EFFECTS OF ALGEBRAIC REASONING INTEGRATION OF COMPUTATIONAL THINKING ON WORD PROBLEM-SOLVING IN AN INTERNATIONAL SCHOOL IN MALAYSIA

By

KU SOH TING

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

October 2022

FPP 2022 62

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

EFFECTS OF ALGEBRAIC REASONING INTEGRATION OF COMPUTATIONAL THINKING ON WORD PROBLEM-SOLVING IN AN INTERNATIONAL SCHOOL IN MALAYSIA

By

KU SOH TING

October 2022

Chair : Othman bin Talib, PhD
Faculty : Educational Studies

Word problems solving refers to the students' ability on interpreting the problems, converting their knowledge into mathematical statements, and then doing arithmetic computations. In this study, the strength and precision of students' word problem-solving skills based on their additive and logical reasoning are studied. This study expanded coding by integrating it with the computational thinking and algebra reasoning that strengthened the communication, collaboration, logical reasoning, additive reasoning, and word problem solving abilities among students. The algebraic reasoning integration of computational thinking (AR-CT) instructional design was developed from the ADDIE model (Analyze, Design, Develop, Implement, and Evaluate). Sequential mixed method approaches incorporating interview, systematic literature review, and quasi-experimental procedures were used to collect the data. The experimental group (AR-CT) and the conventional instruction as control group (CVI) were investigated in this research. Through paired t-test results, the AR-CT group intervention outperformed than CVI group in terms of word problem solving, additive reasoning, and logical reasoning. Meanwhile, the impacts of the prior knowledge of arithmetic, computational thinking and ability of word problem solving on the effectiveness of AR-CT on performance of word problem solving are studied. When the analysis of covariance (ANCOVA) was adjusted for prior knowledge, the post-test of word problem-solving skills and additive reasoning remained significant, but not for logical reasoning. The results shown the students is increasingly affected in the order of prior computational thinking followed by prior arithmetic knowledge and word-problem solving skills, which these factors are selected as statistical covariates in this analysis. Adoption of AR-CT instructional strategy in math lessons can improve the additive reasoning however, there is no sign of enhancement on the logical reasoning of the students. The modules' benefits students' pre-algebra concepts and coding when solving word problems. Meanwhile, encouraging teachers to interact with students and teachers' creativity in creating excellent teaching situations.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KESAN INTEGRASI ANTARA PENAAKULAN ALGEBRA DAN PEMIKIRAN KOMPUTASIONAL TERHADAP PENYELESAIAN MASALAH PERKATAAN DI SEBUAH SEKOLAH ANTARABANGSA DI MALAYSIA

Oleh

KU SOH TING

Oktober 2022

Pengerusi : Othman bin Talib, PhD
Fakulti : Pengajian Pendidikan

Penyelesaian masalah perkataan merujuk kepada kebolehan pelajar mentafsir masalah, menukar pengetahuan mereka kepada pernyataan matematik, dan kemudian melakukan pengiraan aritmetik. Dalam kajian ini, keupayaan dan ketepatan kemahiran menyelesaikan masalah perkataan pelajar berdasarkan penaakulan tambahan dan logik mereka dikaji. Kajian ini memperluaskan pengekodan melalui pengintegrasian dengan pemikiran komputasi dan penaakulan algebra yang mengukuhkan komunikasi, kerjasama, penaakulan logik, dan penaakulan aditif serta kebolehan menyelesaikan masalah perkataan di kalangan pelajar. Rekabentuk pengajaran penaakulan algebra berintegrasikan pemikiran komputasi (AR-CT) dibangunkan menerusi model ADDIE (Menganalisis, Merekabentuk, Pembangunan, Pelaksanaan, dan Penilaian). Pendekatan kaedah campuran berurutan yang meliputi temu bual, tinjauan literatur sistematik dan prosedur kuasi-eksperiman telah digunakan untuk mengumpul data. Kumpulan eksperimen (AR-CT) dan pengajaran konvensional sebagai kumpulan kawalan (CVI) telah dikaji dalam kajian ini. Berdasarkan keputusan ujian t-berpasangan, kumpulan intervensi AR-CT mengatasi prestasi kumpulan CVI dari segi penyelesaian masalah perkataan, penaakulan aditif, dan penaakulan logik. Manakala, kesan pengetahuan sedia ada tentang aritmetik, pemikiran komputasi dan kebolehan menyelesaikan masalah perkataan terhadap keberkesanan AR-CT dalam prestasi penyelesaian masalah perkataan juga dikaji. Apabila analisis kovarians (ANCOVA) diselaraskan dengan pengetahuan sedia ada, ujian pasca kemahiran menyelesaikan masalah perkataan dan penaakulan aditif kekal signifikan, tetapi tidak untuk penaakulan logik. Keputusan menunjukkan pelajar semakin terkesan menurut susunan pemikiran komputasi sedia ada diikuti oleh pengetahuan aritmetik sedia ada dan kemahiran menyelesaikan masalah perkataan, dimana faktor-faktor ini dipilih sebagai kovariat statistik dalam analisis ini. Penggunaan strategi pengajaran AR-CT dalam pelajaran matematik boleh menambah baik

penaakulan aditif namun, tiada tanda peningkatan pada penaakulan logik pelajar. Modul ini memanfaatkan konsep algebra sedia ada dan pengekodan pelajar apabila menyelesaikan masalah perkataan. Sementara itu, galakan guru berinteraksi dengan pelajar dan kreativiti guru dalam mencipta situasi pengajaran yang cemerlang ditingkatkan.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank Universiti Putra Malaysia (UPM) for providing financial assistance through GP-IPS/2020/9683300 to support the operation of this research project.

Second, I would like to thank my main supervisor, Dr. Othman Talib, who provided ideas, advice, and unwavering support to keep this research on track when I was having difficulty carrying out the work of this research. Of course, I would like to thank my co-supervisors, Prof Dr Ahmad Fauzi Mohd Bin Mohd Ayub, Dr Maslina Zolkepli, and Dr Chen Chuei Yee, who shared their respective expertise and knowledge in this research.

Third, I would like to thank all of the staff from the Department of Science and Technical Education, as well as the staff from the Faculty of Educational Studies and the School of Graduate Studies, who assisted and guided me in submitting the research documents and thesis.

Finally, I'd like to thank my husband, Mr Teh, who has always been a morale booster for me, as well as my two sons, Kayson and Hudson, who have been willing to collaborate with me while I've been working on this research. I love you all.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Othman bin Talib, PhD
Senior Lecturer
Faculty pf Educational Studies
Universiti Putra Malaysia
(Chairman)

Ahamad Fauzi bin Mohd Ayub, PhD
Professor
Faculty of Educational Studies
Universiti Putra Malaysia
(Member)

Maslina binti Zolkepli, PhD
Senior Lecturer
Faculty of Computer Science and Information Technology
Universiti Putra Malaysia
(Member)

Chen Chuei Yee, PhD
Senior Lecturer
Faculty of Science
Universiti Putra Malaysia
(Member)

____
ZALILAH MOHD SHARIFF, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 11 May 2023

Declaration by the Graduate Student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any institutions;
- intellectual property from the thesis and the copyright of the thesis are fully-owned by Universiti Putra Malaysia, as stipulated in the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from the supervisor and the office of the Deputy Vice-Chancellor (Research and innovation) before the thesis is published in any written, printed or electronic form (including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials) as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld in accordance with the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2015-2016) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software

Signature: ________________________ Date: __________________

Name and Matric No.: Ku Soh Ting____________________

Declaration by Members of the Supervisory Committee

This is to confirm that:

- the research and the writing of this thesis were done under our supervision.
- supervisory responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2015-2016) are adhered to.

Signature: ______________________________
Name of Chairman of Supervisory Committee: ______________________________

Signature: ______________________________
Name of Member of Supervisory Committee: ______________________________

Signature: ______________________________
Name of Member of Supervisory Committee: ______________________________

Signature: ______________________________
Name of Member of Supervisory Committee: ______________________________

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

OECD	Organisation for Economic Co-operation and Development
PISA	Programme for International Students Assessment
NCTM	National Council of Teachers of Mathematics Commission on Standards for School Mathematics
NGA	National Governors Association
CCSSO	Council of Chief State School Officers
MOE	Ministry of Education
HOC	Hour of Code
TMK	*Teknologi maklumat dan komunikasi*
KSSR	*Kurikulum Standard Sekolah Rendah*
ASK	*Asas komputer dan sains*
SK	*Sains komputer*
KSSM	*Kurikulum Standard Sekolah Menengah*
CompT	computational thinking
TIMSS	Third International Mathematics and Science Study
CVI	Conventional instruction
AR-CT	Algebraic reasoning integration of computational thinking
ICMI	12th International Conference on Multimodal Interaction
ADDIE	Analyze, Design, Develop, Implement, and Evaluate
DDR	Design and Development Research
ICT	Information and communication technology
IQ	Intelligence quotient
NRC	National Research Council
SREB	Southern Regional Education Board

IFTF	Institute for the future
CAS	Computer algebra systems
CAME	Computer Algebra in Mathematics Education
DBR	Design based research
ASSURE	Analyze learner characteristics, state objectives, select, modify, or design materials; utilize materials, require learner response and evaluation
SLR	Systematic literature review
IGCSE	The International General Certificate of Secondary Education
CIS	Cambridge International School
TCISKL	Tzu Chi International School Kuala Lumpur
IEEE	Institute of Electrical and Electronics Engineers
ACM	Association for Computing Machinery
SPSS	Statistical Package for Social Sciences
ANCOVA	Analysis of Covariance
CUBES	Circle the number, Underline the questions, Box math ‘action’ word, Evaluate, Solve and Check
TIOBE	The Importance of Being Earnest
UML	Unified Modeling Language
PPW	Part-Part-Whole
SW	Shapiro Wilk
COMPS	Conceptual Model-based Problem Solving
ARCS	Attention, relevance, confidence and satisfaction

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

In this information age, high levels of mathematical competence and reasoning skills are required for entry jobs in the 21st century (Ellis et al., 2018; Organisation for Economic Co-operation and Development (OECD), 2010). Mathematics skills are integral to all areas and situations in daily life, employment depends on one's ability to apply mathematically model to solve real-world problem situations which students have learnt in school (so called application function of word problems) (de Walle, Karp, & Bay-Williams, 2013; Depaepe, De Corte, & Verschaffel, 2010; Geary, Hoard, Nugent, & Bailey, 2012; Price & Ansari, 2013). Of these skills, problem solving may be the most important as "virtually everyone, in their everyday lives and professional lives, regularly solves problems" (Jonassen, 2000).

1.2 Research Background

Understanding number concepts and the operations that go with them is important to basic mathematics. Problem solving and the application of mathematical principles to real-world situations are being emphasized as vital components of mathematics training and education in elementary schools worldwide (Mullis et al., 2008). Professional development is critical to the success of an innovative mathematics program (Hart et al., 2016). There has long been a desire to improve primary teachers' knowledge of elementary number theory (Liljedahl et al., 2006; Zazkis, 2011). Despite this, they have received far too little attention for their pedagogical knowledge for teaching arithmetic word problems, despite the fact that primary students have always demonstrated difficulty in solving multi-step word problems involving whole numbers in international assessments such as the Trends in International Mathematics and Science Study (TIMSS) (Mullis et al., 2016).

Davydov (1982) presents an alternative viewpoint to the usual one on how students can enhance their problem-solving ability in mathematics. The additive link is the cornerstone of knowledge about addition and subtraction since it is "the law of composition by which the relationship between two components generates a unique third element as a function." In other terms, it is "the law of composition that determines a unique third element as a function through the interaction between two components" (Davydov, 1982). He is adamant about teaching this additive relationship initially, even before counting, because it is so fundamental. The method in question has been dubbed the Relational Paradigm. Word problems with addition highlight addition interactions and can be solved using either addition or subtraction. While it comes to teaching and learning, there is a huge difference between the solution approach and the calculation methodology used when attempting to answer an issue.

The progression of mathematical thinking is considered as progressing from knowing the additive relationships between physical objects (without numbers) to grasping the additive structures in word problems in a more flexible manner (with numbers). It is difficult for students to answer word problems when they do not comprehend and operate on the additive relationship. Thus, knowing additive interactions is essential for addressing additive word problems.

