information that were assumed to have been understood by the English participants. All the texts typed by the English children were retrieved from the database and the number of items of information they were deemed to have understood were counted. A piece of meaningful information was marked as UNDERSTOOD if the meaning conveyed by the child in their interpretation MATCHED the meaning conveyed by the writer in their Nepalese text (as translated by the human). During these calculations of matching the text, a coding method had to be put in place for the consistency just like in case of accuracy calculation. The following situations were considered during that process:

- If synonyms were used in the retold text, they were considered matched.

  E.g., Original text: My father's name is Ram.
  Retold text: His dad's name is Ram.

- The spelling, grammatical or punctuation errors made during retelling were ignored.

  E.g., Original text: My dog's name is Lucky.
  Retold text: His dog name is Lucky.
  E.g., Original text: My school is called Sharada Secondary School.
  Retold text: His school is called Shard Secodary School.

- If the structure of the sentence in retold text was different but meant the same, it was considered matched.

  E.g., Original text: My best colour is Red.
  Retold text: Red is her best colour.

- Counting the amount of information in a sentence with conjunction: If two information items were presented as joint, they were regarded as two pieces of information.

  E.g., Original text: I like playing football and cricket. (2 pieces of information)
  But if those two words form one meaningful information, then it is counted as one.
  E.g., I like fish and chips. (1 information as Fish and Chips is one dish).

Given that understandability may depend on an individual's ability to make sense of a phrase, each letter was looked at by at least 5 child participants.

4.5.4.5 Results

In **Table 18**,

TLC = Translated letter's code
NMIO = Number of items of meaningful information in original letter (before translation)
NMIT = Number of items of meaningful information in translated letter
NMIU = Number of items of meaningful information understood by the children
P1- P7 = Number of items of meaningful information by participants for each particular letter

The different values for P1-P7 for individual rows shows that the understandability varies person by person but not by large numbers. Note that here P1 does NOT refer to one particular participant, it simply refers to the first child's response to that single letter. For instance P1 for GTN1 is not necessarily the same participant for GTN2.

Table 18. Number of items of meaningful information conveyed (NMIO), translated (NMIT) and understood (NMIU)

TLC	NMIO	NMIT	NMIU						
			P1	P2	P3	P4	P5	P6	P7
GTN1	8	7	6	6	3	6	5		
GTN2	4	2	2	2	2	2	2	2	
GTN3	3	3	2	1	2	2	1	1	
GTN4	5	5	5	3	3	4	3	5	5
GTN5	3	3	2	1	1	1	2		
GTN6	3	3	1	2	1	1	2		
GTN7	4	4	3	4	2	3	3	3	
GTN8	7	5	3	3	3	2	1	3	
GTN9	7	6	5	5	5	5	6	5	
GTN10	7	4	3	3	3	3	2		
GTN11	8	6	4	2	4	3	4		
GTN12	6	3	3	2	3	3	3	4	
GTN13	6	4	4	2	3	3	4	3	2
GTN14	4	4	3	4	3	4	4	4	3
GTN15	16	7	3	3	3	3	5	6	5

Understandability can be calculated separately for each letter and child pair, and later an average can then be calculated for that letter by looking at all the children's responses that align with that one letter.

For example.

Letter GTN1 was read by 5 different participants: P1, P2, P3, P4, P5. Based on the number of meaningful things shared and understood by each child, the understandability of GTN1 is calculated as follows:

NMIO = Number of items of meaningful information in original letter (before translation)
NMIT = Number of items of meaningful information in translated letter
NMIU = Number of items of meaningful information understood by the children
U/O = Understandability based on the original text (UO)
U/T = Understandability based on Google Translated text (UT)

Table 19. Understandability calculation for Individual Letter

Participants	NMIU	NMIO	NMIT	(U/O) %	(U/T) %
P1	6	8	7	75	85.71
P2	6			75	85.71
P3	3			37.5	42.85
P4	6			75	85.71
P5	5			62.5	71.43
Average				65	74.28

For each letter, two average understandability scores can be calculated; The table below shows these average understandabilities for each letter. Because some items are lost during the calculation, the Understandability based on Google Translated text (UT) will always show a higher percentage than Understandability based on the original text (UO) despite there being fewer items understood. If we are concerned with Understandability as a metric for Google Translate in its entirety, then we should consider UO, if we are looking to see the understandability of translated text, then we would consider UT.

Table 20. Understandabilities on original and translated letters

Letters	UO	UT
GTN1	65	74.28
GTN2	50	100
GTN3	50	50
GTN4	80	80
GTN5	46.7	46.7
GTN6	46.7	46.7
GTN7	75	75
GTN8	35.7	50
GTN9	73.8	86.1
GTN10	40	70
GTN11	42.5	56.67
GTN12	50	75
GTN13	50	75
GTN14	89.3	89.3
GTN15	25	57.14

The values ranged from 45.6 to 100 for UTs and 25 to 89.3 for the UOs. etc.

4.5.5 Accuracy of Google Translation of English Letters

In much the same way that the Nepalese letters were assessed for accuracy of translation into English, similarly the accuracy of Google translation of the English letters was calculated. The table below shows the full results for the 22 letters:

Table 21. Edit distance, Error rate and Accuracy of Google Translation of English letters

Letter Code	|CTE|	|GTE|	MSD	ER	A
E1	114	91	40	35.09	64.91
E2	176	198	76	43.18	56.82
E3	218	223	77	35.32	64.68
E4	250	226	113	45.2	54.8
E5	332	240	201	60.54	39.46
E6	137	109	60	43.8	56.2
E7	286	242	130	45.45	54.55
E8	96	70	49	51.04	48.96
E9	232	217	95	40.95	59.05
E10	118	103	37	31.36	68.64
E11	317	270	181	57.1	42.9
E12	376	342	168	44.68	55.32
E13	498	525	266	53.41	46.59
E14	109	90	54	49.54	50.46
E15	222	192	97	43.69	56.31
E16	256	199	110	42.97	57.03
E17	389	321	191	49.1	50.9
E18	412	411	174	42.23	57.77
E19	141	121	62	43.97	56.03
E20	151	115	74	49.01	50.99
E21	247	227	94	38.06	61.94
E22	206	185	99	48.06	51.94
Average	**240.14**	**214.41**	**111.27**	**45.17**	**54.83**
SD	**110.6**	**111.95**	**61.04**	**6.97**	**6.97**

Here,

|CTE| = Number of Characters in Correct Translation

|GTE| = Number of Characters in Google Translation

ER= Error rate

A=Accuracy

It is clear that the edit distance varies letter by letter which causes the variation in the error rates and the accuracy. The accuracy varied from 39.46% to 68.64%. The average is 54.83% but the high standard deviation of 6.97 indicates the data are scattered out from the mean.

Two correlation calculations are done to see the relation

1. Between CTE and MSD = 0.96
2. Between GTE and MSD = 0.91

Both the numbers suggest that longer texts seem to have more errors, but these increases or decreases are not proportional to the increase and decrease of the number of characters. Another correlation calculation between CTE and ER came out as 0.38 which is a weak correlation that shows that the increase in MSD is not proportional to the number of characters. One observation that is obvious and needs to be looked at, is that there were many spelling and grammatical errors in the text entry, and these influenced Google translate which will be discussed later in this chapter.

4.5.6 Understandability of Google Translation of English Letters

The Google translations of the English letters were tested with Nepalese children in the same way that the Nepalese letters were tested with English children. 22 English letters went through the same procedure as the Nepalese ones as described in **Section 4.5.1**. Initially the number of items of meaningful information contained in each letter was counted then the letters were translated using Google translate, a count was then made of the meaningful information retained and then these translated letters were presented to Nepalese children to ‘retell’.

4.5.6.1 Participants

36 Nepalese children from suburb of Banepa, a small city in Nepal, participated in this study. They were aged 8-12 and were selected by the headteacher of their school after all the consent process was completed by all concerning parties. They took part in a two-day activity session in which one of the activities was this one.

4.5.6.2 Tool

The same Android app used in the previous study was used in this study too. A few changes were made to ensure the children could use it:

Welcome page: Remained the same but the writing was in Nepalese.

Example page: This page contained an example of the task. The page contained a letter in English at the top, it's translation in Nepalese in the middle and another piece of text at the bottom which was an example of understood text of the Google translation. At the very bottom, a button which says 'let's start' in Nepalese takes the child to the next page.

Code page: Participants can enter the code of the translation letter here and submit.

Read and Introduce: The letter corresponding to the code entered in the previous page was visible here. Underneath that there was a text box where the participants can enter what they understood and then submit. After submitting, a confirmation was received, and the participant redirected to the Code page.

Figure 46. DigiPal Understandability: Welcome page in Nepalese

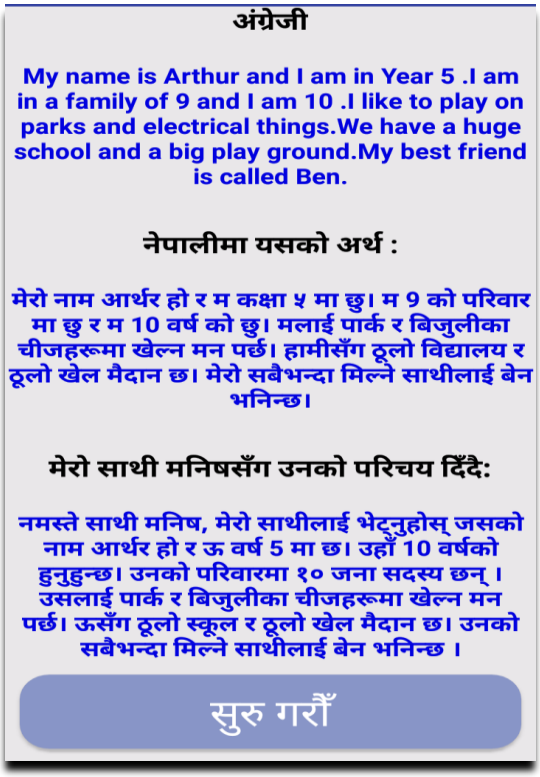


Figure 47. DigiPal Understandability: Example page in Nepalese

Figure 48. DigiPal Understandability: Code page Nepalese

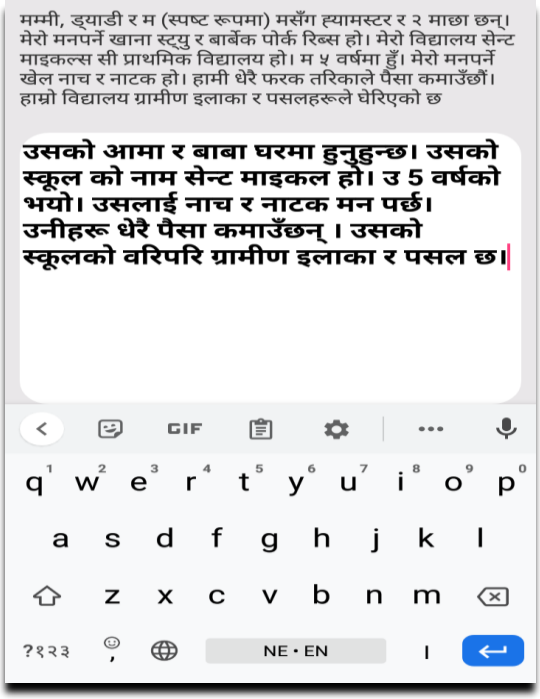


Figure 49. DigiPal Understandability: Retelling Page Nepalese

4.5.6.3 Method

All the Google translated letters (GTEs) were gathered and saved in a database with the respective codes given previously GTE1, GTE2 and so on. The children were taken in a group of 4 at a time for the activity. Each was given an Android mobile phone (Make: Cubot Magic, Screensize:5") installed with the app DigiPal Understandability. The same method was followed as in **Section 4.5.4** which included reading letter and explaining it to third reader. Most children looked at around three letters.

4.5.6.4 Results

After the study was finished, each Google translated letter was compared with the original English letter to see the how much information was retained. Out of 22 letters, only 15 letters retained all the information, 6 retained one less and 1 retained two less information.

The table below shows the number of children who responded to each letter, the number of items of information they were deemed to have understood, and averages and understandability calculations based on translated and original texts.

In **Table 22**,

NMIO = Number of items of meaningful information in original letter (before translation)

NMIT = Number of items of meaningful information in translated letter

NMIU = Number of items of meaningful information understood by the children

Ave = Average number of items of information understood per letter

P1-P4 = Number of items of meaningful information understood by individual children for the particular letter

Table 22. Number of items of meaningful information present in original and translated English letters and corresponding understandability

Translated Letter code	**NMIO**	**NMIT**	**NMIU**						
			P1	**P2**	**P3**	**P4**	**Ave**	**UO**	**UT**
GTE1	4	3	3	3	3		3.00	75.00	100.00
GTE2	7	6	6	5	6		5.67	80.95	94.44
GTE3	8	8	8	8	7	8	7.75	96.88	96.88
GTE4	7	7	7	7	7	7	7.00	100.00	100.00
GTE5	10	9	9	9	8	8	8.50	85.00	94.44
GTE6	3	3	3	3	3		3.00	100.00	100.00
GTE7	8	8	7	8	7	8	7.50	93.75	93.75
GTE8	3	3	3	3	3		3.00	100.00	100.00
GTE9	7	7	6	5	6		5.67	80.95	80.95
GTE10	4	4	4	4	4	3	3.75	93.75	93.75
GTE11	9	8	8	8	7	8	7.75	86.11	96.88
GTE12	10	9	9	9	9		9.00	90.00	100.00
GTE13	15	15	15	15	14		14.67	97.78	97.78
GTE14	5	5	5	5	5		5.00	100.00	100.00
GTE15	6	6	6	6	6	6	6.00	100.00	100.00
GTE16	7	7	7	7	7		7.00	100.00	100.00
GTE17	11	9	7	9	8		8.00	72.73	88.89
GTE18	12	12	11	7	10	9	9.25	77.08	77.08
GTE19	5	4	4	3	4		3.67	73.33	91.67
GTE20	7	7	5	6	6	5	5.50	78.57	78.57
GTE21	8	8	8	8	8		8.00	100.00	100.00
GTE22	5	5	5	5	5		5.00	100.00	100.00

The different values for P1-P4 for individual rows shows again that the understandability varied person by person. P1-P4 are not same set of children but any four children out of 36 children who were involved. Some of the P4 columns are empty which indicates that only 3 children read the corresponding text.

The average understandabilities for the letters ranged from 72.73 to 100 for UOs and 77.08 to 100 for the UOs. For 8 of the letters the understandabilities were 100 for both UO and UT. 2 more letters had 100% understandability for UT too.

4.5.7 Discussion – Understandability and Accuracy

The tables below show the comparison between accuracy and understandability:

A= Accuracy
UO=Understandability based on original text
UT = Understandability based on Google Translated text

Table 23. Accuracy and understandability comparison for Nepalese to English translation

Letters	Translated letters	A	UO	UT
N1	GTN1	57.53	65	74.28
N2	GTN2	66.67	50	100
N3	GTN3	38.71	50	50
N4	GTN4	54.19	80	80
N5	GTN5	37.61	46.7	46.7
N6	GTN6	35.05	46.7	46.7
N7	GTN7	48.28	75	75
N8	GTN8	50	35.7	50
N9	GTN9	66.36	73.8	86.1
N10	GTN10	46.87	40	70
N11	GTN11	56.21	42.5	56.67
N12	GTN12	39.66	50	75
N13	GTN13	68.57	50	75
N14	GTN14	62.04	89.3	89.3
N15	GTN15	29.18	25	57.14

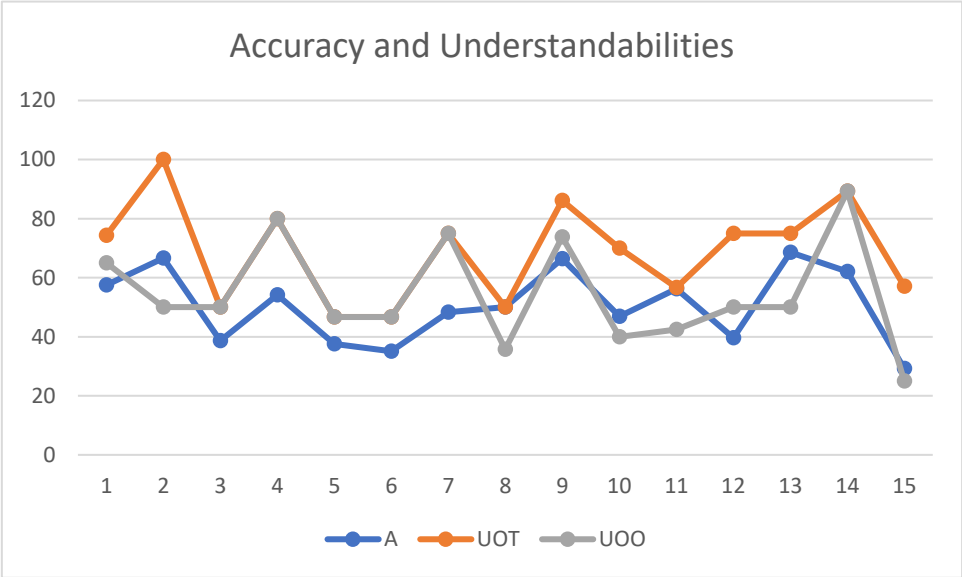
It is noted that even with relatively low accuracy, the level of understandability can be quite high. This shows even if the translation is not accurate, the letters can still be understandable.

The two metrics do not have a high correlation. The correlation between:

- accuracy and understandability on original = 0.51
- accuracy and understandability on translate = 0.73

These are positive values, but better accuracy does not always mean better understandability. The graph below shows the variability:

Chart 1. Accuracy and understandability comparison for Nepalese to English translation



The letter codes are on the X-axis and its corresponding accuracy and understandability on Y. The accuracy is seen by the blue line on the graph. If the understandabilities improved with accuracy, the grey (UOO) and orange (UOT) should also rise constantly like the accuracy line, but they haven't. There are several reasons for this, one being the choice to compute accuracy based on characters rather than words. For example, it can be the case that a badly translated section of a single phrase might result in low accuracy but the meaning of two of the three phrases might be retained.

Table 24 below shows the translated English letters with their corresponding accuracy, understandability, and the difference.

From the table, both UT and UO are higher than the accuracy for every letter. This strongly indicates that even inaccurate translation can be understandable. The difference in accuracy and UT ranged from 19.31% all the way to 54.98% and between A and UO from 17.37% to 51.21%.

Table 24. Accuracy and Understandability comparison for Google translated English letters

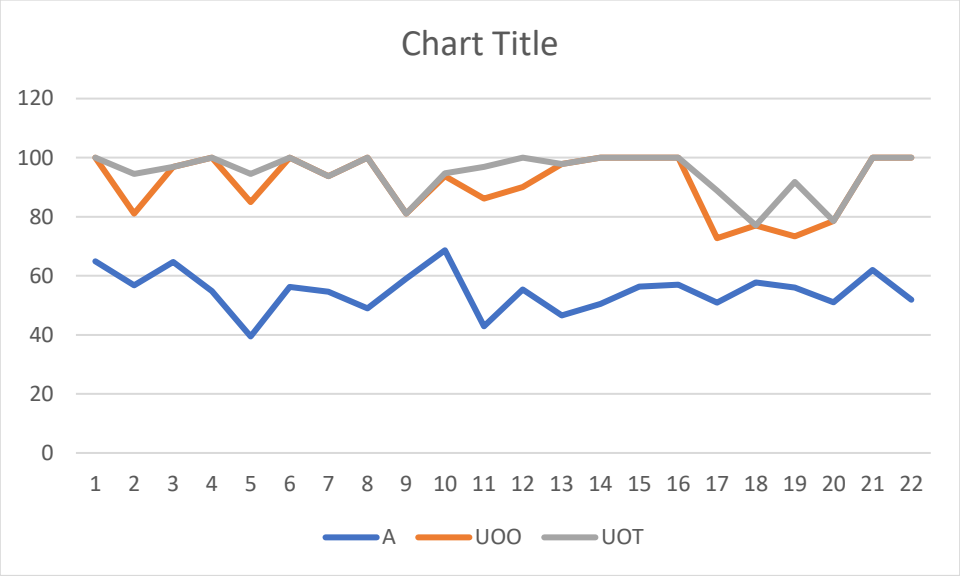
Original Letter	Translated Letter	A	UO	UT	UO-A	UT-A
E1	GTE1	64.91	100	100	35.09	35.09
E2	GTE2	56.82	81	94.5	24.18	37.68
E3	GTE3	64.68	96.86	96.86	32.18	32.18
E4	GTE4	54.8	100	100	45.2	45.2
E5	GTE5	39.46	85	94.44	45.54	54.98
E6	GTE6	56.2	100	100	43.8	43.8
E7	GTE7	54.55	93.75	93.75	39.2	39.2
E8	GTE8	48.96	100	100	51.04	51.04
E9	GTE9	59.05	81	81	21.95	21.95
E10	GTE10	68.64	93.75	94.75	25.11	26.11
E11	GTE11	42.9	86.11	96.86	43.21	53.96
E12	GTE12	55.32	90	100	34.68	44.68
E13	GTE13	46.59	97.8	97.8	51.21	51.21
E14	GTE14	50.46	100	100	49.54	49.54
E15	GTE15	56.31	100	100	43.69	43.69
E16	GTE16	57.03	100	100	42.97	42.97
E17	GTE17	50.9	72.73	88.89	21.83	37.99
E18	GTE18	57.77	77.08	77.08	19.31	19.31
E19	GTE19	56.03	73.4	91.75	17.37	35.72
E20	GTE20	50.99	78.57	78.57	27.58	27.58
E21	GTE21	61.94	100	100	38.06	38.06
E22	GTE22	51.94	100	100	48.06	48.06

Again, the correlation between accuracy and understandability are calculated to see if there is any relation. The correlation between:

- Accuracy and UT = -0.003
- Accuracy and UO = 0.18

Both the numbers are near 0 indicating that there is no correlation between those values. This data is shown in the line graph in Chart 2:

Chart 2. Comparison chart for Google translation of English letters



The numbers 1-12 on the X-axis represent the letters and accuracy is represented by the blue line. The orange and grey lines show the understandabilities on translated and original text respectively. This inconsistency certainly supports the phenomenon that the understandability is individual thing and really depends on the person who is reading it.

4.5.8 Comparing Accuracy and Understandability

Table 25 shows the comparison between the Accuracy and Understandability of translation of Nepalese and English Text where:

AN = Accuracy of translation of Nepalese text
AE= Accuracy of translation of English text
UN = Understandability of translation of Nepalese text
UE = Understandability of translation of English text

Table 25. Comparing Accuracy and Understandability of Translation of Nepalese and English texts

	AN	AE	UN	UE
	57.53	64.91	74.28	100
	66.67	56.82	100	94.44
	38.71	64.68	50	96.88
	54.19	54.8	80	100
	37.61	39.46	46.7	94.44
	35.05	56.2	46.7	100
	48.28	54.55	75	93.75
	50	48.96	50	100
	66.36	59.05	86.1	80.95
	46.87	68.64	70	93.75
	56.21	42.9	56.67	96.88
	39.66	55.32	75	100
	68.57	46.59	75	97.78
	62.04	50.46	89.3	100
	29.18	56.31	57.14	100
		57.03		100
		50.9		88.89
		57.77		77.08
		56.03		91.67
		50.99		78.57
		61.94		100
		51.94		100
Average	**50.462**	**54.83**	**68.79**	**94.78**
Standard Deviation	**12.54**	**6.97**	**16.76**	**7.25**
Variance	**157.33**	**48.55**	**280.86**	**52.59**

With the text, there was no significant effect for language, t (20) = -1.2, p = .23, despite English (M = 55, SD = 7) attaining higher average accuracy than Nepalese (M = 51, SD = 12.5).

For understandability there was a significant effect for language, t (18) = -5.6, p < .01, with English (M = 95, SD = 7) attaining higher average understandability than Nepalese (M = 69, SD = 17).

4.6 Improving Text Entry and Translation by Checking Input Errors

As observed by, and seen in, (Lamichhane and Read, 2017), children do make many input mistakes while typing which certainly have a direct impact on the translation. The only way to quantify that impact is by comparing the translation of a piece of text in two forms, one with input errors like spelling mistakes, grammatical errors, or punctuation errors i.e., the text written by the children, and another text that is error free and cleaned. In **Section 4.5**, the accuracy and the understandability of children's written letters were calculated and analysed. Now in this section, the same set of letters were used to investigate changes in accuracy and understandability that result from checking and cleaning the errors.

The original Nepalese letters (NLs) N1, N2,……,N15 and their correct translations CTN1, CTN2……,CTN15, as well as the English letters (ELs) E1, E2,……,E22 and their correct translations CTE1, CTE2,…..,CTE22 were already available along with their calculated accuracies and understandabilities. For this analysis these two sets of letters were first corrected in terms of grammar, punctuation and spelling to get Corrected Nepalese letters (NCs) NC1, NC2, ……,NC15 and Corrected English letters (ECs) EC1, EC2, ……., EC22 which were then translated using Google Translate to get GTNCs and GTECs respectively.

4.6.1 Accuracy of Google Translation of Corrected Nepalese Letters (GTNCs)

The accuracy of Google translation of the each corrected Nepalese letters are calculated using the same Edit Distance Calculation tool used previously in **Section 4.5.2**.

From the table below, it is clear that even with the correct inputs, none of the translations were 100% accurate. The accuracy ranged from 59.59 to 91.45% averaging 80.13% with SD 8.63 which is definitely better than that of translations before checking which was just 50.46% with SD 12.5. Statistically - the results before cleaning (M = 50.46, SD = 12.5) and after cleaning (M = 80.13, SD = 8.63) indicate a significant improvement in accuracy, $t(14) = -8.964$, $p < .00001$.

Table 26. Table. Edit distance, Error rate and Accuracy of Google Translation of Corrected Nepalese letters

Letter Code	|CTN|	|GTNC|	MSD	ERC	A
NC1	186	188	50	26.88	73.12
NC2	129	108	28	21.71	78.29
NC3	93	89	10	10.75	89.25
NC4	155	141	28	18.06	81.94
NC5	117	110	10	8.55	91.45
NC6	97	93	25	25.77	74.23
NC7	116	117	25	21.55	78.45
NC8	164	150	30	18.29	81.71
NC9	220	206	50	22.73	77.27
NC10	128	119	38	29.69	70.31
NC11	169	170	28	16.57	83.43
NC12	174	173	29	16.67	83.33
NC13	140	135	13	9.29	90.71
NC14	108	104	12	11.11	88.89
NC15	490	445	198	40.41	59.59
Average	**165.73**	**156.53**	**38.27**	**19.87**	**80.13**
SD	**96.49**	**87.3**	**45.93**	**8.63**	**8.63**

Looking at each letter and their corresponding minimum string distance and accuracy before and after the checks will certainly make it clearer.

Further comparison data for before and after the check are shown below:

LC = Letter codes

MSD1=MSD before

MSD2=MSD after

ER1=Error rate before

ER2=Error rate after

A1= Accuracy before

A2 = Accuracy after

A2-A1=Difference in accuracy

AI% = Percentage of Accuracy improvement

Table 27. Comparison between the translations of Nepalese letters before and after the checks

LC	MSD1	MSD2	ER1	ER2	A1	A2	A2-A1	AI%
NC1	79	50	49.45	26.74	57.53	73.12	15.59	27.10
NC2	43	28	38.61	23.82	66.67	78.29	11.62	17.43
NC3	57	10	57.03	10.99	38.71	89.25	50.54	130.56
NC4	71	28	47.22	18.96	54.19	81.94	27.75	51.21
NC5	73	10	73.64	8.82	37.61	91.45	53.84	143.15
NC6	63	25	63.06	26.33	35.05	74.23	39.18	111.78
NC7	60	25	50.86	21.46	48.28	78.45	30.17	62.49
NC8	82	30	52.33	19.15	50	81.71	31.71	63.42
NC9	74	50	36.09	23.5	66.36	77.27	10.91	16.44
NC10	68	38	71.9	30.81	46.87	70.31	23.44	50.01
NC11	74	28	43.53	16.52	56.21	83.43	27.22	48.43
NC12	105	29	59.67	16.71	39.66	83.33	43.67	110.11
NC13	44	13	32.64	9.46	68.57	90.71	22.14	32.29
NC14	41	12	39.9	11.32	62.04	88.89	26.85	43.28
NC15	347	198	102.66	42.45	29.18	59.59	30.41	104.22

For each letter, MSD is lower, error rate is lower, and the accuracy is higher for the corrected version. The increases in accuracy from 10.91 to as much as 53.84 certainly backs the idea of checking the Nepalese input text before translation as this undoubtedly improves the accuracy of translation to English.

4.6.2 Understandability of Google Translation of Corrected Nepalese Letters (GTNCs)

4.6.2.1 Procedure

During the studies described in **Sections 4.5.4** and **4.5.6** earlier in this chapter, while the children were meeting texts in the DigiPal Understandability app, they also met corrected texts. In the earlier sections only the data from the uncorrected texts was considered. In this section the data from the corrected texts is analysed. During the studies, no child met both the corrected and uncorrected version of same text. In the same way as earlier, each Google translated Corrected letter was compared with the Corrected Nepalese letter to see the number of information retained. Out of 15 letters, only 6 letters retained all the information, 3 retained half or less information.

4.6.2.2 Results

The table below shows the understandability calculations for corrected text:

Table 28. Number of meaningful information and Understandability of Corrected Nepalese Letters

TLC	NMIC	NMITC	NMIU								
			P1	P2	P3	P4	P5	P6	Ave	UTC	UCO
GTNC1	8	8	6	6	8	6	8		6.8	85	85
GTNC2	4	3	3	3	3	3	3		3	100	75
GTNC3	3	3	3	3	3	3	3	3	3	100	100
GTNC4	5	5	5	5	5	5	5	5	5	100	100
GTNC5	3	3	3	3	3	3	3		3	100	100
GTNC6	3	3	3	2	3	3	2		2.6	86.67	86.67
GTNC7	4	4	4	4	4	4	4	4	4	100	100
GTNC8	7	6	6	5	5	5	6	6	5.5	91.67	78.57
GTNC9	7	7	5	7	7	7	6	7	6.5	92.8	92.8
GTNC10	7	6	4	5	5	6	5		5	83.33	71.43
GTNC11	8	6	3	5	4	5	4		4.2	70	52.5
GTNC12	6	6	6	6	6	5	5		5.6	93.33	93.33
GTNC13	6	5	3	5	5	5	4		4.6	88	73.33
GTNC14	4	4	3	4	3	4	4	4	3.7	91.67	91.67
GTNC15	16	12	7	8	11	11	8	11	9.3	75	52.5

In **Table 28**,

NMIC = Number of items of meaningful information in corrected letter (before translation)

NMITC = Number of items of meaningful information in the translation of the corrected letter

NMIU = Number of items of meaningful information understood by the children

P1-P6 = Number of items of meaningful information by individual participant for the particular letter

UTC = Understandability on Translation of corrected

UCO = Understandability on corrected original

The values ranged from 70 to 100 for UTCs and 52.5 to 100 for the UCOs. Only 4 letters showed 100% understandability in both the calculation against the original corrected letter and Google translated text of the original corrected letter. An important comparative observation here is that this understandability is higher than that of the ones with the letters with errors. The table below shows the comparison:

Understandability on Translate = UT
Understandability on Translation of corrected = UTC
Improvement on the understandability on translation = IT
Understandability on original = UO
Understandability on corrected original = UCO
Improvement on the understandability on original = IO

Table 29. Understandability comparison on the translated letters before and after error checking

UT	UTC	IT	UO	UCO	IO
74.28	85	10.72	65	85	20
100	100	0	50	75	25
50	100	50	50	100	50
80	100	20	80	100	20
46.7	100	53.3	46.7	100	53.3
46.7	86.67	39.97	46.7	86.67	39.97
75	100	25	75	100	25
50	91.67	41.67	35.7	78.57	42.87
86.1	92.8	6.7	73.8	92.8	19
70	83.33	13.33	40	71.43	31.43
56.67	70	13.33	42.5	52.5	10
75	93.33	19.26	50	93.33	43.33
75	88	13	50	73.33	23.33
89.3	91.67	2.37	89.3	91.67	2.37
57.14	75	17.86	25	52.5	27.5

For each letter, both understandability calculations, one on the translated text and another on the original text is higher in case of the letter where the errors were checked prior to the translation. The improvement on understandability on the translated text ranged from 0 to as

high as 53.3 and in case of original corrected from 2.37 to as high as 53.3 again. The average improvement was 21.7 in case of translated and 28.87 in case of the original. This observation supports that the understandability of the translated text will improve if the error checking is done before the translation process.

