



A Systematic Literature Review on Learning Software Application Design Framework for Children with Cerebral Palsy

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Abstract— Background Cerebral palsy (CP) is a disorder of physical body movement and posture caused by a lesion or injury of the immature brain. Many children with cerebral palsy frequently develop learning disabilities. A child with a learning disability has an average or above average level of intelligence, but has difficulty processing certain types of information.

Aim The aim of this study is to discover the existing learning and other application design frameworks for children with and without CP, their weaknesses and strengths and the type of empirical evaluations performed in this domain. Learning difficulty among children with CP is the biggest problem that requires immediate attention by the application designers and developers.

Method Our broad search found a number of Systematic Literature Reviews (SLR) corresponding to unique studies. In this review, we could identify the current research on learning software design frameworks for the children with CP and the learning issues based on the lessons learned from the existing works.

Finding / Result Our finding in this SLR shows that most of the developers develop learning software application for children with autism. The studies on children with cerebral palsy are becoming popular throughout the years.

Conclusion The current work is part of the ongoing study for developing a new learning application design framework for the children with CP. This effort will help in improving the learning and hence living standard of special children.

Keywords — Cerebral Palsy, Learning Application Software, Disabled Children

I. INTRODUCTION

Cerebral palsy (CP) is one of the three most common lifelong developmental disabilities, with prevalence rates ranging from 1.5 to 3 per 1000 live births [1]. CP describes

a group of disorders affecting the development of physical body movement and posture, causing activity limitation that is attributed to non-progressive disturbances. CP is the most prevalent chronic childhood motor disability with an estimated lifetime medication cost of nearly \$1 million per person in a 2003 report [2].

CP is the leading cause of childhood deformity and the second leading cause of severe mental retardation [3]. Children with CP have an increased prevalence of associated comorbidities, including intellectual disability (52%), epilepsy (45%), speech/language deficits (38%), vision impairment (28%), and hearing impairment (12%) [4].

Children with CP sometimes face additional physical and cognitive difficulties. As mentioned earlier, damage can extend to multiple areas of the brain that can result in impairing several kinds of functions. Meanwhile, abnormal muscle tone and poor motor control can pose obstacles to learning and development.

Most of the mentioned problems may lead to learning difficulties among children with CP. This requires immediate attention of application designers, so that these children may also benefit by the advancements of technology to ease their livings. This is because we do not want them to lose in this technologies century. Negligence towards this issue may cause children with CP to face a digital divide between them and normal healthy children.

One of the common problems in learning by the children with CP is the difficulty with hand control affecting the basic life necessities of holding, gripping, handwriting, cutting, pasting and cooking etc. The problems in handwriting task may include difficulty in keeping the paper steady, setting out work or completing work within a specific duration.

Other than that, the brain damage that leads to CP can also lead to other health issues, including vision, hearing, and speech problems, and learning disabilities. As the result, the system or applications that need developed for children with CP must focus on their limitation and requirement, which can give the users useful way of learning process and interaction with others.

The intended or proposed Software Application Design Framework (SADF) focuses for developing a learning software application; it must first solve the learning issues among children with CP. The SADF have the management application and the learning application. These two applications are orientated to two types of users: Final users (children with cerebral palsy), who can obtain the best benefices of the system, and the users in charge of manage the application (parents, teachers or people in charge of the tracking of the final user progress and his/her learning).

SADF need to be done for solve the learning issue and as a guideline for the developer to develop the system or application for children with CP.

This paper focuses on the study of learning application design framework and learning issues among children with CP in order to learn how the learning application design framework could later be applied in especially at the two community rehabilitation centers (*Pusat Pemulihan Dalam Komuniti - PDK*) in Malaysia as our case studies.

The objectives of this paper are:

- To identify related works regarding learning application design framework for children with CP.
- To identify the empirical evaluation for evaluating the frameworks for children with CP.

This paper is organized in the following sections; Section II explains the review process followed during the study, Section III reports the study results, and Section IV discusses the study corresponds to the research questioned. Lastly, Section V concludes the study.