Critical thinking, according to Halpern (2014), is "purposeful, reasoned, and goal-directed." According to Halpern (2014), many definitions of critical thinking in the literature contain the phrase "reasoning/logic," having the ability to apply logic principles can be considered as a necessity for critical thinking. People of various ages have problems with logical reasoning, according to studies (Daniel & Klaczynski, 2006; Galotti, 1989; O'Brien et al., 1971; Stanovich et al., 2016). Because of these difficulties, it is unlikely that children in schools will be able to reason coherently and so improve their critical thinking skills on their own. Liu et al. (2015) stated that logical reasoning is a fundamental component of sound critical thinking. Some authors believe that one of the key purposes of education should be to help students develop their logical reasoning abilities as part of their higher order thinking abilities (Zohar & Dori, 2003).

21st century mathematical literacy includes mathematical reasoning and application of computational thinking to facilitate problem-solving (Lee & Cho, 2018). In the PISA 2021 framework that students should have and be able to demonstrate computational thinking skills as they contribute to mathematics as part of their problem-solving practice. Coding as an essential bridge to learn mathematics in the 21st century (Gadanidis et al., 2017). As quoted by Bill Gates on "Learning to write coding stretches your mind, and helps you think better, creates a way of thinking about things that I think is helpful in all domains".

Coding become technology tool as a partner in the computational practices learning process which easily and effective to acquire computational problem solving skills (Howland et al., 2013) and foster their computational thinking to enhance general problem solving ability (Lin & Liu, 2012; Ratcliff & Anderson, 2011). Coding languages can be taught as the foundation for teaching mathematics, and coding concepts and experience can be used to provide a conceptual structure for the presentation of the subject in mathematics. The use of a computer with sufficient programming language adds this additional dimension to the experience of mathematics; a new and efficient operating environment that is essential for mathematical experiments. Coding able to develop computational thinking, logical reasoning, critical thinking skills and at the same time helping students to understand the 21st century world.

Furthermore, coding also to be used to develop learners' digital literacy for sharing and expressing their idea to create and solve the problems by remixing digital resources (Hague & Payton, 2011; Mills, 2010; Ng, 2012). Coding is a platform to shape learners' computational perspective about technology and engage the building of technology products so that learners are no longer be passive consumers of the digital technology (Resnick et al., 2009). Throughout math lessons, students are helped to work in close coordination with the computer-based discussion of the classroom as an experimental laboratory. In addition to inspiring students 'interest in the study, a mathematical laboratory at a realistic educational level may prevent the loss of vital components (Feurzeig et al., 2011). Moreover, this approach can ensure all students access to computing education and engage with core content in new and creative ways.

By emphasizing the importance of computational thinking as it relates to mathematics, the framework anticipates that the participating countries will focus on the role of computational thinking in curricula and pedagogy. Teachers have been asked to increase the depth of student discourse mathematics, to teach students about real-world problems, and to give them opportunities to connect with and across mathematical themes, to use different methods to solve problems, and to connect functions through different representations (Kieran, 2007; National Council of Teachers of Mathematics Commission on Standards for School Mathematics (NCTM), 1989, 2000; National Governors Association Center for Best Practices Council of Chief State School Officers (NGA Center and CCSSO), 2010).

1.3 Awareness of Coding in Education

There are three technology corporations (Microsoft, Intel, Cisco) were alarmed that current graduated students did not fit for employment to enter in a digital age workforce. They identified there is shifting workplace requirements which focus on 21st century skills, but they concerned about graduated students lack fostering thinking skills in school and university (Griffin et al., 2012). Many technology corporations in developed countries structural unemployment crisis, support "call to action" that there was a need to change the bases for firing and hiring to reflect the possession of 21st century skills (Griffin & Care, 2015). Nowadays, students are required to possess 21st century skills to be success such as collaboration, communication, critical thinking, and creativity.

According to the report from Digital Workforce of The Future conducted by LinkedIn Talent Solutions (2017), digital skills is the top five high demands in Malaysia. Malaysia is facing shortages of software development professionals. Due to high demand of coding skills in our current job market, the Ministry of Education (MOE) of Malaysia is decided to propose coding program in the current curriculum. MOE of Malaysia organized Hour of Code (HOC) campaign since 2017 (Ministry of Education Malaysia (MOE) & Malaysia Digital Economy Corporation (MDEC), 2022).

HOC is an hour activity where students were introduced to the basic of coding and computer science in every school. This activity was joined by about 100 million of students from 180 countries. Students were able to solve problem through gamification-based drag and drop programming online within a duration time of 30 – 60 minutes in this activity. HOC functioned as an awareness campaign which aimed to provide an early exposure and improve the awareness of the students on coding, programming, and computer science.

This campaign was in accordance to the implementation of information technology and communication (*teknologi maklumat dan komunikasi* (TMK)) in primary school standard curriculum (*Kurikulum Standard Sekolah Rendah* (KSSR)). Moreover, reviews of the current basic computer science (*asas komputer dan sains* (ASK)) and computer science (*komputer sains* (SK)) syllabus in secondary school standard curriculum (*Kurikulum Standard Sekolah Menengah* (KSSM)) also has been conducted where computational thinking and computer science element are being emphasized. This campaign also is a part of strategic component under the implementation of #mydigitalmaker movement. (Ministry of Education Malaysia (MOE) & Malaysia Digital Economy Corporation (MDEC), 2022).

Many countries implemented rapid changes in the primary and secondary school curriculums, in order to incorporate computational thinking (CompT) as part of theirs 21st century skills. In the recent years, many countries around the world have integrated computer coding in their primary and secondary education curriculums, such as UK (England), Finland, Belgium, Czech Republic, Malta, France, Austria, Bulgaria, Hungary, Denmark, Estonia, Lithuania, Ireland, Israel, Poland, Spain, Slovakia, Portugal and so on. One of our goal in our vision 2020 is to raise a sufficient number of qualified graduates to establish a scientific and innovative society (Ministry of Education Malaysia, 2013). According to Malaysia Education Blueprint 2013-2025, national and school-based assessment are focused on creative and problem-solving skills.

1.4 Learning Theories and Process Related to Problem Solving

The National Mathematics Advisory Panel (2008) proposed working together on algebra curriculum to facilitate problem solving. Algebra is an important subject in mathematics learning for pursuing success to access higher mathematics (Adelman, 2006; National Mathematics Advisory Panel, 2008). Algebra has been recognized as a major stumbling block in students' mathematics learning in the past and even at present time. Many students having learning difficulties in the formal algebraic system and problem solving (Kieran, 1992). Therefore, there has been a concern to address students' difficulties in learning algebra word problem.

Concerns emerged that conventional teaching, which concentrated on procedures and symbolic manipulation, particularly without focusing on the concepts underlying those procedures, inhibited student understanding (e.g., Carpenter & Lehrer, 1999) and created impediments higher-level cognitive processes, such as the transition from learning to new contexts (Skemp, 2006). It is very important that procedural knowledge and conceptual knowledge to carry out bidirectional, with increase in these two types of knowledge leading to better understand knowledge development (Rittle-Johnson et al., 2015). Further insight into algebra education is needed due to improvements in the conceptualization and teaching of algebra. Historically, algebra has been seen as a generalized arithmetic, with emphasis on symbol manipulation in terms of expressions and equations (Kaput, 1999; Kieran, 2007). Over time, it has developed to emphasize functions and relationships, patterns and structure, and to place algebraic concepts in the real-life sense of mathematical modelling (Fey & Smith, 2017; Kieran, 2007).

At the secondary level, mathematics curriculum focus on problem solving skills where students understand the mathematics concepts and solve the mathematics word problems, rather than computational skill (Brandell et al., 2008). At university level, is necessary routine skills in algebraic and arithmetic computations to solve the computational complexity of exercise; which is way above the words problem from secondary level (Filipsson & Thunberg, 2008). It seems there is a gap between secondary level and university level; so there is a concern that an increased focus on computational skills in secondary level to facilitate the transition from secondary level to university level (Kouvela et al., 2018).

Computer technology become increasingly important in daily life even in the field of education. Many researchers noted that computer technology is a useful and powerful tool in learning and teaching mathematics for students to understand the perception of mathematics (Bakker et al., 2015; Barkatsas et al., 2009) as well as their mathematics concepts (Guyer, 2008; Hohenwarter & Jones, 2007) by expressing and exploring mathematical ideas (Ghosh, 2012). Apart from this, it also found out that computer technology has positive effect on students' mathematics achievement (Li & Ma, 2010).

Computer technology can enhance students' mathematical problem-solving skills and the ability to solve the informal problems (Kolovou et al., 2013; Panhuizen et al., 2013). Meanwhile, using computer technology in algebra has a significant positive impact on the learning outcome (Rakes et al., 2010). Learners able to develop the notion of function (Doorman et al., 2012) and gain insight of symbol sense. Bokhove and Drijvers (2010, 2012) also immensely improve learners' conceptual understanding and procedural skills in algebra.

Wing (2006) advocated the necessity of computational thinking in our education by stating, “To reading, writing, and arithmetic, we should add computational thinking to every child’s analytical ability”. The fundamental subjects currently taught in school are generally introducing reading, writing, and mathematics which are accepted because all these subjects have cross-disciplinary benefits. In real life situations, the computation skill is needed to easily navigate life tasks such as using doubling or halving in cooking recipes, comparing the cheapest price during promotion sales, estimating the driving speed etc.

In a recent report, for example, when computational thinking is integrated into the sixth grade mathematical classroom, the students 'understanding of mathematics has substantially increased compared to students in the control group (Calao et al., 2015). These results shown that coding not only affects the ability of students to solve problems in general, but also has a significant impact on academics (Calao et al., 2015). Computational thinking is a way of thinking about life in which a 4-step approach to problem-solving is defined, questions are defined, abstract, answers are computed, and results are interpreted. This 4-way problem-solving approach is innovative and cleverly applied to thoughts, problems, and opportunities to move forward.

Coding provided features that support the learner not only with activities, but also with cognitive processing and motivation. Graphic coding software programs are provided to meet these requirements in this regard. Coding designed to improve algorithmic thinking and learn programming skills, are particularly popular with high school students, such as Scratch, Alice, Python, Microsoft Small Basic, Toontalk, Stagecast Creeor and Code GameLab.

Coding considered as an important skill in this present day and plays an important role. Coding is the most crucial element of computing and mutual strategies for developing computational thinking. With the awareness of the importance of coding skill, this has caused an increasing approach for introducing of computational coding skill since the early education of an individual development (Bers et al., 2014) until the high education (Allan et al., 2010), combining this skill with other key competences such as writing, reading, and math skills.

It is believed that the use of different coding tools in the process of early curriculum education may have influenced on the level of development of various skills such as “behaving like a computer”. Computational modelling is an effective approach for learning challenging mathematics concepts (Hambrusch et al., 2009) where it closely aligns mathematics with coding and through this way it brings mathematics to life (Felleisen & Krishnamurthi, 2009). Let students use computational power as an application for mathematics, design of traffic structures, or crack hidden codes instead of rotating long-division learning methods. Such tasks train creativity and conceptual understanding, as well as practical tests, just as computer computing is needed for real world computing (Wolfram, 2016).

Meanwhile, learning to code improves problem-solving skills in mathematics (Papert, 1972). Most of the coding research that seek to improve problem-solving skill in mathematics through coding have failed to produce ideal results (Noss, 1987). Indeed, researchers clarified that learning coding is not known as to transfer problem solving skills to solve the word problem in mathematics. Transfer of learning between two different disciplines requires proper instruction in how to deep structural connections and apply concepts from one discipline to the other disciplines (Bransford & Schwartz, 1999; Perkins, 2010; Rich et al., 2013).

Research studies reported that computing education and computational thinking have the potential to develop students' problem-solving skills, higher-order thinking, communication skills and collaboration in ways that can advance learning across the curriculum and empower students to be creative inventors with technology. Many studies have shown that coding instructions enable learners to solve problems (Calao et al., 2015; Saez-Lopez et al., 2016), to think critically (Dogan & Kert, 2016), to make people think creatively (Navarrete, 2013), to think algorithmically (Hromkovic et al., 2016), to think reflectively (Kalelioglu, 2015) and to think logically (Kafai & Burke, 2015). Coding instruction has a significant potential for ways to improve these capabilities (Saez-Lopez et al., 2016).