This increase in understandability is most likely a result of the fact that the number of items of information retained in the case of NLCs is much improved. The table below shows the comparison between number of information retained by GTNs and GTNCs.

TLC = Letter Code
NMIO/NMIC = Number of meaningful information in original letter
NMIT = Number of meaningful information retained in translated letter
NMITC = Number of meaningful information retained in translation of corrected letter
INIR = Improvement in number of meaningful information retained

Table 30. Comparison of number of information retained by the translated Nepalese letters before and after error checking.

TLC	NMIO/NMIC	NMIT	NMITC	INIR
GTN1	8	7	8	1
GTN2	4	2	3	1
GTN3	3	3	3	0
GTN4	5	5	5	0
GTN5	3	3	3	0
GTN6	3	3	3	0
GTN7	4	4	4	0
GTN8	7	5	6	1
GTN9	7	6	7	1
GTN10	7	4	6	2
GTN11	8	6	6	0
GTN12	6	3	6	3
GTN13	6	4	5	1
GTN14	4	4	4	0
GTN15	16	7	12	5

For 8 out of 15 letters, the number of items of information retained is higher in the case of error checked letters. None has less. For the remaining 7, 6 are equal viz. both retained all the information. Only one is the exception that even after the error checking the number didn't

increase. That means 1 out of 15 letters didn't improve in terms of number of meaningful things. From this it is clear that the loss in meaningful information can be minimised by checking the presented text for errors.

4.6.2.3 Discussion

In some cases, when the children didn't understand a piece of text, they added some extra information either by guessing or by being creative. If they guessed something right, we wouldn't know that because it would show as they understood it. When they clearly came up with something completely new, it was interesting to see their creativity and imagination. Looking at the 156 individual responses across both corrected and uncorrected text, 48 of them had surprise things in them which varied from 1 to 4 new things per retell. The table below shows how this compared across corrected and uncorrected texts:

Table 31. Guesses in the translated Nepalese texts before and after error checks

Text number	Total number of things guessed or imagined	
	On the text before the check	On the text after the check
N 1	3	1
N 2	1	8
N 3	3	0
N 4	6	1
N 5	6	1
N 6	13	5
N 7	11	0
N 8	8	5
N 9	4	3
N 10	7	4
N 11	2	2
N 12	3	2
N 13	9	2
N 14	8	1
N 15	5	4

The total number of things guessed for the translation of a particular text is lower after the errors checked. Except for one, all 14 texts showed a similar trend. The total number of things guessed for the text before the check was 89 and for after the check was 39. This clearly shows that the guessing decreases after checking because the text is much more understandable and there is no need for guessing.

4.6.3 Accuracy of Google translation of Corrected English Letters (GTECs)

In the same way as for Nepalese letters, the accuracy of Google translation of each of the Corrected English letters were calculated. The table below shows the full results:

Table 32. Edit distance, Error rate and Accuracy of Google Translation of Corrected English letters

Letters	|CTE|	|GTE|	MSD	ER	A
E1	114	115	24	21.05	78.95
E2	176	177	62	35.23	64.77
E3	218	217	24	11.01	88.99
E4	250	228	101	40.4	59.6
E5	332	284	140	42.17	57.83
E6	137	126	53	38.69	61.31
E7	286	260	120	41.96	58.04
E8	96	83	48	50	50
E9	232	235	67	28.88	71.12
E10	118	110	29	24.58	75.42
E11	317	297	137	43.22	56.78
E12	376	353	148	39.36	60.64
E13	498	508	174	34.94	65.06
E14	109	97	38	34.86	65.14
E15	222	192	80	36.04	63.96
E16	256	222	94	36.72	63.28
E17	389	335	123	31.62	68.38
E18	412	414	142	34.47	65.53
E19	141	132	52	36.88	63.12
E20	151	131	42	27.81	72.19
E21	247	230	85	34.41	65.59
E22	206	196	90	43.69	56.31
Average	**240.14**	**224.64**	**85.14**	**34.91**	**65.09**
SD	**110.6**	**108.62**	**45.2**	**8.5**	**8.5**

Again, even with the correct inputs, none of the translations were 100% accurate. The accuracy ranged from 50 to 88.99 % averaging 65.09 with SD 8.5 which is definitely better than that of translations before check which was just 54.83% with SD 6.97. Statistically - the results before cleaning (M = 54.83, SD = 6.97) and after cleaning (M = 65.09, SD = 8.5) indicate a significant improvement in accuracy, t (21) = -7.356, p < .00001.

Looking at each letter and their corresponding minimum string distance and accuracy before and after the checks shows the impact of corrections.

Further comparison data for before and after the check are shown below:

Table 33. Accuracy comparison between the translations of English letters before and after the checks

Letters	MSD1	MSD2	ER1	ER2	A1	A2	A2-A1	AI%
E1	40	24	35.09	21.05	64.91	78.95	14.04	30.69
E2	76	62	43.18	35.23	56.82	64.77	7.95	9.54
E3	77	24	35.32	11.01	64.68	88.99	24.31	36.72
E4	113	101	45.2	40.4	54.8	59.6	4.8	10.02
E5	201	140	60.54	42.17	39.46	57.83	18.37	94.86
E6	60	53	43.8	38.69	56.2	61.31	5.11	17.88
E7	130	120	45.45	41.96	54.55	58.04	3.49	10.98
E8	49	48	51.04	50	48.96	50	1.04	16.73
E9	95	67	40.95	28.88	59.05	71.12	12.07	23.71
E10	37	29	31.36	24.58	68.64	75.42	6.78	12.31
E11	181	137	57.1	43.22	42.9	56.78	13.88	45.87
E12	168	148	44.68	39.36	55.32	60.64	5.32	11.78
E13	266	174	53.41	34.94	46.59	65.06	18.47	36.37
E14	54	38	49.54	34.86	50.46	65.14	14.68	39.25
E15	97	80	43.69	36.04	56.31	63.96	7.65	15.61
E16	110	94	42.97	36.72	57.03	63.28	6.25	18.85
E17	191	123	49.1	31.62	50.9	68.38	17.48	44.05
E18	174	142	42.23	34.47	57.77	65.53	7.76	13.68
E19	62	52	43.97	36.88	56.03	63.12	7.09	18.08
E20	74	42	49.01	27.81	50.99	72.19	21.2	61.73
E21	94	85	38.06	34.41	61.94	65.59	3.65	6.71
E22	99	90	48.06	43.69	51.94	56.31	4.37	12.16

In the table above,

MSD1=MSD before

MSD2=MSD after

ER1=Error rate before

ER2=Error rate after

A1=Accuracy before

A2 = Accuracy after

A2-A1=Difference in accuracy

AI% = Percentage of Accuracy improvement

For each letter, MSD is lower, error rate is lower, and the accuracy is higher for the corrected input version. The increase in accuracy ranged from 1.04 to 24.31. This backs the idea of checking the English input text before translation.

4.6.4 Understandability of Google translation of Corrected English Letters (GTECs)

In just the same way as with the Nepalese letters, the understandability of the Translations of Corrected English letters was computed. Each letter was read by at least 3 different participants and the results were as follows:

Table 34. Understandability of translation of corrected English letters

TCL	NMIO	NMITC	NMIU				U		
			P1	P2	P3	P4	AMI	UCO	UCT
GTE1	4	4	4	4	4		4.00	100.00	100.00
GTE2	7	6	6	6	6		6.00	85.71	100.00
GTE3	8	8	8	8	7	8	7.75	96.88	96.88
GTE4	7	7	7	7	7	7	7.00	100.00	100.00
GTE5	10	9	9	9	9	8	8.75	87.50	97.22
GTE6	3	3	3	3	3		3.00	100.00	100.00
GTE7	8	8	7	8	8	8	7.75	96.88	96.88
GTE8	3	3	3	3	3		3.00	100.00	100.00
GTE9	7	7	7	6	6	7	6.50	92.86	92.86
GTE10	4	4	4	4	4	3	3.75	93.75	93.75
GTE11	9	8	8	8	7	8	7.75	86.11	96.88
GTE12	10	10	10	10	10		10	100	96.67
GTE13	15	15	15	15	14		14.67	97.78	100
GTE14	5	5	5	5	5		5.00	100.00	100.00
GTE15	6	6	6	6	6	6	6.00	100.00	100.00
GTE16	7	7	7	7	7		7.00	100.00	100.00
GTE17	11	10	9	9	10	9	9.25	84.09	92.50
GTE18	12	12	12	11	10	11	11.00	91.67	91.67
GTE19	5	5	5	5	4	5	4.75	95.00	95.00
GTE20	7	7	6	6	6	6	6.00	85.71	85.71
GTE21	8	8	8	8	8		8.00	100.00	100.00
GTE22	5	5	5	5	5		5.00	100.00	100.00

In the Table above,

Translated letter codes = TLC

Number of items of meaningful information on original text = NMIO

Number of items of meaningful information on translation of corrected text = NMITC

Number of items of meaningful information understood = NMIU

Average of items of meaningful information understood for particular letter = AMI

Understandability = U

Understandability on corrected original = UCO

Understandability on translation of corrected letters= UTC

P1-P4 = Number of items of meaningful information by individual children for the particular letter

The understandability values ranged from 85.71 to 100 for UOTCs and 79.55 to 100 for the UOCOs. 10 letters showed 100% understandability in both the calculation against the original corrected letter and the Google translated text of the original corrected letter. This understandability is considerably higher than for the letters with errors. The table below shows the comparison:

Translated letters code = TLC

Understandability on original before error check = UO

Understandability on original after error check = UCO

Improvement on understandability on original = IUO

Understandability on translation before error check = UT

Understandability on translation after error check = UCT

Improvement on understandability on translation = IUT

Table 35. Understandability comparison on the translated letters before and after error checking

TLC	UO	UCO	IUO	UT	UCT	IUT
GTE1	75.00	100.00	25.00	100.00	100.00	0.00
GTE2	80.95	85.71	4.76	94.44	100.00	5.56
GTE3	96.88	96.88	0.00	96.88	96.88	0.00
GTE4	100.00	100.00	0.00	100.00	100.00	0.00
GTE5	85.00	87.50	2.50	94.44	97.22	2.78
GTE6	100.00	100.00	0.00	100.00	100.00	0.00
GTE7	93.75	96.88	3.13	93.75	96.88	3.13
GTE8	100.00	100.00	0.00	100.00	100.00	0.00
GTE9	80.95	92.86	11.90	80.95	92.86	11.90
GTE10	93.75	93.75	0.00	93.75	93.75	0.00
GTE11	86.11	86.11	0.00	96.88	96.88	0.00
GTE12	90.00	96.67	6.67	100.00	100.00	0.00
GTE13	97.78	97.78	0.00	97.78	97.78	0.00
GTE14	100.00	100.00	0.00	100.00	100.00	0.00
GTE15	100.00	100.00	0.00	100.00	100.00	0.00
GTE16	100.00	100.00	0.00	100.00	100.00	0.00
GTE17	72.73	84.09	11.36	88.89	92.50	3.61
GTE18	77.08	91.67	14.58	77.08	91.67	14.58
GTE19	73.33	95.00	21.67	91.67	95.00	3.33
GTE20	78.57	85.71	7.14	78.57	85.71	7.14
GTE21	100.00	100.00	0.00	100.00	100.00	0.00
GTE22	100.00	100.00	0.00	100.00	100.00	0.00
average	90.09	95.03	4.94	94.78	97.14	2.37

For each letter, both understandability calculations, one on the translated text and another on the original text, are higher in the cases of the letter having the errors checked prior to the translation. The improvement on understandability on the translated text ranged from 0 to as high as 53.3 and in case of the original from 2.37 to as high as 14.58 again. The average improvement was 2.37 in case of translated and 4.94 in case of the original. This observation supports that the understandability of the translated text will improve if the error checking is done before the translation process. This increase is again associated to the fact that more information is retained in the case of ELCs. The table below shows the comparison between number of information retained by GTEs and GTECs.

TLC = Letter Code

NMIO = Number of meaningful information in original letter

NMIT = Number of meaningful information retained in translated letter =

NMITC = Number of meaningful information retained in translation of corrected letter

INIR = Improvement in number of meaningful information retained

Table 36. Comparison of number of information retained by the translated English letters before and after error checking.

TLC	NMIO	NMIT	NMITC	INIR
GTE1	4	3	4	1
GTE2	7	6	6	0
GTE3	8	8	8	0
GTE4	7	7	7	0
GTE5	10	9	9	0
GTE6	3	3	3	0
GTE7	8	8	8	0
GTE8	3	3	3	0
GTE9	7	7	7	0
GTE10	4	4	4	0
GTE11	9	8	8	0
GTE12	10	9	10	1
GTE13	15	15	15	0
GTE14	5	5	5	0
GTE15	6	6	6	0
GTE16	7	7	7	0
GTE17	11	9	10	1
GTE18	12	12	12	0
GTE19	5	4	5	1
GTE20	7	7	7	0
GTE21	8	8	8	0
GTE22	5	5	5	0

For 4 out of 22 letters, the number of information retained is higher in case of error checked letters.

Like English readers, Nepalese children also tried to make sense out of unclear text and wrote something completely new. Looking at the 153 individual responses, 25 of them had new things expressed which varied from 1 to 4 new things for a letter.

Table 37. Comparison of number of information children guessed on the translated English letters before and after the error check

Text number	Total number of things guessed or imagined	
	On the text before the check	On the text after the check
GTE1	2	0
GTE2	3	0
GTE3	1	1
GTE4	3	0
GTE5	2	1
GTE6	3	1
GTE7	2	1
GTE8	1	0
GTE9	2	1
GTE10	1	0
GTE11	2	0
GTE12	1	0
GTE13	3	2
GTE14	2	1
GTE15	1	1
GTE16	3	1
GTE17	2	1
GTE18	4	2
GTE19	2	1
GTE20	1	0
GTE21	1	0
GTE22	1	0

The total number of things guessed for the translation of a particular text is lower after the errors checked. Except 2, all 22 texts showed the similar trend. The total number of things guessed for the text before the check was 43 and after the check was14. This clearly shows that the guessing decreases after check because it is much more understandable and there is no need for guessing.

4.6.5 Comparing Accuracy and Understandability of Corrected Letters

Table 38 shows the comparison between the Accuracy and understandability of translation of the corrected Nepalese and English text:

AN = Accuracy of Nepalese text

AE = Accuracy of English text

UN = Understandability of Nepalese text

UE = Understandability of English text

Table 38. Comparing Accuracy and Understandability of Translation of Corrected Nepalese and English texts

	AN	AE	UN	UE
	73.12	78.95	85	100
	78.29	64.77	100	100
	89.25	88.99	100	96.88
	81.94	59.6	100	100
	91.45	57.83	100	97.22
	74.23	61.31	86.67	100
	78.45	58.04	100	96.88
	81.71	50	91.67	100
	77.27	71.12	92.8	92.86
	70.31	75.42	83.33	93.75
	83.43	56.78	70	96.88
	83.33	60.64	93.33	96.67
	90.71	65.06	88	100
	88.89	65.14	91.67	100
	59.59	63.96	75	100
		63.28		100
		68.38		92.5
		65.53		91.67
		63.12		95
		72.19		85.71
		65.59		100
		56.31		100
Average	**80.13**	**65.09**	**90.5**	**97.09**
Standard Deviation	**8.63**	**8.5**	**9.37**	**3.82**
Variance	**74.54**	**72.24**	**87.88**	**14.61**

For accuracy there was a significant effect for language, t (34) = 5.2, $p < .00001$, with English (M = 65, SD = 8) attaining lower average accuracy than Nepalese (M = 80, SD = 8.7).

With corrected text, for understandability, there was a significant effect for language, t (34) = -2.97, $p < .05$, with English (M = 97, SD = 4) attaining higher average understandability than Nepalese (M = 90, SD = 9.4).

4.7 Discussion

4.7.1 Informing Design of the DigiPal App – Version 4.

From the Calculation and Analysis described in **Sections 4.5 and 4.6**, it appears that Google Translate can be used as a translation tool for the DigiPal app. The accuracy might not be great, but the understandability is better, and if input errors can be checked, this will improve further. Therefore, a decision was made to integrate Google Translate into the app. To use the Google Translate functionality, a project was created in Google Cloud that received the API key to use within the app to enable the translation of the letters (More details on **Appendix 3.3 Google Translation API Implementation)**.

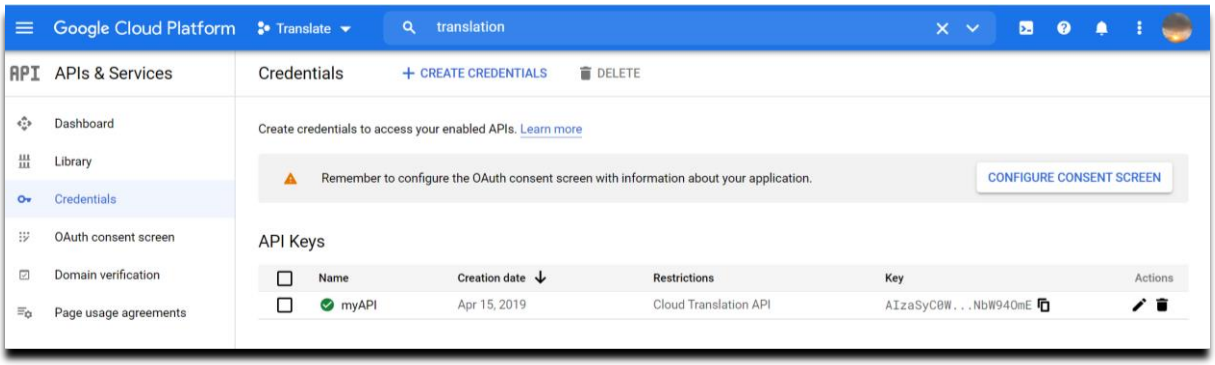


Figure 50. Using Google Cloud Translation API for the app

To store the letters and their translations, a database was created in the University server with the help of the University IT department. The database consisted of the following tables:

Table 39. User Table from Database

Users Table		
username	Primary key, unique	Varchar2(50)
Password		Varchar2(50)
FirstName	First name	Varchar2(50)
MiddleName	Middle name	Varchar2(50)
LastName	Last name	Varchar2(50)

Table 40. Letters Table from Database

Letters		
LetterID	Primary key, unique	Int(11)
sender	Username of sender	Varchar2(50)
receiver	Username of receiver	Varchar2(50)
LetterDate	Date and time of letter sent	Date
Letter	Original Letter	Varchar
LetterLanguage	Language of original letter, ISO Language code	Varchar(2)
Translated letter	Letter translated by Google	Varchar
TranslatedLanguage	Language of translated language, ISO Language code	Varchar(2)

Table 41. Users Pair Tables from Database

UserPairs		
User1	Username of first user	Varchar2(50)
User2	Username of second user	Varchar2(50)

Table 42. Example UserPairs

UserPairs	
User 1	User2
Nep1	Eng1

Once a user is created, their details are saved in the Users table. The username has to be unique. Once a user is connected with another user, for the letter exchange process, their usernames are saved in the UserPairs Table. When a letter is typed and sent by one user, it is first translated to the targeted language which is the language of the receiver and then both the letters, sender username, receiver username, date and time of letters sent, ISO codes for both original letters and translated letter codes are saved in the Letters table. When the receiving user logs in into the app, they can see translated letters written by the sender and their own letters in their own original language.

For example:

There are two users Nep1 from Nepal and Eng1 from England chatting with each other in Nepalese and English Languages respectively.

Nep1 sends the first letter NL1 in Nepalese which will be translated to English and saved as NLT1. Eng1 then opens the app and only sees NLT1 and then replies in English with letter EL1 which is translated to Nepalese as ELT1 and saved. When Nep1 logs in and checks he / she sees NL1 (Nepalese) and ELT1(Nepalese). If Nep1 replies again with NL2, NLT2 will be created and Eng1 can see all three letters NLT1, EL1 and NLT2.

The Letters table in the database looks as follows:

Table 43. Example of user pair letters

LetterId	Sender	Receiver	Letter	LetterDate	LetterLanguage	TranslatedLetter	TranslatedLetterLanguage
L1	Nep1	Eng1	NL1	21/12/2020	NP	NLT1	EN
L2	Eng1	Nep1	EL1	22/12/2020	EN	ELT1	NP
L3	Nep1	Eng1	NL2	23/12/2020	NP	NLT2	EN

On the screen the letters appear as threads:

Table 44. English user's screen

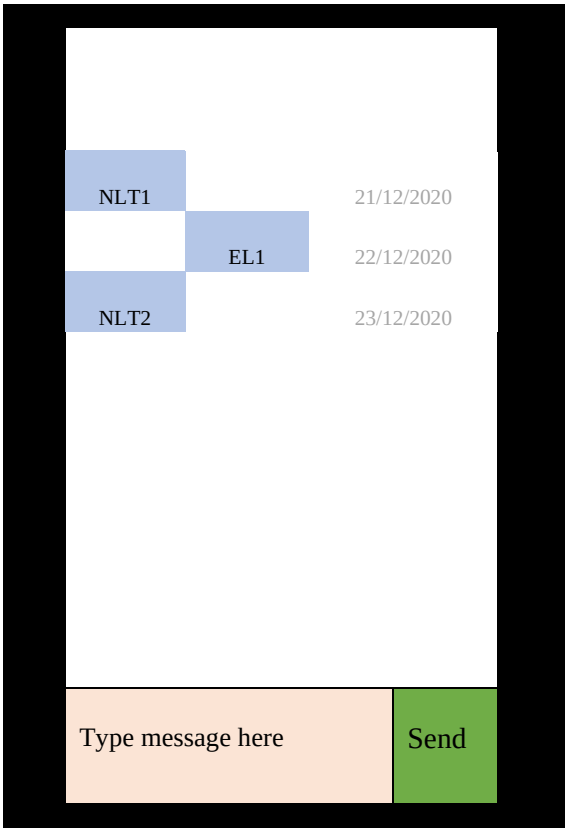
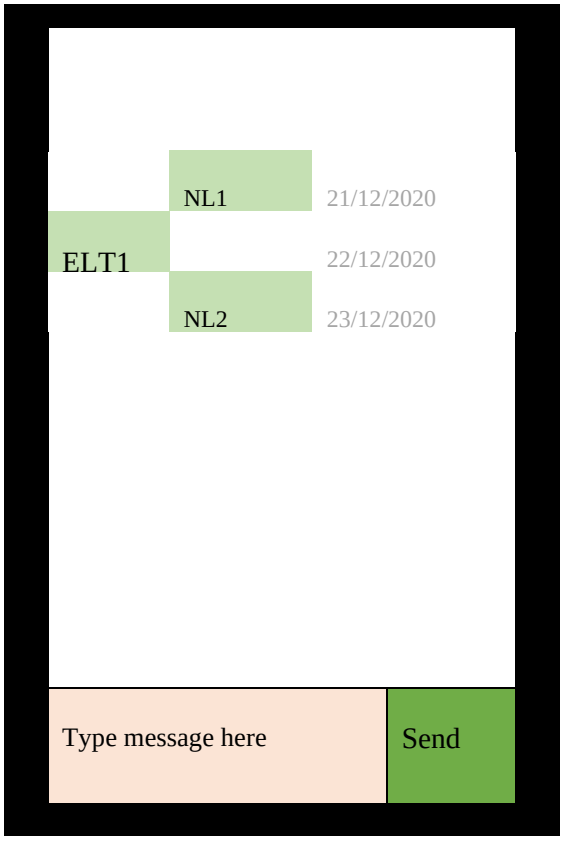


Table 45. Nepalese user's Screen



4.7.2 Cultural Evenness.

This chapter mainly contributes to the Translation Layer of the Model. The conclusion from this chapter is that a translation tool can be used to facilitate cross-lingual communication. This tool doesn't need to be Google, but in this work, Google is used because that's the only and best option available for English to Nepalese and vice-versa translation. It further appears that preferably pre checking of spelling, grammar and punctuation of written text should be implemented to improve the accuracy and even the understandability of texts when they are translated. Ideally these checks should be done behind the scenes which the children wouldn't see. Just like the texts were corrected in this chapter manually before translation, a similar kind of automatic text cleaning intelligence could be implemented that runs just before the translation.

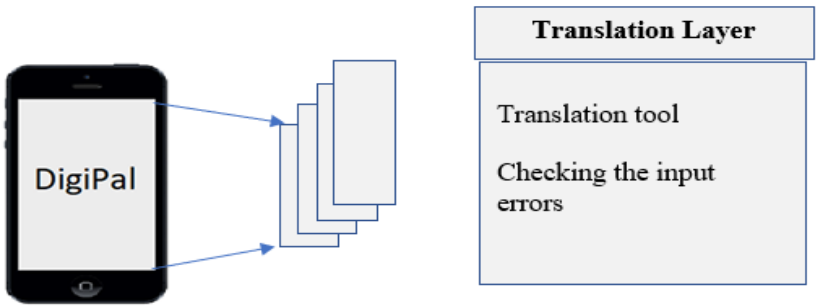


Figure 51. Proposed translation layer for DigiPal

A confound in this chapter could be around the way the accuracy and understandability calculations were done. The accuracy was calculated looking at each character from the translated text and comparing it with the corresponding correct translation that means the calculation or checking was on the character level. Understandability counted the number of phrases or sentences understood by the children which means it was a phrase/sentence level calculation; this raises the question can they be compared and what is the impact of these choices?

On the first issue, due to the redundancy of language, a character changed in a word, can completely change the meaning of the phrase (e.g., him to ham (I like him, I like ham)) but the opposite can happen with the way Google operates where a character error can result in a non-word which can result in lost information. Here is an example from a participant's letter:

- Original text: मेरो घरमा बुवा आमा **दिद** हुनुहुन्छ। (With missing vowel and a conjunction)
- Intended text: मेरो घरमा बुवा आमा **दिदी र** हुनुहुन्छ।
- Expected Translation: I have father, mother and sister in my house.
- Google Translate: My father and mother are in my house.
- Understood: Father and mother are in the house.

Google missed the sister part of the original text as it was missing a vowel and the new word didn't make sense in the context, so Google omitted it. This affected both the accuracy and the translation of the text. The output text is fully understandable but missing some information. If the mistake was corrected, the Google Translate would give a fully correct answer. Further work would need to be done with languages with less redundancy to determine to what extent character level errors affect overall understandability.

4.7.3 Contribution/Insights for Follow on Work

The accuracy and understandability of the Google translation of Nepalese and English text provided by the children were both calculated in this chapter. This is the first documented study showing the effectiveness of GT for children's text in this context. It appears that while the translation is erroneous, it may well be good enough for use in a children's app. Using a novel child centred method to evaluate understanding, it was seen that correction of text before translation helped both understandability and effectiveness. This error correction would be a good feature to add in future versions of the app. The findings from this study, that translation was manageable, inspired the next study which would bring the translation live to children in a cross-country chat application.

4.8 Summary of the Chapter

The studies have shown that translation accuracies for the letters vary a lot according to the construction of the letter. Accuracy is not dependent on the length of the text – it is very much associated with the content of the child's input. Understandability was significantly higher than accuracy. Children were able to understand text which was not accurately translated. The context of the text definitely helped with that. The children who could understand the context, understood the phrase or the sentence even though there were some mistakes in the translation. This is good news for translation-based interfaces for children.

Machine translation is always improving and with the learning that is built into products like Google Translate there is likely to be improvement over time in the general translation of children's texts although clearly some of the content they write about may be some way outside the main vocabulary of Google. Most of the text children entered had spelling and grammar mistakes. This was shown, in this chapter to have an impact on the translation of those texts. Building in checking of spelling and grammar will improve accuracy and understandability. The method used in this chapter to measure understandability is offered as a contribution to knowledge. This method was easy to implement with the children and didn't cause anxiety or worry. The algorithm used to determine an understandability score was new but fitted this particular context well.

Chapter 5. Study 4: Realtime DigiPal Letters Exchange

5.1 Introduction

With translation integrated into the app, the new version was tested with children from Nepal and England where they took part in a real time letter sending activity. This chapter contributes towards answering the sub research question: *SRQ1. To what extent, and with what limitations and consequences, does automatic translation work with children's chat?* by demonstrating that children could carry on conversations even with sub-optimal translation, but it also importantly unpicks why errors happened in translation – identifying the effect of input errors by the children as well as errors in the design of the Google Translate operation. It also provides some insights as to the sub research question: *SRQ2. To what extent can children, from two different cultures, equally participate in the design of a single application?* and it contributes insights towards the **design of the digital app** as well is towards a general model for design for **cultural evenness**.

This study mainly focuses on the analysis of Google translate in the wild; unearthing its smartness and stupidity and considering improvement points, inconsistencies, and the understandability of translated text alongside its use to facilitate cross lingual communication. The aim of the study described here was to further explore the possibilities for the use of machine translated text in a chat application for children. The hypothesis was that problems with translation would have an impact on the chat process.

Work from this chapter is published in:

Maybe I Can Help? Google as a Translator and Facilitator for an Inter-lingual Children's Chat Application

Authors: Dev Raj Lamichhane, Janet C. Read, Zixi You
Conference name: International Conference on Human-Computer Interaction, HCII 2021
Pages: 208-215
Publisher: Springer, Cham
Publication date: 03 July 2021
Digital Link: https://link.springer.com/chapter/10.1007/978-3-030-78635-9_29

Sections 5.2, 5.3 and 5.4 explain the study where children from Nepal and England participated in a real time pen pal exchange activity. The results from the study in terms of text input, errors and translation are discussed in **Section 5.5**. Further discussion around informing the design from the results and the cultural aspects that need to be considered can be found in **Section 5.6** followed by the conclusions in **Section 5.7**.

5.2 Participants and Location

The study took place in two locations. Thirty-eight children participated from a Nepalese school situated in the suburb of a small city, Banepa, and twenty children participated from a small town, Kirkham, in England. The children were aged between 9 and 12 and they participated in the study during their school lessons. Ethics clearance for the study was obtained for both locations. For the facilitation of the study, two HCI postgraduate students from the University from Banepa volunteered to assist myself in Nepal, whereas in Kirkham, my PhD supervisor volunteered and supervised the process, and each location was attended by the class teacher too.

5.3 Apparatus – DigiPal Version 4

In both locations the children used the same bespoke mobile app, the DigiPal Version 4, Children in Nepal used it on Android mobile phones (Make: Cubot Magic, Screensize:5") and the English children used it on Android tablets (Samsung Galaxy Tab E, with 9.6" display). All the phones were identical, and all the tablets were identical, and each had the app which allowed children to send and receive letters or chat from one to the other. The app had a built-in translation system (integrated Google translation API) which allowed each child to send and receive text in their own language.

DigiPal App. The welcome page contained the name of the app, the logo and country flags. The user clicks on their country's flag and based on this, the texts/labels are translated. For example, when Nepalese children click on the Nepalese flag, all the components (Titles, labels, headers etc.) on the app, as well as any received text, will be shown in Nepalese. The home page allows the child to leave the app or view and reply to chat. On selecting view / reply, the child is taken to the letter writing page where he / she enters text or reads other chat. The overall design of the app is similar to Digipal version 3, integrated translation being the only difference.

The Google translate API was integrated within the app and letters that are sent are translated to the target language. Both the original and translated text are saved in the database along with a sender and receiver ID The same letters are retrieved in the intended language and shown in the letter activity page for the corresponding users.

Figure 52. DigiPal Version 4 Home page

5.4 Procedure

After ethics clearance and the completion of consent processes with the children, parents, and the headteachers of the respective schools, all the children were met one day before the activity to ensure they fully understood what they would be doing the next day (writing to a child in Nepal or England) and to ensure there was no uncertainty. On that day, all the tablets and phones and the internet connections were checked.

Day 1. On the first day, a series of activities started in Banepa School around 09:00 local (NPT) time (+4:45 GMT). The letter exchange activity, core to this study, was one of several activities as due to there being only six mobile devices available, the children had to take turns to write their letters. Others continued doing other activities. The children selected the Nepalese flag to start, and each was given a unique user id like (user 2, user 4, user 6 and so on) and asked to remember this for later and this was recorded on a sheet against their name. The children logged on and started writing their first letter which would be an introduction of themselves to the

children in England. They were encouraged to ask one or more questions to the English child in order to encourage a reply.