II. REVIEW PROCESS

This study has been undertaken as a systematic literature review based on a few guidelines [5][6].The guidelines have three main phases: review planning, review execution, and review reporting phase. The next subsection defines the review planning phase. This phase involves with defining research questions, search strategy, and selection criteria, and finally undertaking qualitative analysis.

Research Questions

The research questions addressed by this study are:

- [RQ1] What is the intensity of the research activities on learning software application framework?
- [RQ2] What are the existing learning software application design frameworks for children with CP? Identify strengths and weaknesses.
- [RQ3] What are the existing learning software application design frameworks for other children? Identify strengths and weaknesses.
- [RQ4] What are the existing any application design frameworks for children with CP? Identify strengths and weaknesses
- [RQ5] What are the types of empirical evaluation framework that usually performed for children with CP?

In order to address RQ1, the papers of existing frameworks are collected from journals and conferences that published between 2008 and 2012. RQ2 focuses on the learning design framework for CP, while RQ3 tries to identify learning application frameworks for children general. Meanwhile, RQ4 attempt to discover any type of design application framework specifically for children with CP. For each RQ2, RQ3 and RQ4, the strengths and weaknesses are discussed respectively. RQ5 elicits the types of empirical evaluation that has been done for children with CP.

The questions were scored as follows:

- RQ1: Y (yes), the inclusion criteria are explicitly defined in the study, N (no), the inclusion criteria are not defined and cannot be readily inferred.
- RQ2: Y Information is presented about each study; N the results of the individual primary studies are not specified.
- RQ3: Y Information is presented about each study; N the results of the individual primary studies are not specified.
- RQ4: Y Information is presented about each study; N the results of the individual primary studies are not specified.
- RQ5: Y Information is presented about each study; N the results of the individual primary studies are not specified.

A. Search Strategy

1. Preliminary search strings in major indexing databases.

Eleven search strings were formed to search the electronic resources listed in next subsection. The following search strings were formed after evaluating the keywords of related literature that were found during a general search of the selected resources:

- i. "Cerebral Palsy" OR "Children with Cerebral Palsy."
- ii. "Children with cerebral palsy" OR Children with CP"

- iii. "Cerebral Palsy with Children" OR Children having cerebral palsy"
- iv. "Learning Software application framework" AND "Education framework."
- v. "Learning Software Design framework"
- vi. "Learning Design framework for children with Cerebral Palsy"
- vii. "Learning Design framework for children"
- viii. "Design framework for children with Cerebral Palsy"
- ix. "Design framework for children"
- x. "Applications Design framework for children with Cerebral Palsy"
- xi. "Applications Design framework for children"

2. Research in major indexing databases

The SLR process recommends searching from several selected electronic sources. The following major indexing databases have been used:

- Google Scholar
- IEEE Explore
- ScienceDirect
- Scopus
- Digital Library
- SpringerLink
- CiteseerX

3. Record search results.

All material that has been found are recorded as search results.

4. Categorization of papers according to types of publications:

The types of publications are conference proceedings, journals, book chapters, books, and technical reports.

B. Selection Criteria

Inclusion and exclusion criteria were used to confirm that only relevant literature was accepted for the SLR.

1. Inclusion Criteria

- a) Only those publications that report on the type of framework that helps the children with CP in learning software application and any application design framework for children with CP.
- b) Papers that involve an empirical study or have a "lessons learned" (experience report) element were included.
- c) Where several papers reported the same study only the most recent paper was included.

2. Exclusion Criteria

- a) Papers and reports were excluded when only the

abstract but not the full text was offered.

- b) Excluded the publication if they are not written in English.

C. Quality Assessment

Quality assessment was done after the data collection was performed from the selected studies. The objective of this phase was to evaluate how relevant the source studies are for our study on learning application design framework for children with CP.

After done the search strategy process; there are 65 papers that suitable for this study. The number of paper after inclusion or exclusion decrease to 24 papers only.

III. RESULT

This section summarizes the results of the study.