1.5 Students' Performance in Word Problems

When Malaysia first took part in Third International Mathematics and Science Study (TIMSS) in 1999, Malaysia's 8th grade mathematical success was above average around 519 and Malaysia was 16th out of 38. However, Malaysia's success in TIMSS mathematics has shown a declining trend over the next few years, with a low average of 440 in TIMSS 2011. Malaysia ranked 26th out of 45 countries. However, at TIMSS 2015, mathematics improved by 25 points, with a total 465 score, ranked 22nd out of 39 countries. Malaysia has shown higher results in mathematics in TIMSS in 2015 compared to TIMSS in 2011.

In 2015, There are 69 items to evaluate mathematics knowledge and an average score of 472 is shown to improve compared to the 2011 results. However, there are 94 items to evaluate the ability to apply mathematics, while there are 46 items to evaluate the reasoning for mathematics, with an average score of 463 and 453, respectively. The two results showed a significant decrease compared to the results of 2011. The average score for the assessment of algebra mathematics content is 467 which has shown no improvement compared to 2011. The overall result has shown that Malaysian students have achieved a low level of achievement in terms of advanced and high international benchmark.

According to the TIMSS, Malaysia's overall average mathematics score was 465, which is the intermediate benchmark, while students can only apply basic mathematical knowledge in a variety of situations. According to the TIMSS 2019 Mathematics Framework, TIMSS assesses the problem of solving around two-thirds of the items requiring students to use their application and reasoning skills.

Organization for Economic Co-operation and Development (OECD) Program, PISA (Program International Student Assessment) is a worldwide program which study 15 years old students' scholastic performance on mathematics, science and reading in every three years. The purpose of this program is to gauge how well students acquire the basic skills and knowledge besides evaluating their readiness for the real situation in adult world. In 2012, the average score for mathematics was 421 points, which was 52nd worldwide. The average score in 2018 was 440 points, 47th in the world. However, Malaysia's ranking is still well below the OECD benchmark of some 490 points. Malaysia has only reached a minimum level 2 of competence in mathematics.

According to the findings of PISA, many developed countries have faced problems with student engagement in the future study of mathematics. Most students only manage to perform basic arithmetic, but they have not been able to calculate two or more steps of complex situations. Current core mathematics curricula are insufficient to support students 'ability to solve and identify mathematical problems in context; it is rare for students to explore complex and interactive issues that can uncover the information they need and stimulate students' knowledge to solve the problem (Organisation for Economic Co-operation and Development (OECD), 2014a).

According to the Organisation for Economic Co-operation and Development (OECD) (2012) and the National Mathematics Advisory Panel (2008), there are significant weaknesses in the ability of students to solve word problems compared to other areas of achievement. In PISA 2012, there are two key results showed that: (1) only 13% of students from 34 OECD countries could work strategically by using reasoning skills and well-developed thinking in complex situations model. (2) 32% of the students have difficulties to extract relevant information and using formulae, algorithms and procedure in solving word problems (Organisation for Economic Co-operation and Development (OECD), 2014b). There is considerable evidence from intervention studies that learners have persistent difficulties in solving word problems, specifically have difficulties in selecting the correct operation, identifying important features of a problem, reasoning, not cognizant of available strategies, metacognitive skills (e.g., ability to do a plan, monitor, check, and evaluation) and computing the solution (Cirino et al., 2007; Fuchs & Fuchs, 2005; Geary et al., 2007; Jordan et al., 2003; Maccini & Ruhl, 2001; Montague & Applegate, 1993; Rosenzweig et al., 2011; Vukovic & Siegel, 2010).

1.6 Problem Statement

Conventional teaching way widely used in mathematics education has been criticized for being taught in content-oriented, isolated and teacher-centered (Ministry of Education Malaysia, 2013; Schoenfeld & Kilpatrick, 2013). Students being highly passive and act as an empty vessel waiting for teachers to fill up them with new knowledge (Goeke, 2009). This kind of lecture seems to be an efficient and easy to present the knowledge that students' need; but students understand the mathematics in such a rote way and only know superficial. At the same times, students having difficulties in constructing knowledge and ability to absorb the information. A typical conventional instruction mathematics classroom takes up to 84% of classroom time in lecturing, do the demonstration and the individual practice (Boaler, 2008). The conventional mathematics only focus on learners' accuracy and fluency in arithmetic computations. Manual estimation, rigor and rigor are wrong with the broader issue of the mathematical solution. The mechanical hands of the past, once required, had been mistaken for most of which were then unused and timeless mathematics (Wolfram, 2016).

The main point of current education is not only to teach reading, writing or arithmetic, and to teach how to use creative thinking skills (Runco, 2007), but also to improve learning skills, scientific and technological literacy among students (Lawless & Brown, 2015; Tortop, 2013). Mathematics is the most efficient way to solve problems in the world. While in word problem solving, learners must have the capability to construct their knowledge to transform the equivalent algebraic expressions. It's about taking real things, applying, or inventing mathematics to get the answer. These skills are required for sustainability and lifelong education in addition to basic education for the young generation.

Word problem solving is a process to figure out the solution by moving from a given state to a goal state (Mayer & Hegarty, 1996). Students failed to represent discerning relevant information in the word problem correctly from irrelevant information, its due to language barrier and also requires a planning strategy, coordinating procedures, execute the plan by applying previously learned and verify the solution (Agostino et al., 2010; Hegarty et al., 1995). Current conventional education still important and effective but in the last 50 years or so, the fundamental shift in realm mathematics is that we simply quantify beyond our previous imaginations. Pedagogical factors also affect student's understanding of arithmetic word problem (Lean et al., 1990). Students' views on what mathematics means learning and practicing are very different from ideals (Jimenez & Verschaffel, 2014). Many researchers have called for change the mathematics teaching method and highlighted the importance of constructivist perspectives to provide accessibility and equity for all (Cobb & Yackel, 2011; Leder, 1992).

Researchers have started to investigate the difficulties experienced by students in solving various word problems, from simple arithmetic to more complicated situations requiring non-routine thinking (Verschaffel & De Corte, 1997). Based on the recent literature review by Daroczy, Wolska, Meurers, and Nuerk (2015), the interaction between linguistic and numerical factors are factors which have an impact on the ability to solve word problems. Word problem solving not only requires to retrieve an answer from student's memory and apply mathematical concepts and procedures but the crucial part is demanding different levels of text comprehension to construct a mental representation (Reusser et al., 1990; van Dijk & Kintsch, 1983;Verschaffel et al., 2015). Although master in the concept of mathematical procedures which prerequisite for solution accuracy but word problem solving go beyond procedural and conceptual knowledge (Jonassen, 2000).

Logical reasoning is the cornerstone upon which mathematics is built (Bako, 2002). A significant number of students were unable to identify the logical connections that exist between the concepts, theorems, instances, and counterexamples that were used to demonstrate those notions. Instead, they concentrated entirely on the mathematical aspects of the instances, paying no attention to the purposes underlying the examples (Liu & Raghavan, 2009; Raghavan et al., 2008). Because of this, their learning is limited to the replication of algorithmic processes, and they demonstrate very little comprehension. Many of them were not aware of which of the inverse, converse, or contrapositive of an if-then conditional statement is the same as the conditional statement (Hawthorne & Rasmussen, 2015). Because of this deficiency in logical reasoning, students may have a significantly reduced capacity for critical and analytical thinking. The ability to think in an additive sense is another domain-specific talent that students need to gain while studying mathematics. According to Cramer et al. (1993), additive reasoning is predicated on numbers that are linked together by part-whole relations, erroneous additive modelling problem scenarios, the inverse mistake, and missing-value word problems that have an additive underlying mathematical model

The scope of computational thinking research includes mathematics, logical reasoning, problem solving, computer use, coding, and the integration of technology in the classroom (Sands et al., 2018). While computational thinking is vital to computer science (Denning, 2017; Wing, 2006), we believe it is also an important ability for students to master in other disciplines (Yadav et al., 2016). Malara and Navarra (2018) define algebraic thinking in the context of problem-solving as a shift in attention from the outcome to the technique. Computational thinking (CompT) is similarly focused on problem-solving strategies like debugging and experimenting to examine algorithmic structure. Both domains place an emphasis on the framework of problem-solving processes.

1.7 Purpose of the Study

The aim of this study is to investigate the impact of the computational thinking module on technology coding where algebraic reasoning is adopted to solve word problem in mathematics. Moreover, the impacts of the algebraic reasoning integration of computational thinking (AR-CT) module on word problem-solving skills, critical thinking and logical thinking are compared with conventional instruction (CVI) word problem-solving teaching strategies among grade 4 students.

1.8 Research Objectives

Develop potential mathematics learning, there are essential skills to be incorporated into our current mathematics curriculum, which are coding and computational thinking skills. This research aims to contribute to AR-CT's theoretical notions and the impact of word problem solving on student's learning experience. This research aimed at:

1. Develop a teaching and learning module that algebraic reasoning integration of computational thinking (AR-CT).
2. Compare the effectiveness of the algebraic reasoning integration of computational thinking (AR-CT) to conventional instruction (CVI) with word problem-solving skills.
3. Compare the effectiveness of the algebraic reasoning integration of computational thinking (AR-CT) to conventional instruction (CVI) with logical reasoning and additive reasoning in word problems solving.

1.9 Research Questions

With the aim of being globally competitive and the coherence between the provision of skilled computational thinking for graduates and the demand to meet the computational thinking needs, teachers need to develop more curriculum and pedagogical suggestions to improve the rigor and relevance of computational teaching. This review addresses six research questions:

RQ 1: What content or activities do grade 4 students require in order to develop a module for learning and teaching mathematics word problems solving?

RQ1.1: Based on expert opinion, to what extent is it necessary to develop a module for learning and teaching word problem solving?

RQ1.2: How do the previous studies have instructional strategy in their implemented a computational thinking strategy in their studies?

RQ1.3: To what extent has the validity and reliability of the module been achieved between raters?

RQ 2: To determine whether there is a difference in students' ability to solve word problems before and after intervention using algebraic reasoning integration of computational thinking (AR-CT) and conventional instruction (CVI).

RQ 3: To determine whether there is a difference in students' logical reasoning and additive reasoning before and after intervention using algebraic reasoning integration of computational thinking (AR-CT) and conventional instruction (CVI).

1.10 Hypothesis

Based on RQ 2, four hypotheses have been developed for this research study.

H 2.1: There is a significant difference in the mean score of the word problem pre-test and post-test for the CVI group.

H 2.2: There is a significant difference in the mean score of the word problem pre-test and post-test for the AR-CT group.

H 2.3: There is a significant difference in the mean score of the word problem post-test between AR-CT and CVI while controlling for word problem pre-test.

H 2.4: There is a significant difference in the mean score of the word problem post-test between AR-CT and CVI while controlling for arithmetic pre-test.

H 2.5: There is a significant difference in the mean score of the word problem post-test between AR-CT and CVI while controlling for computational thinking pre-test.

Based on RQ 3, three hypotheses have been developed for this research study.

H 3.1: There is a significant difference in the mean score of the logical reasoning pre-test and post-test for the CVI group.

H 3.2: There is a significant difference in the mean score of the logical reasoning pre-test and post-test for the AR-CT group.

H 3.3: There is a significant difference in the mean score of the logical reasoning post-test between AR-CT and CVI while controlling for logical reasoning pre-test.

H 3.4: There is a significant difference in the mean score of the additive reasoning pre-test and post-test for the CVI group.

H 3.5: There is a significant difference in the mean score of the additive reasoning pre-test and post-test for the AR-CT group.

H 3.6: There is a significant difference in the mean score of the additive reasoning post-test between AR-CT and CVI while controlling for additive reasoning pre-test.

1.11 Operational Definition

In the context of this study, the definitions and functional specificities of some key words used in this research are clarified.

1.11.1 Conventional Instruction without Computational Thinking Strategy (CVI)

Conventional Instruction without Algebraic Computational Thinking Strategy (CVI) of mathematics is associated with teacher-centered instruction. Teachers based upon assumption of mathematics knowledge verbally presented to large group of students who passively receive the rote knowledge and mainly assess their recall ability (Fitzgerald, 2014). Students are preoccupied by taking notes, memorize the formula, practicing the exercises and procedures that need to be learned as mentioned by Cobb, Wood, Yackel and McNeal (1992). This kind of instructional limited use of unfamiliar situations and unproblematic knowledge transfer exhibits poor problem solving skills, poor attitudes and lack of interests among the students toward learning word problem (Greeno et al., 1993).

