THE EFFECTIVENESS OF LEARNING PROGRAMMING USING ROBOT-BASED LEARNING APPROACH ON STUDENTS' ACADEMIC PERFORMANCE AND MOTIVATION

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SULTAN IDRIS EDUCATION UNIVERSITY
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ABSTRACT

This research aimed to evaluate the effectiveness of learning programming using robot-based learning (RBL) approach on students' academic performance and motivation. The study used a quasi-experimental research design involving a control group and a treatment group, each consisting of 20 students. Learning in both groups was carried out for a month, during which data were collected through programming tests and Course Interest Survey (CIS). Data were analyzed using the ANOVA and the Kruskal-Wallis H-test. The F-test revealed that the difference in the mean scores of academic performance between the treatment group (mean=19.55) and control group (mean=23.45) was not significant (F (1,38) =0.730, p=.398). Likewise, the Kruskal-Wallis H-test, which was performed on four motivational factors, showed that the difference in the mean scores of the attention factor between the treatment group (mean=18.93) and control group (mean=21.13) was not significant ($x^2(1)$ =.368, p=.544). The relevance factor also did not show any significant difference between the treatment group (mean=18.93) and control group (mean=21.13), with a significance of ($x^2(1)$ =2.854, p=.091). The confidence factor showed no significant difference ($x^2(1)$ =.244, p=.622) between the treatment group (mean=20.88) and the control group (mean=19.08). The satisfaction factor also showed no significant difference ($x^2(1)$ =.156, p=.693) between the treatment group (mean=19.30) and the control group (mean=20.74). In conclusion, these findings suggest that learning using the RBL approach is as effective as using the conventional approach. Nonetheless, evidence from classroom observations showed that students who used the RBL approach were more active than their counterparts who used the conventional approach. The study implies that RBL approach helps students to learn programming in a more active learning environment.

KESAN PEMBELAJARAN PENGATURCARAAN MENGGUNAKAN PENDEKATAN PEMBELAJARAN BERASASKAN ROBOT TERHADAP PRESTASI AKADEMIK DAN MOTIVASI PELAJAR

ABSTRAK

Kajian ini bertujuan untuk menilai kesan pembelajaran pengaturcaraan menggunakan pendekatan pembelajaran berasaskan robot (RBL) terhadap prestasi akademik dan motivasi pelajar. Kajian ini menggunakan reka bentuk kajian kuasi-eksperimen yang melibatkan satu kumpulan kawalan dan satu kumpulan rawatan dengan setiap kumpulan mempunyai 20 orang pelajar. Rawatan pembelajaran dua kumpulan ini telah dijalankan selama sebulan di mana data dikumpulkan melalui ujian pengaturcaraan dan Kaji Selidik Minat Kursus (CIS). Data dianalisis menggunakan ujian ANOVA dan Ujian-H Kruskal-Wallis. Ujian ANOVA menunjukkan perbezaan tidak signifikan ($F(1,38)=0.730$, $p=.398$) dalam skor min prestasi akademik di antara kumpulan rawatan (min=19.55±16.27) dan kumpulan kawalan (min=23.45±12.32). Begitu juga dengan analisis Ujian-H Kruskal-Wallis yang digunakan terhadap empat faktor motivasi yang menunjukkan perbezaan tidak signifikan ($x^2(1)=.368$, $p=.544$) dalam skor min faktor perhatian di antara kumpulan rawatan (min=18.93±6.609) dan kumpulan kawalan (min=21.13±6.609). Faktor relevansi juga menunjukkan perbezaan tidak signifikan ($x^2(1)=2.854$, $p=.091$) antara kumpulan rawatan (min=18.93±6.609) dan kumpulan kawalan (min=21.13±6.609). Faktor percaya diri mempunyai perbezaan tidak signifikan ($x^2(1)=.244$, $p=.622$) antara kumpulan rawatan (min=20.88±5.789) dan kumpulan kawalan (min=19.08±5.789). Faktor kepuasan juga mempunyai perbezaan tidak signifikan ($x^2(1)=.156$, $p=.693$) antara kumpulan rawatan (min=19.30±7.167) dan kumpulan kawalan (min=20.74±7.167). Kesimpulannya, dapatan menunjukkan pembelajaran menggunakan pendekatan RBL adalah berkesan sama seperti dengan pembelajaran berdasarkan pendekatan konvensional. Namun, bukti dari pemerhatian dalam kelas menunjukkan pelajar yang menggunakan pendekatan RBL lebih aktif dari mereka yang menggunakan pendekatan konvensional. Implikasi kajian membayangkan pendekatan RBL membantu pelajar mempelajari pengaturcaraan di dalam persekitaran pembelajaran yang lebih aktif.