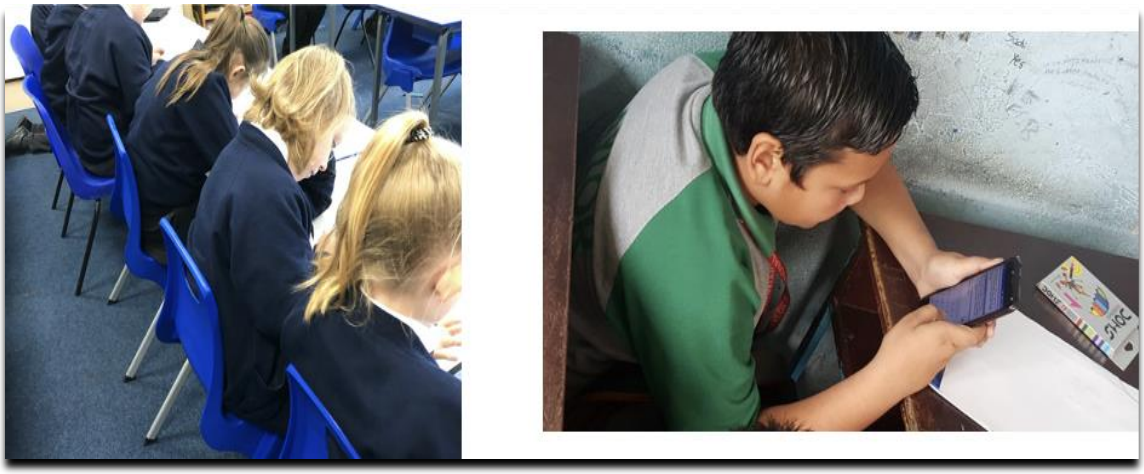


Figure 53. Children in England and Nepal chatting with each other same time

Similar to the observation in the study in **Section 3.3**, these children used the phonetic typing method for writing letters. To facilitate this an Android keyboard ad-in as shown in **Figure 54** was installed for the app. While writing, the children would write a word phonetically, and in the suggestion box they could see the corresponding Nepalese text as shown in **Figure 55** which they would click (detail to this is added in **Section 5.5.4**). Once a child finished, he or she was asked to check in with the researcher or the assistants before sending the letter. This was to make sure the text inserted was appropriate and had enough words.

Meanwhile, in England, the day started at 09.00 local time (GMT). Again, the children were doing similar activities like the Nepalese children including this letter exchange activity. Due to the time difference, by 09.00 GMT, the letters from Nepal (which was then at 13.45 NPT) had arrived and so in England, the children began by answering those letters. Once again, six children at a time could see and reply to letters due to only having a limited number of mobile devices (see **Figure 53**). These children logged on in the same way as the Nepalese children selecting English flag but had odd numbered logins (user 1, user 3, user 5 and so on and it was arranged so that user 1 and user 2 would write one to the other etc.

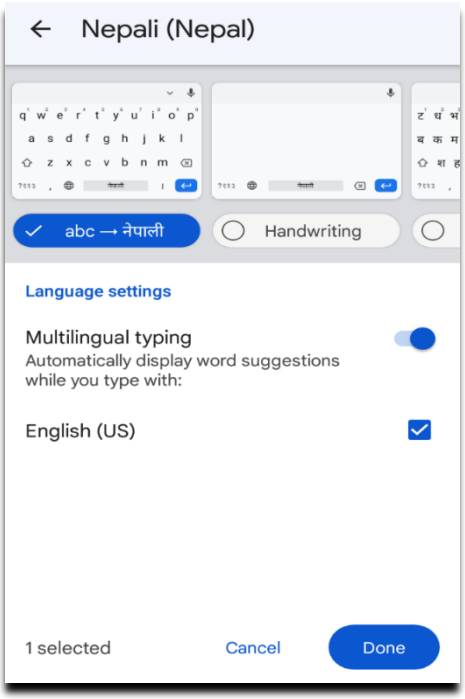


Figure 54. Keyboard add-ins for phonetic to Nepalese conversion

Figure 55. Phonetic typing with Nepalese suggestive text

Due to the 4:45 hour difference, whilst some of the children were still typing their first letter in Nepal, most of the English children already had letters to reply to. Though they were not typing/sending at the exact same time, there was only a few minutes difference between some of the letter exchanges, it can be said that it was a semi- synchronous letter sending activity. Even though these letters were written in Nepalese, with the help of Google translation, they arrived in English. The children receiving letters were asked to read them carefully, try to understand what was being said (even if there were some mistakes), introduce themselves, answer any questions and ask what they wanted to know about the child who had written to them. Once they finished typing and checked with the facilitator for the appropriateness, they sent the letter and handed the tablet back to the facilitator and then continued with their activities so another child could reply to their letter.

At the end of day one, all the children in Nepal had written a first letter and half of them also got chance to read the reply for it and write a second letter. In England, by the end of day one, all the children had written one letter as a reply.

Day 2. On Day two, similar activities continued.

5.5 Results

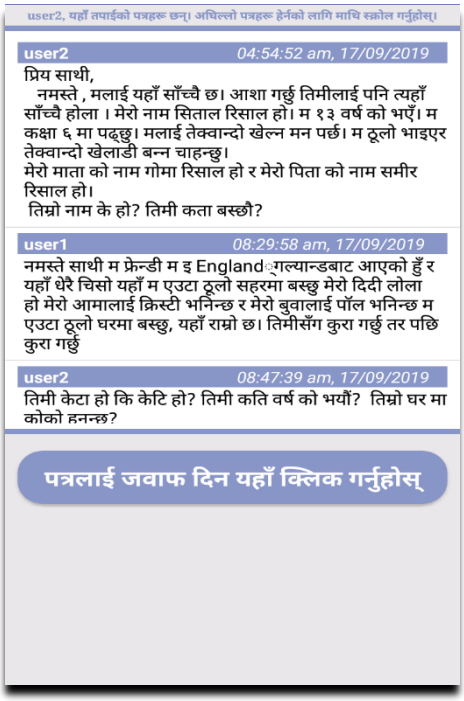


Figure 56. Letters seen by Nepalese child part 1

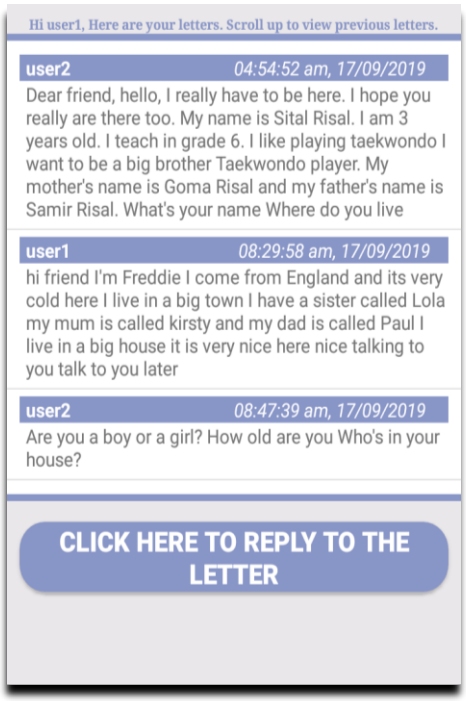


Figure 57. Letters seen by English child part 1

Figure 58. Letters seen by Nepalese child part 2

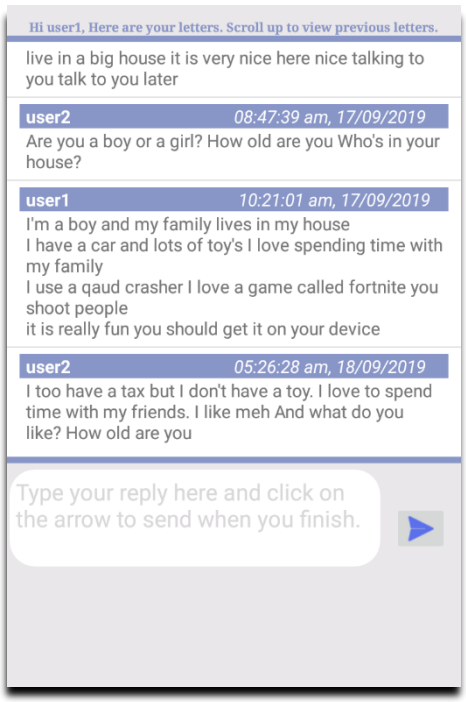


Figure 59. Letters seen by English child part 2

The total number of letters exchanged was 190, among which there were 111 Nepalese letters and 79 English letters. All the children exchanged at least two letters each. Some of the children exchanged three letters, and one pair managed to send four letters each. **Figure 56** to **Figure 59** below show an example of a conversation between user 1 (an English child) and user 2 (a Nepalese child):

5.5.1 Structure of Letters

The letters in both languages, though 'written' (by typing on digital devices), were actually short (on average 51.1 words per English letter) and casual, with no formal letter headings or salutations. Most of the letters consisted of short sentences with simple sentence structures – from a conversational point – we can consider them to be 'written conversations', or even 'transcripts' of children's conversations, though the 'transcription' was done by children themselves.

It was not possible to do pure 'conversation analysis' in its narrower sense (for example, there is nothing reflecting overlapping utterances, simultaneous pronunciation, sound feature (dialect, accent, intonation), or simultaneous repetition). It appeared that letter conversations usually started with identity of speakers, such as names. Turn - taking was not as frequent as it would have been in face-to-face oral conversation, however, children were aware of the social functions of taking turns, and usually explicitly used prompt questions to invite the hearer (recipient) to participate in the conversations. For example, questions like, 'what is your name?' 'What is the national animal of your country?' were used to end their part of the conversation after they had introduced themselves. As seen in the early study in **Chapter 3**, some children used emojis in their letters.

5.5.2 Things Shared by Children in Their Letter Exchanges

In the PenPal exchange study done by (Barksdale et al., 2007) much was written about the things the children shared about each other. In that work, the common topics of conversation were family, school, pets, religion, food, favourites, physical features, weather, technologies and so on.

Table 46. Common things involved in the chat from both English and Nepalese Participants

Greetings
Hi, Hello, Namaste, How are you? Thank you, Wish you are fine
Personal Information
Name, age, gender, birthdays, where they live
Personal favourites
Sports, computer games, food, hobbies, football team, football player, colour, animals/birds, fruits, movies, subject, book, perfume, song, cartoon, what they want to be in future
Personal possessions
Toys, PS4, Xbox, computer, laptop, mobile phones
Family and house
Parent's and grandparent's name, age, profession family members number, siblings name and age, about the house and rooms, pets, pet name
Friends
Names, about their best friends, number of friends
School and Education
Name, where it is, what year, number of teachers, teachers' names, subjects, and lessons
Weather
Cold, hot, rainy, snow
Community
Shop, road, park
Country and country related
Name, national animal, capital city, national bird, national flower
Other
Current time

In this DigiPal letter sending activity similar patterns were seen; as the exchanges only lasted for two days, they were not as deep as (Barksdale et al., 2007) which ran for 3 years and the letters' patterns were observed to be different. The things children shared or asked about in this study can be categorised as follows based on (Bogdan and Bilken, 1992).

Some differences in their lifestyle were seen while comparing the contents of the letters from Nepalese and English children. These depended on the location they live in, technology accesses, local trends, culture etc. Some examples are listed in the table below:

Table 47. Simple cultural difference seen in the letters

What	Nepalese letters	English letters
Favourite games	Pub G	Fortnite
Gaming consoles	Mobile phones, computers	X box, PS4
Favourite food	Momo	Pizza, burger, nuggets

These were further supported by the questions the children asked during the conversations. Here are some examples:

- *What is XBOX?*
- *What is PS4?*
- *What is Fortnite? How do you play it?*
- *What is Nepali?*

5.5.3 Participants' Reaction

Children were excited before the activity started thinking that they would be talking to other children from a different country and language. The Nepalese children were happy writing their first letter and equally excited to read the letter they received and reply to it. The English children were also very surprised and happy at the same time to receive letters from complete strangers, and they too were also excited to reply to, and receive more, letters. This excitement was evident in the sessions with children constantly asking the facilitators if they had got a reply back from their partner or not? Even though the letters were sometimes difficult to make sense of, the children seldom complained – the activity was very engaging.

One thing that the children never asked was what to write. They were able to answer the letters and ask questions or share things comfortably. Most of the children answered the questions

that were asked unless they became too difficult to understand. Replying to a letter, children typically followed the same pattern and content as found in the received letter.

While analysing the letters, it was found that in many letters children didn't understand something. Some of them were complaining in their letter about not understanding whereas others were apologizing for the unclear text. There were occasional 'requests' for repair sent by the recipient, mainly due to translation errors, e.g., asking for clarification of age, when Google Translate did not pick the age number up in the first attempt of translation. These breakdowns however helped the conversation continue. When they didn't understand they asked again. If some part of text got deleted during translation either the children didn't realize it at all, or they asked again for the response. Some even realized that the translation was not good enough and were okay with it.

5.5.4 Entry Errors

As mentioned earlier – children often make mistakes at the point they enter text into a device. Errors that occur while typing are generically called text entry errors, and these are defined as the deviation from the intended text. Since in this study only the entered text and translation text were available, it is impossible to say what was the intended text; however, looking at the context, it was possible to figure out in some extent when things went wrong at the point of entry of text. In terms of Nepalese typing, error understanding was compounded by the use of the phonetic keyboard. For example: when typing 'Where do you live?' the writer might type as follows to write the sound of the Nepalese words:

- *Phonetic: Timi kaha baschhau?*
- *Nepalese: तिमि कहाँ बस्छौ?*
- *Meaning: Where do you live?*

One problem is that there is no consistency on how individuals carry out phonetic typing as this is not a language of its own. For example, for the previous example the user can type in at least three different ways:

- *Timi kaha baschhau?*
- *Timi kaha baschau?*
- *Timi kaha basxau?*

The receiver of these texts would understand the meaning regardless of how it was written because all three of these phonetic phrases sound or look similar. In this activity, the Nepalese children had to type in phonetic Nepalese, but this had to then be directly translated into real (native) Nepalese so that Google could then translate it to English. Google translate could only deal with a limited set of words when written in phonetic input (like Namaste) so that was why a keyboard add-in from the Google play store was used that converted the phonetically typed text to Nepalese. When using this technique, the child writes a word in Latin script - as it sounds) and then sees the Nepalese word appear. If that word is wrong, other words are available to pick from as shown in **Figure 60**. If the word written by the child doesn't map onto a known Nepalese word, then Google would keep the Latin writing.

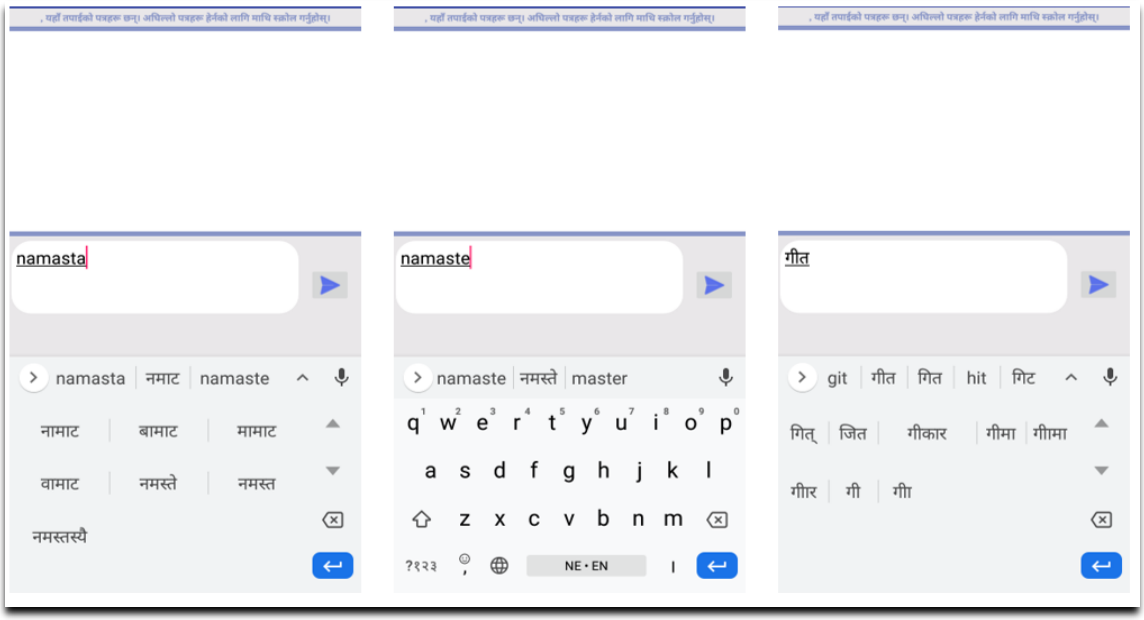


Figure 60. Phonetic input - Nepalese output

- **Wrong word carried in:** An error occurs if the phonetically typed word is returning the wrong word, but the child ignores it or doesn't realize it is wrong - this is seen in **Figure 60** (first screen) where the child has written 'git' (meaning song) Instead of typing 'jit' meaning 'win'. If the child had realized, then he /she could have selected the right word from the suggestion box – the second word in second row.

- **No clean native text found:** Another problem is seen if the phonetically typed word is wrong and is not resulting in a clean match in Nepalese – then the app might not return a Nepalese word at all. This is shown in **Figure 60** (second screen) where the child

wrote Namasta – again had he/she noticed there was a chance to correct it as the eighth word is the Nepalese word for Namaste.

- **Figure 60** (third screen) shows what happens when the word (see under the text box on the LHS) is spelt in such a way (correct way) that the app can make the correct match without interruption.

Therefore, for the Nepalese text that was being written there were actually three strings to each letter segment:

IPT: Inputted phonetic text
CNT: Converted Nepalese text
GTN: Google translation of Nepalese text to English

Because IPT was not captured, CNT as to be the baseline text taken for any text entry analysis. After all that was the text that we have to assume (with the exception of the error situations described above) the children intended to send. For Google translate, CNT is the input for the translation and will be referred to hereafter as the Nepalese input text (NIT).

In the case of English typing, there was no phonetic typing which means each letter had two text strings.

EIT: English Input text
GTE: Google translation of English text to Nepalese

Input errors can be analysed by looking at what children typed but we cannot be sure what children intended to write. E.g., If the child writes ‘There is a bad in my room’, the most likely explanation is that the child spelt ‘bed’ incorrectly, but it could be that the child meant to write ‘There is a bad smell in my room’ and simply got distracted and missed out a word. In other words, without understanding intended text we can only guess at entry errors. Despite those limitations, the following sections aim to pick up on errors that appeared to be made by children. These are important as earlier chapters have shown that errors of composition, be they grammar or spelling have a significant effect on both accuracy and understanding of translated text.

5.5.5 Analysing Entry Errors

For the analysis of text entry errors, each chat block was analysed to look for errors on the basis of unexpected insertions, deletions and substitutions as explained by (Soukoreff and MacKenzie, 2001) in their paper. Various types of errors were observed with various types of reactions from Google translate for those errors. The errors were then counted and categorised to see where the children made most mistakes.

Among the 190 exchanged letters fragments (where a fragment is a single chunk of text sent at a single moment by a single child), only 13 had no (apparent) input mistakes, ten of these were written in Nepalese, and three in English. In other words, more than 90% of Nepalese letters, and more than 96% of English letters contained source text input errors (including spelling and punctuation mistakes). In the following sections, examples are given of the main errors found and these are categorised according to the situations that might have caused them.

5.5.5.1 Character Level Mistake:

Table 48. Character level spelling mistakes

From English letters	From Nepalese letters
Missing consonant (deletion)	
Where – were (has meaning) Nearly – nealy (no meaning)	भनेको (have said) - भने (if) धन्यवाद (Thank you) - धनवाद (no meaning)
Wrong consonant (substitution)	
World – would (has meaning) But – vut (no meaning)	भन (tell) - वन (forest) बस्छु (Live) – बछु (no meaning)
Missing vowel (deletion)	
Said – sad (has meaning) Meant – ment (no meaning)	कक्षा (Class) – कक्ष (Room) खेल्छु (Play) – खल्छु (no meaning)
Wrong vowel (substitution)	
Meat – meet (has meaning) England – Ingland (no meaning)	लेख (write) – लाख (100 thousand) मेरो (My) – मारो (no meaning)
Extra vowel (insertion)	
To – too (has meaning) Nuggets – nouggets (no meaning)	म (I) - मा (at/on) थर (Surname) – थार (no meaning)

These are the errors when there seems to be only one character involved. This missing character can change the structure of the word and result in a completely different word or can result in something meaningless. The effect of these errors on translation doesn't depend on the type of mistake made – it depends on the newly formed word, both its meaning and the meaning of the whole phrase or sentence. In the following examples, some of the various reactions from Google Translate are shown:

A: If the newly formed word has a meaning the translation will use that meaning.

Example 1.

- *Written text: साथी, नमस्ते , मलाई यहाँ साँच्चै छ।*
- *Word by word translation: Dear friend hello, I am really here.*
- *Intended text: साथी, नमस्ते , मलाई यहाँ सञ्चै छ।*
- *Expected output: Dear friend, hello, I am fine here.*
- *Google output: Dear friend, hello, I really have to be here.*
- *Input error category: Wrong consonant*

Here the word that has error is सञ्चै (fine), but साँच्चै (really) was entered and Google translated the text accordingly. Even though साँच्चै is a real word, but it doesn't really mean anything in this context.

Example 2.

- *Written text: मेरो पनि एउटा कर छ तर मेरो खेलौना छैन।*
- *Word by word: I too have a tax but don't have my toy.*
- *Intended text: मेरो पनि एउटा कार छ तर मेरो खेलौना छैन।*
- *Expected output: I too have a car but I don't have my toy.*
- *Google output: I too have a tax but I don't have a toy.*
- *Input error category: Missing vowel*

In this example, कार (car) was wrongly entered as कर (tax) and Google translated as it is because it's a real word but again in the context it doesn't make sense.

Example 3.

- *Written text: I used to have a dog buy he died.*
- *Intended text: I used to have a dog but he died.*
- *Expected output: मसँग कुकुर थियो तर ऊ मर्यो।*
- *Google output: म एउटा कुकुर किन्नको लागि प्रयोग गर्थें ऊ मरेको थियो ।*
- *Word to word Google output: I used to use a dog for buying he had died.*
- *Input error category: Wrong consonant*

This is an example of wrong consonant in case of English letter where 'buy' was entered instead of 'but'. Now 'buy' is a real word and Google tried to translate the whole phrase accordingly and it doesn't make sense in the context.

Example 4.

- *Written text: मैले के के लेखेको तिमी पनि लाख है ।*
- *Word by word: What I have written you also million okay?*
- *Intended text: मैले के के लेखेको तिमी पनि लेख है ।*
- *Expected output: You also write what I have written okay?*
- *Google output: what you wrote is also worth millions.*
- *Error type: Wrong vowel*

लाख was translated to its corresponding English word Million which changed the meaning of the whole sentence.

Occasionally Google got lucky and did the right thing even where there was a mistake. Even though the new (mistaken) word has a meaning in the following example, the translation was fine. This happened in less than 5% of the occurrences.

- *Written text: मा बनेपामा बस्छु।*
- *Intended text: म बनेपामा बस्छु।*
- *Word by word: In Banapa in live.*
- *Expected And Google output: I live in Banapa.*

Unpicking this, the clue for Google here could be the verb बस्छु which is the verb form for 'live' only for the subject 'I'. This extra vowel mistake was very common in Nepalese letters and every time it was translated fine.

B: If the newly formed word doesn't have a meaning Google Translate had several different reactions.

Example 1. Transliteration: this was seen in more than half of the mistakes.

- *Written text: I'm neally 10.*
- *Intended text: I'm nearly 10.*
- *Expected output: म करीव १० वर्षको हुँ।*
- *Google output: म नेली १० वर्षको हुँ।*
- *Word to word: I am neli 10 years.*
- *Error category: Wrong consonant*

Here ***neally*** doesn't have a meaning that is why only the sound of it just got translated which has no meaning in the context.

Example 2. Translating to closest sounding word

- *Written text: म कक्षा ६ मा पड्छु।*
- *Word by word translation: I *** in class 6.*
- *Intended text: म कक्षा ६ मा पढ्छु।*
- *Expected output: I study in class 6.*
- *Google output: I fall in class 6.*
- *Error category: wrong consonant.*

Here the entered word पड्छु has no meaning. This might be due to Google Translate being smart, fulfilling the translation task based on the context, or an auto spelling correction before the actual translation process.

Example 3. Translating fine

- *Written text: प्यरो साथि, म तिम्रो साथी कृषा बिक।*
- *Word by word: *** friend, I am your friend Krisha Bika.*
- *Intended text: प्यारो साथि, म तिम्रो साथी कृषा बिक।*
- *Expected/Google output: Dear friend, I am your friend Krisha Bika.*

Even though, the newly formed word has no meaning, Google in this case translated fine. It might be because this is something Google has seen in the past a lot. As it's explained earlier that Google learns from itself. That might be why Google could act smart here to produce right translation.

5.5.5.2 Space Error

A space can be considered as character. Extra spaces divide words into two new words whereas missing spaces join two words into one. The translation again depended on the newly formed word/words.

C: In case of extra space, if both the newly formed words had meaning, they normally translated separately which changed the meaning completely.

Example 1.

- *Written text: मेरो विद्या लयको नाम Baylor international academy हो।*
- *Word by word: The name of my learning rhythm is Baylor international academy.*
- *Intended text: मेरो विद्यालयको नाम Baylor international academy हो।*
- *Expected output: My School's name is Baylor International Academy.*
- *Google output: The name of my learning rhythm is Baylor international academy.*

Example 2. This is a similar example from an English letter:

- *Written text: I have a mansion in black pool.*
- *Intended text: I have a mansion in Blackpool.*
- *Expected output: मेरो ब्ल्याकपूलमा हवेली छ।*
- *Google output: मेरो कालो पोखरीमा हवेली छ।*
- *Google output meaning: I have mansion in black pond.*

When an extra space appeared in this intended word, Google still managed to translate it right.

Example:

- *Written: तिमीलाई के मन पर्छ?*
- *Word by word: What do you heart should?*
- *Intended: तिमीलाई के मनपर्छ?*
- *Expected/Google output: What do you like?*

D: Missing space: There was only one case in English where two words were joined (i.e., one space missing). The newly formed word in this case did not have any meaning, and Google Translate did not translate it.

Example:

- *Written text: My favorite film is avengers endgame and avengers infinity war.*
- *Google output: मनपर्ने फिल्म बदला लिनेहरू endgame र बदला लिनेहरू अनन्त युद्ध हो ।*

5.5.5.3 Word Level Mistake

Word level mistakes were generally more grammatical but could also be missing words or things used in the wrong way. Again, the word that results from the mistake can be a completely different word or can just be a set of characters that don't make sense together.

E: Missing / wrong verbs one example in this category was using the wrong verb form or missing a verb which was a common problem but only seen in English letters.

The reaction from Google was not consistent. Sometimes it translated fine.

Example:

- *Written text: I love to swimming.*
- *Intended text: I love swimming. OR I love to swim.*
- *Google output: म पौडी खेल्न मन पराउँछु।*
- *Meaning of Google output: I love to swim.*

There were cases in English letters where an axillary verb was missing. They were translated accordingly, resulting in change of meaning.

Example:

- *Written text: My friend kind to me.*
- *Intended text: My friend is kind to me.*
- *Google translate: मेरो साथीले मप्रति दयालु।*
- *Meaning of Google output: My friend kind to me.*

F: Noun and apostrophe: This type of error was again only seen in English letters. For example, a singular noun was typed as plural by mistake. As Google saw a plural noun, it translated it as plural.

Example:

- *Written text: I attend ST Michaels CE primary schools.*
- *Intended: I attend St. Michael's CE primary school.*
- *Google output: म एसटी माइकल सीई प्राथमिक विद्यालयहरूमा जान्छु।*
- *Meaning of Google output: I go to ST Michael CE primary schools.)*

There were two types of apostrophe errors in English letters. The first type is using apostrophe 's in a plural form.

Example:

- *Written text: I have lot's of toys.*
- *Intended: I have lots of toys.*
- *Expected/Google output: मसँग धेरै खेलौनाहरू छन्।*

In this example, the extra 's' was ignored by Google and translated fine.

The other type, which is more frequent, is a missing apostrophe. When the newly formed word (with the letter ‘s’ added without apostrophe) becomes a plural form, these were translated as plurals, and the meaning changed. But again, most of the time they were translated fine without mistakes.

Example:

- *Written text: My Schools name is St. Michael’s.*
- *Intended text: My School’s name is St. Michael’s.*
- *Expected output: मेरो स्कूलको नाम सेन्ट माइकल हो।*
- *Google output: मेरो स्कूलहरूको नाम सेन्ट माइकल हो।*
- *Meaning of Google output: My Schools name is St. Michael’s.*
- *Observation/Potential explanation: Here the plural of school was translated.*

Example:

- *Written text: My mums name is Alix.*
- *Intended text: My mum’s name is Alix.*
- *Expected/Google output: मेरो आमाको नाम एलेक्स हो।*
- *Meaning of Google output: My mums’ name is Alix.*
- *Observation/Potential explanation: Here the word mums was translated fine as mum’s.*

In a few cases the letters had words with multiple characters wrong or missing. The Google translation for such mistakes followed the same pattern as above meaning it translated according to the new word. If the new word had a meaning, then it translated that word. If the new word didn’t have a meaning, then Google either translated the closest word or even deleted the word completely if it didn’t fit in the sentence.

Example 1:

- *Written text: म त बारह वर्ष को छु।*
- *Word by word : I am *** years old.*
- *Intended text: म बाह्र बर्षको भएँ।*
- *Expected output: I am twelve years old.*
- *Google output: I am twelve years old.*
- *Observation/Potential explanation: New word sounds close to intended word*

Example 2:

- *Written text: what relogian do you have ?*
- *Intended: What religion do you have?*
- *Expected output: तपाईसंग कुन धर्म छ?*
- *Google output: तपाईसँग के छ?*
- *Google output meaning: What do you have?*
- *Observation/Potential explanation: Here the word relogian got deleted completely.*

5.5.5.4 Phrase Level Mistake.

Errors that involved a complete word or more than one word are placed in this category.

G: Extra (isolated) letter or word. Unlike extra letters within a word, like extra vowels that have been discussed in one of the previous sections, in some letters there were extra letters typed in isolation (not as part of any word). There is an example of a Nepalese phrase where translation was not affected by the extra letter (which happened to be a single letter word with the meaning 'and').

Example:

- *Written word: तिमीलाई कुन **र** रंग मनपर्छ?*
- *Word by word: What **and** colour do you like?*
- *Expected/ Google output: What color do you like? (Smart)*

In English letters, there was also an occurrence of an extra 'i' (which can be analysed either as an extra letter or an extra word) in the sentence 'I also love chips fris i pizza burgers nuggets and tuna sandwich' in the phrase below. The translation continued as it is.

Example:

- *Written text: I also love chips fries i pizza burgers nuggets and tuna sandwich.*
- *Intended text: I also love chips, fries, pizza, burgers, nuggets and tuna sandwich.*
- *Google output: मलाई चिप्स फ्राइज पनि मन पर्छ, म पिज्जा बर्गर नगहरू र टुना स्यान्डविच।*
- *Google output meaning: I also like chips fries, I pizza burger nuggets and tuna sandwich.*

In the same letter, there was also an extra word, ‘as’ in ‘My as school name is ...’. The translation was done accordingly, and the translation did not then make sense with the extra word translated.

Example:

- *Google text: My as school name is kirkham St Michael's.*
- *Google output: मेरो स्कूलको नाम किर्कहम सेन्ट माइकलको हो ।*
- *Expect output/ Google output meaning: My school’s name is Kirkham of St. Michael. (‘as’ is ignored: smart)*

In Nepalese letters, there was one example of an extra word in a sentence, which was not a simple letter word. Like the example from the English letter, it was translated accordingly, with the translation ‘Calendar Dear Friend’ not making any sense.

Example:

- *Written text: पात्रो प्यारो साथी ,मेरो नाम युङदुङ लामु लामा हो ।*
- *Word by word: Calendar Dear Friend, My name is Yungdung Lamu Lama.*
- *Expected output: Dear friend, my name is Yungdung Lamu Lama*
- *Google output: Calendar Dear Friend, My name is Yungdung Lamu Lama.*

H: Phrase with multiple mistakes. Similar to words with multiple mistakes, there are phrases with multiple mistakes. In the majority of the cases, some phonemic transcription was applied, which did not make any sense – in others Google just gave up.