1.11.2 Algebraic Reasoning Integration of Computational Thinking (AR-CT)

Computational thinking practices such as abstraction, algorithm, decomposition, pattern recognition and automation with coding software that are effectively disseminated in word problem solving strategy using algebraic reasoning (Google Inc., 2018). The AR-CT module explores how computational thinking encoding applications can provide students with complementary skills to be enabled in their digital culture and even reflective students. A complementary link between computer thinking and coding with a wide range of capabilities helps students navigate critically and create digital content creatively to solve word problems.

1.11.3 Word Problem Solving Skill

The ability of students solving word problem by understanding a question and transform the information from question into mathematical statements and proceeded by arithmetic computation (Fuchs et al., 2014; Lannin, Barker, & Townsend, 2006; Lee, Ng, & Ng, 2009). In this study, examine the strength and accuracy of students' problem solving abilities in word problem through critical thinking and logical thinking related to executive functioning, arithmetic and working memory (Wang, 2015).

1.11.4 Additive Thinking

Additive thinking in a variety of contexts and in different ways to understand and able to manipulate numbers by joining, separating, and comparing while engaging in flexible mathematical reasoning (Nunes et al., 2012). It is more than just addition and subtraction as they occur in a wide range of contexts.

1.11.5 Logical Thinking

Logical thinking is a rational process of brain by which transforming knowledge from a given context and way of reasoning derives conclusions, but it is one of the most difficult learning concepts to achieve (Bronkhorst et al., 2019). In this study, logical thinking involves mathematical reasoning to interpret information from word problem, and expressions to logically form mathematical symbols and to solve the equations.

1.12 Significance of Study

In the last two decades, there has been a growing interest in teaching and learning algebra has investigated an international discussion on what we believe algebra should be and to be. Many researchers have been identified different aspect of algebra into core characteristics of algebraic language and algebraic reasoning, such as formalizing, generalizing and symbolizing (Bernarz et al., 1996; Filloy & Rojano, 1989; Herscovics, 1989; Herscovics & Linchevski, 1994; Kaput, 1998; Kieran, 1989, 1990, 1992; Linchevski & Herscovics, 1996; Sfard, 1995, 1991; Sfard & Linchevski, 1994).

12th International Conference on Multimodal Interaction (ICMI) raised the issues of algebra in the aspect of algebra language, approaches to algebra, early education of algebra, technology learning environment, why algebra and so on. Meanwhile, studied 'The Future of the Teaching and Learning of Algebra' has become clear that there is no agreement on what algebra should be or what algebra is; each classification has its weak and strong points. Therefore, instead of trying to find out what algebra is, why don't consider the role of application algebra in different areas.

Bednarz et al. (1996) distinguish four principal algebra trends in curriculum development, there are problem solving, generalizing, functions and modelling. Learners find the meaningful of algebra by conceiving different role of algebra which associated with various characteristics of algebraic thinking. The classification of algebra eased to approach beginning algebra to the learners which all four components are needed in learning algebra. Valuable pedagogical tools are needed for education researchers and teachers to introduce algebra in school.

Core activity in every algebra curriculum is involved problem solving by constructing equations followed by solving equations. Problem solving seen in a wider and complex sense which through the process of exploring the problems in an open and many alternative ways, developing and expanding it in general ones and look for more best solutions. Algebra is not the separate branch from mathematics, because translating algebra word problems into equations form required the fundamental mathematics to transit from arithmetic to algebra, in terms of concept, symbolism and methods (Bell, 1996).

AR-CT will integrate with technology learning tool to enhance learners' word problem solving skills, additive thinking and logical thinking in the mathematics classroom. This research study would provide an alternative module as a guideline framework for mathematics teacher to perform collaboration learning activity during mathematics lesson. There are few research studies has shown that the learning coding with collaboration will produce promising effect on learners' performance in solving problems, and it also provides 21st century skills during learning process (Barg et al., 2000; Phumeechanya & Wannapiroon, 2014; Saez-Lopez et al., 2016).

The employment of analyze, design, develop, implement, and evaluate (ADDIE) Type 1 and Type 2 methodology as the selected approach to execute the development of AR-CT and focus on the experimental design to test the effectiveness of the module to the real respondents. Richey and Klein (2007) stated that using the DDR approach is very systematic which involving establishing a new instructional design, techniques, and tools by the process from the process and evaluation where it based on an empirical and specific need analysis.

1.13 Limitation of Study

This study focused on the development of an AR-CT module for use as a teaching tool. It aims to increase students' word problem-solving skills, additive reasoning and logical reasoning while emphasizing computational thinking to promote a broad understanding of programming. T-Test sampling was used in the study, and students served as participants. This lesson is intended for upper elementary and lower secondary students, and it only covers the chapter on word problems. The breadth of the inquiry is limited by infrastructure constraints such as a shortage of available classrooms and limited access to high-speed internet.

1.14 Conclusion

This chapter briefly presents the main concept of the research study. The discussion started with the research background of word problem in mathematics, the importance of computer technology in learning mathematics, integration of computational thinking and coding in learning mathematics and the awareness of coding in education curriculum. Problem statements of the research study with the need to address the issues, the research objective and purpose of study are discussed. Research questions and research hypotheses are presented respectively, followed by operational definition, significance and limitation of the study are expanded as well. The chapter closes with a summary of the thesis organization.

This chapter summarizes the importance of computational in our current education system. The integration of the computational thinking element in the mathematic curriculum helps to enhance the ability of the word problem solving skill of the students. Issues that arise in the mathematics are also highlighted in this chapter.

REFERENCES

Abouchedid, K., & Nasser, R. (2000). *The role of presentation and response format in understanding, preconceptions and alternative concepts in algebra problems*. https://files.eric.ed.gov/fulltext/ED438174.pdf

Abramovich, S., & Connell, M. L. (2015). Digital fabrication and hidden inequalities: Connecting procedural, factual, and conceptual knowledge. *International Journal of Technology in Teaching and Learning*, *11*(2), 76–89.

Abu-Allam, R. M. (2003). *Statistical analysis of data using SPSS program*. University Publishing House.

Adelman, C. (2006). *The Toolbox Revised: Paths to Degree Completion From High School Through College P*. https://doi.org/ED490195

Agostino, A., Johnson, J., & Pascual-Leone, J. (2010). Executive functions underlying multiplicative reasoning: Problem type matters. *Journal of Experimental Child Psychology*, *105*, 286–305.

Aho, A. V., & Ullman, J. D. (1995). *Foundations of computer science*. W. H. Freeman and Company.

Aho, A. V. (2012). Computation and computational thinking. *The Computer Journal*, *55*(7), 833–835. https://doi.org/10.1093/comjnl/bxs074

Allan, V., Barr, V., Brylow, D., & Hambrusch, S. (2010). Computational thinking in high school courses. *SIGCSE'10 - Proceedings of the 41st ACM Technical Symposium on Computer Science Education*, 390–391. https://doi.org/10.1145/1734263.1734395

Allen, M. (2017). Designing Online Asynchronous Information Literacy Instruction Using the ADDIE Model. In T. Maddison & M. Kumaran (Eds.), *Distributed Learning: Pedagogy and Technology in Online Information Literacy Instruction* (pp. 69–91). Elsevier Ltd. https://doi.org/10.1016/B978-0-08-100598-9.00004-0

Allensworth, E., Nomi, T., Montgomery, N., & Lee, V. E. (2009). College preparatory curriculum for all: Academic consequences of requiring Algebra and English I for ninth graders in Chicago. *Educational Evaluation and Policy Analysis*, *31*(4), 367–391.

Ally, M. (2009). *Mobile learning: Transforming the delivery of education and training*. Au Press, Athabasca University. https://doi.org/10.1111/j.1467-8535.2007.00809.x

Almomen, R. K., Kaufman, D., Alotaibi, H., Al-Rowais, N. A., Abeik, M., & Albattal, S. M. (2016). Applying the ADDIE—Analysis, Design, Development, Implementation and Evaluation— Instructional Design Model to Continuing Professional Development for Primary Care Physicians in Saudi Arabia. *International Journal of Clinical Medicine*, *7*(8), 538–546. https://doi.org/10.4236/ijcm.2016.78059

Anzai, Y., & Simon, H. A. (1979). The theory of learning by doing. *Psychological Review*, *86*(2), 124–140. https://doi.org/10.1037/0033-295X.86.2.124

Arip, M. A. S. M., & Yusoff, F. (2010). Kesan kelompok bimbingan ke atas konsep kendiri, penilaian konsep kendiri-rakan sebaya, daya tahan dan kelangsangan remaja pertengahan yang sederhana rendah konsep kendiri. *Jurnal Psikologi Malaysia*, *24*, 31–47.

Arnau, D., Arevalillo-Herraez, M., Puig, L., & Gonzalez-Calero, J. A. (2013). Fundamentals of the design and the operation of an intelligent tutoring system for the learning of the arithmetical and algebraic way of solving word problems. *Computers & Education*, *63*, 119–130.

Asquith, P., Stephens, A. C., Knuth, E. J., & Alibali, M. W. (2007). Middle school mathematics teachers' knowledge of students' understanding of core algebraic concepts: Equal sign and variable. *Mathematical Thinking and Learning: An International Journal*, *9*(3), 249–272.

Atay, P. D. (2006). *Relative ınfluence of cognitive and motivational variables on genetic concepts in traditional and learning cycle classrooms*. Middle East Technical University.

Bakker, M., van den Heuvel-Panhuizen, M., & Robitzsch, A. (2015). Effects of playing mathematics computer games on primary school students' multiplicative reasoning ability. *Contemporary Educational Psychology*, *40*, 55–71. https://doi.org/10.1016/j.cedpsych.2014.09.001

Bako, M. (2002). *Why we need to teach logic and how can we teach it?* https://www.cimt.org.uk/journal/bakom.pdf

Balanskat, A., & Engelhardt, K. (2014). Computing our future Computer programming and coding - Priorities, school curricula and initiatives across Europe. In *European Schoolnet (EUN Partnership AISBL)*. http://www.eun.org/c/document_library/get_file?uuid=521cb928-6ec4-4a86-b522-9d8fd5cf60ce&groupId=43887

Barg, M., Fekete, A., Greening, T., Hollands, O., Kay, J., & Kingston, J. H. (2000). Problem-Based Learning for Foundation Computer Science Courses. *Computer Science Education*, *10*(2), 109–128. https://doi.org/10.1076/0899-3408(200008)10:2;1-c;ft109

Barkatsas, A. (T.)., Kasimatis, K., & Gialamas, V. (2009). Learning secondary mathematics with technology: Exploring the complex interrelationship between students' attitudes, engagement, gender and achievement. *Computers and Education*, *52*(3), 562–570.

https://doi.org/10.1016/j.compedu.2008.11.001

Barr, V., & Stephenson, C. (2011). Bringing computational thinking to K-12: what is Involved and what is the role of the computer science education community? *ACM Inroads*, *2*(1), 48–54. https://doi.org/10.1145/1929887.1929905

Barrows, H. S., & Tamblyn, R. M. (1980). *Problem-Based Learning: An Approach to Medical Education*. Springer Publishing Company, Inc.

Baytak, A., & Land, S. M. (2011). An investigation of the artifacts and process of constructing computers games about environmental science in a fifth grade classroom. *Educational Technology Research and Development*, *59*(6), 765–782.

Bell, A. (1996). Problem-Solving Approaches to Algebra: Two Aspects. In N. Bernarz, C. Kieran, & L. Lee (Eds.), *Approaches to Algebra: Perspectives for Research and Teaching* (pp. 167–185). Kluwer Academic Publishers.

Benton, L., Hoyles, C., Kalas, I., & Noss, R. (2017). Bridging primary programming and mathematics: Some findings of design research in England. *Digital Experiences in Mathematics Education*, *3*(2), 115–138.

Benton, L., Saunders, P., Kalas, I., Hoyles, C., & Noss, R. (2018). Designing for learning mathematics through programming: A case study of pupils engaging with place value. *International Journal of Child-Computer Interaction*, *16*, 68–76.

Bernarz, N., Kieran, C., & Lee, L. (1996). *Approaches to Algebra*. Kluwer Academic Publishers.