CONTENTS

		Page
DECLARATION OF ORIGINAL WORK		ii
DECLARATON OF DISSERTATION		iii
AKNOWLEDGEMENT		iv
ABSTRACT		v
ABSTRAK		vi
CONTENTS		vii
LIST OF TABLES		xi
LIST OF FIGURES		xiii
LIST OF ABBREVIATIONS		xiv
LIST OF APPENDICES		xv
CHAPTER 1 INTRODUCTION		
1.1	Introduction	1
1.2	Research Background	3
1.3	Problem Statement	7
1.4	Research Aim	8
1.5	Research Objectives	8
1.6	Research Questions	9
1.7	Research Hypothesis	10
1.8	Importance of Research	11
1.9	Study Limitations	13
1.10	Operational Definitions	14

CHAPTER 2 LITERATURE REVIEW

2.1	Introduction	15
2.2	STEM Education	17
2.3	Computer Programming	19
2.4	Generation	21
2.5	Motivation	25
2.6	ARCS-Based Measures of Motivation	28
2.7	Constructivism	30
2.8	Learning Approach	33
	2.8.1 Active Learning Approach	36
2.9	Robot	37
2.10	Robot-based Learning (RBL)	41
2.11	Conclusion	44

CHAPTER 3 METHODOLGY

3.1	Introduction	46
3.2	Research Design	47
3.3	Population and Sample	49
3.4	Instruments	52
	3.4.1 Content Validity	55
3.5	Pilot Study	57
3.6	Data Collection Procedures	59
3.7	Techniques of Analysing Data	60
3.8	Potential Sources of Bias or Errors	62
3.9	Conclusion	64

CHAPTER 4 DATA ANALYSIS AND DISCUSSION

4.1 Introduction 65

4.2 Pre-Test 67

4.2.1 Descriptive Statistics 67

4.2.2 Normality Test 68

4.2.3 Kruskal-Wallis H-Test 69

4.3 Academic Performance 71

4.3.1 Normality Test 71

4.3.2 Homogeneity of Variance Test 72

4.3.3 ANOVA: Research Question One 73

4.4 Post-Test 74

4.4.1 Normality Test 75

4.4.2 Homogeneity of Variance Test 76

4.4.3 ANOVA: Research Question Two 77

4.5 Motivation 78

4.5.1 Attention 79

4.5.2 Relevance 81

4.5.3 Confidence 83

4.5.4 Satisfaction 84

4.6 Summary of the Research Findings 85

4.7 Conclusion 87

CHAPTER 5 DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction 88

5.2 Discussion on Research Findings 89

5.3 Implications of the Findings 93

5.4 Limitations 95

5.5 Recommendations for Future Research 96

5.6 Concluding Remarks 97

REFERENCES 98

LIST OF TABLES

Table No.		Page
3.1	Determining Sample Size from a Given Population	50
3.2	CIS Internal Consistency Estimates	54
3.3	Research Objectives and their Respective Data Analysis Techniques	61
4.1	Pre-Test Descriptive Statistics	68
4.2	Pre-Test Normality Test	69
4.3	Pre-Test Ranks	69
4.4	Pre-Test Statistics	70
4.5	Academic Performance Normality Test	71
4.6	Academic Performance Test of Homogeneity of Variance	72
4.7	Academic Performance Descriptive Statistics	73
4.8	Academic Performance ANOVA Results	74
4.9	Post-Test Normality Test	75
4.10	Post-Test Test of Homogeneity of Variance	76
4.11	Post-Test Descriptive Statistics	77
4.12	Post-Test ANOVA Results	77
4.13	Attention Descriptive Statistics	79
4.14	Attention Ranks	79
4.15	Attention Statistics	80
4.16	Relevance Descriptive Statistics	81