Example:

- *Written text: तिमीले आफ्नो थार लेख लेख्न विर्षाउनी।*
- *Word by word: You ***(verb) to ****(verb) your ****(something-noun).*
- *Expected output: You forgot to write your surname. (Looking at the context of the letter and converting the wrongly spelled words to closest words)*
- *Google output: whole phrase got deleted.*

5.5.5.5 Punctuation Mistakes

Missing full stops, commas and question marks were quite common in the children's letters. Punctuation mistakes occurred more frequently in English letters than in Nepalese ones. The type and frequency of punctuation errors present in Nepalese and their effect on translation are represented in following table.

Table 49. Effect of Punctuation Errors on Translation of Nepalese texts

Mistakes	**Total occurrence (times)**	**Effect on translation**	
		What?	Times
Missing full stop	58	Translated fine and added full stops.	8
		Translated fine but did not fix it	46
		Mixed two sentences and did not make sense	4
Missing question mark	17	Translated fine and added question mark	1
		Translated fine but did not fix it	11
		Changed to affirmative statement and the meaning changed too	3
		Joined two sentences which changed the meaning	2
Unnecessary question marks	2	Deleted what was before the question mark	2
Missing commas	12	Translated fine, but did not add comma	10
Full stops instead of question marks	15		
		Joined the phrases and meaning changed	2
		Translated and fixed	3
		Translated fine, but did not fix the mistake	12
Total	104		

As one can see from this table, there were 104 mistakes related to full-stops, commas or question marks, and in most of the cases, translation was correct. In some cases, Google even fixed the error that was made.

Table 50. Effect of Punctuation errors in Google Translation of Nepalese letters

Type	Frequency	%
Fixed it completely (right translation and fixed mistake)-Smart	12	11.5
Translated correctly without fixing the mistake	79	76
Struggled	13	12.5

The English letters had more occurrences of punctuation mistakes, and these had similar effects on translation, as summarized in the table below.

Table 51. Effect of Punctuation Errors on Google Translation of English Letters

Mistake	Total occurrence (times)	Effect	
		What?	Times
Missing full stop	397	Translated fine and added full-stop too	31
		Translated fine but didn't fix.	346
		Removed the sentence	9
		Joined two sentences and meaning changed	11
Missing question mark	26	Translates fine and fixed.	7
		Translated fine without fixing.	19
Missing commas	33	Translated fine without fixing.	33
Full stop instead of QM	17	Translated fine and fixed.	5
		Translated fine. Didn't fix the mistake.	12
Total	473		

Table 52. Effect of Punctuation Error on Google Translation of English Text

Type	Frequency	%
Fixed it completely (right translation and fixed mistake)-Smart	43	9.1
Translated correctly without fixing the mistake	410	86.7
Struggled	20	4.2

Similarly, most of the translations were correct but Google typically didn't fix the original punctuation error.

As an example, in the following sentence, there was a missing full stop and a missing comma, and these were missing in the translated version, too.

Example:

- *Written text: hi friend I'm Freddie I come from England*
- *Expected output: Hi Friend, I'm Freddie. I come from England*
- *Google output: नमस्ते साथी म फ्रेन्डी म इ England ा गल्यान्डबाट आएको हुँ*
- *Google output meaning: Hello friend I am Freddie I have come from England*

Compared with spelling input mistakes at lexical or phrasal levels, the punctuation mistakes at clausal or sentential levels (incl. full-stops, commas and question marks) had less impact on translation. In these cases, Google translate struggled only 11.4% of the time while translating from Nepalese to English and 4.2% of the times while translating from English to Nepalese. In some of the occasions, Google Translate has even fixed the issue while translating it correctly. As illustrated in the following example, the originally missed full stop was added to the translated version.

Example:

- *Written text: मेरो नाम आँशु यादव हो* म कक्षा ६ मा पढ्छु* मेरो घर धनुषा धाम हो*
- *Expected/Google output: My name is Anshu Yadav. I read in class 4. My house is Dhanusha Dham.*

Google did struggle with input errors. As an algorithm it tried to translate what was given and then tried to do the best translation by mapping it to its known language patterns. Sometimes it succeeded and sometimes didn't. Sometimes the sound was translated and sometimes it just left the text as it is. As Google learns from its translation history, common input errors had almost no effect on translation as it knew how to overcome these. There were cases when Google acted smart and translated right even if the input was wrong. Some cases where Google did particularly well are as follows.

- Added missing full stops and question marks.
- Unnecessary apostrophe sign in plural word was corrected.
- Extra letters in the input were removed.
- Full stop in question statement is corrected
- Wrong verb forms were fixed (I likes)
- Spelling mistakes in famous people name translates fine (e.g., Ronaldo)
- Unnecessary words and letters discarded
- Extra space between a word combined and translated fine.

From the earlier work in **Chapter 4**, it is evident that fixing errors at entry will benefit translation.

5.5.6 Translation Errors

Whilst the earlier section highlights all the many mistakes that children made when writing, translation still sometimes went wrong even when the child had made no mistakes. For an analysis of translation mistakes, an approach was taken in this instance to count translation at the word level using an MSD approach in which each sentence / phrase was being considered independently. If the sentence/ phrase was aligned there were no errors counted for it. If a part of a phrase – made of adjoining words, was missing – this counted as one error. If a word was substituted this counted as one error.

The table below shows how many translation mistakes occurred to input source texts that had no mistakes in them in both languages.

Table 53. Letters with perfect input but imperfect translation

Translation Mistakes	Nepalese Letters with no input error	English
0	3	0
1	3	1
2	4	1
3	0	1

As shown in the table above, perfectly entered source text does not imply perfect translation. Out of the ten Nepalese letters with perfect input, only three were translated without any

mistakes, and of the three English letters which were input perfectly, none of them received error-free translation. In the next sections the things that went wrong in translation are categorized with examples given. Note that these examples include the perfect texts outlined above but also take examples from other letters.

5.5.6.1 Numerals

Surprisingly, there were 92 times when Nepalese numbers (written in digits, e.g., class, age, number of family members) were translated to the wrong number (e.g., 13 translated to 3), resulting in a change of meaning. Indeed, there were 9 times as many incorrect as correct translations of numbers. This error occurred with different numbers, and there was no consistent observation of which number would be correct in the output of the translation. For instance, number 6 was translated to 3, 4 or 8.

Example:

- *Written text: म १३ वर्ष को भएँ।*
- *Expected output: I am 13 years old.*
- *Google output: I am 3 years old.*

Number translation was also a problem with the English letters. However, instead of having a wrong output, Google Translate typically deleted the numbers from the sentence and added an English word ‘years’ (47 times deleted, compared with 8 times correct output), as illustrated in the following example. Again, these numbers tended to be in the letters when children talked about age, class, number of family members.

Example:

- *Written text: I am 9 years old.*
- *Google output: म years बर्षको भएँ। (I am years years old.)*

By contrast, when numbers in Nepalese letters were spelled out as Nepalese words, the translation were fine (11 instances). This is also true for numbers spelled out in English letters (29 instances).

Example 1:

- *Written text: मBaylor international academy को कक्षा छ मा पढ्छु।*
- *Expected/ Google output: I teach in class six of Baylor international academy. (word study is translated to teach but that will be explained later)*

Example 2:

- *Written text: I'm in year five.*
- *Google output: म पाँच बर्षमा छु।*
- *Google output meaning: I am in year five.*

5.5.6.2 Pronouns

In the Nepalese letters, there are four times where pronouns were translated incorrectly. For example, in the following sentence, 'she' in Nepalese was translated as 'he' in English.

Example:

- *Written text: मेरो आमाको नाम जानुका तिमल्सिना हो। उहाँ ३२ वर्षको हुनुभयो।*
- *Expected output: My mother's name is Januka Timalsina. She is 32 years old.*
- *Google output: My mother's name is Januka Timalsina. He is 3 years old.*

This is possibly due to the fact that in Nepalese language there are no different pronouns for different genders as in English, and Google Translate was not able to figure out which one to match based on the context.

Similarly, in English letters, there were three instances of translation errors for pronouns, such as translating 'you' into 'I', in the following example, which received critical reaction (response) from the receiver.

Example:

- *Written text: What food do you like*
- *Google output: मलाई कस्तो खाना मनपर्छ*
- *Google output meaning: What food do I like*

Apart from personal pronouns, there were also nine instances where Wh-question words were translated wrongly in Nepalese letters. For example, ‘what’ was translated into ‘who’ in the following sentence.

Example:

- *Written text: तपाई को नाम के हो?*
- *Expected output: What is your name?*
- *Google output: Who is your name?*

5.5.6.3 Nouns

One of the most outstanding cases was in regard to ‘momo’, which is a popular food that was frequently mentioned in the Nepalese children’s letters. This noun was translated to a variety of terms in English, e.g., ‘me’, ‘mum’, and none of them functioned properly in the context.

The table below summarises the different ways ‘momo’ was translated:

Table 54. Word MOMO translated several ways

Translated to	frequency
Me	6
Mum	5
Masmah	3
Momah	3
Mahmah	2
Moe	1
Meh	1
Ma’am	1

The reason ‘momo’ was translated in so many different ways could be because it was unknown to the translation software and so the software made a ‘guess’ each time based on the context around the sentence. This is both a drawback of, but also in other cases a strength of, a smart translation application. Sadly, the software never managed to substitute a food name for ‘momo’.

When Nepalese people or place names have meaningful parts, they were usually translated incorrectly (not as names, but as other nouns according to the meanings). There were eleven such occurrences.

Example 1:

- *Written text: मेरो नाम **विशाल पाठक** हो ।*
- *Expected output: My name is **Bishal Pathak.***
- *Google output: My name is **huge reader.***

Both name and surname had meanings as seen in the translation.

Example 2:

- *Written text: मेरो स्कूल गोदाम चोकमा छ ।*
- *Expected output: My school is in Godam Chowk.*
- *Google output: My school is in warehouse chowk.*

The place name has a meaning.

There are also cases (six occurrences) where Nepalese persons' names translated to the closest English word.

Example:

- *Written text: मेरो भाई छ अनि उसको नाम **युक्रित** हो।*
- *Expected text: I have a brother and his name is **Ukrit.***
- *Google output: I have a brother and his name is **Ukraine.***

Other random errors (18 of them) of nouns included national bird, fruit, and, like 'momo', the word 'mango' in Nepalese also experienced recurring and inconsistent translation errors. When children talked about their favourite fruits (mango) this was translated to 'snake' once, 'you' twice, and 'amp' once, and certainly caused confusion.

Example:

- *Written text: मेरो मन पर्ने फलफूल को नाम **आँप** हो*
- *Expected output: My favourite fruit is **mango.***
- *Google output: My favourite fruit is **amp.***

In English letters, the errors related to nouns also happened most frequently with place names. The word ‘England’ itself was translated wrongly 8 times.

Example:

- *Written text: I live in **England.***
- *Google output: म **इ England ्ल्याण्डमा** बस्छु।*
- *Google output meaning: I live in **EEnglandland.***

Similar to Nepalese persons’ names, when the name had a meaning, these were translated not as a name and then did not make sense in the context.

Example:

- *Written text: My teacher's name is **miss pickles**.*
- *Google output: मेरो शिक्षकको नाम **मिस मिसिएको अचार** हो*
- *Google output meaning: My teacher’s name is miss **mixed pickles***

Other errors included animal terms, such as ‘monkey’ and ‘rhino’.

Example:

- *Written text: I also like **monkeys** snakes **rhinos** crocodiles and birds .*
- *Google output: म **बाँकी** सर्प **गण्डिका** गोही र चराहरू पनि मन पराउँछु।*
- *Google output meaning: I also like **remaining** snake, **Gandika** crocodile and birds)*

5.5.6.4 Verbs

In the Nepalese children’s letters, like the noun ‘momo’, there is a verb that had a high frequency of translation errors (32 times wrong compared to 3 times correct), and that was the

verb ‘study’. It was commonly translated into ‘teach’, which changed the meaning of sentences significantly.

Example:

- *Written text: म कक्षा ६ मा पढ्छु।*
- *Expected output: I study in class 6.*
- *Google output: I teach in class 8.*

Another verb that was translated incorrectly was ‘have’.

Example:

- *Written text: मसँग दाई त छैन*
- *Expected output: I don’t have brother.*
- *Google output: I don’t like brother.*

Apart from the complete change of the meaning of a verb, there was also three instances where the tense of a verb was translated incorrectly.

Example:

- *Written text: म12 वर्ष को भएँ।*
- *Expected output: I am 12 years old.*
- *Google output: I was 12 years old.*

English letters, on the other hand, had no pure translation error that resulted in the change of meaning or tense of the main verbs. However, there were 6 instances where an auxiliary verb was wrongly translated.

Example 1:

- *Written text: I live in Kirkham and have a big house.*
- *Google output: म किर्खाममा बस्छु र ठूलो घर पाएको छु।*
- *Google output meaning: I like in Kirkham and I found a big house.*

Example 2:

- Written text: And I also have a big brother.
- Google output: *र म पनि एक ठूलो भाइ छ।* (And I am also a big brother)

5.5.6.5 Adjectives

Among all adjectives seen in both Nepalese and English letters translated well. There was only one pure translation error, in the sentence below. It was from the Nepalese language and whilst the basic meaning of the adjective was translated correctly, it was translated into its superlative 'best'.

Example:

- *Written text: तिम्रो **राम्रो** साथी को हो?*
- *Expected translate: Who is your **good** friend ?*
- *Google translate: Who is your **best** friend?*

5.5.6.6 Punctuation:

There were also pure translation errors relating to punctuation, for example, in Nepalese letters, question marks were removed 29 times (compared with only twice being kept). There was no effect of this error observed by the receivers.

Example:

- *Written text: तिमी कति वर्षको भयौ ?*
- *Expected output: How old are you?*
- *Google output: How old are you*

5.5.6.7 Other translation errors

In this section, pure translation errors that are not specific to any categories of parts of speech are included. There were occasions where Nepalese was translated based on the Hindi language. This is possibly due to the typological similarity between these two languages. There

were nine such instances where the impact of another language was observed, as illustrated in the examples below.

Example 1:

- *Written text: मलाई मनपर्ने फल आप र बनाना हो।*
- *Expected output: My favourite fruits are mango and banana.*
- *Google output: My favorite fruit is your make and make.*
- *Possible reason: बनाना in hindi means make.*

Example 2:

- *Written text: मेरो दादा पनि england मा छ ।*
- *Original meaning: My brother is also in England.*
- *Translated into: My grandfather is also in England.*
- *Possible reason: दादा in Nepalese is brother where in Hindi is grandfather.*

Similar translation errors were seen in the case of English letters too when the words were translated into the wrong language. There were four times when English was translated into Hindi, and five times when English was translated into French.

Example:

- *Cousins translated to चचेरो भाई (Hindi) should instead of भाई (Nepalese).*
- *Papaya translated to पपीता (hindi) instead of मेवा (Nepalese).*
- *Pineapple translated to अनानास (French) instead of भुईकटहर (Nepalese).*

Moreover, there are eight instances in Nepalese letters where the whole sentence was deleted, even though there was no input mistake in it.

Example:

- *Written text: म बनेपामा बस्छु । म १२ वर्षको भए।*
- *Expected output: I live in Banepa. I am 12 years old.*
- *Google output: NA*

There were also a few translation errors unique to English (i.e., not observed in Nepalese letters), such as synonyms confusion. There are altogether ten instances where English was translated but a wrong sense was selected.

Example 1:

- *Written text: my **step** dads name is Ashley.*
- *Google output: मेरा **चरण** बुबाहरूको नाम एशले हो।*
- *Google output meaning: My **level** dads name is Ashley.*

Example 2:

- *Written text: that is just **mean**.*
- *Google output: त्यो केवल **मतलब** हो।*
- *Google output meaning: That is just the **meaning**.*

There were also a few English words (eight in total), that were translated phonetically even though they have meanings.

Example:

- *Written text: When I'm old and Want to play for man united and be **striker** in it.*
- *Google output: जब म बूढो हुन्छु र मान्छेको लागि खेल्न चाहन्छु र एकतामा **स्ट्राइकर** बन्न चाहन्छु।*
- *Google output meaning: When I am old and want to play for man and want to be **striker** in united.*

These are another 8 instances where English words were left untranslated. They are arguably not translation errors, as they are proper nouns such as game names and person names, and they did not affect communication as Nepalese children understood they were names in English.

5.5.7 Inconsistency in Translation:

Google tries to translate using smart methods that include looking at words and looking at the context of the phrase being translated. This process means that even for the same word the translation an end up being different. The example from ‘momo’ that is highlighted in **Section 5.5.6.3** is the most interesting in this study, but so too was the ‘mango’ example.

Example 1:

- *Written Text: मलाई मोमो मन पर्छ।*
- *Word to word meanings: I love/like Momo.*
- *Google outputs: I love me, I love mum, I love mah etc.*

Example 2:

- *Translation of आँप (Mango) into snake, you, mango etc.*
- *Translation of अध्ययन (Study) into study, read etc.*

In these instances, the context altered and so the different end results can be explained but in other cases even though the context was same, the translation changed. For example, one Nepalese surname was translated 3 different ways. This translation mistake can be because there is no meaning for that word in English.

बजगाईं (Bajgain) into Bazgain, Bazgayan, Bazgaine

This is clearly worth noting for future applications that will use translate across countries. Possible fixes might be to have a keypad code that highlights the following word as being unique to that country but the problem with this, especially with children, is how would they know? It is highly likely that children in rural Nepal have little idea that most of the Western world has no idea what momo is.

5.5.8 Untranslated Words

There were many words that were simply not translated. English words with spelling mistakes didn't make it; for example, vsco, sksksk, fuoball, spor etc. But there were other cases where one might have expected a translation, but none came. These are covered in the next few sections.

Proper nouns. Some names of a person or a pet, even where they could have a ‘non proper-noun’ meaning, were left untranslated. Example words included: Willacy, Dana, Sandy, Itchy.

Example 1:

- *Written text: My mom is called **Dana**. (Dana=no meaning)*
- *Expected text: मेरी आमालाई **डना** भनिन्छ।*
- *Google output: मेरी आमालाई **Dana** भनिन्छ।*

Example 2:

- *Written text: My name is **Sandy**. (Sandy=has meaning)*
- *Expected text: मेरो नाम **स्यान्डी** हो।*
- *Google output: मेरो नाम **Sandy** हो।*

Abbreviations. Abbreviations tended to stay as they were, for example DKNY, PS4, PC which kind of makes sense because either these would otherwise be nonsense words and wouldn’t be translated, but it is more likely that Google has learned these to be abbreviations that have common understanding.

Example:

- *Written text: My favourite clothes brand is **DKNY**.*
- *Google output: मेरो मनपर्ने कपडाहरूको ब्रान्ड **DKNY** हो।*

Struggle with other nouns. Some words didn’t get translated even if they had corresponding words in Nepalese. Example words included: study, avengers, uncle, brothers, game, people, blue, granny, couple

Example:

- *Written text: My favourite colour is **blue**.*
- *Expected output: मेरो मनपर्ने रंग **निलो** हो*
- *Google output: मेरो मनपर्ने रंग **blue** छ।*

With no corresponding word. Some words where not translated because there was no corresponding word. Example words included: YouTube, Xbox, Minecraft, PUBG, Pizza

Example:

- *Written text: I watch YouTube.*
- *Google output: म YouTube हेर्छु।*

Phonetic output. In some cases, when creating Nepalese text from English text, only the phonetic sound of a word was outputted when there was no obvious corresponding word. Example words included: Bacon, pasta, Adidas, Nike, strawberries, pizza, cartoon, sandwich, burger, tuna, console etc.

Example:

- *Written text: I love **bacon pasta.***
- *Google output: मलाई **बेकन पास्ता** मनपर्छ।*

This also happened for some words which had corresponding Nepalese words; it has to be assumed that this was partly to do with the context of the other words which somehow reduced confidence in the translation algorithms. Example words included: striker, mine, craft, star, mountain, range, mythical, program, code, high

Example:

- *Written: Tell me about **mountain range.***
- *Expected: मलाई **हिमशृंखला**बारे बताउनुहोस्।*
- *Output: मलाई **माउन्ट रेंज** बारे बताउनुहोस्।*

The last peculiarity of translation was that in some cases, the words or phrase that came next to a number just didn't get translated.

Example 1:

- *Written text: I am 9 **years** old.*
- *Google output: म **years** बर्षको भएँ*

Example 2:

- *Written text: I'm 9* ***nearly*** *10.*
- *Google output: म****nearly*** *nearly*

Example 3:

- *Written text: my family has 5* ***people****.*
- *Google output: मेरो परिवारमा****people*** *जना मानिस छन्*

In summary, there do seem to be some peculiarities about translation and whilst Google Translate did well overall, the relative rarity of Nepalese, when compared to English, probably means that there is still learning to be done with the translation engine.

5.5.9 Children's Reaction to the Translated Text and Understandability

As translation errors are very common in children's conversations, a very important aspect not to forget is understandability. Even when there were errors and the translation was not accurate, the children continued to reply back. Just as Google used context to do its best with translation, so too did the children! Even if the whole sentence didn't make sense, the children seemed to look at the words individually and tried to understand from them and reply accordingly.

5.5.9.1 Understanding the Context

Some children seemed to understand the context or the pattern of the text in a sentence and reply accordingly even if the translation was not great. Sometimes they ignored the phrase out of context continued within the context.

Example 1:

- *Written text: मेरो मनपर्ने फलफूल अँप हो।*
- *Expected output: My favourite* ***fruit*** *is* ***mango****.*
- *Google output: My favourite* ***fruiting*** *name is* ***Amp****.*
- *Reply: my favourite* ***fruit*** *is* ***mango*** *and* ***pineapple*** *.*

In the example above, even though ‘Mango’ was not translated correctly, and fruit appeared as fruiting, the receiver got the idea that the sender was talking about their favourite fruit. As a result, they wrote about their favourite food.

Example 2:

- *Written text: तपाईंको मनपर्ने जनावर को नाम **भन्नु** न।*
- *Expected output: **Tell** me your favourite animal name.*
- *Google output: **Don’t tell** the name of your favourite animal.*
- *Reply: My favourite animal is bunny.*

In this example, even though the translation was wrong, the receiver got the idea that the sender was asking about their favourite animal because it doesn’t make sense when they say don’t tell me as they were sharing their favourite things.

Example 3:

- *Written text: **माली** त रेड कलर मन पर्छ।*
- *Expected output: **I** like red colour.*
- *Google output: **The gardener** likes red colour.*
- *Reply: **My** favourite colour is black, blue, green and red.*

Talking about a gardener didn’t make sense in the context, so the receiver just ignored that and just followed the pattern and shared their favourite colours.

Example 4:

- *Written text: मलाई फुटबल मन**baibai वैवाहिकपर्छ।***
- *Word by word: I like **marital baibai** football.*
- *Expected output: I love football a lot.*
- *Google output: I want a football mind **baibai marriage**.*
- *Reply: I don’t want a marriage.*

Here the receiver didn’t understand *baibai,* so just replied to the marriage part!

Example 5:

- *Written: मलाई पानी साथीहरु संग **खलान** मनपर्छ।*
- *Expected: I also like **playing** with friends.*
- *Google output: I like to **drink** water with friends.*
- *Reply: I like to drink water.*

This translation error caused no real alarm, and the recipient appears to have just seen it as a normal thing to be saying and has replied literally.

Example 6:

- *Written text: मेरो मनपर्ने खाना मःमः हो।*
- *Expected output: My favourite food is momo.*
- *Google output: My focourite food is mum.*
- *Reaction: My favourite food is tuna.*

Here, the receiver didn't react to the wrong translation but just continued with the conversation.

Example 7:

- *Written text: मैले तिमीले भनको कुरा बुझिन फेरि एकचोटि राम्रोसित भन्नुहोला।*
- *Written text meaning: I didn't understand anything please write again.*
- *Google output: If you do not understand what I am saying then say it well once again.*
- *Reply: sorry if you don't under stand me I now we live in defrent parts of the world an some times I don't now what you say but most of the time I do now what you say.*

Here the receiver even apologised but did understand that they are using different languages.

5.5.9.2 Asking for Clarification and the Beginning of Humour

In many cases, children asked in the letters about things they didn't understand. Sometimes creativity was also observed within the reaction. In some cases, translation created some confusion that resulted in a question which would open a conversation. That also showed some beginning of humour and the chatting pair being closer (Example 4).

Example 1:

- *Written: I am 9 years old.*
- *Expected: म 9 वर्षको छु।*
- *Google output: म years बर्षको भएँ।*
- *Google output meaning: I am years year.*
- *Reply: मैले तिम्रो उमेर बुझिन।*
- *Reply meaning: I didn't understand your age.*

Example 2:

- *Written: मेरो नाम शेरफ राजभण्डारी हो।*
- *Expected output: I am sherrif rajbhandari.*
- *Google output: I am sherrif prince.*
- *Reply: Are you really a prince?*

Example 3:

- *Written: अनि तिमी कति कक्ष मा पढ्छौ?*
- *Expected output: Which class do you study?*
- *Google: And how many cells do you study?*
- *Reply: What are cells?*

Example 4:

- *Written: मेरो मनपर्ने पेट बिरालो हो*
- *Expected output: My favourite pet is a cat.*
- *Google output: My favourite belly is a cat.*
- *Reply: Do you eat cat? Do you want to be best friend?*
- *Reply 2: मलाई बिरालो मनपर्छ । हामी तिम्रो साथि बन्न चाहन्छु*
- *Reply 2 meaning: No I like cat. Yes I want to be friend.*

5.5.9.3 Surprised with the Reply and React

A poor translation sometimes caused the respondent to become somewhat antagonistic. The receiver was surprised and reacted immediately.

Example 1:

- *Written: म सँग दाई त छैन*
- *Expected: I don't have a brother*
- *Google output: I don't like brother*
- *Replyn: Why don't you like your brother? That's mean.*

Example 2:

- *Written: तपाईँलाई के मन पर्छ?*
- *Expected: What do you like?*
- *Google output: What do you need?*
- *Reply: I don't need anything. Why are you asking this?*

5.5.9.4 Disbelief and Challenge

In some of the conversations, there was some disbelief that the recipient challenged.

Example 1:

- *Written text: के तिमी youtube मा logan paul गर्छौ?*
- *Expected output: Do you watch Logan Paul on YouTube?*
- *Google output: Are you Logan Paul on YouTube?*
- *Reply: I am not Logan Paul.*
- *Expected output: म लोगान पल होइन।*
- *Google output: म लोगान पल हो।*
- *Google output meaning: I am Logan Paul.*
- *Reply 2: तिमी किन ठट्टा गर्दैछौ? तिमी लोगन पल होईन।*
- *Reply 2 meaning: Why are you joking? You are not Logan Paul.*

Example 2:

- *Written text: मलाई मेस्सी मन पर्छ।*
- *Expected output: I like Messi.*
- *Google output: I am Messi.*
- *Reaction: I am Ronaldo.*

Example 3:

- *Written text: मेरो निके नाम चिङ हो। अनि तिम्रो के हो?*
- *Expected output: My nickname is Ching. What is yours?*
- *Google output: My very name is Ching. What is yours?*
- *Reaction: I don't have a very name.*

5.6 Discussion

Of the 632 English sentences translated into Nepalese, 356 were translated correctly (57%). Of the 847 Nepalese sentences translated into English, 522 were translated correctly (62%). We can see that Google translate was able to do a decent job with translation – faring slightly better with Nepalese to English than with English to Nepalese. The technology had difficulties with proper nouns and with pronouns as well as with numbers. The difficulty with proper nouns actually created humour but with pronouns this was seen to cause some anxiety with children in England as they saw this as 'bad English' rather than as something that was just funny. This is one area where user input of corrections to the recognizer will drive improvement over time. The difficulties with month translation were unexpected and were probably noticed due to the content of the children's letters given that birthdays and ages have considerable significance for children. Similarly, the confusion over *'momo'* was probably something Google had just not learned yet.

The translation process created some unusual sentences/letter segments which were often quite different to what had probably been intended but even so, children were able to continue their conversations. Some of the errors, if we can call them that, were caused by the differences in the structure of the two languages (e.g., pronouns) and others by the inevitability of proper names not being in dictionaries. It was surprising to see numbers doing so badly in translation and also to note that months could not be translated with any accuracy. The multiple different translations of *'momo'* did point to the way Google uses context to determine translations when word for word fails – this had the unintended consequence of making out that one of the children in the study had reverted to cannibalism!.

During the conversation, Nepalese children typed phonetically which was then converted to Nepalese with the help of keyboard ad-in and then translated to English with the help of Google translate. But when the English letters were translated, they were only translated to Nepalese

but not phonetic Nepalese after that. One reason behind that is there no phonetic conversion tool available that could be integrated in the DigiPal App.

Another logical reason is that the Phonetic words are not consistent or standardized. The way different readers/writers read/write a word phonetically can be completely different. That shows ambiguity. For There example:

Table 55. Phonetic conversion ambiguity

	Word	**Can be read as**	**Which means in Nepalese**
काम	Kam	Kaam (काम)	Work
		Kam (कम)	Less
पानी	pani	Pani (पनी)	also
		Paani (पानी)	Water

The examples shown do rather show how translation software when applied with children needs to be handled with some care. In this study, which was moderated, if the translation software had produced a problematic line, then it could have been dealt with; it was imagined to be a rare occurrence however and believed that in the main the advantages, even of interesting translations, far outweighed the disadvantages. The translations that were a little odd were not problematic for the children who either took them in their stride, reacted for clarification or responded with more humour. It is also considered that extended use of the software will produce creative humorous outputs (Reynolds et al., 2020).

Because the children were not instructed to write their letters grammatically correct, punctuation mistakes like missing commas or full stops seemed normal in both Nepalese and English letters. If instructed so, they might double check the spellings too before sending the letters.

5.6.1 Informing Design of the DigiPal App

After seeing how Google Translate reacted with texts that had input errors and seeing their impact on the conversation, the argument of having a text input mistake checker tool has become strong. For spell checking, in the case of Nepalese children, it was a bit easier as they could select the right word from a list because they were typing phonetically. For English children, if suggestive text were made active, this might help. But it's not only about the

spelling mistakes. Grammar and punctuation also had a big part to play so a checker tool like that seen in Microsoft Word would be useful but probably not on the front end, rather as a layer where it's checked before translation. This would ensure that letter sending remained smooth and uninterrupted. This is an area where further work is needed as the effect on children's composition, of interruptions for spelling and grammar is known to be problematic (ten Peze et al., 2021).

This study has highlighted some ethical issues around the use of such a tool. As seen above, the translation was struggling even when there were no input errors. Sometimes the output was completely different than what the sender wanted to say. Luckily there was no 'improper output' from the translation which could have had a very bad impact on the child's understanding of their chat partner, their culture or the country, but this possibility cannot be ignored, and it cannot be assumed that bad language or offensive language might not happen. Indeed, the study described in **Section 3.5.3** showed that children, when unsupervised and chatting with friends they know well, may write some fairly crazy things. For these reasons, as well as a hidden grammar / spell checker, the app should preferably have some sort of Artificial Intelligence implemented that would check for 'harmful' intentional/unintentional comments both before and after the translation of a text. These are defined in a new layer : Ethic Layer.

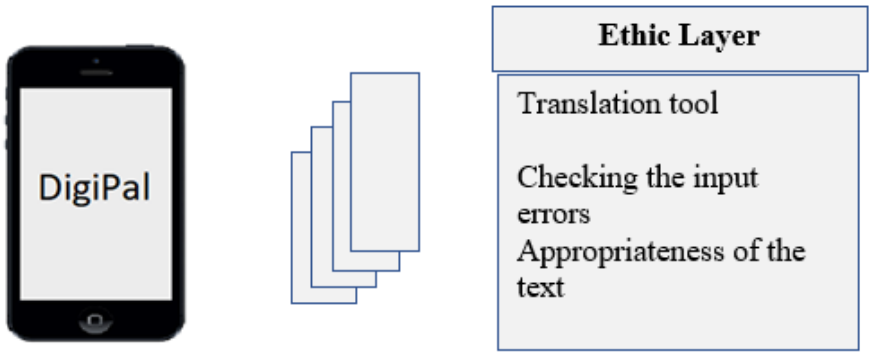


Figure 61. Proposed Ethic Layer for DigiPal

5.6.2 Contribution/Insights for Follow on Work

After successfully completing the implementation of Google translate in the DigiPal app this study demonstrated how a cross country semi-synchronous letter exchange could work. This can be considered as an 'in the wild' study of the possible app use and it exposed many interesting points about how children dealt with poor translation and how they managed to keep conversations going. Specifically, it showed how children were enthused to take part and how broken translation could create humour. The insights from this chapter are brought towards the final app design and the confidence in the possibility of the app lead to the follow on work which sought to discover how design elements could improve the children's experience.