3.1 Search results

Appendix A shows the result of the research sources that have been found during the search process. After evaluating the papers, only 24 papers were short-listed based on the inclusion criteria. The papers that were excluded did not present enough information or contain incomplete information about relevant study and also did not realize the defined research questions.

Subsequently, a review on these identified papers has been conducted. In Figure 1, the publication count per year is presented. The papers that have been selected follow the criteria as defined in study process. In Figure 1, ten papers came from the year 2008. The number of papers increased in the year 2009 and 2010, 15 and 16 publications, respectively. In 2011, the number stayed as 16 publications. In 2012, the number of selected studies increased to 20 publications.

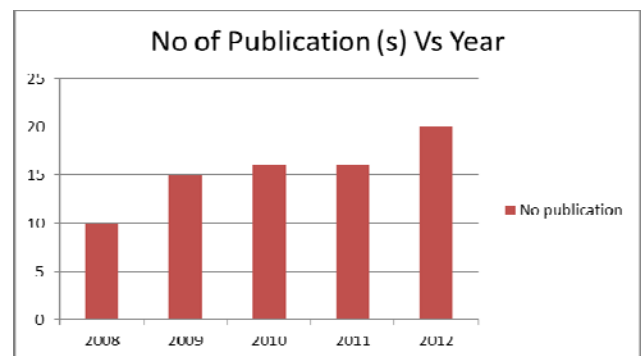


Fig.1: Number of Publications verses Year

The search process was a manual search of specific journals and conference proceedings between 2008 and 2012. The selected journals and conferences proceedings are shown in Table 1. There are seven selected electronic databases are searched during the SLR because there are reliable and trusted published paper and sources and most related to this study area such as Information and Software

Technology (IST), Journal of Systems and Software (JSS), IEEE Transactions on Software Engineering (ISE), IEEE Software (IEEE SW) and etc. The journals and conference were selected because they were known to include either empirical studies or literature surveys, and to have been used as sources for other literature reviews related to design framework for children with CP and other disabled children.

Table 1. The selected journals and conferences proceedings

No	Source	Acronym
1	Information and Software Technology	IST
2	Journal of Systems and Software	JSS
3	IEEE Transactions on Software Engineering	TSE
4	IEEE Software	IEEE SW
5	Empirical Software Engineering Journal	EMSE
6	IET Software	IET SW
7	Proceedings International Conference on Software Engineering	ICSE

Each journal and conference proceedings was reviewed by one of three different researchers (i.e. Nuraini, Masitah and Mahmood) and the papers that addressed literature surveys of any type were identified as potentially relevant. Nuraini coordinated the allocation of researchers to tasks based on the availability of each researcher and their ability to access the specific journals and conference proceedings. The researcher responsible for searching the specific journal or conference applied the detailed inclusion and exclusion criteria to the relevant. Another researcher checked any papers included and excluded at this stage.

3.2. Quality evaluation of SLRs

We assessed the studies for quality using the Quality Assessment that mention in section Review Process. The score for each study is shown in Table 2. The fields marked with an asterisk in Table 2 were originally marked as unknown and were re-assigned after communicating with the study authors. Table 2 shows the quality evaluation of SLRs. Total score get from the total of question that the paper answers for RQ.

Table 2: Quality evaluation of SLRs

No	Article type	RQ1	RQ2	RQ3	RQ4	RQ5	Total Score
S1	Proceeding	Y	N	Y	N	Y	3
S2	Proceeding	N	N	Y	N	Y	2