4.17	Relevance Ranks	82
4.18	Relevance Statistics	82
4.19	Confidence Descriptive Statistics	82
4.20	Confidence Ranks	83
4.21	Confidence Statistics	83
4.22	Satisfaction Descriptive Statistics	84
4.23	Satisfaction Ranks	84
4.24	Satisfaction Statistics	85

LIST OF FIGURES

Figure No.		Page
2.1	10 most popular programming languages in 2018	20
2.2	The different generations according to Mccrindle	22
2.3	Characteristics of generation Z	24
2.4	Six high-impact motivation strategies	26
2.5	Keller's ARCS Model with Four Motivational Factors	27
2.6	Deep and surface approaches to learning	34
2.7	Types of robots based on their application	38
2.8	Types of robots based on their movements	39
2.9	Three dimensions of computational thinking	44
3.1	Tests of Normality	58

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
API	Application Programming Interface
ARCS	Attention, Relevance, Confidence and Satisfaction
CIS	Course Interest Survey
ER	Educational Robotics
ICT	Information & Communication Technology
IDII	Interaction Design Institute Ivrea
IMMS	Instructional Materials Motivation Survey
ISTE	International Society for Technology in Education
IT	Information Technology
MOE	Ministry of Education Malaysia
NSF	National Science Foundation
PBL	Problem-based Learning
RBL	Robot-based Learning approach
STEM	Science, Technology, Engineering, and Mathematics
TT	Traditional Teaching approach

LIST OF APPENDICES

A	Research Information Sheet
B	Informed Consent
C	Content Validity Booklet
D	Test that was given to the students as both a pre-test and post-test
E	Course Interest Survey (CIS)
F	Treatment Group Data
G	Control Group Data
H	Pre-Test Analysis Output
I	Academic Performance Analysis Output
J	Post-test Analysis Output
K	Attention Analysis Output
L	Relevance Analysis Output
M	Confidence Analysis Output
N	Satisfaction Analysis Output

CHAPTER 1

INTRODUCTION

1.1 Introduction

“With the "flattening" of the global economy in the 21st century, the teaching of Science, Technology, Engineering, and Mathematics (STEM) has taken on new importance as economic competition has become truly global” (Kennedy & Odell, 2014, p. 246). According to Bybee (2013, p. 1) “contemporary STEM originated in the 1990s at the National Science Foundation (NSF) as an acronym for science, technology, engineering and mathematics”. STEM has evolved and removes the traditional barriers between these subjects and makes use of the current tools, technologies and innovation

to create solutions to complex contextual problems (Kennedy & Odell, 2014). According to Fadzil and Saat (2014), emphasis has been placed on the importance of science and the affective teaching and learning of it in schools in order to help Malaysia attain its aspirations of being fully developed and industrialized by the year 2020. In addition, STEM can help Malaysia's efforts in attaining the status of a knowledge-based economy by producing a knowledgeable and competent population that is creative and capable of leading the Malaysian nation in attaining its Vision 2020 (Fadzil & Saat, 2014). In this dissertation the researcher concentrated on programming as a subset of science, technology, engineering and mathematics (STEM) in education.

According to Christenson (2011) "A programming language is a set of commands, instructions, and other syntax use to create a software program". "Teaching programming to school students is challenging as different concepts have to be conveyed to the learners, who most of the time do not understand why the concepts have certain rules" (Mahdin, Senan, Kasim, Ibrahim & Abdullah, 2016). In addition Mahdin et al. (2016) stated that "Current teaching methods are not suitable especially when we have to use back slash, asterisk and space to the beginners. These can be considered as tedious tasks to learn computer as they only need to slide most of the time when using their tablet, such as the iPad". With all the different problems that have been hindering the teaching and learning of programming, stakeholders in education have tried different teaching approaches with an intent of finding the best one. Zhang, Zhang, Stafford and Zhang (2013) divided the teaching and learning approach into two categories: Traditional teaching approach and Active Learning Approach. Where the traditional teaching approach is teacher centred while the active learning approach uses

exercises and peer learning combined with mini-lectures where necessary, as compared to the traditional extended lecture approach.