Bers, M. U., Flannery, L., Kazakoff, E. R., & Sullivan, A. (2014). Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. *Computers and Education*, *72*, 145–157. https://doi.org/10.1016/j.compedu.2013.10.020

Bloor, M., & Wood, F. (2006). *Keywords in Qualitative Methods:A Vocabulary of Research Concepts* (1st Ed.). SAGE Publications Ltd.

Boaler, J. (2008). Promoting "relational equity" and high mathematics achievement through an innovative mixed-ability approach. *British Educational Research Journal*, *34*(2), 167–194. https://doi.org/10.1080/01411920701532145

Bocconi, S., Chioccariello, A., Dettori, G., Ferrari, A., Engelhardt, K., Kampylis, P., & Punie, Y. (2016). Developing Computational Thinking in Compulsory Education - Implications for policy and practice. In *Joint Research Centre (JRC)* (Issue June). https://doi.org/10.2791/792158

Bocconi, S., Chioccariello, A., & Earp, J. (2018). *The nordic approach to* *introducing computational thinking and programming in compulsory education. Report prepared for the Nordic@BETT2018 Steering Group*. https://doi.org/10.17471/54007

Bokhove, C., & Drijvers, P. (2010). Symbol sense behavior in digital activities. *For the Learning of Mathematics*, *30*(3), 43–49.

Bokhove, C., & Drijvers, P. (2012). Effects of a digital intervention on the development of algebraic expertise. *Computers & Education*, *58*(1), 197–208.

Boonen, A. J. H., Van Der Schoot, M., Van Wesel, F., De Vries, M. H., & Jolles, J. (2013). What underlies successful word problem solving? A path analysis in sixth grade students. *Contemporary Educational Psychology*, *38*, 271–279. https://doi.org/10.1016/j.cedpsych.2013.05.001

Boonen, A. J. H., van Wesel, F., Jolles, J., & van der Schoot, M. (2014). The role of visual representation type, spatial ability, and reading comprehension in word problem solving: An item-level analysis in elementary school children. *International Journal of Educational Research*, *68*, 15–26. https://doi.org/10.1016/j. ijer.2014.08.001

Booth, L. R. (1988). Children's difficulties in beginning algebra. In A. F. Coxford (Ed.), *The ideas of algebra, K–12(1988 Yearbook)* (pp. 20–32). National Council of Teachers of Mathematics.

Booth, L. R., & Watson, J. (1990). Research for teaching: Learning and teaching algebra. *Australian Mathematics Teacher*, *46*(3), 12–14.

Bragg, L. A. (2007). Students' conflicting attitudes towards games as a vehicle for learning mathematics: A methodological dilemma. *Mathematics Education Research Journal*, *19*(1), 29–44. https://doi.org/10.1007/BF03217448

Branch, R. M. (2018). Characteristics of instructional design models. In R. A. Reiser & J. V. Dempsey (Eds.), *Trends and issues in instructional design and technology* (4th Editio). Pearson Merrill Prentice Hall.

Brandell, G., Hemmi, K., & Thunberg, H. (2008). The widening gap-a Swedish perspective. *Mathematics Education Research Journal*, *20*(2), 38–56. https://doi.org/10.1007/BF03217476

Bransford, J. D., & Schwartz, D. L. (1999). Rethinking transfer: A simple proposal with multiple implications. *Review of Research in Education*, *24*(1), 61–2100.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Brennan, K., & Resnick, M. (2012). New frameworks for studying and assessing the development of computational thinking. In *Annual American Educational Research Association Meeting*. https://web.media.mit.edu/~kbrennan/files/Brennan_Resnick_AERA2012_CT.pdf.%0D

Bronkhorst, H., Roorda, G., Suhre, C., & Goedhart, M. (2019). Logical Reasoning in Formal and Everyday Reasoning Tasks. *International Journal of Science and Mathematics Education*. https://doi.org/10.1007/s10763-019-10039-8

Bryman, A. (2006). Integrating quantitative and qualitative research: How is it done? *Qualitative Research*, *6*(1), 97–113. https://doi.org/10.1177/1468794106058877

Bugis, Y. M. (2018). *Creating digital stories with Saudi Arabian pre-service teachers: using the analysis, design, development, implementation, and evaluation model to promote lesson plan development*. University of Northern Colorado.

Bush, S. B., & Karp, K. S. (2013). Prerequisite algebra skills and associated misconceptions of middle grade students: A review. *Journal of Mathematical Behavior*, *32*(3), 613–632. https://doi.org/10.1016/j.jmathb.2013.07.002

Buteau, C., Jarvis, D. H., & Lavicza, Z. (2014). On the integration of computer algebra systems (CAS) by Canadian mathematicians: Results of a national survey. *Canadian Journal of Science, Mathematics and Technology Education*, *14*(1), 35–57.

Cai, J., Moyer, J. C., Wang, N., & Bikai, N. (2011). Examining students' algebraic thinking in a curricular context: A longitudinal study. In J. Cai & E. Knuth (Eds.), *Early algebraization* (pp. 161–185). Springer-Verlag.

Calao, L. A., Moreno-Leon, J., Correa, H. E., & Robles, G. (2015). Developing mathematical thinking with scratch an experiment with 6th grade students. In G. Conole, T. Klobucar, C. Rensing, J. Konert, & E. Lavoue (Eds.), *Design for Teaching and Learning in a Networked World* (pp. 17–27). Springer International Publishing.

Calder, N. (2010). Using Scratch: An Integrated Problem-Solving Approach to Mathematical Thinking. *Australian Primary Mathematics Classroom*, *15*(4), 9–14.

Campbell, D. T., & Kenny, D. A. (1999). *A primer on regression artifacts*. Guilford Publications.

Campbell, D. T., & Stanley, J. C. (1963). Experimental and quasi-experimental designs for research on teaching. In N. L. Gage (Ed.), *Handbook of research on teaching* (pp. 171–246). Rand McNally.

Campbell, P. C. (2014). Modifying ADDIE: Incorporating new technologies in library instruction. *Public Services Quarterly*, *10*(2), 138–149. https://doi.org/10.1080/15228959.2014.904214

Capraro, M. M., & Joffrion, H. (2006). Algebraic equations: Can middle-school students meaningfully translate from words to mathematical symbols? *Reading Psychology*, *27*, 147–164.

Capraro, R. M., Capraro, M. M., Ding, M., & Li, X. (2007). Thirty years of research: Interpretations of the equal sign in China and the USA. *Psychological Reports*, *101*, 784–786.

Carpenter, T. P., Ansell, E., Franke, M. L., Fennema, E., & Weisbeck, L. (1993). Models of Problem Solving: A Study of Kindergarten Children's Problem-Solving Processes. *Journal for Research in Mathematics Education*, *24*, 428–441.

Carpenter, T. P., & Lehrer, R. (1999). Teaching and learning mathematics with understanding. In Elizabeth Fennema & T. A. Romberg (Eds.), *Mathematics classrooms that promote understanding* (pp. 19–32). Lawrence Erlbaum Associates, Inc.

Carpenter, T. P., & Moser, J. M. (1982). The development of addition and subtraction problem solving. In T. P. Carpenter, J. M. Moser, & T. A. Romberg (Eds.), *Addition and subtraction: A cognitive perspective* (pp. 10–24). Lawrence Erlbaum.

Carraher, D. W., Schliemann, A. D., & Schwartz, J. L. (2008). Early algebra is not the same as algebra early. In *Algebra in the early grades* (pp. 235–272). Routledge, Inc.

Carraher, T. N., Carraher, D. W., & Schliemann, A. D. (1985). Mathematics in the streets and in schools. *British Journal of Developmental Psychology*, *3*, 21–29.

Chaudron, S., Gioia, R. D., & Gemo, M. (2018). Young children (0-8) and digital technology, a qualitative study across Europe. In *Publications Office of the European Union*. https://doi.org/10.2788/00749

Chen, C. Y., & Teng, K. C. (2011). The design and development of a computerized tool support for conducting senior projects in software engineering education. *Computers & Education*, *56*(3), 802–817.

Chen, H., Wigand, R., & Nilan, M. S. (1999). Optimal experience of web activities. *Computers in Human Behavior*, *15*, 585–608.

Chen, T., Mdyunus, A., Ali, W. Z. W., & Bakar, A. (2008). Utilization of intelligent tutoring system in mathematics learning. *International Journal of Education and Development Using Information and Communication Technology*, *4*(4), 50–63.

Cheung, L. (2016). Using the ADDIE Model of Instructional Design to Teach Chest Radiograph Interpretation. *Journal of Biomedical Education*, *2016*(9502572), 6.

Cheung, R. H. P. (2013). Exploring the use of the pedagogical framework for creative practice in preschool settings: A phenomenological approach. *Thinking Skills and Creativity*, *10*, 133–142. https://doi.org/10.1016/j.tsc.2013.08.004

Chevalier, R. D. (2011). When did ADDIE become addie? *Performance Improvement*, *50*(6), 10–14. https://doi.org/10.1002/pfi.20221

Cirino, P. T., Ewing-Cobbs, L., Barnes, M., Fuchs, L. S., & Fletcher, J. M. (2007). Cognitive arithmetic differences in learning disability groups and the role of behavioral inattention. *Learning Disabilities Research & Practice*, *22*, 25–35.

Clement, J. (1982). Algebra word problem solutions: Thought processes underlying a common misconception. *Journal for Research in Mathematics Education*, *13*(1), 16–30.

Clement, J., Lockhead, J., & Monk, G. (1981). Translation difficulties in learning mathematics. *American Mathematical Monthly*, *88*, 286–290.

Cobb, P., Wood, T., Yackel, E., & McNeal, B. (1992). Characteristics of Classroom Mathematics Traditions: An Interactional Analysis. *American Educational Research Journal*, *29*(3), 573–604. https://doi.org/10.3102/00028312029003573

Cobb, P., & Yackel, E. (2011). Introduction. In E. Yackel, K. Gravemeijer, & S. Anna (Eds.), *A Journey in Mathematics Education Research: Insights from the Work of Paul Cobb* (pp. 33–40). Springer.

Coben, D., Colwell, D., Macrae, S., Boaler, J., Brown, M., & Rhodes, V. (2003). Adult numeracy : Review of Research and Related Literature. In *National Research and Development Centre for Adult Literacy and Numeracy* (Issue November). www.nrdc.org.uk

Cohen, H. G. (1980). Dilemma of the objective paper-and-pencil assessment within the Piagetian framework. *Science Education*, *64*(5), 741–745.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd Editio). Erlbaum.

Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8th Ed.). Routledge.

College Board. (2017). *AP Computer Science Principles: Course and exam description Updated Fall 2017*. https://apcentral.collegeboard.org/pdf/ap-computer-science-principles-course-and-exam-description.pdf

Cook, T. D. (1991). Clarifying the warrant for generalized causal inferences in quasi-experimentation. In M. W. Mclaughlin & D. C. Philips (Eds.), *Evaluation and education: At quarter-century* (pp. 115–144). National Society for the Study of Education.

Cook, T. D., & Campbell, D. T. (1979). *Quasi-experimentation: Design and analysis issues for field settings.* Houghton Mifflin Company.

Cook, T. D., & Campbell, D. T. (1986). The causal assumptions of quasi-experimental practice. *Synthese*, *68*, 141–180.

Cortes, K., Goodman, J., & Nomi, T. (2015). Intensive math instruction and educational attainment: Long-run impacts of double-dose algebra. *Journal of Human Resources*, *50*(1), 108–158.

Cramer, K. A., Post, T., & Currier, S. (1993). Learning and teaching ratio and proportion: Research implications: Middle grades mathematics. In D. Owens (Ed.), *Research ideas for the classroom: Middle grades mathematics* (pp. 159–178). MacMillan Publishing Company.

Creswell, J. W., & Clark, V. L. P. (2017). *Designing and Conducting Mixed Methods Research* (3rd Ed.). SAGE Publications.

Cronbach, L. J., & Meehl, P. E. (1955). Construct validity in psychological tests. *Psychological Bulletin*, *52*(4), 281–302. https://doi.org/10.1037/h0040957

Daniel, D. B., & Klaczynski, P. A. (2006). Developmental and individual differences in conditional reasoning: Effects of logic instructions and alternative antecedents. *Child Development*, *77*(2), 339–354. https://doi.org/10.1111/j.1467-8624.2006.00874.x

Dann, W. P., Copper, S., & Pausch, R. (2008). *Learning To Program with Alice* (2nd Editio). Prentice Hall Press.