S3	Proceeding	N	N	Y	N	Y	3
S4	Proceeding	Y	N	N	Y	N	1
S5	Proceeding	Y	N	N	Y	Y	2
S6	Proceeding	Y	N	N	Y	N	1
S7	Proceeding	Y	N	N	Y	N	1
S8	Proceeding	Y	N	N	Y	N	1
S9	Proceeding	Y	N	N	Y	N	1
S10	Proceeding	N	N	N	Y	N	1
S11	Proceeding	N	N	Y	Y	N	3
S12	Proceeding	Y	Y	Y	N	N	3
S13	Proceeding	N	Y	N	Y	Y	4
S14	Proceeding	Y	Y	N	N	Y	3
S15	Journal	Y	Y	Y	Y	N	5
S16	Proceeding	N	Y	N	Y	Y	3
S17	Journal	N	Y	N	Y	Y	3
S18	Proceeding	N	N	Y	N	N	1
S19	Proceeding	N	N	N	Y	N	1
S20	Proceeding	Y	N	Y	N	N	2
S21	Proceeding	N	N	Y	N	N	1
S22	Journal	N	N	Y	N	N	1
S23	Journal	N	N	Y	N	N	1
S24	Proceeding	Y	Y	N	Y	Y	4

IV. DISCUSSION

This section answers the research questions proposed earlier and several lessons are learned based on the findings. The papers in Appendix A were reviewed for answering the proposed research questions.

[RQ1] What is the intensity of the research activities on learning software application framework?

Overall, we identified 24 relevant studies in the sources that we searched, as shown in Appendix A. The studies from S1 to S20 focused on learning software application framework but did not mention about learning software application framework for children with CP. The results of Figure 1 clearly suggest that research activities on this topic have increased during the last year.

[RQ2] What are the existing learning application design frameworks for children with CP? Identify strengths and weaknesses.

According to our designed criteria and the selected data sources we have, any learning software application design framework for children with CP has yet to be found. These points are necessary for research in this area. Most of the design framework only focuses for children rehabilitees and only training their muscles.

[RQ3] What are the existing learning application design frameworks for other children? Identify strengths and weaknesses.

The selected paper (author and year), strengths, weaknesses, and the type of children are listed in Appendix B. From the selected paper, the existing learning software application papers focus on children with autism and slow learner. An application for student with autism to determine the learning agenda and be in control of their on learning but the application is very difficult to be acquired by human experts [8]. While another different application enables the end users to build application software to suit the different need of an autistic child but the application only focus on pre-reading (A to Z) and pre-number skill (1 to 100)[4].

Another work employs both real- world objects and virtual environments equipped with humanoids but the application only focus to children with autism spectrum disorders [10].

[RQ4] What are the existing application design frameworks, besides learning, for children with CP? Identify strengths and weaknesses

The selected paper (author and year), strengths, weaknesses, and the type of application are listed in Appendix C. Most of the applications focus on rehabilitee (motor exercise). The strengths for each application are different. The application focus on colored cards with graphic symbols that replace the music keyboard [5]. Even though it is unique, the weakness of this application is it needs a supervisor or a musical therapist to control and guide the music therapy session. A customized application to the game's parameters that already makes the game different from others, but the video was designed for upper limb rehabilitation robot for children with CP [7]. An application that gives advantage to all children in advancing their driving skill and the children benefited in GMFM-88 functional scores [4]. However, the application is only suitable for children from 18 months to 8 years.

[RQ5] What are the types of empirical evaluation framework for children with CP?

Studies S2 and S3 proposed an experiment for the empirical evaluation of their framework. In S1, it has two instances; design of the framework architecture itself and the limitation and the careful task of addressing the various issues detected in several studies while authors of S1 used the experiment for the empirical evaluation to validate their

framework having two users with different disabilities. Additionally, they build the prototype of a smart house. Likewise, studies S2 and S5 use the case study for the empirical evaluation to validate the transformation of the existing framework. Therefore, empirical evaluation is conducted using experiment or case study.

V. CONCLUSION

This Systematic Literature Review (SLR) on learning application design framework for children with CP presents the latest efforts and challenges by searching the relevant studies. This study has answer the aim of the SLR that we want to discover the existing learning and other application design frameworks for children with and without CP, their weaknesses and strengths and the type of empirical evaluations performed in this domain. Insufficient work has been done in this area. There is a need to further study and evaluate the successes and weaknesses highlighted in the studies mentioned in this SLR of learning application design frameworks. It will support and help the children with CP.