5.7 Summary of the Chapter

This chapter described the operation and outcomes from a unique study held across two countries with children communicating in their own languages facilitated by Google Translate. Despite the children in England being shown to be not all that accurate in text entry, and while the children in Nepal made errors in selecting words for the phonetic keyboard, the study was successful in facilitating communication.

Two main areas for concern are highlighted from this study, both pertain to hidden layers that could be implemented in a fully functional version of the app, and both speak to the need to ensure that the child's experience with the app is as smooth as possible. The results confirm that Google translate can be used in a children's conversation application like DigiPal. As a translator it might not be 100% but as a facilitator it certainly performed above that mark.

Chapter 6. Design for Cultural Evenness

6.1 Introduction

This chapter mainly focusses on design and considers the elements that are needed beyond translation to create an engaging and culturally appropriate experience. The focus is on SRQ3. *In what ways can a design ensure cultural evenness whilst also being engaging for children?* which is explored with two informant design studies, with children from both Nepal and England. The effectiveness of these studies additionally informs SRQ2. *To what extent can children, from two different cultures, equally participate in the design of a single application?* with insights on how to carry out drawing methods. This chapter delivers additional insights, from children's design inputs, for the design of the digital app and informs a general model for design for cultural evenness which is presented at the end of this chapter.

Making a child's DigiPal app for cross-cultural communication with Google Translate has been shown to be feasible. Though some weaknesses were identified, Google translate does a good enough job to be used for such an application but the use in this way would probably need to be moderated by an adult until such time the translation can be seen to be more accurate.

In this chapter, two studies (**Section 6.2 & Section 6.3**) are described that aimed to identify some of the cultural aspects that might be useful in a future version of the app and to consider what could be usefully modelled for other developers looking to create games that were culturally even. The construct 'Cultural Evenness' is defined here as an approach to design that seeks to not favour one culture over another and that seeks to not promote a bias towards one particular cultural view. Work has been done in this area especially in terms of HCI4D; one example is a study done in Nairobi, Kenya that showed how the constraints of security, cost, bandwidth and responsiveness in that environment impacted on ICT design (Wyche et al., 2010). We see cultural levelling (being the process towards evenness) as beginning with what is seen on the interface of a product but then going below this to extend to how a system operates in terms of its philosophy and its attitude. Methodologically, we can learn from work on cultural appropriateness with a focus on meaning rather than representation (Bourges-Waldegg and Scrivener, 1998).

Works from this chapter are published in the following papers:

Beneath the Himalayas — Exploring Design for Cultural Evenness with Nepalese Children

Authors: Dev Lamichhane, Janet C Read, Daniel Fitton
Conference name: Proceedings of the 32nd International BCS Human Computer Interaction Conference (HCI), July 2018
Conference theme: Human Computer Interaction Conference
Pages: 1-5
Publisher: BCS-Chartered Institute for IT
Publication date: July 2018
Digital Link: https://www.scienceopen.com/hosteddocument?doi=10.14236/ewic/HCI2018.149

Play It My Way: Participatory Mobile Game Design with Children in Rural Nepal

Authors: Dev Raj Lamichhane, Janet C Read
Conference name: International Conference on Human-Computer Interaction
Pages: 325-336
Publisher: Springer, Cham
Publication date: 19/07/2020
Digital Link: https://link.springer.com/chapter/10.1007/978-3-030-49788-0_24

6.2 Study 5: Exploring Meanings using Drawings

Drawings can richly explain how children see the world as drawing is a familiar, and enjoyable, task to them (Profice, 2018). Children aged 4-6 expressing their feelings and experience in drawings is regarded as a successful activity as seen in (Einarsdottir et al., 2009). In another study, authors observed that children from age of 3 can understand the emotion expressed via drawings (Misailidi and Bonoti, 2008). One thing we need to consider, in this kind of activity, is the freedom given to children when using drawing as an expressive tool. Drawing freely, as mentioned by (Villarroel et al., 2018) is more beneficial and more effective to capture what the children really think. In this work, children drew images of their homelands alongside other detail. (Rollins, 2005), in their paper, showed how children could communicate through drawings things they couldn't do using any other method of communication. From the results from 22 children aged 7-18, they found out that the communication was enhanced with the help of drawing.

In this section, using drawings as a cross - cultural communication is explored with the aim to consider the meanings found in images and to consider how imagery could be integrated into the DigiPal app to make it better suited to children in the two countries.

Drawings can be a common language for children to communicate and art based methods for communication are worth exploring as children can find it hard to express things orally (Salmon and Lucas, 2011). The aim of this study was therefore to gather ideas and insights for artefacts that could be included in the DigiPal app but also to explore the method of drawing in the two different cultures to determine how it could be used to support equal participation in informing the app.

6.2.1 Participants

In two studies held at different times, 35 children from Nepal, and 20 children from England, aged 9-12, participated in drawing activities. The Nepalese children were from a school in Kharpa, a rural village in northeast Nepal and the English children were from a school in Kirkham, Preston in northwest England.

6.2.2 Method

The children were asked to draw something about themselves that they would otherwise write in a letter to another child to introduce themselves. Thus, a letter expressed in drawings. The Nepalese children were asked to consider an English child as the receiver of this drawn letter and vice-versa. Each child was given a piece of paper, coloured pencils, a sharpener and an eraser. There was no time limit imposed because that might put constraints on how much, or on what, they wanted to express. The children passed their drawings to the researcher once they had finished.

Similar to (Honkanen et al., 2018; Kullman, 2012) and (Profice, 2018) children in this study were free to draw whatever they wanted to, and no instruction was given as to what to draw. The authors also told the children to draw anything they liked and said that nothing is right or wrong, this provided them with the freedom they needed.

6.2.3 Results

Thirty-five drawings from Nepalese children (hereafter labelled D1) and 20 drawings from English children (labelled D2) were collected. Two colleagues from the thesis author's department and from the HCI field volunteered to be coders to analyse the data. During the analysis, a small number of assumptions were made about the implied meaning in the drawings.

For example, that a group of flowers together represented a garden, and group of trees together represented a forest. These were discussed and agreed on between all the coders.

All the children did the activity concurrently in the classroom, so some group effects were quite visible, for example children sitting next to each other often drew very, or somewhat, similar pictures. A similar observation was seen by (Honkanen et al., 2018) in their research. This behaviour is inevitable but we can still consider that the drawings are personal expressions and thoughts that the children had (Punch, 2002), which means they are still valuable data.

Unsurprisingly, given the difficulty of drawing ideas, the children mainly drew 'things' but during coding it was considered that there were some non-tangible things represented in the drawings. For example, in the Nepalese drawings, love hearts and welcoming words around Nepalese flags were drawn. In some drawings - it was quite difficult to see what the drawings were of. Some things, like the school and the temple were very obvious, but other things, like lentils, rice, mangos and oranges benefitted from labelling. The children seemed to understand what 'needed' labelling and included labels for such things – viz. the school was seldom labelled but fruits often were. Similarly, in case of English drawings (D2), children generously labelled their drawings. All 20 of the drawings from the English children had at least one label.

6.2.3.1 Items, Elements and Themes

To explore the content of the drawings a count was made of items, elements, and themes. An item was defined as a thing that might be drawn, e.g., a school, a tree, The number of elements represented the number of things drawn across the set of children. For example, if 20 children drew a school, and 10 drew a river, then school and river are items, thus two items, and as they are drawn by 30 children altogether, which was recorded this effort as 30 elements drawn.

Table 56. Number of Items and Elements represented in the drawings

Drawings	items	elements	Average elements per drawing
Nepalese (D1)	75	335	9.5
English (D2)	65	226	11.3

Table 56 shows the total number of items and elements present in D1 and D2 and the average elements per drawing. This shows that children typically had between 8 and 14 elements on their drawings – in other words they put quite a lot of effort in.

Table 57. Thematic Analysis of the Drawings

Landscape	
D1 and D2	Sun, blue sky, cloud, birds flock, hill, fields, flower garden, flowers
Only on D1	Star, mountain, snow, forest, river, pond, spring
Only on D2	Park, rainbow
Community	
D1 and D2	Neighbours, neighbour's house, school, classroom, shops, road, path, vehicles, bus, plane
Only on D1	Bridge, hospital, police station, village development office, temple, rest stop, chain linked fence, helicopter
Only on D2	Market, train and track, farm, pub, bank, highstreet fast food, nursery, church, graveyard,
Family	
D1 and D2	Home, family members, pets
Only on D1	Cattle, vegetable garden
Only on D2	Family car
Identity	
D1 and D2	Flag of the country
Only on D1	Country map, national flower, national animal, national bird
Only on D2	
Themselves	
D1 and D2	Oneself, favourite food/fruits/sweets/chocolate, favourite game/activity, favourite things
Only on D1	
Only on D2	Bike, gaming console, toys, favourite colour, holiday destination, tablet, favourite football player, favourite football club logo, favourite band, favourite tv show,

Collections of items in the drawings could be categorized into themes in much the same way as was seen in (Villarroel et al., 2018) where the children drew pictures of plants which were easy to group. Following guidelines from (Bogdan and Bilken, 1992), using open thematic analysis, the items from both D1 and D2 were categorized into 5 different themes as shown on **Table 57** and explained below:

Landscape:

This included the visible features in the area the children lived in. There were some similarities in their pictures like blue skies with sun, intermittent clouds, birds flying, green hills and flower gardens. These images speak very much to the comfort of a landscape. Indeed, in Lancashire, where the English children lived, sun was a fairly rare occurrence, but a sunny day is certainly an optimistic portrayal of the world. The notable differences were that in D1, given that this was Nepal and in the foothills of the Himalayas, mountains and snow featured and D2 included parks, a concept pretty much unknown to children in the rural Nepalese village where the study took place. It is important to understand that the author did this study in Nepal and in England so was able to see the areas where the children lived so could interpret what was seen.

Community:

This category included the items that showed how the community was structured. Both groups included portrayals of neighbourhoods with the school, shops, road, and vehicles etc. Almost all the children had most of these on their pictures which could be taken as them understanding the importance of these structures for them. D1, being a rural village, included recently built structures that the local children and villagers were very proud of and happy for. For example, the hospital, police station and village development office etc, whereas the English children, despite having a GP surgery and police station in their village seemed more likely to capture places they might have frequented like the market, the trainline, pub, bank and fast-food outlets. Both groups had places of worship on their pictures; D1 having temples and D2 having churches.

Family:

Many, but not all, children expressed something about their family and their possessions. Children drew their individual farming fields, their own homes or pets, and their own gardens. D1 included cattle and their own vegetable gardens whereas D2 often included family cars.

Some of the D2 drawings even had all the rooms from their houses with the internal structures drawn and labelled.

Identity:

The children, in particular from Nepal, were delighted to share things that would identify themselves or the whole country. For example. the national flags were present in many pictures from both D1 and D2. Nepalese children included more identifying pictures like the national bird, national flower, Mt. Everest etc.

Themselves:

This category included the pictures of personally connected things. Some of them drew pictures of themselves and others drew their favourite foods, fruits, or sweets. The favourite foods included were quite regional; with D1 including Nepalese and D2 including English food. Children openly shared their favourite things where D1 included birds and flowers and butterflies whereas D2 included toys, gaming console, tablet etc. It was noted that there were no toys included, and personal possessions appeared very limited, in D1. Football was present in both as a favourite sport. On top of that, D1 included volleyball and D2 included things like holiday destinations, camping, birthday party hats and Christmas trees.

Uncategorized:

Some abstract items like love hearts and smileys were present in some pictures. From both the groups there were items (32 in D1 and 23 in D2) that couldn't be recognized by the coders that's why they are not included in the total count or the analysis.

6.2.3.2 Most Popular Items:

The items drawn the most are shown in **Table 58.** Note that the frequency is the number of times each was seen in the drawings rather than a count of the number of children drawing it.

Table 58. The frequencies of common items in Nepalese and English drawings (Top 10)

Nepalese (D1)		**English (D2)**	
Items	**frequency**	**Items**	**frequency**
Home	29	**Home**	16
School	25	Favourite food	14
Temple	18	Pet	12
Flowers	15	**Trees**	11
Mountain	13	**Church**	11
Path	13	**School**	10
Duck	12	Flag	10
Bird	12	Favourite game	10
Sun	12	**Road**	9
Trees	11	**Sun**	9

Similarities in the way children introduce themselves can be seen from the table above. Six items(emboldened); home, school, temple/church, path/road, sun, trees are in the top ten items for both groups of children. The remaining 4 items were also common in both groups. This suggests that for these two quite different populations, living thousands of miles apart, their local understanding of their place is quite similar.

6.2.3.3 The Method: Ways of Representation

In looking at the effectiveness of the method across the two populations, it has already been noted that most of the children managed to draw a good number of items and that the items drawn were quite similar. Interestingly, both sets of children represented their environments through drawings constructed in one of two ways. Either they drew the things items into one complete picture consisting of everything that they wanted to convey in a connected and relational structure – a landscape - (see **Figure 62 & Figure 64**) or they drew a set of items in a list form without relational connections – a list - (see **Figure 63 & Figure 65**).

Figure 62. Landscape drawing from a Nepalese Participant

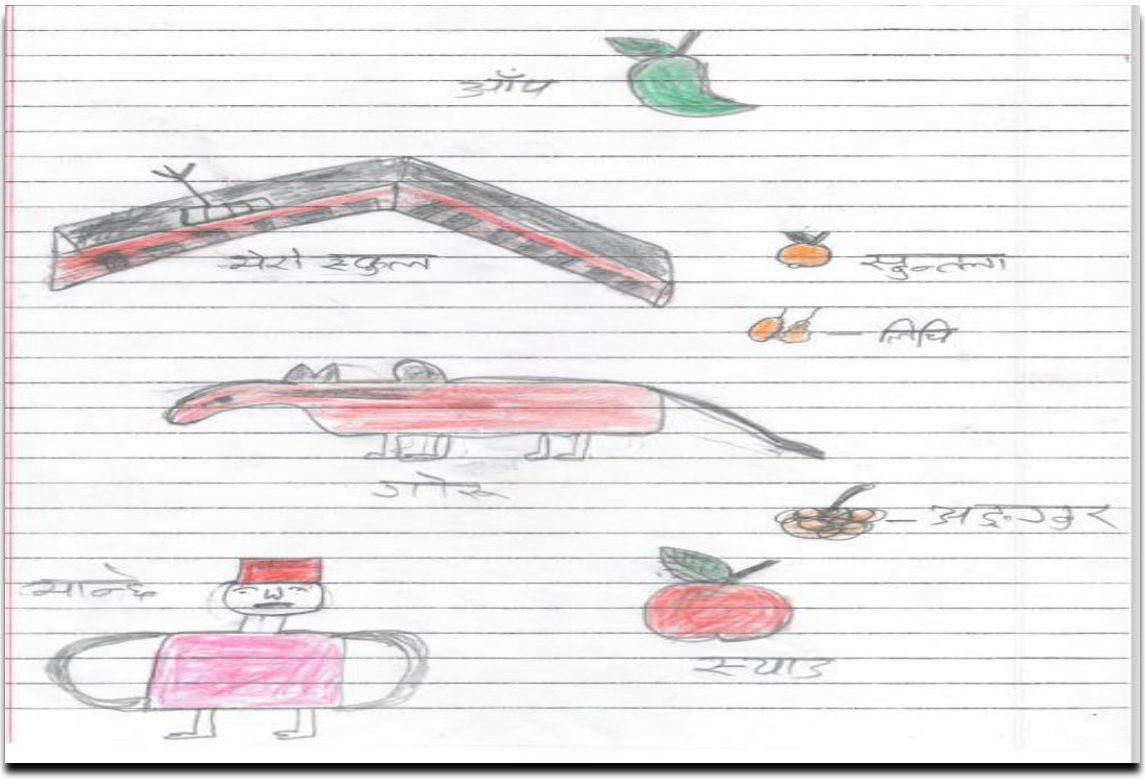


Figure 63. List drawing from a Nepalese Participant

Figure 64. Landscape drawing by an English Participant

Figure 65. List drawing by an English Participant

6.2.3.4 Method: Drawing as Communication

When comparing the drawings with the content of the letters that children wrote in **Section 5.5.2**, drawings included items, mainly in the landscape category, which were not mentioned in the letters. For example, sun, sky, cloud, flowers, river, pond, forest etc. Some of the items from the Community category were common in both drawings and letters such as school, shops, road etc., but drawings had many more items like bridge, hospital, temple, church, pub, bank police station etc.

There were more similarities in the Family category where both drawings and letters had mention of home, family members, pets, family car etc., and the same with the country, national animal, national bird, national flower etc., from the Identity category. In terms of things, they like, both mediums shared some rich information from their favourites including food, fruits, game, sports, football team, player, video games etc.

The things they were present in drawings but not in letters are interesting as they were potentially further away from the self and so in the act of writing perhaps children didn't think about these things. They may also have been quite abstract to describe in words. It could be that these would come later in conversation just like they appeared in (Barksdale et al., 2007) where the letter exchange was for a longer time.

In both sets of drawings, children successfully expressed who they were, what they had, and what they liked but it was hard to get a sense of what they did. Other authors have seen similar, where children see the things around them and can express them using drawings (Cox, 2005). In a way drawing could be thought of as an introduction to a conversation. Focussing on things that can be easily imagined and drawn is commonly seen in children's hand written letters when they initially write to one another (Barksdale et al., 2007) and there are some cases where drawings are the best method to communicate something, like when drawing complex diagrams (Jang et al., 2014) or trying to visualise things that cannot easily be described in words. Children did ask for the facility to put images and drawings in the app (**Section 3.5)**, but time prevented this being facilitated although it would certainly be a nice add on although there would probably need to be translation effected for the labels.

6.2.4 Capturing Culture

Spaces and places are constitutive dimensions of children's lives as they live in particular geographical, cultural, historical, interactional, material and situational spaces (Farrugia, 2014). These were represented in the drawings collected from the children. The children are like a local expert of their area as they see the things in detail in their everyday life as explained by (Cox, 2005) who wrote, "*Children's drawings include social and cultural elements and clearly reflect their cultural context and also constitute the cultural practice."*

The drawings exposed some of the cultural interpretations of the children where the land and the community are very important. Nepalese children represented through drawings that they are being often outdoors, being family and community centred, proud of their community and country and proud of their natural landscapes; we could consider this representative of their Nepalese, rural culture. English children also included landscapes, but they also gave some hint that they may give importance to the things within their home. Their houses were drawn with much more detail, each room and items inside the room, their toys, tablets, gaming consoles kind of supports that. This speaks to an English, urban and digital culture. In both cases, the central position of the school was useful in showing how both 'saw' their community, this is part of a general 'shared' childhood culture. The school was, for the children, their focal point and many had put a great deal of effort into drawing this with great accuracy so that we could be impressed by its scale and design. See examples in **Figure 62 & Figure 64**.

6.2.5 Contribution/Insights for Follow on Work

Children were able to represent themselves, the things that mattered to them, the area around them, their identity, and their culture, with the help of drawings. These are really important aspects for a culturally even design. Reflecting on what children could and could not represent in drawings also gave confidence that text had to be alongside images for communication across cultures. The insights from this study helped finalise aspects of the design of the app and directs to the next step to research around the cultural evenness and engagement possibilities.

6.3 Study 6: Designing Engagement

When the children from different parts of the world are writing letters to each other, there are many complexities with a significant one being the different time zones. For example, taking the participants of this research, Nepalese and English children, into consideration, they are nearly 4500 miles away from each other and have a time zone difference of 4 hours, 45 minutes or 5 hours, 45 minutes (depending on the UK time) (see **Figure 66**). Because of this, maintaining the sustainability of the communication is a concern since the children might need to wait for hours or even a day to get a reply. On the one hand, this should be okay because that matches with the traditional pen pal activity when children would wait for days or months for real letters, but the internet connected world is different and as soon as children are using Internet connected technology, they assume instant responses.

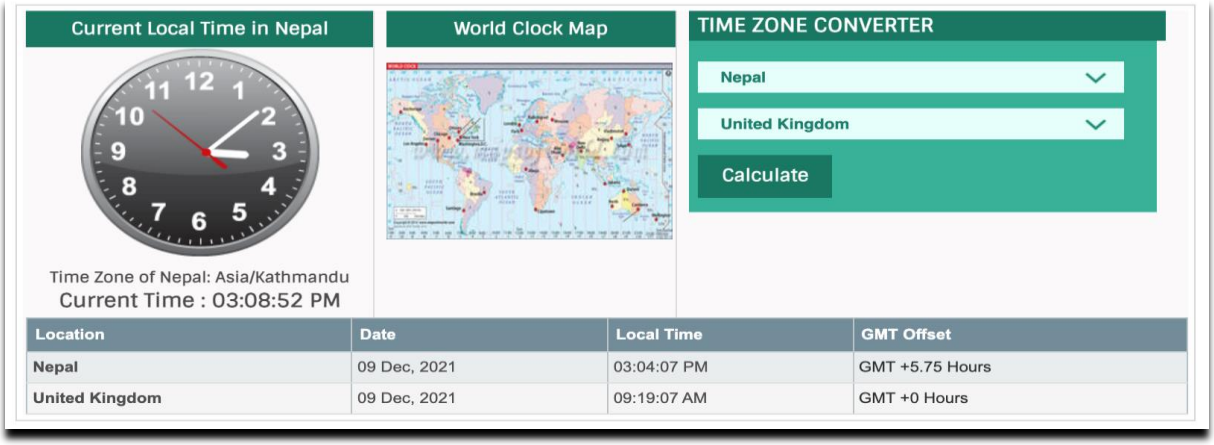


Figure 66. UK and Nepal Time difference (Source: https://www.mapsofworld.com)

Having a mini-game or some games in the App was determined to be a good idea to improve engagement. Early work described in **Chapter 3** showed that including games top 10 ideas for the app from both Nepalese and English children. Including games is beneficial to children as they help children in their cognitive development and also play a key role in the development of their sociocultural and emotional competences during childhood (Vygotsky, 1967). To gather some insights into the sorts of games children played in the two locations, both from a cultural position but also to inform design, a small study was undertaken to discover the preferences of children and to gather some game designs. The aim was to establish if there were common game play ideas that could be included with some confidence whilst also seeing what a game design activity might inform about cross cultural design and to see again if children could equally contribute to this from both countries.

6.3.1 Location and Participants

Two separate studies, one in a school in Khotang, a rural village in Nepal and another in Preston, a town in England were carried out. In Khotang, 35 children within the age group of 9-12 were chosen by the head teacher and in England, 108 children of the same age group from local schools took part in a Mess Day (A Day where the researchers invite children from different schools to participate in the studies for their research, E.g. **Appendix 2.1** University Mess Day Example Tuesday 25/06/2019) conducted by the university. In both cases, each child and their parents consented to take part in this study. The study was clearly explained to the children before the activity started. The work was covered by ethical approval from the host university and approved by the school boards.

6.3.2 Tools and Procedure

The DigiPal app was used for this study as a supportive tool. The children used this app, on an Android mobile device, to understand the context of the design task. Then, to design they used a sketched prototype of a mobile phone (shown in the **Figure 67 &**

Figure 68), and were given a pencil, some colours, an eraser, and a sharpener for the drawing activity. The Nepalese children were taken into a classroom in their school which was set aside for the sole use of the researcher for the study. For English children, it was in the child computer interaction lab in the University.

Five children at a time used the app and were then told that the app was being developed for children like themselves which would allow them to talk to children from other countries. After establishing that all the children liked to play games on mobile phones, each child was given the paper mobile prototype and all the drawing tools required as explained above. They were asked to draw a picture or pictures of a game that they would like to have in the digital pen pal app. They were also asked to name their imagined games, describe in words how the games would be played, including how to score points if relevant, and how to win. No time limit was imposed, and no instructions were given other than that. Influenced by the method used in (Profice, 2018), the children drew freely and handed the drawings to the researcher once they finished.

6.3.3 Results

All the children from both groups were able to draw some games; some drew one and some more than one. Altogether 58 game designs were collected from 35 Nepalese children out of which 7 were new game ideas. The data showed that 18 of the children drew one game, 14 drew 2 games and 3 drew 4 games. The average number of games drawn by the children came to 1.65. In England, 108 children drew 131 games which is an average of 1.21 per child. Again, some children drew more than one game; 2 drew 3 games and 19 drew 2 games. This multiple game design, in case of both sets of children, might be because they were drawing freely without any time limit, so many had enough time to draw more than one. The results seen in (Kullman, 2012) are similar as the children were drawing freely that encouraged them to be more creative.

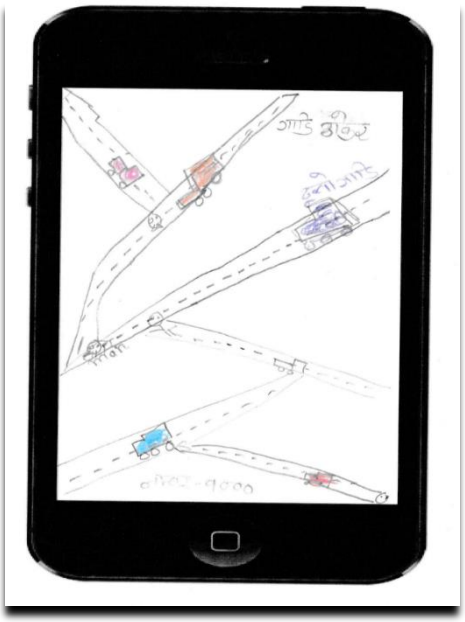


Figure 67. Game design from a Nepalese child

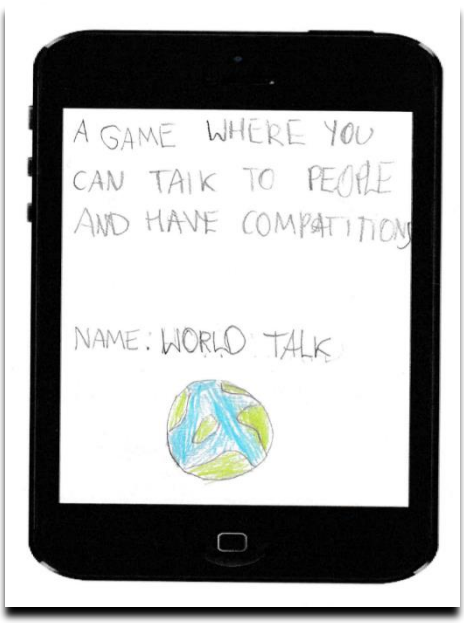


Figure 68. Game design from an English child

6.3.3.1 Game Designs

The game designs from both sets of participants were examined and analysed using thematic analysis to categorise similar games together. For Nepalese children's drawings, this analysis resulted in 20 unique game design themes with 6 of these being drawn by more than one child. These six are shown in **Table 59.**

Table 59. Frequency of Nepalese children's repetitive game ideas.

Game	Number of Children
Driving	19
Snake	14
Car race	4
Bubble Shooter	2
Shooting	2
Break Wall	2

Driving and snake games were both very popular with 19 and 14 of the drawings being of these respectively. Note: Driving and car race may seem similar, but they were distinguished based on the number of cars present in the drawing. When there was more than one car on a track or it had a start or finish line, that was classified as a car race.

Table 60. Frequency of English children's repetitive game ideas.

Game	Number of Children
Minecraft	15
Roblox	11
Fortnite	9
Football	7
Pokémon	5
Chatting	4
Educational	4
Food	4
Drawing	3
Slime	2
Pool	2
Slide	2

The English children's drawings represented 88 unique game design themes where 12 of them were drawn by more than one child. Table 60 shows the list and frequency of repetitive game ideas:

Minecraft, Roblox and Fortnite were the most popular ideas given by children from England with 15, 11 and 9 times respectively. Examining the similarities in drawings it did appear that this was sometimes because the children were sitting next to each other; a similar observation was made in (Honkanen et al., 2018). Other researchers add to this aspect mentioning that children's drawings' results are easily influenced by so many factors like what others draw or say in the group., (Richards, 2003). However, (Punch, 2002) argues that the drawings still represent personal expressions and thoughts so should not be summarily dismissed. Even if they were influenced from another, the drawings looked a bit different anyway with some extra or less details on them.

6.3.3.2 Game Designs Inspired by Culture and Daily Lives

Seven of the drawings from Nepalese children seemed to be wholly or partially influenced by their situational culture. For example: one was a drawing of a card game that is known to be played only in Nepal; another example included a Nepalese flag on the finish line of a car race. One child drew a game that involved fighting a tiger which was possibly a result of the village they lived in being close to the forest where tigers were found. There were some cases where the children designed a game which seemed quite well related to their daily life or to something they loved to do. Examples included games of cricket, which is very popular in Nepal, slingshot catapult games, carrom board, snakes and ladders board game, cycling, card games etc. These are all based on games or activities the children were known to play or do in their daily lives.

Drawings from the English children also had some influences from their situational culture. For example, one drew a game called 'Christmas ninja' which included a Christmas tree, gift boxes and a ninja; and we know the importance of Christmas in England. Some children drew pictures of a game about a theme park or games based on shopping that show that they were trying to include something that they do or like to do. Other examples like drawing and art games, computer typing games, geometry and maths fun games clearly show the influence of their school activities in the game designs. These cultural images confirm research that reports that children include social and cultural elements in their drawings (Cox, 2005).

6.3.4 Method: Game Design by Children across Cultures

Both sets of children were able to come up with game designs for the app. The way the activity was introduced (by playing with the app) and then bounded using phone sketches for the drawings was effective and children were seen to be busy. In terms of what was learned, it was clear that the activity gave some cultural insights but failed to deliver an obvious game that would fit the context well for the DigiPal app.

Games that are already out there. Even though the children were encouraged to come up with new game ideas, most of the children drew games that are already out there. For example, snakes and ladders, car races, cycling, football, Minecraft, Roblox, Fortnite, and Pokémon. This was useful as it gave some insights into what children knew about.

Cultural Insights. The children included some cultural objects in the game designs, for example a Nepalese flag at the finish line of the car race game, but these can only at best be referred to as *low-cost cultural overlays* – namely things that could easily and cheaply be skinned onto a relatively complex game design in order to give it some cultural positioning. This reminds us of the iceberg effect of culture from (Hoft, 1995). There is a much bigger challenge to design deeper culturally situated games especially when the app is intended to cross cultures. Skinning an English or Nepalese flag is easy – making a game that is on the one hand Solitaire (for England) and the other Carrom (for Nepal), is much more challenging. The Nepalese children are already playing games that have been developed for children from western and developed countries and that was evident in the drawings they made, but the children in England were not accessing Nepalese traditions which provides a lop-sided ness to cultural balancing. The challenge is therefore how to enable this deeper cultural meaning in cross cultural design.

Possible Implementation. One aim of this study was to find out about children's mobile games experience, and it had been hoped to gather insights for a game that could eventually be built into the app. Most of the Participants proposed games that are already available in the market. The more creative children came up with new game ideas that represented their daily lives or culture. As a proof of concept a decision was made to attempt to add a game to the app that could use both surface level skinning and some slightly more meaningful adaptations.

6.4 Discussion

6.4.1 Informing Design of the DigiPal App

The two studies here gave ideas for the design of the app and in particular about the design of an add on game. Taking the landscapes of the children's lives as a backdrop, and with some direct cultural information and skinned design, a decision was made to add a quiz to the app that was logically the same in both languages/cultures but that had bespoke content and that used some skinning of images and visuals based on landscape. This would then inform the model for culturally level design.

6.4.2 Children as Informants

These two studies presented here showed how methods commonly used in informant design could be used with two different populations to bring together insights of commonalities and differences. Children were able to express their landscapes and artefacts by drawing and were able to describe game ideas that either represented things they already played or things they might like to play. The game design activity gave some insights into both digital and physical play – with more insights on physical play from the Nepalese children.