This dissertation focused on a subset of the active learning approach, called robot-based learning approach and analysed how effective it was in teaching programming to diploma students as compared to the traditional learning approach. Robot-based learning approach is part of educational robotics which can be defined as, "a field of study that aims to improve learning experience of people through the creation, implementation, improvement and validation of pedagogical activities, tools (e.g. guidelines and templates) and technologies, where robots play an active role and pedagogical methods inform each decision" (Angel-Fernandez & Vincze, 2017, p. 41). The motivation behind the research was based on current ongoing issues experienced during the teaching and learning of programming such as, young talents leaving because of the inappropriate approaches used to teach the subject (Mahdin et al., 2016). Mahdin et al. (2016) further stated that "learning computer need to be revolutionize to cater for the needs of this iPad generation", also that programming is not as hard as many think unless learners are introduced to it incorrectly which results in them losing interest.

1.2 Research Background

"Since the 1960s, computer scientists and enthusiasts have paralleled computer programming to literacy, arguing it is a generalizable skill that should be more widely taught and held" (Vee, 2013, p. 42). Computer programming falls under STEM education and it also encompasses all the other fields in STEM, namely: science,

technology, engineering and mathematics as it is being used to solve different STEM problems using computers and different emerging technology. One can realise the importance of computer programming to help the advancement of STEM education in the different sectors of education in Malaysia. Vee (2013, p. 59) urged that "programming could eventually become the foundation of a new, computational literacy. But regardless of programming's future path, it is already a material intelligence and a powerful form of composition".

The current teaching methods for computer programming in schools are not suitable (Mahdin et al., 2016), because as Grout and Houlden (2014) explained rather than studying programming, computer systems, computational thinking and problem solving the school children are being taught Information Technology (IT) and Information & Communication Technology (ICT). In addition, Grout and Houlden (2014) stated that a typical IT/ICT syllabus included a combination of coursework based mainly on office software and a project to create a video or presentation which is uninspiring. This type of syllabus goes hand in hand with a traditional teaching approach, which is teacher centred and includes extended lectures where the teacher delivers content to the students and tests them at the end to find out if the learning objectives are met. Zhang et al. (2013, p. 148) further explained that "this traditional teaching approach, used for decades in programming courses, usually produces satisfactory results in terms of student learning performance on tests covering lecture concepts". The problem with this approach arises when learners are presented with problems that do not cover the lecturing concept, and in order to mould the learners into innovative problem solvers, who after grasping the different programming concepts can

tackle different programming or technological problems an active learning approach is slowly being implemented in schools.

Using the traditional approach creates learners who are passive recipients of information from the teacher and they will often find the programming classes dry and boring (Zhang et al., 2013).

> In view of this common perception, some educators have begun to experiment with established instructional approaches, redesigning software development courses into more active learning experiences, using exercises and peer learning combined with mini-lectures, where necessary, as compared to the traditional extended lecture approach.
> (Zhang et al., 2013, p. 149)

Zhang et al. (2013) further stated that the active approach to learning emerged in literature in the early 1990s, and involves instructional activities that lead students in "doing things and thinking about what they are doing" (Bonwell and Eison, 1991, p. 1). In this dissertation the researcher looked at the effectiveness of only one of the active learning approaches, which is called Robot-based Learning (RBL) approach. Equally important the RBL approach was selected because "robotics systems were initially designed for industry; however, have been quickly adapted by educators despite the lack of research supporting their effectiveness" (Erdogan, Corlu & Capraro, 2013, p. 3). Also, "researchers have claimed that robotics systems would help students assimilate concepts that would otherwise be abstract and obscure" (Erdogan et al., 2013, p. 3) and that these systems can effectively boost learner and teacher motivation. In addition to motivational benefits RBL has a potential to provide a medium for holistic and interdisciplinary learning (Erdogan et al., 2013).

Furthermore, “various studies show that educational robots are effective in promoting communication between students, improving the working environment, and generating very satisfying teaching and learning experiences” (Ortiz, Franco, Garau & Martín, 2016, p. 1). Ortiz, Franco, Garau and Martín (2016, p. 1) also stated that “there is evidence that incorporating new technologies in these environments increases students’ interest and motivation”. In the same way researchers are trying to ensure that interest in the classes does not quickly diminish as the novelty in robotics wears off (Chiou, 2012). RBL uses a problem-based approach, which is defined as an “instructional method that presents information on the course topic followed by inviting the students to consider how they might use the information to solve related problems and whether they need to learn more in order to master such problems” (Zhang et al., 2013, p. 149). Additionally RBL can also makes use of a project-based approach when a particular lesson activity requires it.

