

Contents

Contents.....	xiii
I Preliminaries	1
1 Introduction	3
1.1. Motivation	3
1.2. Research Hypothesis	5
1.3. Research Methodology.....	5
1.4. Goals and Contributions.....	5
1.5. Outline of the Thesis	8
2 Interactive Technologies for Preschool Game-Based Instruction: Experiences and Future Challenges	13
2.1. Introduction	14
2.2. Technology-Supported Games for Preschool Children.....	15
2.2.1. Traditional Computers	15
2.2.2. Interactive Surfaces.....	17
2.2.3. Robots and Technologically-Enhanced Toys.....	22
2.3. Discussion	26
2.3.1. The Technological Evolution.....	26
2.3.2. A Future Challenge: Ubiquitous games.....	27

2.3.3. The Interplay between Age, Cognitive Skills and Interaction Modalities.....	30
2.4. Conclusions	32
3 Multi-touch Technology in Early Childhood: Current Trends and Future Challenges	33
3.1. Introduction	34
3.2. State of the art.....	35
3.3. Future challenges.....	38
3.4. Conclusions	40
4 KINDERTIVITY: Using Interactive Surfaces to Foster Creativity in Pre-kindergarten Children.....	43
4.1. Introduction	44
4.2. Related work.....	45
4.3. Contribution.....	45
II Usability	47
5 Multi-touch Gestures for Pre-kindergarten Children.....	49
5.1. Introduction	50
5.2. Related work.....	51
5.2.1. Commercial perspective on multi-touch technology.....	53
5.3. Experimental study.....	55
5.3.1. Participants.....	56
5.3.2. Apparatus	56
5.3.3. Procedure.....	56
5.4. Tasks.....	57
5.4.1. Task 1: Tap.....	57
5.4.2. Task 2: Double Tap.....	57

5.4.3.	Task 3: Long Pressed	57
5.4.4.	Task 4: Drag.....	58
5.4.5.	Task 5: Scale up.....	58
5.4.6.	Task 6: Scale down	58
5.4.7.	Task 7: One-finger rotation.....	59
5.4.8.	Task 8: Two-finger rotation	60
5.5.	Results	60
5.5.1.	Completion time.....	61
5.5.2.	Success.....	63
5.5.3.	Comparing tasks.....	66
5.5.4.	Qualitative results	69
5.6.	Discussion	71
5.6.1.	Debunking myths	71
5.6.2.	The impact of gender and age	71
5.6.3.	Designing multi-touch applications for pre-kindergarteners.....	72
5.6.4.	Revisiting multi-touch interactions for adults.....	73
5.6.5.	Applications beyond HCI.....	75
5.7.	Threats to Validity.....	75
5.8.	Conclusions and future work.....	76
6	Improving Pre-Kindergarten Touch Performance.....	83
6.1.	Introduction	84
6.2.	Related work	84
6.3.	Experimental study.....	85
6.3.1.	Participants.....	85
6.3.2.	Apparatus	85
6.3.3.	Tasks	86
6.3.4.	Procedure	86
6.4.	Results	87
6.4.1.	Assisted vs non-Assisted Interaction	87

6.4.2.	Age and Gender Influence.....	88
6.5.	Discussion and Conclusions	89
7	Evaluating the Accuracy of Pre-Kindergarten Children Multi-touch Interaction	91
7.1.	Introduction	92
7.2.	Related works	92
7.3.	Experimental study	93
7.3.1.	Participants.....	94
7.3.2.	Apparatus	94
7.3.3.	Tasks	94
7.3.4.	Procedure.....	95
7.4.	Results	96
7.4.1.	Success	96
7.4.2.	Completion time	96
7.4.3.	Accuracy	97
7.5.	Discussion and future work	97
8	Are Kindergarten Children Ready for Indirect Drag Interactions?	101
8.1.	Introduction	102
8.2.	Related work.....	103
8.3.	Experimental study	103
8.3.1.	Drag operations overview	104
8.3.2.	Participants.....	104
8.3.3.	Apparatus	104
8.3.4.	Task.....	105
8.3.5.	Procedure.....	106
8.3.6.	Design	106
8.4.	Results	106

8.4.1.	Success.....	106
8.4.2.	Completion time.....	107
8.4.3.	Precision.....	108
8.5.	Discussion	109
8.6.	Conclusions and future work.....	112

III Communicability 117

9 Exploring Visual Cues for Intuitive Communicability of Touch Gestures to Pre-kindergarten Children 117

9.1.	Introduction	118
9.2.	Related work	118
9.3.	Languages overview.....	119
9.4.	Experimental study.....	120
9.4.1.	Participants.....	120
9.4.2.	Apparatus	121
9.4.3.	Procedure	121
9.4.4.	Design	122
9.5.	Results	122
9.6.	Discussion and future work.....	123

10 Evaluating Multi-touch Semiotics to Empower Pre-kindergarten Instruction with Interactive Surfaces..... 125

10.1.	Introduction	126
10.2.	Related work	128
10.2.1.	Industrial perspective on the communicability of multi-touch gestures 130	
10.3.	Language overview	131
10.4.	Study context.....	133
10.4.1.	Participants.....	134
10.4.2.	Equipment.....	135

10.4.3.	Procedure.....	135
10.4.4.	Design	137
10.5.	Tasks.....	137
10.5.1.	Task 1: Tap.....	137
10.5.2.	Task 2: Long pressed.....	138
10.5.3.	Task 3: Drag.....	139
10.5.4.	Task 4: One finger rotation	140
10.5.5.	Task 5: Scale up	141
10.5.6.	Task 6: Scale down	142
10.6.	Results	143
10.6.1.	Phases.....	143
10.6.2.	Languages	144
10.6.3.	Gender.....	147
10.6.4.	Age group.....	149
10.7.	Discussion.....	152
10.8.	Threats to validity.....	155
10.9.	Conclusions and future work.....	156
11	Exploring Visual Languages for Communicating Directional Awareness to Kindergarten Children	159
11.1.	Introduction	160
11.2.	Related work.....	162
11.2.1.	Industrial perspective on the communicability of spatial and directional awareness in touch devices.....	165
11.3.	Visual languages for directional awareness.....	166
11.4.	Study context	169
11.4.1.	Participants.....	170
11.4.2.	Equipment	170
11.4.3.	Task.....	170
11.4.4.	Procedure.....	172

11.4.5.	Design	173
11.5.	Results	173
11.5.1.	Success rate	173
11.5.2.	Completion time	174
11.5.3.	Relative positioning awareness	175
11.5.4.	Visual Interference	177
11.6.	Discussion	178
11.7.	Conclusions	182
12	Evaluating Assistive Communication Languages with Kindergarten Children on Touchscreen Devices.....	187
12.1.	Introduction	188
12.2.	Related work	190
12.3.	Study context.....	193
12.3.1.	Visual languages	193
12.3.2.	Participants.....	194
12.3.3.	Equipment	194
12.3.4.	Task.....	195
12.3.5.	Procedure	198
12.3.6.	Research questions	199
12.3.7.	Design	199
12.4.	Results	199
12.4.1.	Time dedicated by stage.....	199
12.4.2.	Spatial exploration scope	201
12.4.3.	Gestural interaction language effectiveness	203
12.4.4.	Observational findings	204
12.5.	Discussion	205
12.6.	Conclusions	208

IV Closure	215
13 Discussion	215
13.1. On multi-touch technology usability by kindergarten children	216
13.2. On communicability strategies targeted to young children	219
14 Conclusions and Future Work	223
Bibliography	227
List of Figures	247
List of Tables	253