Darley, J. W. (2009). Traveling from arithmetic to algebra. *Mathematics Teaching in the Middle School*, *14*(8), 458–464.

Daroczy, G., Wolska, M., Meurers, W. D., & Nuerk, H. C. (2015). Word problems: A review of linguistic and numerical factors contributing to their difficulty. *Frontiers in Psychology*, *6*(APR), 1–13. https://doi.org/10.3389/fpsyg.2015.00348

Davies, A., Fidler, D., & Gorbis, M. (2011). *Future work skills 2020*.

Davis, A. L. (2013). Using instructional design principles to develop effective information literacy instruction: The ADDIE model. *College & Research Libraries News*, *74*(4), 205–207. https://doi.org/10.5860/crln.74.4.8934

Davydov, V. V. (1982). Psychological characteristics of the formation of mathematical operations in children. In T. P. Carpenter, J. M. Moser, & T. A. Romberg (Eds.), *Addition and subtraction: Cognitive perspective* (pp. 225–238). Lawrence Erlbaum Associates.

De Walle, J. A. V., Karp, K. S., & Bay-Williams, J. M. (2013). *Elementary and Middle school Mathematics Teaching Developmentally* (8th Ed.). Pearson Education Inc.

Dede, C., Ketelhut, D. J., Whitehouse, P., Breit, L., & McCloskey, E. M. (2008). A research agenda for online teacher professional development. *Journal of Teacher Education*, *60*(1), 8–19. https://doi.org/10.1177/0022487108327554

Dede, Y. (2004). The concept of variable and identification its learning difficulties. *Theory and Practice*, *4*(1), 50–56.

Demirel, O. (2000). *Planlamadan değerlendirmeye öğretme sanatı*. Pegem A Yayıncılık.

Denning, P. (2017). Remaining trouble spots with computational thinking. *Communications of the ACM*, *60*(6), 33–39. https://doi.org/10.1145/2998438

Depaepe, F., De Corte, E., & Verschaffel, L. (2010). Teachers' approaches towards word problem solving: Elaborating or restricting the problem context. *Teaching and Teacher Education: An International Journal of Research and Studies*, *26*, 152–160. https://doi.org/10.1016/j.tate.2009.03.016

DeSantis, L., & Ugarriza, D. N. (2000). The concept of theme as used in qualitative nursing research. *Western Journal of Nursing Research*, *22*(3), 351–372. https://doi.org/10.1177/019394590002200308

Dey, I. (1993). Creating categories. In G. R. Gibbs (Ed.), *Qualitative data analysis* (pp. 94–112). Routledge, Inc.

Dogan, U., & Kert, S. B. (2016). Bilgisayar Oyunu Geliştirme Sürecinin, Ortaokul Öğrencilerinin Eleştirel Düşünme Becerilerine ve Algoritma Başarılarına Etkisi. *Boğaziçi Üniversitesi Eğitim Dergisi*, *33*(2), 21–42.

Doorman, M., Drijvers, P., Gravemeijer, K., Boon, P., & Reed, H. (2012). Tool use and the development of the function concept: From repeated calculations to functional thinking. *International Journal of Science and Mathematics Education*, *10*, 1243–1267.

Dougherty, S. M., Goodman, J. S., Hill, D. V., Litke, E., & Page, L. C. (2017). Objective course placement and college readiness: Evidence from targeted middle school math acceleration. *Economics of Education Review*, *58*, 141–161.

Drijvers, P. (2004). Learning algebra in a computer algebra environment. *The International Journal of Computer Algebra in Mathematics Education*, *11*(3), 77–89.

Driver, M. K., & Powell, S. R. (2015). Symbolic and nonsymbolic equivalence tasks: The influence of symbols on students with mathematics difficulty. *Learning Disabilities Research & Practice*, *30*, 127–134.

Duncan, C., Bell, T., & Tanimoto, S. (2014). Should your 8-year-old learn coding? *WiPSCE '14: Proceedings of the 9th Workshop in Primary and Secondary Computing Education*, 60–69.

Egodawatte, G., & Stoilescu, D. (2015). Grade 11 Students' Interconnected Use of Conceptual Knowledge, Procedural Skills, and Strategic Competence in Algebra: A Mixed Method Study of Error Analysis. *European Journal of Science and Mathematics Education*, *3*(3), 289–305. http://search.proquest.com/docview/1826544808?accountid=10673

Ehmke, T., Pesonen, M. E., & Haapasalo, L. (2010). Assessment of university students' understanding of abstract binary operations. *Nordic Studies in Mathematics Education*, *15*(4), 25–40.

Ellis, A., Ozgur, Z., & Reiten, L. (2018). Teacher moves for supporting student reasoning. *Mathematics Education Research Journal*, *31*(1), 1–26.

Erdogan, T., Akkaya, R., & Celebi Akkaya, S. (2009). The Effect of the Van Hiele Model Based Instruction on the Creative Thinking Levels of 6th Grade Primary School Students. *Educational Sciences: Theory & Practice*, *91*(1), 181–194.

Erümit, K. A., Karal, H., Şahin, G., Aksoy, D. A., Gencan, A. A., & Benzer, A. I. (2019). A model suggested for programming teaching: Programming in seven steps. *Egitim ve Bilim*, *44*(197), 155–183. https://doi.org/10.15390/EB.2018.7678

Esmonde, I. (2009). Ideas and identities: supporting equity in cooperative mathematics learning. *Review of Educational Research*, *79*(2), 1008–1043.

Farrokhi, F., & Mahmoudi-Hamidabad, A. (2012). Rethinking convenience sampling: Defining quality criteria. *Theory and Practice in Language Studies*, *2*(4), 784–792. https://doi.org/10.4304/tpls.2.4.784-792

Felleisen, M., & Krishnamurthi, S. (2009). Viewpoint: Why computer science doesn't matter. *Communications of the ACM*, *52*(7), 37–40. https://doi.org/10.1145/1538788.1538803

Feurzeig, W., Papert, S., & Lawler, B. (2011). Programming-languages as a conceptual framework for teaching mathematics. *Interactive Learning Environments*, *19*(5), 487–501.

Fey, J. T., & Smith, D. A. (2017). Algebra as part of an integrated high school curriculum. In S. Stewart (Ed.), *And the rest is just algebra* (pp. 119–129). Springer International Publishing.

Field, A. (2013). *Discovering Statistics using IBM SPSS Statistics* (4th Editio). SAGE Publications Ltd.

Fife-Schaw, C. (2000). Quasi-Experimental Designs. In G. M. Breakwell, S. Hammond, & C. Fife-Schaw (Eds.), *Research Methods in Psychology* (2nd Ed.). Sage Publication Ltd.

Figueira-Sampaio, A. D. S., dos Santos, E. E. F., & Carrijo, G. A. (2009). A constructivist computational tool to assist in learning primary school mathematical equations. *Computers & Education*, *53*(2), 484–492.

Filipsson, L., & Thunberg, H. (2008). Aims Versus Expectations – A Swedish Study of Problems Related to the Transition from Secondary to Tertiary Education in Mathematics. *International Congress on Mathematical Education-ICME 11*, *January 2008*. http://www.math.kth.se/~thunberg/full-pdf/ICME11_aims_vs_expect.pdf

Filloy, E., & Rojano, T. (1989). Solving Equations: the Transition from Arithmetic to Algebra. *For the Learning of Mathematics*, *9*(2), 19–25.

Fitzgerald, K. (2014). Instructional methods and settings. In S. B. Bastable (Ed.), *Nurse as Educator: Principles of Teaching and Learning for Nursing Practice* (4th Ed., pp. 469–516). Jones & Bartlett Learning, LLC.

Freiman, V., & Lee, L. (2004). Tracking primary students' understanding of the equal sign. *Proceedings of the 28th Conference of the International Group for the Psychology of Mathematics Education*, *2*, 415–422. http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:TRACKING+PRIMARY+STUDENTS+?+UNDERSTANDING+OF+THE#1

Fuchs, L. S., & Fuchs, D. (2005). Enhancing mathematical problem solving for students with disabilities. *The Journal of Special Education*, *39*(1), 45–47.

Fuchs, L. S., Powell, S. R., Cirino, P. T., Schumacher, R. F., Marrin, S., Hamlett, C. L., Fuchs, D., Compton, D. L., Changas, P. C., & Changes, P. C. (2014). Does Calculation or Word-Problem Instruction Provide A Stronger Route to Pre-Algebraic Knowledge? *Journal of Educational Psychology*, *106*(4), 990–1006.

Fuchs, L. S., Powell, S. R., Seethaler, P. M., Cirino, P. T., Fletcher, J. M., Fuchs, D., & Hamlett, C. L. (2010). The effects of strategic counting instruction, with and without deliberate practice, on number combinations skill among students with mathematics difficulties. *Learning and Individual Differences*, *20*, 89–100.

Funke, A., & Geldreich, K. (2017). Measurement and Visualization of Programming Processes of Primary School Students in Scratch. *WiPSCE '17: Proceedings of the 12th Workshop on Primary and Secondary Computing Education*, 101–102. https://doi.org/10.1145/3137065.3137086

Funke, A., Geldreich, K., & Hubwieser, P. (2017). Analysis of Scratch Projects of an Introductory Programming Course for Primary School Students. *Proceedings of the 2017 IEEE Global Engineering Education Conference (EDUCON)*, *April*, 1233–1240. https://doi.org/10.1109/EDUCON.2017.7943005

Fuson, K. C. (1992). Research on whole number addition and subtraction. In *Handbook of research on mathematics teaching and learning* (pp. 243–275). Macmillan Publishing Company.

Futschek, G. (2006). Algorithmic Thinking: The Key for Understanding Computer Science. In R. T. Mittermeir (Ed.), *Informatics Education – The Bridge between Using and Understanding Computers. ISSEP 2006. Lecture Notes in Computer Science, vol 4226* (pp. 159–168). Springer Berlin Heidelberg.

Gadanidis, B. G., Brodie, I., & Minniti, L. (2017). *Computer Coding in the K – 8 Mathematics Curriculum ?* http://www.edu.gov.on.ca/eng/literacynumeracy/inspire/research/computer_coding_k8_en.pdf

Galotti, K. M. (1989). Approaches to studying formal and everyday reasoning. *Psychological Bulletin, 105*(3), 331–351.

Garner, S. (2009). Learning to program from Scratch. *Proceedings of the 9th IEEE International Conference on Advanced Learning Technologies*, 451–452.

Garson, G. D. (2012). *Testing Statistical Assumptions*. Statistical Publishing Associates.

Gasco, J., & Villarroel, J. D. (2014). The motivation of secondary school students in mathematical word problem solving. *Electronic Journal of Research in Educational Psychology*, *12*, 83–106.

Gay, L. R., Mills, G. E., & Airasian, P. W. (2019). *Educational Research: Competencies for Analysis and Applications* (12th Ed.). Pearson Education, Inc.

Geary, D. C., Hoard, M. K., Byrd-Craven, J., Nugent, L., & Numtee, C. (2007). Cognitive mechanisms underlying achievement deficits in children with mathematics learning disability. *Child Development*, *78*, 1343–1359.

Geary, D. C., Hoard, M. K., Nugent, L., & Bailey, D. H. (2012). Mathematical cognition deficits in children with learning disabilities and persistent low achievement: A five-year prospective study. *Journal of Educational*

Psychology, *104*(1), 206–223. https://doi.org/10.1037/a0025398

Ghosh, J. B. (2012). Learning Mathematics in Secondary School: The Case of Mathematical Modelling Enabled by Technology. *12th International Congress on Mathematical Education*, 203–222. https://doi.org/10.1007/978-3-319-17187-6_12

Gijbels, D., van de Watering, D., Dochy, F., & van den Bossche, P. (2006). New learning environments and constructivism: the students' perspective. *Instructional Science*, *34*(3), 213–226.

Glaser, B. G., & Strauss, A. L. (2012). *The discovery of grounded theory: Strategies for qualitative research*. AldineTransaction, A Division of Transaction Publishers.

Goeke, J. L. (2009). *Explicit Instruction: A Framework for Meaningful Direct Teaching* (1st Ed.). Pearson Education, Inc.