Mubin, Stevens, Shahid, Mahmud and Doug (2013, p. 2) supported that “The use of robots in education is either intra-curricular or extra-curricular”. Intra-curricular activities are part of the school curriculum and a formal part of the syllabus (Mubin et al., 2013), this includes robot competitions or projects that take place at the end of the learning process and make up the assessment-based learning. The extra-curricular take place after school hours at the school as workshops under the guidance of instructors or at home under guidance of parents or other designated locations (Mubin et al., 2013). Depending on the content, teacher, type of learner and the nature of the learning activity the robot can be a tool/teaching aid, a peer and have spontaneous participation or tutor. Mubin et al. (2013, p. 3) further added that “there exist numerous robotic kits, ranging

from low-cost single function kits to LEGO Mindstorms to humanoid robots costing thousands of dollars".

One of the most difficult aspects of becoming a teacher is learning how to motivate your students. It is also one of the most important as "studies have concluded that students who are motivated to learn are more likely to engage, persist, and expend effort in completing tasks than students who are unmotivated" (Chin, Hong & Chen, 2014, p. 333). In this dissertation, the students' motivation was determined using the ARCS model, which was developed by John Keller in the year 1984. The ARCS model is an instructional design approach that focuses on the motivational aspects of learning environment. "The ARCS Model defines four major conditions (Attention, Relevance, Confidence, and Satisfaction) that have to be met for people to become and remain motivated" (Keller, 1987, p. 3). The four major conditions defined by the model were used to create the acronym ARCS.

1.3 Problem Statement

One of the biggest problems with the current traditional teaching approach is that the learners do not find the lessons interesting as all they do is sit in the class and the teacher talks about different concepts over a period of time. According to Zhang et al. (2013) the learners become passive receivers of information. With this method the learners will find the class boring and their interest is not sparked which cause the following problems: firstly the learners will find the classes dry and boring (Zhang et al., 2013),

which would finally affect how much interest and effort they put into completing their tasks, projects and studying.

The second problem was that "students are falling behind, failing the exams, and eventually dropping out of the study program" (Lykke, Coto, Mora, Vandel & Jantzen, 2014, p. 545). Also, Lykke et al. (2014, p. 545) stated that this happens because of the "lack of immediate and successful results that often comes with learning programming", which demotivates and frustrates the students "this situation is even more serious, given the lack of patience exhibited by current programming students" (Lykke et al., 2014, p. 545).

1.4 Research Aim

The aim of this research is to evaluate the effectiveness of the robot-based learning (RBL) approach, by comparing it to the traditional teaching approach in learning programming by looking at the learners' academic performance and motivation in both the approaches.

1.5 Research Objectives

Looking at the research aim the following were the three formulated research objectives:

1) To compare the Robot-Based Learning (RBL) approach to the Traditional Teaching (TT) approach towards the students' academic performance in learning programming.
2) To analyse the performance of the students that were taught using the RBL approach against the performance of the students that were taught using the TT approach.
3) To measure and compare the four motivational factors (attention, relevance, confidence, and satisfaction) listed in Keller's ARCS Model, for the students that were taught using RBL approach and the students that were taught using the TT approach.

1.6 Research Questions

Looking at the research objectives, the following were the six formulated research questions:

RQ1: Is the academic performance of the students that were taught using the RBL approach higher than the academic performance of the students that were taught using the TT approach?

RQ2: Is the post-test performance of the students that were taught using the RBL approach higher than the post-test performance of the students that were taught using the TT approach?

RQ3: Are the students that were taught using the RBL approach more motivated by the aspect of attention compared to those that were taught using the TT approach?

RQ4: Are the students that were taught using the RBL approach more motivated by the aspect of relevance compared to those that were taught using the TT approach?

RQ5: Are the students that were taught using the RBL approach more motivated by the aspect of confidence compared to those that were taught using the TT approach?

RQ6: Are the students that were taught using the RBL approach more motivated by the aspect of satisfaction compared to those that were taught using the TT approach?

1.7 Research Hypothesis

Looking at the research questions, the following six research hypothesis were formulated:

H01: There is no significant difference between the mean academic performance of the students that were taught using the RBL approach and the students that were taught using the TT approach.

H02: There is no significant difference between the mean post-test score of the students that were taught using the RBL approach and the students that were taught using the TT approach.