6.4.3 Cultural Evenness

It was interesting to note from the drawings that children labelled things that they assumed might not be understood by other children. It would seem to be an important possibility, in a later version of DigiPal to include this sort of functionality where children can mark ambiguous things. Given that the translation software struggled with these very local things it could potentially be automated to react with an 'explain this' prompt when an unknown word was entered. These can be part of the Presentation and Interaction layers of the design model as shown in **Figure 69.**

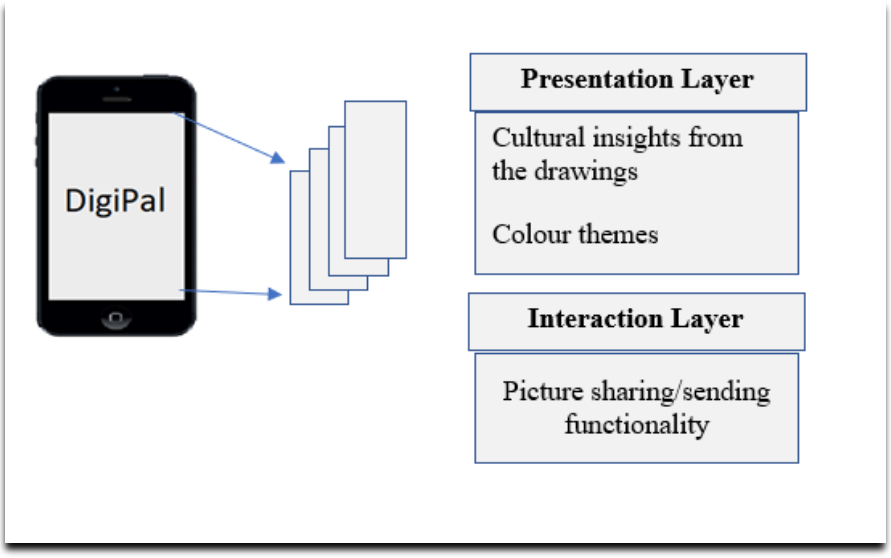


Figure 69. Proposed Presentation and Interaction layer for DigiPal

For products that may be used across significant time differences, it is important to maintain the interest and engagement of the children. This can avoid children losing interest in the app while waiting for replies and because it might take quite some time to read, understand and reply to a letter. This is why a new layer is added to the model which is referred to as the Engagement Layer as shown in **Figure 70.**

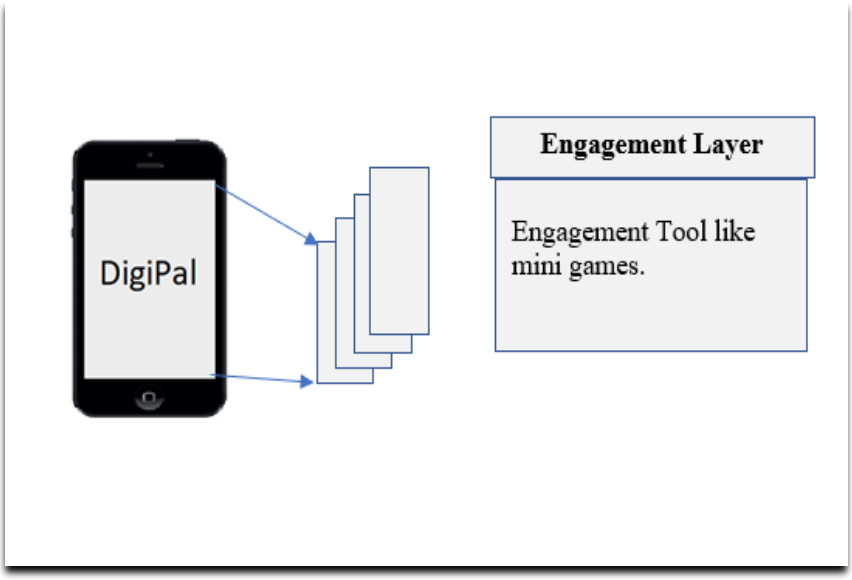


Figure 70. Proposed Engagement layer for DigiPal

6.5 Development of DigiPal Version 5

Version 5 of the DigiPal app was built to include a game that was inspired from the two studies described above. The game uses simple images and minimal text to introduce the country of the recipient of the child's chat. The game that is built demonstrates how a game could be added that would easily be adaptable to different languages and cultures. In DigiPal Version 5, the game is used to 'fill time' when there have been no responses to the chat. The game includes some cultural and some educational questions that were informed from the items found on the drawings from the children and from the many hours spent looking at chat between the two groups.

This version also tries to share the pictures that children drawn from **Section 6.2** of this chapter. Those pictures are shown as an animation in the second page after they selected the flag.

Figure 71. DigiPal Version 5 Welcome page

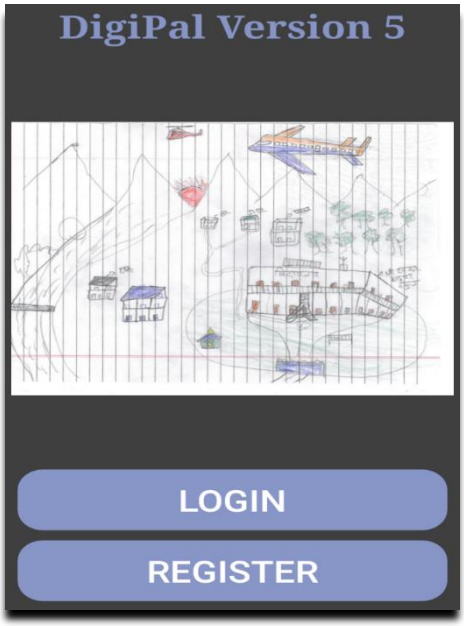


Figure 72. DigiPal Version 5 showing the drawings from the children

Game Starting Point

The link to the Game was added to the user page where the children could just click the button to start. Shown in **Figure 73 & Figure 74.**

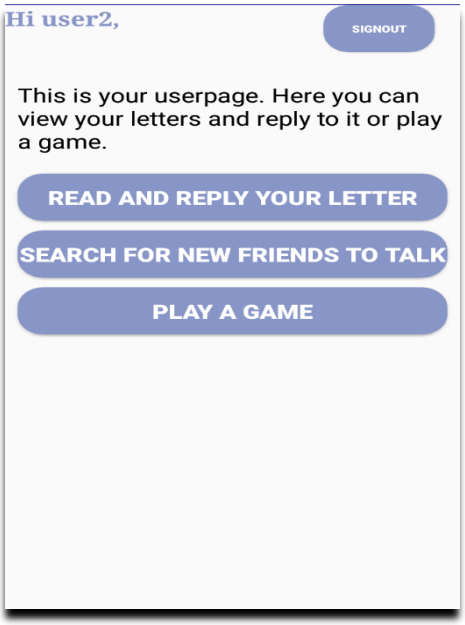


Figure 73. Game option added to the User Page English

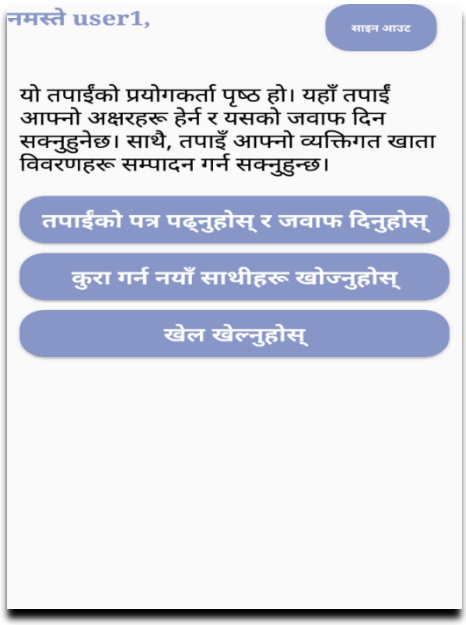


Figure 74. Game option added into the User Page Nepalese

Game Homepage

This is the page where the name of the game is displayed and by clicking the start button the game starts. In future, this page could be modified so that it would have a list of games that children can play. Shown in **Figure 75 & Figure 76.**

Game Information Page

This page explains to the children what the game is about. The English children see a picture of Mount Everest and the information text says that they need to climb the Mount Everest gradually by correctly answering the questions from the quiz. If they answer all of them right, they reach the top of the mountain. The same goes for the Nepalese children where they need to climb the Shard (A tall and popular building in London). The reason behind selecting Mount Everest and the Shard was to give a sense of place and this was inspired by the landscapes from children's drawings. Shown in **Figure 77 & Figure 78.**

Figure 75. DigiPal Quiz English Homepage

Figure 76. DigiPal Quiz Nepalese Homepage

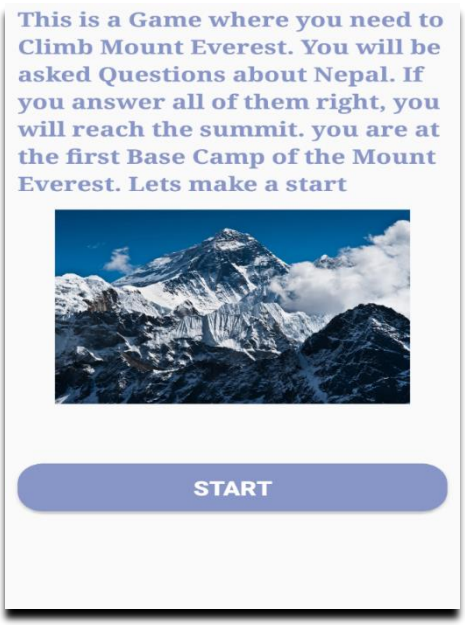


Figure 77. DigiPal Quiz English Information Page

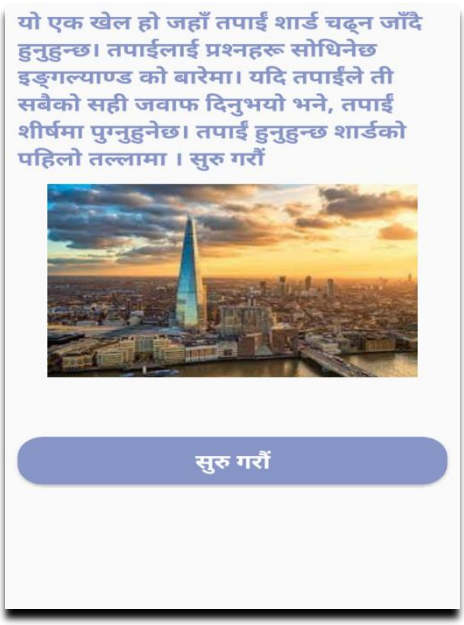


Figure 78. DigiPal Quiz Nepalese Information Page

Question Page

Each question page has a question, four options and a submit button. To make it more visual, a GIF is added into the page. For the English version, this GIF is a person climbing a mountain

and for the Nepalese version, it is a person climbing a building. The children can select one option and submit it to check their answer. **(Figure 79 & *Figure 80*)**

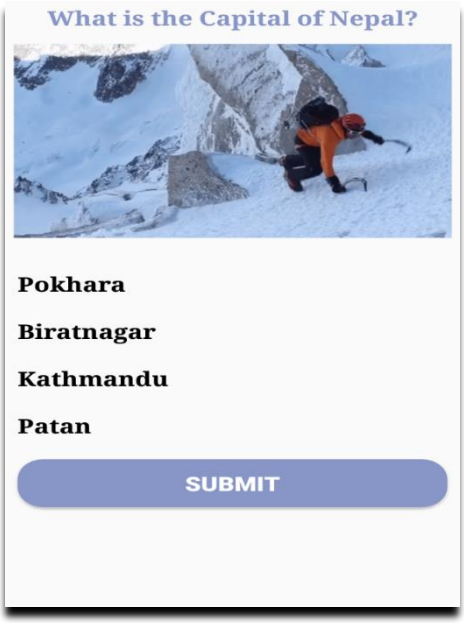


Figure 79. DigiPal Quiz English Question Page

Figure 80. DigiPal Quiz Nepalese Question Page

Correct Answer Page

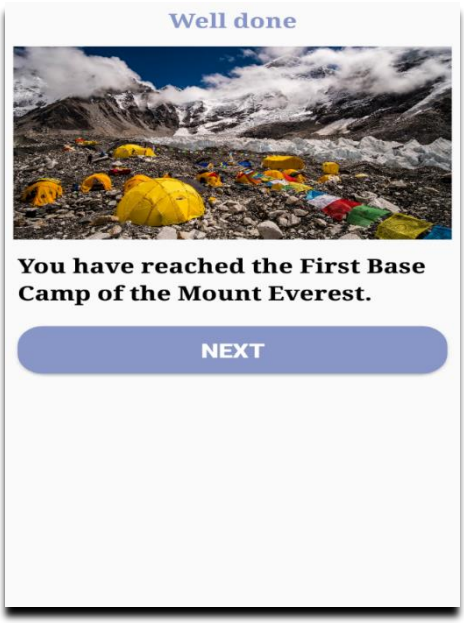


Figure 81. DigiPal Quiz English correct Answer page

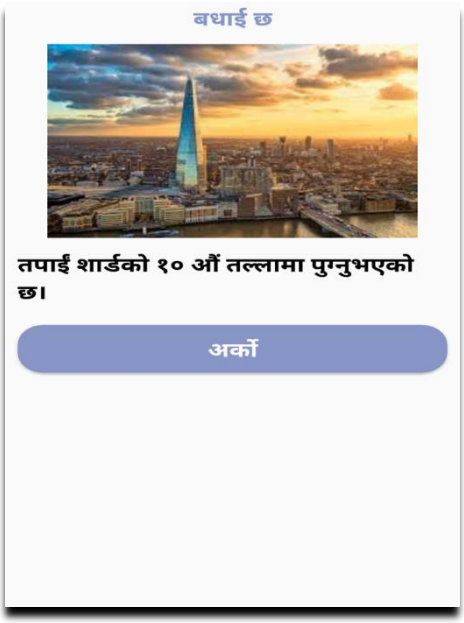


Figure 82. DigiPal Quiz Nepalese correct Answer page

If the correct option is selected, the well-done page appears which has an image and some information and a button. This page changes according to how far the user is in the quiz. Pressing the button goes to the next question **(Figure 81& Figure 82).**

Wrong Answer Page

If the wrong option is selected, the wrong answer page opens which again has a GIF, some information and a button. For the English version, the GIF is a person falling off a mountain and for the Nepalese version it is a person falling off a tall building indicating that they have failed the quiz. The button takes the user back to the home page of the quiz to try again. **(Figure 83 & Figure 84).**

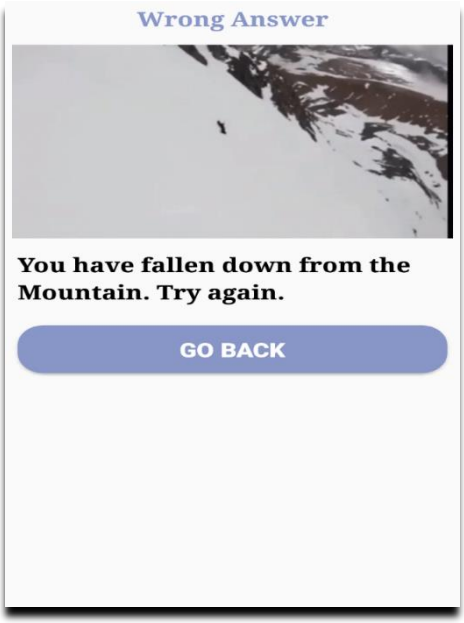


Figure 83. DigiPal Quiz English Wrong Answer page

Figure 84. DigiPal Quiz English Wrong Answer page

Completed the Quiz page

If all the questions are answered correctly, the final page opens where the user is congratulated with a GIF of a person dancing on top of Mount Everest or a person taking a selfie on top of a tall building for the English and Nepalese versions respectively. The button will take the user back to their user home page**. (Figure 85 & Figure 86).**

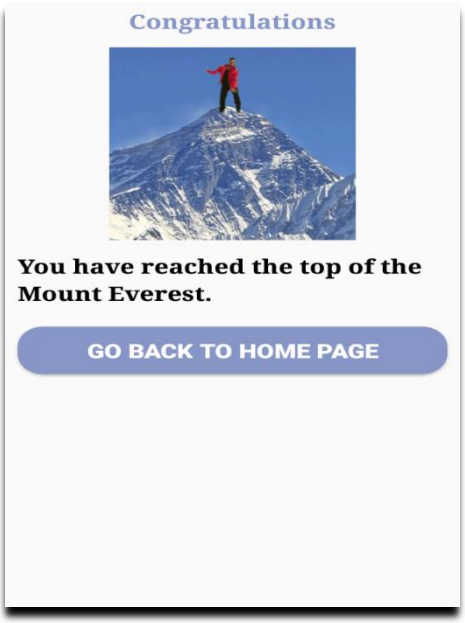


Figure 85. DigiPal Quiz English completed page

Figure 86. DigiPal Quiz Nepalese completed page

6.6 Design for Cultural Evenness – A model

In bringing together some of the insights from this work, a simple five-layer model is presented here that captures the essential aspects needed to develop a culturally level product.

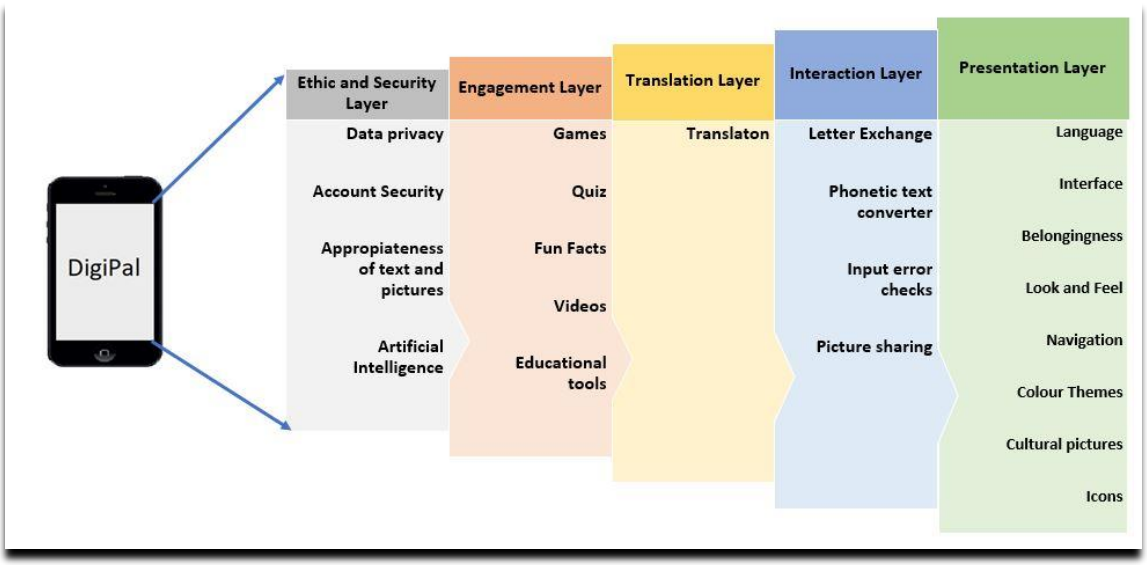


Figure 87. 5 Layered design model for DigiPal like application

6.6.1 Layer 1 – Presentation Layer

The most pressing need for a cross cultural interface is for it to be understood by both parties at the initial user interface layer. Classically this is where the written and spoken language of the users is the barrier or the entry point to any meaning that is imbued in the interface. Early HCI work pressed for the use of a built-in translation of text on user interfaces (often denoted with a flag of the different countries) and / or images to make access to the interface intuitive (Ho et al., 2009). This is described here as the **presentation layer,** and it is what is SEEN by the child before they do any interaction. It is what might be shown on the app store as screens and images, and it is what might be described in a review.

In DigiPal, this layer could include pictures of hills, mountains, and temples to give a touch of Nepal or tall buildings for England. It could be seen in the colour theme of the app that might match with the colours in their flag. For example, the Nepalese app to have blue and red. It could include national flowers, birds, and other identifiable things. Adding these things to an app seems to be the simplest thing to do. At the same time however, the app must deliver for the cultural space, which is childhood, fun bright icons, and other child design features would also be in this layer.

Another very important component, that is already explained earlier is the language. Language can be taken as a vital element of a culture. The texts present in the interface should be in the first language of the user. This is to maintain that language equality as well. Not only the text in the app but also the alerts they get for success or failure will be shown in their own language. Note that in the critique of cultural design by (Hoft, 1995), this presentation layer is often the only area where design changes are made.

6.6.2 Layer 2 – Interaction Layer

As soon as a child interacts with an app, whether using touch or by typing, then they are at the interaction layer. This interaction must match the cultural situation of the child. Much has been written in the literature about input and output within computer systems. If a child cannot make sense of the input system, and if their output does not mean anything to them then they will be unable to use the app. In a culturally even product, each child, no matter where they are, should see their own input and output in a way that suits their situation. In DigiPal, one issue with the use of first language was that Nepalese children can’t or don’t type in Nepalese rather they type

phonetically. That meant the app had to have the functionality of converting phonetically typed words to Nepalese. This functionality had to be visible to the users so that they can check and fix any errors before they sent them. In addition, at the input level, children tended to make grammar and spelling mistakes that had an adverse effect on the translation so checking functionality would be an essential part of an input level – again in its own language.

As seen in the drawings by the children, it was clear that some of the information was easy to convey visually. Photo / picture sharing or sending functionality should be included within the app. If we go back to the traditional pen pal activity, the partners also used to include printed pictures along with their letters.

This layer needs to therefore ensure input and output are appropriately supported but also that where needed there is an opportunity for 'explainers' in the form of pictures or stories. Any 'smoothing' of text could be instigated in this layer to assist in the next layer

6.6.3 Layer 3 – Translation Layer

The premise behind cultural evenness is that an app is designed that allows two users to communicate with one another whilst not biasing one culture over another and whilst not requiring one user to adapt to the other. There needs to be a bridge between the cultures that provides this invisible interaction. In the DigiPal app this is the translation of text from one language to another. In another app it might be the translation or annotation of drawings, or the translation of adaptation of emojis or meanings. As shown in this thesis – this layer is where there will likely be breakdowns, and this might result in a poor experience and so from the point of view of cultural evenness it is most important to start here and ask – can the interaction be done to a good enough standard to allow for cultural evenness. Only if this can be done should the product be considered. There is no point building a product with the right presentation and input if translation breaks the interaction.

6.6.4 Layer 4 – Engagement Layer

This layer is about improving the children's engagement while using the app. In the scenario of two children talking at the same time, and time delay comes into action, some sort of tool should be implemented within the app so that they can read the letter as soon as it arrives. A mini game is one of the ideas put forward as such a tool. Game ideas provided by the children

can be implemented that could include some cultural insights. For example, new games for English children that Nepalese children normally play. Besides having just, the games, this engagement layer could also include videos about different countries or even some educational facts.

6.6.5 Layer 5 – Ethic and Security Layer

With children, it has been mentioned throughout this thesis that there has to be some protections in place to ensure that what is shared is appropriate and safe. Whilst this has not been currently designed into DigiPal, security has been an important issue during the monitored use of the apps. Children were able to understand that they were chatting with other children, there was a human intervention in the live chat that checked that inappropriate text was not sent and this points to the need for a policy to protect children across different places and times and the need to consider this carefully. If one country has a looser view on security than another – that cannot be an excuse to not implement an even security system. If picture sharing is enabled, these should also be checked to make sure they are safe and proper for sharing.

Not only the text that the children input, but also the translated text, must be checked for potential inappropriate meaning. As seen in the **Section 5.5.6**, translation software will make some mistakes and the meaning might completely change for the output text. Thus, at the ethic layer, translated text must be checked before it arrives on the other side. Some sort of artificial intelligence should be implemented to check that shared texts, images and translated text are appropriate.

Chapter 7. Looking Back and Planning Further

7.1 Summary of Research

Children from developed and developing countries have different access to technology, facilities, and infrastructures. This doesn't mean that the former is having a better lifestyle than the later; they are just having different childhoods. Cultural diversity should be valued according to (Feenberg, 2012) and a great way to do this is by ensuring that children can enjoy their own cultures whilst also learning about others. In this thesis children have contributed with ideas of things that are parts of their cultures (Fiske, 2002) but have also provoked the author into looking beneath that iceberg of culture (Hoft, 1995). Using digital pen pal exchanges to share things is a valuable way for children to learn and the DigiPal app that has been developed in this thesis has been shown to be effective in allowing children from two cultures to communicate (Barksdale et al., 2007).

Translation between two languages, Nepalese and English, has been explored in this research to determine to what extent it can be effective in providing a bridge between the children from the two countries. Difficulties similar to those seen in other studies (e.g., Ali et al., 2021) were found and accuracy was relatively poor when children's text was translated without any correction of the input text but with grammar and spell checking, it was shown that accuracy would rise and also that the understandability, for which a new metric was described, increased. And in the wild study of the use of Google Translate with children's chat showed that even though there were difficulties for Google in dealing with cultural words – both from children's culture and from the different countries – children could enjoy dialogue.

Alongside the study of the mechanics of translation, the thesis has also reported on a unique aspect of this work which was to engage equally with children from the two different countries in design and evaluation activities. This engagement included studies where children contributed text, both to explore feasibility and to test out the translation, studies where children evaluated the designed app and gave ideas for improvement, and studies where children suggested design ideas for games for the app and for some look and feel aspects. Throughout the work it was noted that carrying out these dual studies allowed similarities and differences to be distilled.

The work resulted in a functional app being developed as well as a reusable model that broke the cultural aspects of the design into five layers. This model is described in the context of cultural evenness and it is presented here as an example for others to build from. The work on translation has highlighted areas where Google has struggled with Nepalese text and with children's input errors and these findings will be of use to the MT communities.

7.2 Answers to Research Questions

RQ: To what extent, and how best, can a chat application be designed to encourage children from different cultures to talk with one another in their own languages?

The research question was further divided into the following sub research questions:

SRQ1. To what extent, and with what limitations and consequences, does automatic translation work with children's chat?

As seen in **Chapter 4 and Chapter 5** , it was observed that the children were sometimes struggling to understand the letters they received but still they didn't stop replying to them. The process of clarifying what was written actually seemed to keep the conversation going.

Input errors had some impact on the translation which, if minimized, possibly by using some human intervention as seen in (Komeili et al., 2011), this can improve the translation accuracy, as explained in **Section 4.6**. The comparison of accuracy and understandability before and after input error checks proved that point.

In summary it has been shown that Google Translate can work – there is a risk that language may be poorly translated, and the accuracy of translation clearly depends on the accuracy of text input.

Chapter 5 highlighted some specific areas where Google Translate struggled – these included with numbers, real names, local food items and months. With time, Google Translate should get better at many of these aspects as it learns through wider use.

SRQ2. To what extent can children, from two different cultures, equally participate in the design of a single application?

From the very beginning, children from both countries used the same app as it was designed for them in mind. From the beginning they were both able to apply CCI tools and methods to give feedback on the app and they were both able to input text and use the chat facilities. Both

groups of children participated in drawings and game design – both being asked to do the same activity and with the outputs from both groups being used to inform design ideas. In summary, across the thesis children participated on level terms in the evaluation, testing, and design of the app.

SRQ3. In what ways can a design ensure cultural evenness whilst also being engaging for children?

In **Chapter 6**, a model is proposed based on the work of this thesis that explains how to build for cultural evenness. A design is proposed that meets the requirements that are outlined in that model and an app was developed, as proof of concept, that includes presentation, interaction, translation, and engagement layers and has been shown to be easy to use for children across the two countries. In developing this app, there were trade-offs that had to be made in terms of input technology – where a phonetic keyboard was used for the Nepalese children - and in terms of text cleaning, which was not done at the point of text entry as it would be disruptive to children's flow; but this could be built into the deeper mechanisms of the app in the future. In real time use of the app across the two continents, children were seen to be heavily engaged. The use of immediate Google Translate certainly helped with engagement.

7.3 Originality

This thesis describes the first study of the use of Google Translate with children in a synchronous chat interface. The examination of the errors made when children chat in this way is an original contribution and this will help inform future designs for translation-supported apps for children. Errors in this context are divided into those caused by children's input being non-standard and those caused more probably by faults in the translation process. Neither of these have been previously studied.

An original contribution is also made in terms of a way to explore and rate understandability based on children's ability to recount details. This process, described in **Section 4.5.4** is child centred and assumes that retell is a good way to think about whether something has meaning or not. In the live chat described in **Chapter 5**, it was also clear that children were willing to take a guess or ask for clarification to increase their understanding.

The focus throughout the research, on designing for cultural evenness is original as a perspective but also as a product from the work where a model is distilled from the studies and

from the process of reflecting on what culture means in this context. Taking this perspective has also allowed a unique study of paired engagement over a lengthy project by children in different countries as testers, evaluators and design informants - this is also original.

7.4 Contributions of the Research

The main technological contribution of this thesis is in the design and build of software that translates across languages in a way suited to children. This application allows children the opportunity to type in their own language and read in their own language. This democracy and neutralism in interaction is a unique contribution of the design. In this specific instance this level design allows Nepalese children to chat with English children without feeling that English is a superior language.

The main research contribution is the findings around translation of children's chat which point to two key areas that need to be addressed. The first is the entry point where children will make mistakes and slips and will construct their chat in ways that make it hard for the translation software to progress; the second is at the point of translation where there needs to be a more culture centric approach to ensure that local words and local naming conventions can be preserved and included in translations.

Through this work, a new metric to calculate understandability of translation is proposed which looks at the number of phrases or sentences as meaningful items, in a piece of text. Influenced from comprehension and retelling, this metric seems to be very appropriate to compute the performance of a translation activity. Though understandability remains something that will vary child by child, applying a multi child retell approach as shown in **Chapter 4** is a method that others can use.

A smaller, but important, contribution is in terms of insights towards the development of sustainable interaction, despite the time difference, between two countries. Designs and game ideas from the children could be incorporated in an app to help in this. In exploring this possibility, the thesis also points to some important ideas around design in different cultures noting the need for annotations on drawings and for cultural understanding being applied to the analysis of such artefacts.

The design model proposed on **Section 6.6** is the final contribution of the thesis. This gives guidelines to researchers or developers interested in similar fields. Cultural, technological,

ethical, and security related aspects are all discussed and represented in a 5 layered model that contributes towards cultural evenness and bringing cultures together.

7.5 Reflection on Children's Experience of Participation

During the research, children were involved in various stages of the App development, feedback, and re-design. Children introduced one another with letters/drawings, chatted with friends, provided ideas for app improvement, designed and drew games for mobile apps, understood and retold translated texts, and participated in a letter exchange with children from another country. Except for the studies of drawings and improvement ideas, all the other studies involved use of a version of the DigiPal App; the children's experience and reaction to the app and the studies could easily be seen; throughout all the studies children were excited to be taking part.

Almost all of the children already had prior knowledge of chatting/messaging activities through the use of Facebook messenger, WhatsApp or Snapchat. This helped during the studies as there wasn't a need to explain how message exchange worked or what was expected from them. Very few children struggled typing, some were faster than others and, of course, phonetic typing for Nepalese children took longer than English typing. There were cases when children asked for spelling of words maybe because they don't want to make any mistakes. It was clear in all the studies that children wanted to contribute and wanted to do their best.

Choosing to work hands on with children was time consuming and sometimes difficult to organise but it was worth it. To access children in Nepal there were long journeys that had to be made but the children's enthusiasm to participate was worth the effort. There were practical challenges, even around getting ethics for the study, as the school boards in Nepal were unfamiliar with many of the standard practices from the UK.

The choice to engage with children as designers, participants, and as almost as co-researchers (when doing the understandability studies) has added a richness to this work that would have been missing if that had not been the action taken.

7.6 Limitations and Future Directions

7.6.1 Children's Contributions Towards Design

Whilst ideas were sought from children for the aesthetics of the app and for possible games to include, it was not possible to include much of this in the final app due to constraints of time and limitations with graphics skills. Much of what children drew about their locations was object based and would, if it had all been added into the app, have appeared to be just sprinkling a picture layer onto the app which is the very thing that (Hoft, 1995) railed against. Showing that children in both countries could contribute was valuable but it would have been better to have been able to incorporate more of their contributions in a more meaningful way.

7.6.2 Choice of Accuracy and Understandability

In the empirical studies, accuracy of Google Translate was calculated using minimum string distance by comparing two strings and counting at a character level. There were other options that could have been taken and these may have shown slightly different results overall. If there had been more time, an exploration could have been made to determine which was the most appropriate accuracy measure to use. The decision to use character-based string matching was made as it is a long-used method but also as it was able to be automated easily. Understandability, on the other hand, was measured in a semi-novel way by asking children to recount what they had read and by counting 'items' within texts. Though understandability is affected by the correctness of characters, one could argue that both accuracy and understandability should be calculated on the same basis. So, calculation of accuracy on the basis of correctly translated words or phrases could be something interesting to explore further.

7.6.3 Inclusion of Broader Population

When the research started, it was planned to look at least 3 developed and 3 developing countries and a variety of languages. Due to time constraints, only two sets of populations/languages were tested in this research. Testing with other populations would potentially allow for translation across two Latin languages (both using QWERTY input) and even between two languages that used phonetic input. It would be hypothesised that in both these cases additional insights would be gained on accuracy and understandability although possibly little new would have been gained in terms of the overall layers for cultural evenness.