From this review, no publication is found till 2012 that may present any framework solely focusing the children with CP. There are several other learning application design frameworks for healthy children that can be improved and can be adopted to develop a learning application design framework for children with CP. Such framework should also consider the empirical evaluation for better results. This review will be used for our future research which is to design a learning application design framework for children with CP to get the information and knowledge about the design framework for children with CP.

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APPENDIX A

Column Research Question 1 to 5. (RQ1 to RQ5) to identify whether the publication answers the RQ1 to RQ5.

ID	Author	Year	Title	Type	RQ1	RQ2	RQ3	RQ4	RQ5
S1	E. I. Konstantinidis et al.	2009	A Proposed Framework of an Interactive Semi- Virtual Environment for Enhance Educational of Children with Autism Spectrum Disorders	Proceeding	N	N	N	N	Y
S2	Ismail et al.	2009	Developing Learning Software for Children with Disabilities through Block-Based Development Approach	Proceeding	N	N	N	N	Y
S3	M.V. Judy et al.	2009	Constructing a Personalized E-learning System for Student with Autism Based on Soft Semantic Web Technologies	Proceeding	N	N	N	N	Y
S4	Z. Che Embi	2008	The implementation of Framework for Edutainment : Education Games Customization Tool	Proceeding	N	N	N	N	N
S5	C. S. Wang and Y. C. Li	2011	A Game based Learning Content Design Framework for the Elementary School Children Education	Proceeding	N	N	N	N	Y
S6	T. L Wang et al.	2010	An Learner-centred, Game-based, Learning Framework for typing Games in English Course	Proceeding	N	N	N	N	N
S7	A.A I-Badowi and E. Celebi	2009	E-Learning Designing and the Implementation in the Light of the Australian Flexible Learning Framework : In Syrian Virtual University Roadmap to Success	Proceeding	N	N	N	N	N
S8	F. Gaudenco et al.	2009	Sensitive Learning: A new Framework Proposal In Learning Contexts	Proceeding	N	N	N	N	N
S9	K. Bahrami et al.	2007	A Web Service-Based Portal Framework for Distance Learning on Power Line Network	Proceeding	N	N	N	N	N

S10	Y. Liu et al.	2007	Design and Application of Multimedia Mobile Learning Framework	Proceeding	N	N	N	N	N
S11	M. Dragomiroiu et al.	2008	Application Framework Development for Virtual Learning Environment	Proceeding	N	N	N	N	N
S12	S.K. Agrawal et al.	2012	Feasibility Study of Robot Enhanced Mobility in Children with Cerebral Palsy	Proceeding	N	N	N	N	N
S13	E.C.P et al.	2012	Serious gaming to improve bimanual coordination in children with Spastic Cerebral Palsy	Proceeding	N	N	N	N	N
S14	A.G.D. Correa and I.K.Ficheman	2009	Computer Assisted Music Therapy : a Case study of an Augmented Reality Musical System for Children with Cerebral Palsy Rehabilitees	Proceeding	N	N	N	N	N
S15	T. Falkmer et al.	2000	Driver education for persons with cerebral palsy- a retrospective study of educational problem	Journal	N	N	N	N	N
S16	R. H. Eckhouse et al.	2008	Improving Reaching in Preschool Children with Cerebral Palsy Through Regulated Feedback	Proceeding	N	N	N	N	N
S17	H. Dalvand et al.	2009	Comparing Extreme Programming and Feature Effect Of The Bobath Technique, Conductive Education And Education To Parents In Activities Of Daily Living In Children With Cerebral Palsy In Iran	Journal	N	N	N	N	N
S18	A.Z. Romle and D. Singh	2011	Integrated Parent Information System (SMIB) to increase Parental Involvement in Children's Learning Process in Malaysia Primary School	Proceeding	N	N	N	N	N
S19	J. Mezak and N. H. Bozic	2006	An Approach to Modelling Adaptive Hypermedia for Children with Disabilities	Proceeding	N	N	N	Y	N
S20	M.N.H.N.Jono and	2008	A Framework for Reading Comprehension Practise Using	Proceeding	N	N	N	N	N