Good, J. (2011). Learners at the Wheel. *International Journal of People-Oriented Programming*, *1*(1), 1–24. https://doi.org/10.4018/ijpop.2011010101

Google Inc. (2018). *Google for education: Exploring computational thinking*. https://edu.google.com/resources/programs/exploring-computational-thinking/#!ct- overview

Gough, D., Oliver, S., & Thomas, J. (2013). *Learning From Research: Systematic Reviews for Informing Policy Decisions a Quick Guide*. The Alliance for Useful Evidence. http://www.alliance4usefulevidence.org/assets/Alliance-FUE-reviews-booklet-3.pdf

Grbich, C. (2013). *Qualitative Data Analysis: An Introduction* (2nd Ed.). SAGE Publications Ltd.

Green, Alison, J. K., & Gilhooly, K. (2005). Problem solving. In N. Braisby & A. Gellatly (Eds.), *Cognitive Physcology* (1st ed., pp. 347–381). Oxford University Press.

Greeno, J. G., Moore, J. L., & Smith, D. R. (1993). Transfer of situated learning. In D. K. Detterman & R. J. Sternberg (Eds.), *Transfer on trial: Intelligence, cognition, and instruction* (pp. 99–167). Ablex Publishing.

Griffin, P., & Care, E. (2015). The ATC21S Method. In Patrick Griffin & E. Care (Eds.), *Assessment and Teaching of 21st Century Skills: Methods and Approach* (pp. 3–33). Springer. https://doi.org/10.1007/978-94-017-9395-7_1

Griffin, P., McGaw, B., & Care, E. (2012). The changing role of education and schools. In Patrick Griffin, B. McGaw, & E. Care (Eds.), *Assessment and Teaching of 21st Century Skills* (pp. 1–15). Springer.

Grover, S., & Basu, S. (2017). Measuring Student Learning in Introductory Block-Based Programming : Measuring Student Learning in Introductory Block-

Based Programming : Examining Misconceptions of Loops , Variables , and Boolean Logic. *Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education*, 267–272. https://doi.org/10.1145/3017680.3017723

Grover, S., & Pea, R. D. (2013). Computational Thinking in K–12: A review of the state of the field. *Educational Researcher*, *42*(1), 38–43. https://doi.org/10.3102/0013189X12463051

Guttag, J. V. (2013). *Introduction to computation and programming using Python*. MIT Press.

Guyer, T. (2008). Computer Algebra Systems as the Mathematics Teaching Tool. *World Applied Sciences Journal*, *3*(1), 132–139.

Gvozdic, K., & Sander, E. (2020). Learning to be an opportunistic word problem solver: Going beyond informal solving strategies. *ZDM Mathematics Education*, *52*(1), 111–123. https://doi.org/10.1007/s11858-019-01114-z

Haapasalo, L. (2003). The conflict between conceptual and procedural knowledge: Should we need to understand in order to be able to do, or vice versa? In L. Haapasalo & K. Sormunen (Eds.), *Proceedings on the 19th Symposium of the Finnish Mathematics and Science Education Research Association* (pp. 1–20). Bulletins of the Faculty of Education 86.

Haapasalo, L., & Zimmerman, B. (2015). Investigating mathematical beliefs by using a framework from the history of mathematics. In C. Bernack-Schler, R. Erens, T. Leuders, & A. Eichler (Eds.), *Views and Beliefs in Mathematics Education* (pp. 197–211). Springer.

Haapasalo, L., Zimmerman, B., & Rehlich, H. (2004). A versatile tool to promote link between creative production and conceptual understanding. *The Teaching of Mathematics*, *7*(2), 61–70.

Hague, C., & Payton, S. (2011). Digital literacy across the curriculum. *Curriculum & Leadership Journal*, *9*(10).

Halim, A. A., & Mohini, M. (2008). The Use of Interactive Geometry Software (IGS) to Develop Geometric Thinking. *Jurnal Teknologi*, *49*, 93–107.

Halpern, D. F. (2014). *Thought and knowledge: An introduction to critical thinking* (5th Ed.). Psychology Press.

Halpin, R. (1999). A model of constructivist learning in practice: computer literacy integrated into elementary mathematics and science teacher education. *Journal of Research on Computing Education*, *32*(1), 128–138.

Hambrusch, S., Hoffmann, C., Korb, J. T., Haugan, M., & Hosking, A. L. (2009). A multidisciplinary approach towards computational thinking for science majors. *ACM SIGCSE Bulletin*, *41*(1), 183–187.

https://doi.org/10.1145/1539024.1508931

Harel, I., & Papert, S. (1991). *Constructionism: Research Reports and Essays, 1985-1990*. Ablex Publishing Corporation.

Harrison, C. (2013). Collaborative action research as a tool for generating formative feedback on teachers classroom assessment practice: The KREST project. *Teachers and Teaching Theory and Practice*, *19*(2), 202–213. https://doi.org/10.1080/13540602.2013.741839

Hart, L. C., Oesterle, S., Auslander, S. S., & Kajander, A. (2016). *The Mathematics Education of Elementary Teachers: Issues and Strategies for Content Courses*. Information Age Publishing, Inc.

Hawthorne, C., & Rasmussen, C. (2015). A framework for characterizing students' thinking about logical statements and truth tables. *International Journal of Mathematical Education in Science and Technology*, *46*(3), 337–353. https://doi.org/10.1080/0020739X.2014.979895

Hazzan, O. (2003). How students attempt to reduce abstraction in the learning of mathematics and in the learning of computer science. *Computer Science Education*, *13*(2), 95–122. https://doi.org/10.1076/csed.13.2.95.14202

Hazzan, O. (2008). Reflections on teaching abstraction and other soft ideas. *ACMSIGCSE Bulletin*, *40*(2), 40–43.

Hegarty, M., Mayer, R. E., & Monk, C. A. (1995). Comprehension of arithmetic word problems: A comparison of successful and unsuccessful problem solvers. *Journal of Educational Psychology*, *87*, 18–32.

Heid, M. K., & Blume, G. M. (2008). *Research on technology and the teaching and learning of mathematics: Research syntheses*. Information Age Publishing.

Henze, N., & Nejdl, W. (2000). Extendible adaptive hypermedia courseware: integrating different courses and web material. In P. Brusilovsky, O. Stock, & C. Strappavara (Eds.), *Adaptive hypermedia and adaptive web-based systems* (pp. 109–120). Springer-Verlag.

Herscovics, N. (1989). Cognitive Obstacles Encountered in the Learning of Algebra. In S. Wagner & C. Kieran (Eds.), *Research Issues in the Learning and Teaching of Algebra* (pp. 60–92). Lawrence Erlbaum.

Herscovics, N., & Linchevski, L. (1994). A Cognitive Gap between Arithmetic and Algebra. *Educational Studies in Mathematics*, *27*(1), 59–78.

Hill, B. M., & Monroy-Hernández, A. (2017). A longitudinal dataset of five years of public activity in the Scratch online community. *Scientific Data*, *4*, 170002.

Hillis, W. D. (1998). *The pattern on the stone: The simple ideas thatmake computers work*. Basic Books Inc.

Hohenwarter, M., & Jones, K. (2007). Ways of linking geometry and algebra: the case of GeoGebra. *Proceedings of the British Society for Research into Learning Mathematics*, *27*(3), 126–131. http://eprints.soton.ac.uk/50742/

Holzinger, A., Kickmeier-Rust, M. D., Wassertheurer, S., & Hessinger, M. (2009). Learning performance with interactive simulations in medical education: lessons learned from results of learning complex physiological models with the HAEMOdynamics SIMulator. *Computer & Education*, *52*(2), 292–301.

Honey, M., Pearson, G., & Schweingruber, H. (2014). *STEM integration in K-12 education: Status, prospects, and an agenda for research*. National Academies Press.

Howland, J. L., Jonassen, D. H., & Marra, R. M. (2013). *Meaningful learning with technology* (4th Ed.). Pearson Education.

Hoyles, C., & Lagrange, C. (2009). *Mathematics education and technology – Rethinking the terrain*. Springer.

Hromkovic, J., Kohn, T., Komm, D., & Serafini, G. (2016). Examples ofalgorithmic thinking in programming education. *Olympiads in Informatics*, *10*, 111–124.

Hsiao, I. H., & Brusilovsky, P. (2010). The role of community feedback in the student example authoring process: an evaluation of AnnotEx. *British Journal of Educational Technology*, *42*(3), 482–499.

Hsu, T. C., Chang, S. C., & Hung, Y. T. (2018). How to learn and how to teach computational thinking: Suggestions based on a review of the literature. *Computers & Education*, *126*, 296–310.

Hsu, T., Lee, H. J., Turton, M. A., & Cheng, S. (2014). Using the ADDIE model to develop online continuing education courses on caring for nurses in Taiwan. *Journal of Continuing Education in Nursing*, *45*(3), 124. https://doi.org/10.3928/00220124-20140219-04

Huitema, B. (2011). *The analysis of covariance and alternatives: Statistical methods for experiments, quasi-experiments, and single-case studies (Vol. 608)*. John Wiley & Sons.

Hung, Y. C. (2008). The effect of problem-solving instruction on computer engineering majors' performance in Verilog (HDL) programming. *IEEE Transaction on Education*, *51*(1), 131–137.

Hutkemri, E. Z. (2014). Impact of using Geogebra on Students' Conceptual and Procedural Knowledge of Limit Function. *Mediterranean Journal of Social Sciences*, *5*(23), 873–881. https://doi.org/10.5901/mjss.2014.v5n23p873

Hwang, G. J., Chen, C. Y., Tsai, P. S., & Tsai, C. C. (2011). An expert system for improving web-based problem solving ability of students. *Expert Systems with Applications*, *38*, 8664–8672.

Hwang, W. Y., Wang, C. Y., Hwang, G. J., Huang, Y. M., & Huang, S. (2008). A web-based programming learning environment to support cognitive development. *Interacting with Computers*, *20*(6), 524–534.

International Society for Technology in Education, (ISTE)., & Computer Science Teachers Association, (CSTA). (2011). *Operational definition of Computational Thinking*. https://id.iste.org/docs/ct-documents/computational-thinking-operational-definition-flyer.pdf?sfvrsn=2#:~:text=Computational thinking (CT) is a,tools to help solve them.

Jaworski, B. (2015). Mathematics meaning-making and its relation to design of teaching. *PNA*, *9*(4), 261–272.

Jeffries, P. R. (2005). A Frame Work for Designing, Implementing, and Evaluating Simulations Used as Teaching Strategies in Nursing. *Nursing Education Perspectives*, *26*(2), 96–103.

Jimenez, L., & Verschaffel, L. (2014). Development of children's solutions of non-standard arithmetic word problem solving non-standard arithmetic word problems. *Revista de Psicodidáctica*, *19*, 93–123.

Jitendra, A. (2002). Teaching students math problem-solving through graphic representations. *Teaching Exceptional Children*, *34*(4), 34–38.

Johnson, B., & Christensen, L. (2008). *Educational Research: Quantitative, Qualitative, and Mixed Approaches* (B. Johnson (ed.); 3rd Ed.). Sage Publication Ltd.

Jonassen, D. H. (1999). Constructivist learning environment on the web: Engaging students in meaningful learning. *EdTech99: Educational Technology Conference and Exhibition 1999: Thinking Schools, Learning Nation.*

Jonassen, D. H. (2000). Toward a design theory of problem solving. Educational technology research and development. *Educational Technology Research and Development*, *48*(4), 63–85. https://doi.org/10.1007/BF02300500

Jonassen, D. H. (2006). A constructivist's perspective on functional contextualism. *Educational Technology Research & Development*, *54*(1), 43–47.

Jordan, N. G., Hanich, L. B., & Kaplan, D. (2003). Arithmetic fact mastery in young children: A longitudinal investigation. *Journal of Experimental Child Psychology*, *85*, 103–119.

Kadijevich, D. J. (2007). Towards relating procedural and conceptual knowledge by CAS. *5th Computer Algebra in Mathematics Education Symposium*, 1–11.

Kadijevich, D. J., & Haapasalo, L. (2001). Linking procedural and conceptual mathematical knowledge through CAL. *Journal of Computer Assisted Learning*, *17*(2), 156–165.

Kafai, Y. B., & Burke, Q. (2015). Constructionist gaming: Understanding the benefits of making games for learning. *Educational Psychologist*, *50*(4), 313–334.

Kalchman, M., & Koedinger, K. R. (2005). Teaching and learning functions. In M. S. Donovan & J. D. Bransford (Eds.), *How students learn: Mathematics in the classroom* (pp. 351–396). The National Academies Press.