Google translate would probably have performed better when translating Latin to Latin than it did in this study – not because the children would be any different but simply because Latin languages are better supported by Google.

7.6.4 Children's Perception of Other Children's Lives

An overarching aim of the research was to create a solution that would allow children to learn about each other's lifestyle and culture with the aim to break down barriers and better support peaceful co-existence on the planet. The children who participated certainly learned little things about one another through the chatting, but this was too brief and too constrained to be evaluated. With more time, Byram's model could have been applied in a formal way (Byram, 2021) – as it was, we can say that children were curious and open (both traits from the said model) and we can say that engagement in the app helped children discover things about one another. To show a significant effect, the app would have had to be used over time and this was outside the scope of the work. All the children benefitted from engaging with the researcher and his supervisor so all gained glimpses into other lives.

7.6.5 Engagement and Ethic / Security

Game ideas were collected and implemented within the app, but it was not possible, in the time frame, nor with the resources, to test how engagement was improved with this. There could have been an evaluation with children in the UK, but Covid prevented travel to Nepal and a core philosophy of the research was to do studies with children only in parallel in the two countries, so this was not done.

In terms of Ethics and security, it was beyond the scope of the PhD to implement additional AI to clean text and examine text as suggested in the ethic / security layer of the model. The manual cleaning of data in **Chapter 4** showed the possible impact of text cleaning. If there had been another opportunity to gather real time chat data – and over a lengthier period - it might have also been possible to see to what extent AI might be needed to check for unsuitable text and unsuitable translations but this was not seen in the text that was used in cross country chat although it was seen in English to English chat as described in **Chapter 3**.

7.7 Closing Remarks

It has been a great privilege to be able to work with children in the two countries in the development of the app and in the study of the research. At the start of the PhD, I was fairly naïve about working with children and I had to learn on the way how to organise complex studies and how to make materials work in quite different locations. Working with children and technology was not easy especially when I had to find my way into the heart of rural Nepal – I walked for almost 4 hours even after the bus ride from Kathmandu.

My passion was to protect the childhood experiences of children in those rural areas of Nepal where I saw they had great happiness in playing with simple things, but where I also saw the mobile phone had become increasingly a part of their landscape. I wanted to make a small contribution towards protecting their own culture of childhood.

Letting children chat with other children without there being a language barrier is a lovely idea and the solution given by machine translation like Google translate seems to be almost good enough for the task. This is an important first step towards letting children chat without barriers but also, importantly, without thinking that their own language is in some way inferior to another's.

The model I have proposed based on the thesis work has given me ideas for my own future research work. Implementing child friendly spelling and grammar checking, adding in automated prompts to 'explain' hard to translate words and building in engagement tools for interaction across such complicated time zones are all areas of interest to me.

The DigiPal app is currently being used by a colleague in a newer research project, and I am looking for funding to further develop it for longitudinal use.

Bibliography

A. Paragas, I.J., G. Vasquez, A.J., M. Sobremonte, M., N. Young, M., 2021. Improving the Current Educational Application of Early Children Teachings through Games, Interactions and Cultural Lessons. In: The 2021 7th International Conference on Industrial and Business Engineering. pp. 386–392.

Abdel Azim ElShiekh, A., 2012. Google Translate Service: Transfer of Meaning, Distortion or Simply a New Creation? An Investigation into the Translation Process & Problems at Google. English Lang. Lit. Stud.

Africano, D., Berg, S., Lindbergh, K., Lundholm, P., Nilbrink, F., Persson, A., 2004. Designing tangible interfaces for children's collaboration. In: CHI'04 Extended Abstracts on Human Factors in Computing Systems. pp. 853–868.

Ali, Z., Saleh, M., Al-Maadeed, S., Abou Elsaud, S., Khalifa, B., AlJa'am, J.M., Massaro, D., 2021. Understand My World: An Interactive App for Children Learning Arabic Vocabulary. In: 2021 IEEE Global Engineering Education Conference (EDUCON). IEEE, pp. 1143–1148.

Alper, M., Hourcade, J.P., Gilutz, S., 2012. Interactive Technologies for Children with Special Needs. In: Proceedings of the 11th International Conference on Interaction Design and Children, IDC '12. Association for Computing Machinery, New York, NY, USA, pp. 363–366.

Alshamsi, H., Almutairi, A.G., Mashrafi, S. Al, Kalbani, T. Al, 2020. Implications of Language Barriers for Healthcare: A Systematic Review. Oman Med. J. 35, 122.

Amery, R., 2001. Language Planning and Language Revival. Curr. Issues Lang. Plan. 2, 141–221.

Anggaira, A.S., 2017. Linguistic Errors on Narrative Text Translation Using Google Translate. Pedagog. J. English Lang. Teach. 5, 1.

Anokwa, Y., Smyth, T.N., Ramachandran, D., Sherwani, J., Schwartzman, Y., Luk, R., Ho, M., Moraveji, N., DeRenzi, B., 2009. Stories from the Field : Reflections on HCI4D Experiences. Inf. Technol. Int. Dev. 5, 101–115.

Aronoff, M., 1994. Spelling as Culture. In: Watt, W.C. (Ed.), Writing Systems and Cognition: Perspectives from Psychology, Physiology, Linguistics, and Semiotics. Springer Netherlands, Dordrecht, pp. 67–86.

Bahdanau, D., Cho, K.H., Bengio, Y., 2015. Neural machine translation by jointly learning to

align and translate. In: 3rd International Conference on Learning Representations, ICLR 2015 - Conference Track Proceedings.

Barber, W., Badre, A., 1998. Culturability: The merging of culture and usability. In: Proceedings of the 4th Conference on Human Factors and the Web. pp. 1–10.

Barendregt, W., Bekker, T., Börjesson, P., Eriksson, E., Torgersson, O., 2016. The Role Definition Matrix: Creating a Shared Understanding of Children's Participation in the Design Process.

Barksdale, M.A., Watson, C., Park, E.S., 2007. Pen Pal Letter Exchanges: Taking First Steps Toward Developing Cultural Understandings. Read. Teach. 61, 58–68.

Batcheller, A.L., Hilligoss, B., Nam, K., Rader, E., Rey-Babarro, M., Zhou, X., 2007. Testing the technology: Playing games with video conferencing. Conf. Hum. Factors Comput. Syst. - Proc. 849–852.

Bekker, T., Barendregt, W., Skovbjerg, H.M., Landoni, M., Nicol, E., Rubegni, E., 2018. Editorial special issue on assumptions about the concept of childhood and the roles of children in design. Int. J. Child-Computer Interact. 19.

Benton, L., Johnson, H., 2015. Widening participation in technology design: A review of the involvement of children with special educational needs and disabilities. Int. J. Child-Computer Interact. 3–4, 23–40.

Bereiter, C., Scardamalia, M., 1983. Does learning to write have to be so difficult. Learn. to write First Lang. Second Lang. 20–33.

Bi, X., Smith, B.A., Zhai, S., 2012. Multilingual touchscreen keyboard design and optimization. Human-Computer Interact. 27, 352–382.

BITAR, H., ALFAHID, A., ALRIGE, M., ABOGAZAH, W., ALSANBI, N., 2022. Ana Alsukary: an android mobile application to support diabetic children and parents in Saudi Arabia. Rom. J. Inf. Technol. Autom. Control 32, 73–86.

Bogdan, B., Bilken, S.K., 1992. Quality research for education: An introduction to theory and methods 106–156.

Bok, D., 2010. The Politics of Happiness: What Government Can Learn from the New Research on Well-Being. Princeton University Press.

Bonanni, L., Vaucelle, C., Lieberman, J., Zuckerman, O., 2006. PlayPals: Tangible interfaces for remote communication and play. Conf. Hum. Factors Comput. Syst. - Proc. 574–579.

Bourges-Waldegg, P., Scrivener, S.A.R., 1998. Meaning, the central issue in cross-cultural HCI design. Interact. Comput. 9, 287–309.

Bradac, J.J., 1992. Thoughts About Floors Not Eaten, Lungs Ripped, and Breathless Dogs: Issues in Language and Dominance. Ann. Int. Commun. Assoc. 15, 457–468.

Buckingham, D., 2009. “Creative” visual methods in media research: Possibilities, problems and proposals. Media, Cult. Soc. 31, 633–652.

Bushnell, C., Kemp, N., Martin, F.H., 2011. Text-messaging practices and links to general spelling skill: A study of australian children. Aust. J. Educ. Dev. Psychol. 11, 27–38.

Byram, M., 2021. Teaching and assessing intercultural communicative competence. Multilingual Matters, p. 131

Cahill, C., 2004. Defying gravity? raising consciousness through collective research. Child. Geogr. 2, 273–286.

Caspary, G., O’Connor, D., 2003. Providing Low-cost Information Technology Access to Rural Communities in Developing Countries.

Castilho, S., Doherty, S., Gaspari, F., Moorkens, J., 2018. Approaches to Human and Machine Translation Quality Assessment BT - Translation Quality Assessment: From Principles to Practice. In: Moorkens, J., Castilho, S., Gaspari, F., Doherty, S. (Eds.), . Springer International Publishing, Cham, pp. 9–38.

Chatain, J., Bitter, O., Fayolle, V., Sumner, R.W., Magnenat, S., 2019. A creative game design and programming app. Proc. - MIG 2019 ACM Conf. Motion, Interact. Games.

Chaudron, S., 2015. Choudron (2015) - Young Children. 0-8. and Digital Technology. a Qual Exploratory Study Across Seven Countries. Publications Office of European Union, Luxemburg.

Cho, K., van Merrienboer, B., Bahdanau, D., Bengio, Y., 2015. On the Properties of Neural Machine Translation: Encoder–Decoder Approaches 103–111.

Cooper, W.E., 2012. Cognitive aspects of skilled typewriting. Springer Science & Business Media.

Coretti, L., Pica, D., 2019. Facebook’s communication protocols, algorithmic filters, and protest. In: Social Media Materialities and Protest.

Cox, S., 2005. Intention and meaning in young children’s drawing. Int. J. Art Des. Educ. 24, 115–125.

Crawford, E.O., Kirby, M.M., 2008. Fostering students’ global awareness: Technology applications in social studies teaching and learning. J. Curric. Instr. 2, 56–73.

Dagenais, D., Toohey, K., Fox, A.B., Singh, A., 2017. Multilingual and multimodal composition at school: ScribJab in action. Lang. Educ. 31, 263–282.

Daiute, C., 2010. Play as Thought: Thinking Strategies of Young Writers. Harv. Educ. Rev.

59, 1–24.

Daniels, P.T., Bright, W., 1996. The world's writing systems. Oxford University Press, New York.

Doruk, C., Enver, N., Çaytemel, B., Azezli, E., Başaran, B., 2020. Readibility, Understandability, and Quality of Online Education Materials for Vocal Fold Nodules. J. Voice 34, 302.e15-302.e20.

Douglas, S.P., Craig, C.S., 2007. Collaborative and iterative translation: An alternative approach to back translation. J. Int. Mark.

Druin, A., 1999. Cooperative Inquiry: Developing New Technologies for Children with Children. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI '99. Association for Computing Machinery, New York, NY, USA, pp. 592–599.

Druin, A., Bederson, B., Boltman, A., Miura, A., Knotts-Callahan, D., Platt, M., 1998. Children as Our Technology Design Partners. In: The Design of Children's Technology. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA, pp. 51–72.

Druin, A., Foss, E., Hatley, L., Golub, E., Guha, M.L., Fails, J., Hutchinson, H., 2009. How children search the internet with keyword interfaces. Proc. IDC 2009 - 8th Int. Conf. Interact. Des. Child. 89–96.

Durost, D.D., Hutchinson, S.L., 1997. Keypals--e-mail leads to new friends. Dimens. Early Child. 25, 17–22.

Dyson, A.H., 1991. Viewpoints: ThewWord and the world: Reconceptualizing written language development or do rainbows mean a lot to little girls? Res. Teach. English 25, 97–123.

Einarsdottir, J., Dockett, S., Perry, B., 2009. Making meaning: Children's perspectives expressed through drawings. Early Child Dev. Care 179, 217–232.

Evans, L., 2004. Language, translation and the problem of international accounting communication. Accounting, Audit. Account. J.

Farley, S., 1994. From Russians with Love. Exec. Educ. 16, 40–41.

Farokhi, M., Hashemi, M., 2011. The analysis of children's drawings: Social, emotional, physical, and psychological aspects. Procedia - Soc. Behav. Sci. 30, 2219–2224.

Farrugia, D., 2014. Towards a spatialised youth sociology: The rural and the urban in times of change. J. Youth Stud. 17, 293–307.

Feenberg, A., 2012. Questioning technology. Routledge.

Ferreira, S.M., Gouin-Vallerand, C., Hotte, R., 2016. Game Based Learning: A Case Study

on Designing an Educational Game for Children in Developing Countries. In: 2016 8th International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES). pp. 1–8.

Fisher, K.E., Yefimova, K., Yafi, E., 2016. Future's Butterflies: Co-Designing ICT Wayfaring Technology with Refugee Syrian Youth. In: Proceedings of the The 15th International Conference on Interaction Design and Children, IDC '16. Association for Computing Machinery, New York, NY, USA, pp. 25–36.

Fiske, A.P., 2002. Using individualism and collectivism to compare cultures--A critique of the validity and measurement of the constructs: Comment on Oyserman et al. (2002). Psychol. Bull.

Fitria, T.N., 2021. A Review of Machine Translation Tools: The Translation's Ability. Lang. Circ. J. Lang. Lit. 16, 162–176.

Flowers, S.D., 2015. Developing intercultural communication in an ELF program through digital pen pal exchange. Cent. ELF J. 1, 25–39.

Fuentes-Luque, A., 2017. An approach to analysing the quality of menu translations in southern Spain restaurants. J. Multiling. Multicult. Dev.

Gallacher, L.A., Gallagher, M., 2008. Methodological immaturity in childhood research?: Thinking through "participatory methods." Childhood 15, 499–516.

Garzotto, F., Gelsomini, M., Clasadonte, F., Montesano, D., Occhiuto, D., 2016. Wearable immersive storytelling for disabled children. Proc. Work. Adv. Vis. Interfaces AVI 07-10-June, 196–203.

Gellner, D.N., 2001. From group rights to individual rights and back: Nepalese struggles over culture and equality. In: Cowan, J.K., Dembour, M.-B., Wilson, R.A. (Eds.), Culture and Rights: Anthropological Perspectives. Cambridge University Press, Cambridge, pp. 177–200.

Gennari, R., Melonio, A., Rizvi, M., 2017. The participatory design process of tangibles for children's socio-emotional learning. Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics) 10303 LNCS, 167–182.

Grotjahn, R., 2002. Konstruktion und Einsatz von C-Tests: Ein Leitfaden für die Praxis 4, 211–225.

Groves, M., Mundt, K., 2015. Friend or foe? Google translate in language for academic purposes. English Specif. Purp. 37, 112–121.

Hall, P.A.V., Dowling, G.R., 1980. Approximate String Matching. ACM Comput. Surv.

Han, L., 2016. Machine Translation Evaluation Resources and Methods: A Survey 2018.

Hassani, H., 2017. Kurdish Interdialect Machine Translation 63–72.

Ho, M.R., Smyth, T.N., Kam, M., Dearden, A., 2009. Human-Computer Interaction for Development: The Past, Present, and Future. Human-Computer Interact. Dev. Past, Present. Futur. 5, 1–18.

Hofstede, G., 2011. Dimensionalizing cultures: The Hofstede model in context. Online readings Psychol. Cult. 2, 919–2307.

Hoft, N.L., 1995. International technical communication: How to export information about high technology. John Wiley & Sons, Inc.

Holloway, S., Valentine, G., 2000. Children's geographies and the new social studies of childhood. Child. Geogr. Play. living, Learn. 1–26.

Honkanen, K., Poikolainen, J., Karlsson, L., 2018. Children and young people as co-researchers–researching subjective well-being in residential area with visual and verbal methods. Child. Geogr. 16, 184–195.

Hussain, S., 2010. Empowering marginalised children in developing countries through participatory design processes. CoDesign 6, 99–117.

Hutchins, J., 2005. The history of machine translation in a nutshell. Retrieved December 5.

Hutchinson, H.B., Rose, A., Bederson, B.B., Weeks, A.C., Druin, A., 2005. The international children's digital library: a case study in designing for a multilingual, multicultural, multigenerational audience. Inf. Technol. Libr. 24, 4–12.

Jabak, (Omar, 2019. Assessment of Arabic-English translation produced by Google Translate. Int. J. Linguist. Lit. Transl.

Jagne, J., Smith-Atakan, A.S.G., 2006. Cross-Cultural Interface Design Strategy. Univers. Access Inf. Soc. 5, 299–305.

Jang, A., MacLean, D.L., Heer, J., 2014. BodyDiagrams: Improving Communication of Pain Symptoms through Drawing. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI '14. Association for Computing Machinery, New York, NY, USA, pp. 1153–1162.

Jiménez-Crespo, M., 2013. Translation and web localization, Translation and Web Localization.

John, B., Susie, W., 2003. "Is it fun?" developing children centred research methods. Int. J. Sociol. Soc. Policy 23, 33–58.

Jones, M., Smith, M., 2014. Traditional and alternative methods of measuring the understandability of accounting narratives. Accounting, Audit. Account. J. 27, 183–208.

Joshi, M., Joshi, A.N., Emmadi, N., Malsattar, N., 2014. Swarachakra keyboard for Indic

scripts (tutorial). 1st Int. Conf. Mob. Softw. Eng. Syst. MOBILESoft 2014 - Proc. 5–6.

Kalchbrenner, N., Blunsom, P., 2013. Recurrent continuous translation models. In: EMNLP 2013 - 2013 Conference on Empirical Methods in Natural Language Processing, Proceedings of the Conference.

Kano, A., Horton, M., Read, J.C., 2010. Thumbs-up Scale and Frequency of Use Scale for Use in Self Reporting of Children's Computer Experience. In: Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries, NordiCHI '10. Association for Computing Machinery, New York, NY, USA, pp. 699–702.

Kano, A., Read, J.C., 2009a. Text input error categorisation: Solving character level insertion ambiguities using Zero Time analysis. People Comput. XXIII Celebr. People Technol. - Proc. HCI 2009 293–302.

Kano, A., Read, J.C., 2009b. Causes of simultaneous keystrokes in children and adults. In: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics).

Kapoor, R., Truong, A.T., Vu, C.N., Truong, D.T., 2020. Successful Verbal Communication Using Google Translate to Facilitate Awake Intubation of a Patient With a Language Barrier: A Case Report. A&A Pract.

Kelly, S.R., Mazzone, E., Horton, M., Read, J.C., 2006. Bluebells: A Design Method for Child-Centred Product Development. In: Proceedings of the 4th Nordic Conference on Human-Computer Interaction: Changing Roles, NordiCHI '06. Association for Computing Machinery, New York, NY, USA, pp. 361–368.

Kincaid, J.P.J., Jr, R.F., Rogers, R.L., Chissom, B.S.B., Fishburne Jr, R.P., Rogers, R.L., Chissom, B.S.B., 1975. Derivation of new readability formulas (automated readability index, fog count and flesch reading ease formula) for navy enlisted personnel (No. RBR-8-75). Naval Technical Training Command Millington TN Research Branch. Nav. Tech. Train. Command Millingt. TN Res. Branch.

Kintsch, W., 1994. Text comprehension, memory, and learning. Am. Psychol. 49, 294.

Klingner, J.K., 2004. Assessing Reading Comprehension. Assess. Eff. Interv. 29, 59–70.

Koehn, P., Och, F.J., Marcu, D., 2003. Statistical Phrase-Based Translation 48–54.

Kohl, K., Ouyang, W., 2020. Introducing Creative Multilingualism. In: Creative Multilingualism.

Komeili, Z., Hendavalan, J.A.F., Rahimi, A., 2011. An investigation of the translation problems incurred by englishto-persian machine translations: "Padideh, pars, and google softwares." Procedia - Soc. Behav. Sci. 28, 1079–1082.

Kullman, K., 2012. Experiments with moving children and digital cameras. Child. Geogr. 10, 1–16.

Lamichhane, D.R., Read, J.C., 2017. Investigating children's passwords using a game-based survey. IDC 2017 - Proc. 2017 ACM Conf. Interact. Des. Child. 617–622.

Lamichhane, D.R., Read, J.C., Fitton, D., 2018. Beneath the Himalayas — Exploring Design for Cultural Evenness with Nepalese Children 1–5.

Law, E.L.C., Nguyen-Ngoc, A.V., 2008. Case studies of fully online intercultural collaborative learning. IADIS Int. Conf. Cogn. Explor. Learn. Digit. Age, CELDA 2008 168–175.

Lee, N., 2001. Childhood and society: Growing up in an age of uncertainty. McGraw-Hill Education (UK).

Levenshtein, V., 1966. Binary codes capable of correcting deletions, insertions, and reversals. Sov. Phys. Dokl.

Lewis, T., 2000. Technology Education and Developing Countries. Int. J. Technol. Des. Educ. 10, 163–179.

Liaw, M.L., Johnson, R.J., 2001. E-mail writing as a cross-cultural learning experience. System 29, 235–251.

LISAQA, M., 2007. The Globalization Industry Primer: An Introduction to Preparing your Business and Products for Success in International Markets. Geneva Localization Ind. Stand. Assoc.

MacDonald, C.M., Atwood, M.E., 2013. Changing Perspectives on Evaluation in HCI: Past, Present, and Future. In: CHI '13 Extended Abstracts on Human Factors in Computing Systems, CHI EA '13. Association for Computing Machinery, New York, NY, USA, pp. 1969–1978.

MacKenzie, I.S., Zhang, S.X., 2001. An empirical investigation of the novice experience with soft keyboards. Behav. Inf. Technol. 20, 411–418.

Mahfouz, S.M., 2010. A study of Jordanian university students' perceptions of using email exchanges with native English keypals for improving their writing competency. Calico J. 27, 393–408.

Małecka, A., Marecki, P., 2018. Literary Experiments with Automatic Translation: A Case Study of a Creative Experiment Involving King Ubu and Google Translate. In: On the Fringes of Literature and Digital Media Culture. Brill Rodopi, pp. 77–88.

Malsattar, N., Emmadi, N., Joshi, M., 2014. Testing the efficacy of an indic script virtual keyboard: Swarachakra. ACM Int. Conf. Proceeding Ser. 07-09-Dece, 160–165.

Markopoulos, P., Read, J.C., Giannakos, M., 2021. DESIGN OF DIGITAL TECHNOLOGIES FOR CHILDREN. In: HANDBOOK OF HUMAN FACTORS AND ERGONOMICS. John Wiley & Sons, Ltd, pp. 1287–1304.

Masek, W.J., Paterson, M.S., 1980. A faster algorithm computing string edit distances. J. Comput. Syst. Sci.

Matsuda, M., Kitamura, Y., 2009. Development of Machine Translation System for Japanese Children. In: Proceedings of the 2009 International Workshop on Intercultural Collaboration, IWIC '09. Association for Computing Machinery, New York, NY, USA, pp. 269–272.

Mazari, A. & Derraz, N., 2015. Journal of Humanities and Cultural Studies 2, 350–359.

Mazzone, E., Read, J., Beale, R., 2008a. Understanding children's contributions during informant design. Proc. 22nd Br. HCI Gr. Annu. Conf. People Comput. Cult. Creat. Interact. BCS HCI 2008 2, 61–64.

Mazzone, E., Read, J.C., Beale, R., 2008b. Design with and for disaffected teenagers. ACM Int. Conf. Proceeding Ser. 358, 290–297.

McArthur, T., McArthur, T., 2003. English as an Asian language. English Today 19, 19–22.

McBride-Chang, C., Lin, D., Liu, P., Aram, D., Levin, I., Cho, J.-R., Shu, H., Zhang, Y., 2010. The ABC's of Chinese: Maternal mediation of Pinyin for Chinese children's early literacy skills. Read. Writ. 25, 283–300.

Metatla, O., Read, J.C., Horton, M., 2020. Enabling children to design for others with expanded proxy design. In: Proceedings of the Interaction Design and Children Conference. pp. 184–197.

Michelle Lemkuhl, 2002. Pen-Pal Letters: The Cross-Curricular Experience. Int. Lit. Assoc. 55, 720–722.

Miller, A.C., Keenan, J.M., 2009. How word decoding skill impacts text memory: The centrality deficit and how domain knowledge can compensate. Ann. Dyslexia 59, 99.

Misailidi, P., Bonoti, F., 2008. Emotion in children's art: Do young children understand the emotions expressed in other children's drawings? J. Early Child. Res. 6, 189–200.

Moberly, T., 2018. Doctors choose Google Translate to communicate with patients because of easy access. BMJ 362, k3974.

Montgomery, W., 2001. Creating culturally responsive, inclusive classrooms. Teach. Except. Child. 33, 4–9.

Myers, M.D., Tan, F.B., 2002. Beyond models of national culture in information systems research. In: Human Factors in Information Systems. IGI Global, pp. 1–19.

Nadhianti, M., 2016. AN ANALYSIS OF ACCURACY LEVEL OF GOOGLE TRANSLATE IN ENGLISH- BAHASA INDONESIA AND BAHASA INDONESIA-ENGLISH TRANSLATIONS. Sastra Inggris-Quill.

Nagro, S.A., 2019. PROSE Checklist: Strategies for Improving School-to-Home Written Communication. Teach. Except. Child.

Nakamura, S., Markov, K., Nakaiwa, H., Kikui, G., Kawai, H., Jitsuhiro, T., Zhang, J.S., Yamamoto, H., Sumita, E., Yamamoto, S., 2006. The ATR multilingual speech-to-speech translation system. IEEE Trans. Audio, Speech Lang. Process. 14, 365–375.

Newmark, P., 1988. A Textbook of Translation, Text.

Ney, H., 2007. Word Error Rates: Decomposition over P. Comput. Linguist. 48–55.

Nilsson, S., 1997. Understandability of Narratives in Annual Reports. J. Tech. Writ. Commun. 27, 361–384.

O'Haggan, M., AshworthD, 2002. Translation-mediated communication in a digital world: Facing the challenges of globalization and localization.

Ojha, P.K., Ismail, A., Kundumani Srinivasan, K., 2021. Perusal of readability with focus on web content understandability. J. King Saud Univ. - Comput. Inf. Sci. 33, 1–10.

Oyugi, C., Camara, S., Abdelnour-Nocera, J., 2014. A Reflection on Designing Low-End Interactive Products for Rural Users in Sub-Sahara Africa. Cult. Technol. Commun. 28.

Pantsar-Syväniemi, S., Ervasti, M., Karppinen, K., Väätänen, A., Oksman, V., Kuure, E., 2015. A situation-aware safety service for children via participatory design. J. Ambient Intell. Humaniz. Comput. 6, 279–293.

Papineni, K., Roukos, S., Ward, T., Zhu, W.-J., 2002. Bleu: a method for automatic evaluation of machine translation. In: Proceedings of the 40th Annual Meeting of the Association for Computational Linguistics. pp. 311–318.

Piernot, P.P., Felciano, R.M., Stancel, R., Marsh, J., Yvon, M., 1995. Designing the PenPal 511–518.

Pituxcoosuvarn, M., Ishida, T., Yamashita, N., Takasaki, T., Mori, Y., 2018. Machine Translation Usage in a Children's Workshop BT - Collaboration Technologies and Social Computing. In: Egi, H., Yuizono, T., Baloian, N., Yoshino, T., Ichimura, S., Rodrigues, A. (Eds.), . Springer International Publishing, Cham, pp. 59–73.

Plocher, T., Rau, P.-L.P., Choong, Y.-Y., Guo, Z., 2021. CROSS-CULTURAL DESIGN. Handb. Hum. FACTORS Ergon., Wiley Online Books.

Plowman, L., McPake, J., Stephen, C., 2008. Just picking it up? Young children learning with technology at home. Cambridge J. Educ. 38, 303–319.

Profice, C., 2018. Nature as a living presence: Drawings by Tupinambá and New York Children. PLoS One 13.

Prout, A., 2004. The future of childhood. Routledge.

Punch, S., 2002. Interviewing strategies with young people: The 'secret box', stimulus material and task-based activities. Child. Soc. 16, 45–56.

Puspa, N.V., Ratri, D.P., Urifah, U., 2022. ePALS: Utilizing ICT to promote English Language Learning for Young Learners through Global Connection. Educ. J. Educ. English as Foreign Lang. 5, 35–47.

Qgurlg, Q.R.Q., Xdq, X.D.Q., Hlodq, K.H.Q., Dqj, D.Q.J., L, D.K.D., Uhfrjqlwlrq, K., Wudqvfrglqj, D., Vhw, F.V., Lq, F., Vhw, F., Prvw, L., Wkh, R.I., 2019. Multi-Function Tibetan Input Method on Android. 643–648.

Qin, X., Tan, C.-W., Law, E.L.-C., B\odker, M., Clemmensen, T., Qu, H., Chen, D., 2018. Deciphering the Role of Context in Shaping Mobile Phone Usage: Design Recommendations for Context-Aware Mobile Services from a Cross-Cultural Perspective. In: Proceedings of the Sixth International Symposium of Chinese CHI, ChineseCHI '18. Association for Computing Machinery, New York, NY, USA, pp. 39–48.

Read, J., 2001. Optimising text input for young children using computers for creative writing tasks. J. Human-Computer Stud. 2.

Read, J., Gregory, P., Macfarlane, S., Mcmanus, B., Gray, P., Patel, R., 1999. An Investigation of Participatory Design with. Child. – Informant, Balanc. Facil. Des. Proc. Interact. Des. Child. Int. Work. Shak. Publ. 53–64.

Read, J.C., Fitton, D., Sim, G., Horton, M., 2016. How Ideas Make It through to Designs: Process and Practice. In: Proceedings of the 9th Nordic Conference on Human-Computer Interaction, NordiCHI '16. Association for Computing Machinery, New York, NY, USA.

Read, J.C., Horton, M., Fitton, D., Sim, G., 2017. Empowered and Informed: Participation of Children in HCI. In: Bernhaupt, R., Dalvi, G., Joshi, A., K. Balkrishan, D., O'Neill, J., Winckler, M. (Eds.), Human-Computer Interaction - INTERACT 2017. Springer International Publishing, Cham, pp. 431–446.

Read, J.C., MacFarlane, S., 2006. Using the fun toolkit and other survey methods to gather opinions in Child Computer Interaction. Proceeding 2006 Conf. Interact. Des. Child. IDC '06 2006, 81–88.

Read, J.C., MacFarlane, S., Casey, C., 2002. Oops! Silly me! Errors in a handwriting

recognition-based text entry interface for children. ACM Int. Conf. Proceeding Ser. 31, 35–40.

Read, J.C., MacFarlane, S., Casey, C., 2003. “Good enough for what?”

Reed, D.K., Vaughn, S., 2012. Retell as an Indicator of Reading Comprehension. Sci. Stud. Read. 16, 187–217.

Rello, L., Baeza-Yates, R., 2012. Lexical quality as a proxy for Web text understandability. WWW’12 - Proc. 21st Annu. Conf. World Wide Web Companion 591–592.

Reynolds, M., Park, S.S., Clanchy, K., 2020. 6. Prismatic Translation. In: Creative Multilingualism.

Richards, R., 2003. ’My Drawing Sucks!’ : Children’s belief in themselves as artists. Pap. Present. NZARE/AARE Conf. 29 Novemb. - 3 December, 2003, Auckl.

Rivera-Trigueros, I., 2021. Machine translation systems and quality assessment: a systematic review. Lang. Resour. Eval.

Roberts, G., Good, R., Corcoran, S., 2005. Story retell: A fluency-based indicator of reading comprehension. Sch. Psychol. Q. 20, 304.

Rodríguez-Castro, M., Salas, S., Benson, T., 2018. To Google Translate ™ or not? Newcomer Latino communities in the middle. Middle Sch. J. 49, 3–9.

Rollins, J.A., 2005. Tell me about it: Drawing as a communication tool for children with cancer. J. Pediatr. Oncol. Nurs. 22, 203–221.

Rossetti, A., 2019. Intralingual translation and cascading crises: evaluating the impact of semi-automation on the readability and comprehensibility of health content.

Royer, J.M., Carlo, M.S., Dufresne, R., Mestre, J., 1996. The assessment of levels of domain expertise while reading. Cogn. Instr. 14, 373–408.

Rutta, C.B., Schiavo, G., Zancanaro, M., Rubegni, E., 2019. Comic-Based Digital Storytelling with Primary School Children. In: Proceedings of the 18th ACM International Conference on Interaction Design and Children, IDC ’19. Association for Computing Machinery, New York, NY, USA, pp. 508–513.