	A.M. Yasin		Interactive 3D Animation						
S21	A.Mukherjee et al.	2012	A Virtual Predictive Keyboard as a Learning Aid People with Neuro-motor Disorders	Proceeding	N	N	N	N	N
S22	N. Abdollah et al.	2012	Development and Usability Study of Multimedia Courseware for Slow Learners: 'Komputer Saya'	Journal	N	N	Y	N	N
S23	M.Frutos et al.	2011	Computer Game to learn and enhance speech problems for Children with Autism	Journal	N	N	Y	N	N
S24	M. Huber et al.	2007	PlayStation 3-based Tele-rehabilitation for Children with Hemiplegia	Proceeding	Y	Y	N	Y	Y

APPENDIX B

This table describes the strength and weakness for existing learning application design frameworks for other children.

Paper	Strength	Weakness	Type of Children
M.U Judy <i>et al.</i> (2009)	<ul style="list-style-type: none"> • Help student not to look for course distributed across many location. • Determine the learning agenda and be in control of their on learning. • Perform semantic querying for learning materials linked 	<ul style="list-style-type: none"> • Very difficult to be acquired by human experts 	Student with Autism
A. Ismail <i>et al.</i> (2009)	<ul style="list-style-type: none"> • Enables the end users to build application software to suit the different need of an autistic child. 	<ul style="list-style-type: none"> • Focused on pre-reading (A to Z) and pre-number skill (1 to 100) 	Student with Autism
E. I. Konstantinidis <i>at el.</i> (2009)	<ul style="list-style-type: none"> • Used for daily educational of an autism • Employs both real- world objects and virtual environments equipped with humanoids • Provide emotional feedback and demonstrate empathy. 	<ul style="list-style-type: none"> • Integrations of the various independent components • Focus to children with autism spectrum disorders. 	Children with Autism Spectrum Disorders.
N. Abdollah <i>at el.</i> (2012)	<ul style="list-style-type: none"> • Integrates special education syllabus for learning disabled with the multimedia theme. • Use multimedia element in developing courseware. 	<ul style="list-style-type: none"> • Specially designed for slow learners. • The experiment also required researcher to be with the children along the test. 	Slow learner

APPENDIX C

This table describe the strength and weakness for existing any application design frameworks for children with CP

Paper	Strength	Weakness	Type of Application
B. Grasielle <i>et al.</i> (2009)	<ul style="list-style-type: none"> • Colored cards with graphic symbols replace the music keyboard. • Therapist can print cards of different sizes and place them in various ways, according to the desired motor exercise. • Each card represents a different musical note in the timbre of a given musical instrument. 	<ul style="list-style-type: none"> • Need supervisor or music therapy to control and guide the music therapy session. • The system could not serve therapeutic. 	Music Therapy for rehabilitee (motor exercise)
J. E. C. Zaipen <i>et al.</i> (2011)	<ul style="list-style-type: none"> • A video game for the rehabilitation of the pronation and supination movement. • Customization of the game's parameters makes the game different 	<ul style="list-style-type: none"> • Specific for only car games. • The video was designed for upper limb rehabilitation robot for children with CP 	Video Game for the rehabilitation of the pronation and supination movement.
S. K. Agrawal <i>et al.</i> (2012)	<ul style="list-style-type: none"> • Use special purpose robotic chair driven by joystick • All children advanced in their driving skill and benefited in GMFM-88 functional scores. 	<ul style="list-style-type: none"> • Designed to use by neuro-motor dysfunction with spasticity. • Used for children from 18 months to 8 years. 	Driving car for rehabilitee (motor exercise)
B.M Odle (2012)	<ul style="list-style-type: none"> • The platform assist them with achieving those goals, was assessed with functional tasks. • The platforms allow users to play video games for therapeutic. 	<ul style="list-style-type: none"> • Need three supervisor or therapist to control and conduct the game. • The systems are often expensive making not impractical for the clinical and home setting. 	Video Game purpose by tracking speed, accuracy of the games