H03: There is no significant difference in the total number of students who were motivated by the aspect of attention between the students that were taught using the RBL approach and the students that were taught using the TT approach.

H04: There is no significant difference in the total number of students who were motivated by the aspect of relevance between the students that are were taught using the RBL approach and the students that were taught using the TT approach.

H05: There is no significant difference in the total number of students who were motivated by the aspect of confidence between the students that were taught using the RBL approach and the students that were taught using the TT approach.

H06: There is no significant difference in the total number of students who are motivated by the aspect of satisfaction between the students that were taught using the RBL approach and the students that were taught using the TT approach.

1.8 Importance of Research

This research would help teachers in determining whether RBL approach helps increase the learners' academic performance by making the lessons fun and interesting which will consequently catch their attention during the lessons. This would lead to learners that listen in the classroom and who know what they do not understand and can in turn ask the teacher to explain in more detail, whatever concept they do not understand.

Teachers could also determine how many factors motivate the learners when using RBL and if they are more as compared to the traditional teaching approach of computer programming. If the research's findings do indeed support that RBL increases the learners' academic performance, then teachers would have a new tool and approach to help increase learners' computational thinking ability. Eguchi (2014, p. 29) stated that "computational thinking is increasingly being viewed as an important ingredient of STEM learning in primary and secondary education". Eguchi (2014) further claimed that STEM is a pressing matter for policymakers, curriculum designers as well as researchers since modern economies are being influenced by technology related industries. "When designing, constructing, programming and documenting autonomous robots, students not only learn how technology works, but they also apply the skills and content knowledge learned in school in a meaningful and exciting way" (Eguchi, 2014, p. 30). This could results in learners that would grow into members of the population who could use concepts learned in school to solve new problems that arise in the future.

Hence the findings of this research would help determine whether RBL has a positive impact on the learners, if there is a positive impact could it also be incorporated in to the other branches of STEM to help improve the learners' performance. This research will support the earlier statement that "in addition help Malaysia's efforts in attaining the status of a knowledge-based economy by producing a knowledgeable and competent population that is creative and capable of leading the Malaysian nation in attaining its Vision 2020" (Fadzil & Saat, 2014). Incorporating RBL into STEM would mean that it can also be used in other subjects therefore introducing it into education, which would in turn assist the stake holders in education to modify their curriculums to

incorporate emerging learning approaches and create lessons that are more suited for current generation z and alpha learners.

This research would help create awareness and educate the educational stakeholders on RBL, which could lead to more research being carried out on it and as well as all the different sectors it can be incorporated in. This would also allow for more investments into the information technology sector allowing research and development into new breakthroughs as RBL relies heavily on robots which fall under the information technology industry, emphasizing the importance of this industry to everyday life and education.

1.9 Study Limitations

"Comprehensive reviews exist for robotics (in particular social robotics), where educational robotics has been touched upon but not in great detail" (Mubin et al., 2013, p. 1). Researchers are still trying to determine how much more robots can be used in education to benefit the leaners and teachers, as well as if under the right conditions the benefits would outweigh the disadvantages.

The proposed research only focused on a group of diploma students who are pursuing a Diploma in Computer Science at Sultan Idris University of Education. The research ran an experiment comparing RBL and TT approaches for a duration of one month. The required data was collected during the length of the experiment from the students who participated in this research.

1.10 Operational Definitions

Looking at the overall study,, the following are the intended operational definitions:

a) RBL: The use of robotics in the teaching and learning process (in the educational practice) as a subject matter and/or as a cognitive-learning tool to achieve disciplinary learning objectives.
b) Programming: Is the process of designing and building an executable computer program for accomplishing a specific computing task.
c) Effectiveness: The degree to which a person can successfully accomplish a desired action.
d) Academic performance: This is the extent to which a learner has achieved their short or long-term educational goals.
e) Motivation: Is the reason for people's actions, willingness and goals.
f) Robot: A machine capable of carrying out a complex series of actions automatically, especially one programmable by a computer.

This chapter introduced the research and outlined different aspect of the research such as the research background which provided a window into the current state of RBL and what avenues are already explored. This chapter also outlined the research gap, providing an appropriate problem that needed solving during this research along with the different milestones that needed to be achieved and questions that could be answered using the analysed data that was collected during the experiment p[illegible]. Lastly this chapter discussed the importance of this research along with its limitations.