Salmon, A.K., Lucas, T., 2011. Exploring young children’s conceptions about thinking. J. Res. Child. Educ. 25, 364–375.

Santiago, M.E.V., Dias, R., 2018. Using ePals. com in English classes: A tool for internationalization of public elementary education in Brazil. Espec. 39.

Sarangapani, V., Kharrufa, A., Balaam, M., Leat, D., Wright, P., 2016. Virtual.Cultural.Collaboration: Mobile Phones, Video Technology, and Cross-Cultural Learning. In: Proceedings of the 18th International Conference on Human-Computer

Interaction with Mobile Devices and Services, MobileHCI '16. Association for Computing Machinery, New York, NY, USA, pp. 341–352.

Sato, S., Nagao, M., 1990. Toward memory-based translation 247–252.

Schimmel, N., 2009. Towards a sustainable and holistic model of peace education: a critique of conventional modes of peace education through dialogue in Israel. J. Peace Educ. 6, 51–68.

Scott MacKenzie, I., William Soukoreff, R., 2002. Human–Computer Interaction Text Entry for Mobile Computing: Models and Methods,Theory and Practice Text Entry for Mobile Computing: Models and Methods, Theory and Practice. Human-Computer Interact. 17, 2–3.

Sellers, P.H., 1980. The theory and computation of evolutionary distances: Pattern recognition. J. Algorithms.

Shandomo, H.M., 2009. Getting to Knew You: Cross-Cultural Pen Pals Expand Children's World View. Child. Educ. 85, 154–159.

Shulman, S., Seiffge-Krenke, I., Dimitrovsky, L., 1994. The functions of pen pals for adolescents. J. Psychol. Interdiscip. Appl. 128, 89–100.

Sim, G., Read, J.C., Gregory, P., Xu, D., 2015. From England to Uganda: Children designing and evaluating serious games. Human-Computer Interact. 30, 263–293.

Snover, M., Dorr, B., Schwartz, R., Micciulla, L., Makhoul, J., 2006. A study of translation edit rate with targeted human annotation. AMTA 2006 - Proc. 7th Conf. Assoc. Mach. Transl. Am. Visions Futur. Mach. Transl. 223–231.

Soukoreff, R.W., MacKenzie, I.S., 2001. Measuring errors in text entry tasks 319.

Stapleton, P., Leung Ka Kin, B., 2019. Assessing the accuracy and teachers' impressions of Google Translate: A study of primary L2 writers in Hong Kong. English Specif. Purp. 56, 18–34.

Stenou, K., 2002. Universal Declaration on Cultural Diversity a vision a conceptual platform a pool of ideas for implementation a new paradigm.

Sutskever, I., Vinyals, O., Le, Q. V., 2014. Sequence to sequence learning with neural networks. In: Advances in Neural Information Processing Systems.

Tanaka-Ishii, K., Gupta, R., 2010. Writing System Variation and Text Entry. Text Entry Syst. Mobility, Access. Universality 19.

Tarkka, M., Tikka, H., 2001. Cultural usability: towards a design sensibility. Retrieved Oct. 10, 2001.

Taylor, D., 2012. Global software: Developing applications for the international market.

Springer Science & Business Media.

Taylor, W.L., 1953. “Cloze procedure”: A new tool for measuring readability. Journal. Q. 30, 415–433.

ten Peze, A., Janssen, T., Rijlaarsdam, G., Van Weijen, D., 2021. Writing creative and argumentative texts: What’s the difference? Exploring how task type affects students’ writing behaviour and performance. L1 Educ. Stud. Lang. Lit. 21, Runnin, 1–38.

Tillmann, C., Vogel, S., Ney, H., Zubiaga, A., Sawaf, H., 1997. Accelerated {DP}~Based Search for Statistical Translation. Fifth Eur. Conf. Speech Commun. Technol. 2667–2670.

Tipton, F.B., 2008. “Thumbs-up is a rude gesture in Australia.” Crit. Perspect. Int. Bus. 4, 7–24.

Valentine, G., 2017. Public space and the culture of childhood. Routledge.

van den Broek, P., Tzeng, Y., Risden, K., Trabasso, T., Basche, P., 2001. Inferential questioning: Effects on comprehension of narrative texts as a function of grade and timing. J. Educ. Psychol. 93, 521.

van der Graaf, J., Segers, E., Verhoeven, L., 2015. Scientific reasoning abilities in kindergarten: dynamic assessment of the control of variables strategy. Instr. Sci. 43, 381–400.

van Rensburg, A., Snyman, C., Lotz, S., 2012. Applying Google Translate in a higher education environment: Translation products assessed. South. African Linguist. Appl. Lang. Stud. 30, 511–524.

Villarroel, J.D., Antón, A., Zuazagoitia, D., Nuño, T., 2018. Young children’s understanding of plant life: a study exploring rural–urban differences in their drawings. J. Biol. Educ. 52, 331–341.

Vygotsky, L.S., 1967. Play and Its Role in the Mental Development of the Child. Sov. Psychol. 5, 6–18.

Wagner, R.A., Lowrance, R., 1975. An Extension of the String-to-String Correction Problem. J. ACM 22, 177–183.

Wang, Y.P., Pavlidis, T., 1990. Optimal Correspondence of String Subsequences. IEEE Trans. Pattern Anal. Mach. Intell.

Waterman, M.S., 1985. Time warps, string edits, and macromolecules: The theory and practice of sequence comparison. Math. Biosci.

Wiggins, T., Carnoy, M., 1975. Education As Cultural Imperialism. Am. Educ. Res. J. 12, 524.

William Soukoreff, R., Scott MacKenzie, I., 2001. Measuring errors in text entry tasks: An application of the levenshtein string distance statistic. In: Conference on Human Factors in Computing Systems - Proceedings.

Williams, L., 2006. Web-based machine translation as a tool for promoting electronic literacy and language awareness. Foreign Lang. Ann.

Winschiers-Theophilus, H., 2009. The Art of Cross-Cultural Design for Usability BT - Universal Access in Human-Computer Interaction. Addressing Diversity. In: Stephanidis, C. (Ed.), . Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 665–671.

Wyche, S.P., Smyth, T.N., Chetty, M., Aoki, P.M., Grinter, R.E., 2010. Deliberate interactions: Characterizing technology use in Nairobi, Kenya. Conf. Hum. Factors Comput. Syst. - Proc. 4, 2593–2602.

Yamashita, N., Ishida, T., 2006. Effects of machine translation on collaborative work. Proc. ACM Conf. Comput. Support. Coop. Work. CSCW 515–524.

Yang, S.C., Chen, Y.J., 2007. Technology-enhanced language learning: A case study. Comput. Human Behav. 23, 860–879.

Yanisky-Ravid, S., Martens, C., 2019. From the Myth of Babel to Google Translate: Confronting Malicious Use of Artificial Intelligence – Copyright and Algorithmic Biases in Online Translation Systems. SSRN Electron. J.

Yarosh, S., Inkpen, K.M., Brush, A.J.B., 2010. Video playdate: Toward free play across distance. Conf. Hum. Factors Comput. Syst. - Proc. 2, 1251–1260.

Yip, J.C., Sobel, K., Pitt, C., Lee, K.J., Chen, S., Nasu, K., Pina, L.R., 2017. Examining adult-child interactions in intergenerational participatory design. Conf. Hum. Factors Comput. Syst. - Proc. 2017-May, 5742–5754.

Zens, R., Och, F.J., Ney, H., 2002. Phrase-Based Statistical Machine Translation. In: Jarke, M., Lakemeyer, G., Koehler, J. (Eds.), KI 2002: Advances in Artificial Intelligence. Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 18–32.

Zhou, G., Cai, L., Zhao, J., Liu, K., 2011. Phrase-based translation model for question retrieval in community question answer archives. ACL-HLT 2011 - Proc. 49th Annu. Meet. Assoc. Comput. Linguist. Hum. Lang. Technol. 1, 653–662.

Zinar, S., 1990. Fifth-graders' recall of propositional content and causal relationships from expository prose. J. Lit. Res. 22, 181–199.

Appendices

Appendix 1. Ethics and documents

Appendix 1.1 Research approval by STEMH Ethics Committee

uclan
University of Central Lancashire

27 June 2018

Janet Read / Dev Raj Lamichhane
School of Physical Sciences and Computing
University of Central Lancashire

Dear Janet / Dev

Re: STEMH Ethics Committee Application
Unique Reference Number: STEMH 832 FR

The STEMH ethics committee has granted approval of your proposal application 'Digital PenPals – Mobile Interaction across Cultures'. Approval is granted up to the end of project date*.

It is your responsibility to ensure that

- the project is carried out in line with the information provided in the forms you have submitted
- you regularly re-consider the ethical issues that may be raised in generating and analysing your data
- any proposed amendments/changes to the project are raised with, and approved, by Committee
- you notify EthicsInfo@uclan.ac.uk if the end date changes or the project does not start
- serious adverse events that occur from the project are reported to Committee
- a closure report is submitted to complete the ethics governance procedures (Existing paperwork can be used for this purposes e.g. funder's end of grant report; abstract for student award or NRES final report. If none of these are available use e-Ethics Closure Report Proforma).

Yours sincerely

Julie Cook
Deputy Vice-Chair
STEMH Ethics Committee

* for research degree students this will be the final lapse date

NB - Ethical approval is contingent on any health and safety checklists having been completed and necessary approvals gained as a result.

Appendix 1.2 Approval from the Head Teacher of School from Khotang

श्री शारदा माध्यमिक विद्यालय
SHREE SHARADA SECONDARY SCHOOL

रावा बेंसी गाउँपालिका २, खार्पा
RAWA BENSI RURAL MUNICIPALITY- 2, KHARPA
१ नं. प्रदेश, नेपाल
Province No. 1, Nepal

प.सं.: २०७४/०७५ मिति:२०७४/११/२१

च.नं.: 150 | 074 | 075

युनिभर्सिटी अफ सेन्ट्रल ल्यान्कासायर,

विषय:- अनुमति पत्र

उपरोक्त सम्बन्धमा यो पत्र मार्फत म देव राज लामिछाने ज्यूलाई मेरो स्कूल श्री शारदा माध्यमिक विद्यालयमा आई विद्यार्थीहरुसँग मोबायल फोनको प्रयोग र नयाँ एप (प्रविधि) सम्बन्धि विभिन्न क्रियाकलाप र अनुसन्धान गर्न अनुमति दिन्छु।

यस अनुसन्धानको अवधि भरि म वहाँको साथमा नै रहनेछु। हाम्रो देशमा यस्तो अनुसन्धान गर्न प्रहरीसँग कुनै अनुमति लिने प्रक्रिया छैन तर वहाले त्यहाँबाटै प्रहरी रिपोर्ट ल्याउनु भएकोले हामी सन्तुष्ट छौं।

गोपाल बस्नेत
गोपाल बस्नेत
प्रधानाध्यापक
श्री शारदा मा.वि.खार्पा
श्री शारदा माध्यमिक विद्यालय

Date:March 6,2018

To Ethics committee (UCLAN),

Subject:- Letter of authorization.

This letter conforms that I am happy for Dev Raj Lamichhane to visit my school, Shree Sharada Secondary School, in Khotang, Nepal and work with the children to ask about their mobile use and to show them a new mobile app.

I will accompany him at all times when he is with the children. In Nepal, we do not have process for checking that individual are good with the police but Dev has preserved the police report from the UK.

Yours Truly
Gopal Basnet
Gopal Basnet
Head Teacher
Shree Sharada S.S. Kharpa

Appendix 1.3 Ethical Approval from the School from Khotang

श्री शारदा माध्यमिक विद्यालय
SHREE SHARADA SECONDARY SCHOOL

रावा बेंसी गाउँपालिका २, खार्पा
RAWA BENSI RURAL MUNICIPALITY- 2, KHARPA
१ नं. प्रदेश, नेपाल
Province No. 1, Nepal

प.सं.: २०७४/०७५ मिति:२०७४/११/२१

च.नं.: 151/074/075

नैतिक स्वीकृति पत्र

विषय: जो जससँग सम्बन्धित छ,

हामी यो पत्र मार्फत देव राज लामिछाने ज्यूले यस विद्यालयमा गर्न लाग्नु भएको अनुसन्धान नैतिक रुपले ठीक भएको ठहर गछौं। हामीले वहाँको प्रोजेक्टको लक्ष्य र उद्देश्य अध्ययन गरेका छौं र वहाँले आफ्नो अनुसन्धानको खाका र प्रक्रिया बारेमा पनि हामीलाई अवगत गराउनु भएको छ। वहाँले अनुसन्धानको क्रममा सङ्कलन गर्नु भएको डाटा सुरक्षित र गोप्यसाथ राख्ने विशवास दिलाउनु भएको छ।

विद्यालयको नैतिक समिति वहाँको अनुसन्धानलाई स्वीकृति दिँदै सफलताको कामना गर्दछ।

विद्यालय नैतिक समिति

श्री शारदा माध्यमिक विद्यालय

खार्पा, खोटाङ।

नाम: गोपाल बस्नेत	नाम: ध्रुव पाण्डे	नाम: तिर्थराज दाहाल
पद: प्रधानाध्यापक	पद: शिक्षक	पद: शिक्षक
हस्ताक्षर	हस्ताक्षर	हस्ताक्षर

गोपाल बस्नेत
प्रधानाध्यापक
श्री शारदा मा.वि.खार्पा

Date:March 6,2018

Letter of Ethical Approval

To whom it may concern.

This is to certify that our school Ethics committee have approved Dev Raj Lamichhane's research in our school is ethically good. We have studied his project aims and objectives. He also explained us how the field study is designed and will be conducted.

He also assured us that the data will be handle properly and data proction will be maintained.

Ethics committee is happy to approve it and wish him all the best.

Yours truly

Shree Sharada Secondary School Ethics committee

Sign:	Sign:	Sign:
Name: Gopal Basnet	Name:Dhruba Pandey	Name: Tirth Raj Dahal
Post: Head Teacher	Post: Teacher	Post: Teacher

Gopal Basnet
Head Teacher
Shree Sharada S.S. Kharpa

Appendix 1.4 Study information

Child Computer Interaction group
University of Central Lancashire
Preston PR1 2HE
www.chici.org

Dear Parent / Guardian,

Today your child took part in a research study as part of the Digital PenPals Project that is being run by Prof. Janet C Read and Dev Lamichhane. The research was organised by UCLan and was run by the ChiCI research group at UCLan. Today your child did the following activities:

A. Contributed ideas for the app by doing drawings
B. Contributed writing and drawing for the app
C. Tested out the app and gave opinions on it

We took away from the day some of the things your child contributed. We explained this to your child and he / she was happy for us to take away the ideas/ writing / drawings / opinions.

If, when you have chatted with your child about what he / she did today, you want to know more or want to talk to the research team - then do feel free to contact us at jcread@uclan.ac.uk or drlamichhane@uclan.ac.uk

You can follow the project at http://www.chici.org/meet-the-team/dev-raj-lamichhane

Appendix 1.5 Study information Nepalese Translation

बालबालिका कम्प्युटर अन्तरक्रिया समूह
सेन्ट्रल ल्यान्कासायर विश्वविद्यालय
प्रेश्टन, बेलायत
www.chici.org

आदरणिय अभिभावक ज्यू,

आज तपाईंको बच्चाले डिजिटल पेन पाल नाम गरेको एउटा अनुसन्धानमा भाग लिए जुन प्रोफेसर ज्यानेट सि रिड र देब राज लामिछानेले सञ्चालन गरेका थिए। यो अनुसन्धान सेन्ट्रल ल्यान्कासायर विश्वविद्यालयले बालबालिका कम्प्युटर अन्तरक्रिया समूहको साहयतामा सञ्चालन गरेको थियो। त्यस अनुसन्धानको क्रममा बच्चाहरुले निम्नलिखित क्रियाकलापहरु गरेका थिए :

क) नयाँ मोबाइल एपको लागि चित्र बनाएर नयाँ नयाँ विचारको योगदान

ख) सोहि एपको लागि लेख्ने र चित्र बनाउने क्रियाकलाप

ग) एपको जाँच र त्यसको बारेमा धारणा व्यक्त

हामिले बच्चाहरुले गरेको क्रियाकलापको अभिलेख सामाग्री हामी सँगै लगेको छौं। हामिले बच्चाहरुलाई पनि यो कुरा स्पष्ट पारेका छौं।

जब तपाईंले आफ्नो बच्चासँग यि क्रियाकलापहरुको बारेमा कुरा गर्नुहुन्छ, यदि तपाईंलाई अरु जान्न मन लागेमा हामिलाई अवश्य सम्पर्क गर्नुहोला।

हामीलाई सम्पर्क गर्ने ठेगानाहरु jread@uclan.ac.uk अथवा drlamichhane@uclan.ac.uk हुन्।

यो अनुसन्धानको बारेमा अझै जान्न मन भएमा http://www.chici.org/meet-the-team/dev_raj-lamichhane मा जानुहोला।

Appendix 1.6 Participants consent form

University of Central Lancashire

CHILDREN'S CONSENT FORM

Full title of Project: Digital PenPals – Mobile Interaction across Cultures

Dev Raj Lamichhane
PhD Researcher
University of Central Lancashire
Department of Physical Sciences and Computing
Post Code: PR1 2HE

Please read the following statements and initial the boxes to indicate your agreement
NOTE – there are some things here you may NOT agree with that is okay – ONLY initial what you agree with.

	Please initial box
Dev has explained to me what we are doing today.	☐
I know I can choose to not take part and I know I can leave anytime I want.	☐
I am agreeing to join in at the moment.	☐
I am happy for my ideas, writing, drawings and opinions to be used.	☐
I know I can choose to keep these things back once I have done them	☐
I agree for Dev to make notes when I am using the technology.	☐
I agree tfor anything I say to be included as a quote so long as I am not named.	☐

Name of Participant	Date	Signature
Name of Researcher	Date	Signature

Appendix 1.7 Participants consent form Nepalese Translation

University of Central Lancashire

बालबालिका अनुमति फारम

अनुसन्धानको पुरा नाम : डिजिटल पत्रमित्र- विभिन्न संस्कृति बिच मोबाइल अन्तरक्रिया

देब राज लामिछाने
पि एच डि. अनुसन्धानकर्ता
सेन्ट्रल ल्यान्कासायर विश्वविद्यालय
भौतिक विज्ञान र कम्प्युटर शास्त्र, प्रेश्टन, बेलायत

कृपया तलका बुँदाहरु पढेर सहमति भए छेउको बाकसमा चिन्ह लगाउनुहोस्। यदि कुनै बुँदामा सहमति छैन भने पनि ठिक छ।

	चिन्ह
• देवले आज गर्ने कामको बारेमा जानकारी गराउनु भएको छ।	☐
• मलाई थाहा छ कि म भाग लिन नचाहेमा त्यसो गर्न सक्छु र ठिक नलागेमा कुनै पनि बेला निस्कन पाउँछु।	☐
• अहिले चाहिँ म भाग लिनको लागि तयार छु।	☐
• मेरो विचार, लेखाइ र चित्रहरु प्रयोग गर्न म अनुमति दिन्छु।	☐
• मलाई थाहा छ कि म यी चित्रहरु प्रयोग नगर्न भन्न पाउँछु।	☐
• मैले मोबाइल चलाइरहँदा देवलाई नोट लेख्न अनुमति दिन्छु।	☐
• मेरो नाम उल्लेख नगर्ने हो भने मैले भनेका कुराहरु समावेश गर्न स्विकृति दिन्छु।	☐

.....	.....	.....
सहभागिको नाम	मिती	दस्तखत
.....	.....	.....
अनुसन्धानकर्ताको नाम	मिती	दस्तखत

Appendix 1.8 Guardian consent form Nepalese Translation

University of Central Lancashire

(PARENT) CONSENT FORM

Full title of Project: **Digital PenPals – Mobile Interaction across Cultures**

Dev Raj Lamichhane
PhD Researcher
University of Central Lancashire
Department of Physical Sciences and Computing
Post Code: PR1 2HE

Please read the following statements and initial the boxes to indicate your agreement

	Please initial box
I confirm that I have read and understand the information sheet, dated …….. for the above study and have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	☐
I understand that my child's participation is voluntary and that I am free to withdraw his / her participation at any time, without giving a reason.	☐
I agree for my child to take part in the above study.	☐
I agree that my child's data gathered in this study may be stored (after it has been anonymised) in a specialist data centre and may be used for future research.	☐
I agree to the use of anonymised quotes from my child in publications	☐

Name of Participant	Date	Signature
Name of Researcher	Date	Signature

Appendix 1.9 Guardian consent form Nepalese Translation

University of Central Lancashire

अभिभावक अनुमति फारम

अनुसन्धानको पुरा नाम : डिजिटल पत्रमित्र- विभिन्न संस्कृति बिच मोबाइल अन्तरक्रिया

देब राज लामिछाने
पि. एच. डि. अनुसन्धानकर्ता
सेन्ट्रल ल्यान्कासायर विश्वविद्यालय
भौतिक विज्ञान र कम्प्युटर शास्त्र, प्रेश्टन, बेलायत

कृपया तलका बुँदाहरु पढेर सहमति भए छेउको बाकसमा चिन्ह लगाउनुहोस् ।

	चिन्ह
• मैले जानकारी पत्र पढेर बुझेँ जसमा मिती ..... मा गर्न लागिएको अनुसन्धानको बारेमा जानकारी गराइएको थियो र मलाई सो जानकारीको बारेमा विचार गर्न, प्रश्न सोध्न अवसर दिइएको थियो ।	☐
• मैले बुझेँ कि मेरो बच्चाले सहभागी हुने कि नहुने भन्ने हाम्रो हातमा छ र मैले कुनै पनि बेला मेरो बच्चाको सहभागिता फिर्ता लिन पाउँछु ।	☐
• अहिलेलाई म मेरो बच्चालाई सहभागी गराउन स्विकृति दिन्छु ।	☐
• मेरो बच्चाले गरेको क्रियाकलापको अभिलेख सामाग्री भविष्यमा प्रयोग गर्न स्विकृती दिन्छु यदि हाम्रो व्यक्तिगत विवरण गुमनाम राख्ने हो भने ।	☐
• मेरो बच्चाले भनेका कुराहरु, व्यक्ति गुमनाम राखेमा, प्रयोग गर्न, प्रकाशित गर्न अनुमति दिन्छु ।	☐

.....	.....	.....
अभिभावको नाम	मिती	दस्तखत
.....	.....	.....
अनुसन्धानकर्ताको नाम	मिती	दस्तखत

Appendix 2. Participatory Design

Appendix 2.1 University Mess Day Example Tuesday 25/06/2019

TIME	Year3(A)	Year 3 (B)	Year 4 (A)	Year 4 (B)	Year 5 (A)	Year 5 (B)	SPARE
	10	11	9	9	7	7	
945 - 10	Welcome and CTEQ survey (Janet – CM33)						
10 – 10.25	RAID - participatory design (Janet)		Arduino (Matt and Dan – CM33)		Chat (Dev)	Robot racing (Graham)	John, Jonathan, Lorna, Chris
10.25 – 10.50					Robot racing (Graham)	Chat (Dev)	
BREAK							
11.05 – 11.35	Makey Makey etc (Lorna and Jonathan)		Voice Interfaces (Dan)	Chat (Dev)	Privacy (John)	VR (Chris)	Janet, Graham, Matt
11.35 – 12.05			Chat (Dev)	Voice Interfaces(Dan)	VR (Chris)	Privacy (John)	
LUNCH							
12.35 – 1.05	Chat (Dev)	Fun Toolkit (Janet)	Privacy (John)	VR (Chris)	Arduino (Matt and Graham– CM33)		Dan, Lorna, Jonathan,
1.05 – 1.35	Fun Toolkit (Janet)	Chat (Dev)	VR (Chris)	Privacy (John)			
1.40 – 2.05	Voice Interfaces (Dan)	Robot racing (Graham)	RAID - particip design (Janet)		RoboCode (Matt, and Jonathan / Lorna)		John
2.05 – 2.30	Robot racing (Graham)	Voice Interfaces (Dan)					
2.30 – 2.35	WRAP UP						

Appendix 3. Technical stuff

Appendix 3.1 Edit distance algorithm Code used in Edit Distance calculation tool

```
static int calculateEditDistance(String word1, String word2, int len1, int len2) {
  int[][] dp = new int[len1 + 1][len2 + 1];
  for (int i = 0; i <= len1; i++) {
    dp[i][0] = i;
  }
  for (int j = 0; j <= len2; j++) {
    dp[0][j] = j;
  }
  //iterate though, and check last char
  for (int i = 0; i < len1; i++) {
    char c1 = word1.charAt(i);
    for (int j = 0; j < len2; j++) {
      char c2 = word2.charAt(j);

      //if last two chars equal
      if (c1 == c2) {
        //update dp value for +1 length
        dp[i + 1][j + 1] = dp[i][j];
      } else {
        int replace = dp[i][j] + 1;
        int insert = dp[i][j + 1] + 1;
        int delete = dp[i + 1][j] + 1;

        int min = replace > insert ? insert : replace;
        min = delete > min ? min : delete;
        dp[i + 1][j + 1] = min;
      }
    }
  }
  return dp[len1][len2];


}
```

Appendix 3.2 Language and Locale

By default, the locale is England and English. When Nepalese flag is selected in the app, the locale will change as follows.

```
Locale locale = new Locale("ne","NP");
Locale.setDefault(locale);
Configuration config = new Configuration();
config.locale = locale;
```

According to the locale, the display texts will change accordingly as follows:

Values/strings.xml Resources	valuesNep/strings.xml Resources
<string name="app_name">DigiPal Version 3</string>	<string name="app_name">डिजिटल पत्र मित्र संस्करण ३</string>
<string name="select">Select your country flag</string>	<string name="select">आफ्नो देशको झण्डा छान्नुहोस्</string>
<string name="RegistrationTitle">Enter username and password to register.</string>	<string name="RegistrationTitle">दर्ता गर्न प्रयोगकर्ता नाम र पासवर्ड प्रविष्ट गर्नुहोस्।</string>
<string name="username">Username</string>	<string name="username">Username (प्रयोगकर्तानाम)</string>
<string name="password">Password</string>	<string name="password">Password (संकेत शब्द)</string>
<string name="passwordConf">Confirm Password</string>	<string name="passwordConf">Password (संकेत शब्द पक्का गर्नु)</string>
<string name="button3">Register</string>	<string name="button3">रजिस्टर</string>
<string name="loginTitle">Enter your credentials</string>	<string name="loginTitle">तपाईंको लग इन विवरणहरू टाइप गर्नुहोस्</string>
<string name="button1">Login</string>	<string name="button1"> लग – इन </string>
<string name="noAccount">Click here if you dont have account and want to register</string>	<string name="noAccount">यदि तपाइँसँग खाता छैन र दर्ता गर्न चाहनुहुन्छ भने यहाँ क्लिक गर्नुहोस्</string>
<string name="loggedIn">Logged in Successfully.</string>	<string name="loggedIn">सफलतापूर्वक लग इन गरियो।</string>
<string name="userpage">Hi, </string>	<string name="userpage">नमस्ते, </string>

<string name="info">This is your userpage. Here you can view your letters and reply to it.string>	<string name="info"> यो तपाईंको प्रयोगकर्ता पृष्ठ हो। यहाँ तपाई आफ्नो अक्षरहरू हेर्न र यसको जवाफ दिन सक्नुहुनेछ। </string>
<string name="buttonSignout"> Signout</string>	<string name="buttonSignout"> साइन आउट</string>
<string name="buttonLetters">Read and reply your letter</string>	<string name="buttonLetters">तपाईंको पत्र पढ्नुहोस् र जवाफ दिनुहोस्</string>
<string name="button_startreply">Click here to reply to the letter</string>	<string name="button_startreply"> पत्रलाई जवाफ दिन यहाँ क्लिक गर्नुहोस्</string>
<string name="button_submit">Submit</string>	<string name="button_submit"> बुझाउनुहोस्</string>
<string name="letterHeading">Here are your letters. Scroll up to view previous letters.</string>	<string name="letterHeading">यहाँ तपाईको पत्रहरू छन्। अघिल्लो पत्रहरू हेर्नको लागि माथि स्क्रोल गर्नुहोस्।</string>
<string name="reply_hint">Type your reply here and click on the arrow to send when you finish.</string>	<string name="reply_hint">जवाफ दिनहोस्</string>
<string name="buttonOpenLetters">Click here to see your letters</string>	<string name="buttonOpenLetters"> तपाईको पत्र हेर्नका लागि यहाँ क्लिक गर्नुहोस् </string>
<string name="button_replysend">send</string>	<string name="button_replysend"> पठाउनुहोस्</string>
<string name="sent">Letter Sent Successfully.</string>	<string name="sent">पत्र सफलतापूर्वक पठाइयो।</string>

Appendix 3.3 Google Translation API Implementation

- Cloud Translation account was created in Google cloud which provided the API_KEY
- Added this line in build.gradle module inside dependencies

```
implementation 'com.google.cloud:google-cloud-translate:1.66.0'

packagingOptions {
  pickFirst 'META-INF/*'
}
```

- Changed the minsdkversion to 21 from 18 that error is fixed
- Created translator.java file which will handle all the translations

Translator.java

```
import com.google.cloud.translate.Translate;
import com.google.cloud.translate.TranslateOptions;
import com.google.cloud.translate.Translation;

string translatedLetterData;
private static final String API_KEY ="xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx";
letterSubmit{
try {
  translatedLetterData= new Translator().execute(letterData).get();
} catch (InterruptedException e) {
  e.printStackTrace();
} catch (ExecutionException e) {
  e.printStackTrace();
}
```

1. And async task is has following code and returns

```
package com.DigiPal;
import android.os.AsyncTask;
import com.google.cloud.translate.Translate;
import com.google.cloud.translate.TranslateOptions;
import com.google.cloud.translate.Translation;
  public class Translator extends AsyncTask<String, Void, String> {
    private static final String API_KEY = "AIzaSyC0WWpoPpxXGwatvEczr84r1l9NbW94OmE";
    private String letter;
    private String translatedLetter;
    @Override
    protected String doInBackground(String... strings) {
     String letter=strings[0];
      TranslateOptions options = TranslateOptions.newBuilder()
          .setApiKey(API_KEY)
          .build();
      Translate translate = options.getService();
      final Translation translation = translate.translate(letter,
Translate.TranslateOption.targetLanguage("en"));
 translatedLetter=translation.getTranslatedText();
      return translatedLetter;
    }
```

2. To select which language to display all the letters. The locale is retrieved from first set

```
Translate.TranslateOption.targetLanguage(Locale.getDefault().getLanguage()));
```

Appendix 4. Translation

Appendix 4.1 Funny translations

I am 13 years old and I study in class 6.	I am 3 years old and I teach in class 6.	Ignored.
I don't have a brother.	I don't like brother.	Why don't you like your brother? That's mean.
I have one pet dog.	I have yacht pet dog.	I
I like MoMo.	I like me.	I also like myself.
My favourite food is MoMo.	My favourite food is maam.	I
My sisters name is Navina.	My sisters name is unknown.	I don't have a sister.
What do you like?	What do you need?	I don't need anything? Why are you asking this?
My favourite colour is yellow.	Colour of my face is yellow.	I
I like red colour.	The gardener likes red colour.	My favourite colour is blue.
I like to play with friends.	I like to drink water with friends.	I also drink water.
Man united is best football team.	Being united is best football team.	I
My teachers name is mrs pickles.	My teacher is mixed pickle.	Didn't understand your teachers name please write again.
I have a pet dog.	I have a belly dog.	I
She likes dogs.	The wolf likes dogs.	I
My favourite fruit is mango.	My favourite fruit is snake.	My favourite fruit is Strawberry.
My step dad	My level dad	I
My sisters are mean to me.	My sisters are meningful to me.	I
I am getting another cousin.	I am having another baby.	I
What is your surname?	What is your name?	My name is ...
Players of England are good.	England are good players.	I
Are you a boy or a girl?	Are you a dog or a girl?	Don't understand what you are saying.
My birth place is Sabjekhola.	My birth place is vegetable.	I
I am a boy.	I am a chai boy.	I
I am not Logan Paul.	I am logan paul.	Don't joke.
I have three animals.	I have your animals.	
What do you like to play?	What do you like to eat?	
My favourite pet is cat.	My favourite belly is a cat.	Do you eat cat??
My favourite fruit is mango.	My favourite fruit flower is you.	My favourite fruit is strawberry.
मेरो मनपर्ने चरा डाफे हो ।	My favorite bird is red.	

Appendix 5. Miscellanies

Appendix 5.1 3MT Poster presentation