Kalelioglu, F. (2015). A new way of teaching programming skills to K-12 students: Code.org. *Computers in Human Behavior*, *52*, 200–210. https://doi.org/10.1016/j.chb.2015.05.047

Kaput, J. J. (1992). Technology and mathematics education. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 515–556). Macmillan Publishing Company.

Kaput, J. J. (1998). Transforming Algebra from an Engine of Inequity to an Engine of Mathematical Power by “Algebrafying” the K-12 Curriculum. *The Nature and Role of Algebra in the K-14 Curriculum: Proceedings of a National Symposium*.

Kaput, J. J. (1999). Teaching and learning a new algebra. In E. Fennema & T. A. Romberg (Eds.), *Mathematics classrooms that promote understanding* (pp. 133–155). Lawrence Erlbaum Associates, Inc.

Kaput, J. J. (1995). Long term algebra reform: Democratizing access to big ideas. In C. Lacampagne, J. J. Kaput, & W. Blair (Eds.), *The Algebra Initiative Colloquium (Vol. 1)* (pp. 33–49). Department of Education, Office of Research.

Kaput, J. J., Carraher, D. W., & Blanton, M. L. (2007). *Algebra in the Early Grades (Studies in Mathematical Thinking and Learning Series)* (1st Ed.). Routledge.

Kaput, J. J., & West, M. (1994). Missing value proportional reasoning problems: Factors affecting informal reasoning patterns. In G. Harel & J. Confrey (Eds.), *The development of multiplicative reasoning in the learning of mathematics* (pp. 237–287). State University of New York Press.

Kaur, B. (2019). The why, what and how of the ‘Model’ method: a tool for representing and visualising relationships when solving whole number arithmetic word problems. *ZDM: The International Journal on Mathematics Education*, *51*(4), 151–168.

Khadimally, S. (2015). Designing effective curricula with an interactive collaborative curriculum design tool (CCDT). *TOJET: The Turkish Online Journal of Educational Technology*, *14*(3), 32–62.

Kieran, C. (1989). The Early Learning of Algebra: A Structural Perspective. In S. Wagner & C. Kieran (Eds.), *Research Issues in the Learning and Teaching of Algebra* (pp. 33–56). Lawrence Erlbaum.

Kieran, C. (1990). Cognitive Processes involved in Learning School Algebra. In P. Nesher & J. Kilpatrick (Eds.), *Mathematics and Cognition* (pp. 96–112). Cambridge University Press.

Kieran, C. (1992). The Learning and Teaching of School Algebra. In D. Grouws (Ed.), *Handbook of Research on Mathematics Teaching and Learning* (pp. 390–419). Macmillan Publishing Company.

Kieran, C. (2004). Algebraic thinking in the early grades: What is it? *The Mathematics Educator*, *8*(1), 139–151.

Kieran, C. (2007). Learning and teaching algebra at the middle school through college levels. In F. Lester (Ed.), *The second handbook of research on mathematics teaching and learning* (pp. 707–762). National Council of Teachers of Mathematics.

Kieran, C. (2013). The false dichotomy in mathematics education between conceptual understanding and procedural skills: An example from algebra. In K. R. Leatham (Ed.), *Vital directions for mathematics education research* (pp. 153–171). Springer.

Kilpatrick, J., & Swafford, J. (2002). *Helping children learn mathematics*. National Academies Press.

Kim, Y. N., & Steiner, P. (2016). Quasi-Experimental Designs for Causal Inference. *Journal of Educational Psychology*, *51*(3–4), 395–405.

Kimberlin, C. L., & Winterstein, A. G. (2008). Validity and reliability of measurement instruments used in research. *American Journal of Health-System Pharmacy*, *65*(23), 2276–2284.

Kitchenham, B., & Charters, S. (2007). *Guidelines for performing Systematic Literature Reviews in Software Engineering*. https://doi.org/10.1145/1134285.1134500

Koedinger, K. R., & Nathan, M. J. (2004). The real story behind story problems: effects of representations on quantitative reasoning. *Journal of the Learning Sciences*, *13*, 129–164. https://doi.org/10.1207/s15327809jls1302_1

Kölling, M., & Henriksen, P. (2005). Game programming in introductory courses with direct state manipulation. *Proceedings of the 10th Annual SIGCSE Conference on Innovation and Technology in Computer Science Education*, 59–63.

Kolovou, A., van den Heuvel-Panhuizen, M., & Koller, O. (2013). An intervention including an online game to improve grade 6 students' performance in early algebra. *Journal for Research in Mathematics Education*, *44*(3), 510–549.

Koneru, I. (2010). ADDIE: Designing web-enabled information literacy instruction modules. *Journal of Library & Information Technology*, *30*(3), 23–34.

Korkmaz, O. (2016). The Effect of Scratch- and Lego Mindstorms Ev3-Based Programming Activities on Academic Achievement, Problem-Solving Skills and Logical-Mathematical Thinking Skills of Students. *Malaysian Online Journal of Educational Sciences*, *4*(3), 73–88.

Kouvela, E., Hernandez-Martinez, P., & Croft, T. (2018). "This is what you need to be learning": An analysis of messages received by first-year mathematics students during their transition to university. *Mathematics Education Research Journal*, *30*, 165–183. https://doi.org/10.1007/s13394-017-0226-2

Kramer, J. (2007). Is abstraction the key to computing? *Communications of the ACM*, *50*(4), 37–42.

Kumar, D. D., & Sherwood, R. D. (2007). Effect of a problem based simulation on the conceptual understanding of undergraduate science education students. *Journal of Science Education and Technology*, *16*(3), 239–246. https://doi.org/10.1007/s10956-007-9049-3

Lai, A. F., & Yang, S. M. (2011). The learning effect of visualized programming learning on 6th graders' problem solving and logical reasoning abilities. *2011 International Conference on Electrical and Control Engineering, ICECE 2011 - Proceedings*, 6940–6944. https://doi.org/10.1109/ICECENG.2011.6056908

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, *33*(1), 159–174. http://www.ncbi.nlm.nih.gov/pubmed/843571

Lannin, J. K., Barker, D. D., & Townsend, B. E. (2006). Recursive and explicit rules: How can we build student algebraic understanding? *The Journal of Mathematical Behavior*, *25*(4), 299–317.

Lawless, K. A., & Brown, S. W. (2015). Developing scientific literacy skills through interdisciplinary, technology-based global simulations: GlobalEd 2. *The Curriculum Journal*, *26*(2), 268–289. https://doi.org/10.1080/09585176.2015.1009133

Lawson, A. E. (1992). The development of reasoning among college biology students- a review of research. *Journal of College Science Teaching*, *21*, 338–344.

Lawson, A. E., Banks, D. L., & Logvin, M. (2007). Self-efficacy, reasoning ability, and achievement in college biology. *Journal of Research in Science Teaching*, *44*(5), 706–724. https://doi.org/10.1002/tea.20172

Lean, G. A., Clemens, M. A., & Del Campo, G. (1990). Linguistic and pedagogical factors affecting children's understanding of arithmetic word problems: A comparative study. *Educational Studies in Mathematics*, *21*, 165–191.

Leder, G. C. (1992). Mathematics and gender: Changing perspectives. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning: A project of the National Council of Teachers of Mathematics* (pp. 597–622). Macmillan Publishing Co, Inc.

Lee, E. Y., Kafai, Y. B., Vasudevan, V., & Davis, R. L. (2014). Playing in the Arcade: Designing Tangible Interfaces with MaKey MaKey for Scratch Games. *Playful User Interfaces*, 277–292. https://doi.org/10.1007/978-981-4560-96-2_13

Lee, K., Ng, E. L., & Ng, S. F. (2009). The contributions of working memory and executive functioning to problem representation and solution generation in algebraic word problems. *Journal of Educational Psychology*, *101*(2), 373–387.

Lee, S., Kim, J., & Lee, W. (2017). Analysis of factors affecting achievement in maker programming education in the age of wireless communication. *Wireless Personal Communications*, *93*(1), 187–209.

Lee, S. S., Seo, M. H., Kim, J. S., & Kim, J. Y. (2007). Development and Evaluation of the "Doctor and Leadership" Curriculum. *Korean Journal of Medical Education*, *19*(4), 279–286.

Lee, Y. S., & Cho, J. W. (2018). Factor Analysis of Computational Thinking for Software Education Based on Problem-Solving Learning. *International Journal of Pure and Applied Mathematics*, *120*(6), 4953–4967.

Lerman, S. (2020). *Encyclopaedia in mathematics education*. Springer International Publishing.

Lewis, C. M. (2010). How Programming Environment Shapes Perception, Learning and Goals: Logo vs. Scratch. *SIGCSE '10 : Proceedings of the 41st ACM Technical Symposium on Computer Science Education*, 346–350.

Li, Q., & Ma, X. (2010). A meta-analysis of the effects of computer technology on school students' mathematics learning. *Educational Psychology Review*, *22*(3), 215–243. https://doi.org/10.1007/s10648-010-9125-8

Liljedahl, P., Sinclair, N., & Zazkis, R. (2006). Number concepts with number worlds: Thickening understandings. *International Journal of Mathematical Education in Science and Technology*, *37*(3), 253–275. https://doi.org/10.1080/00207390500285909

Lin, J. M. C., & Liu, S. F. (2012). An investigation into parent-child collaboration in learning computer programming. *Journal of Educational Technology & Society*, *15*(1), 162–173.

Lin, M. Y. (2015). *Collaborative Writing in a Computer-Supported Classroom: Mediation, and Self-Assessed Beliefs and Attitudes about Writing*. University of Toronto.

Linchevski, L. (1995). Algebra with numbers and arithmetic with letters: A definition of pre-algebra. *Journal of Mathematical Behavior*, *14*(1), 113–120.

Linchevski, L., & Herscovics, N. (1996). Research Issues in the Learning and Teaching of Algebra. *Educational Studies in Mathematics*, *30*, 39–65.

LinkedIn Talent Solutions. (2017). *The digital workforce of the future: Acquire, build and grow tech talent*. https://business.linkedin.com/content/dam/me/business/en-us/talent-solutions/cx/2017/PDFs/digital_workforce_future.pdf

Liu, C. C., & Tsai, C. C. (2008). An analysis of peer interaction patterns as discoursed by on-line small group problem-solving activity. *Computer & Education*, *50*(3), 627–639.

Liu, D., Ma, S., Ru, Q., Guo, Z., & Ma, S. (2009). Design of multi-strategic learning environment based on constructivism. *Proceedings of the 1st International Workshop on Education Technology and Computer Science*, 226–228.

Liu, H., Ludu, M., & Holton, D. (2015). Can K-12 math teachers train students to make valid logical reasoning? In X. Ge, D. Ifenthaler, & J. M. Spector (Eds.), *Emerging technologies for STEAM education: Full STEAM ahead* (pp. 331–353). Springer International Publishing.

Liu, H., & Raghavan, J. (2009). A mathematical modeling module with system engineering approach for teaching undergraduate students to conquer complexity. *International Conference on Computational Science*, 93–102.

Liu, J. L., & Wang, L. H. (2010). Computational Thinking in Discrete Mathematics. *2010 Second International Workshop on Education Technology and Computer Science*, 413–416.

Lodico, M. G., Spaulding, D. T., & Voegtle, K. H. (2006). *Methods in Educational Research: From Theory to Practice*. John Wiley & Sons.

Lu, J. J., & Fletcher, G. H. L. (2009). Thinking about computational thinking. *SIGCSE Bulletin Inroads*, *41*(1), 260–264. https://doi.org/10.1145/1539024.1508959

Lunenburg, F. C., & Lunenburg, M. R. (2014). Applying Multiple Intelligences in The Classroom: A Fresh Look at Teaching Writing. *INTERNATIONAL JOURNAL OF SCHOLARLY ACADEMIC INTELLECTUAL DIVERSITY*, *16*(1), 1–13.

Lye, S. Y., & Koh, J. H. L. (2014). Review on teaching and learning of computational thinking through programming: What is next for K-12? *Computers in Human Behavior*, *41*, 51–61. https://doi.org/10.1016/j.chb.2014.09.012

Lynn, M. R. (1986). Determination and Quantification of Content Validity.pdf. *Nursing Research*, *35*(6), 382–385. https://doi.org/10.1161/CIRCULATIONAHA.112.092098

Maccini, P., & Ruhl, K. L. (2001). Effects of a graduated instructional sequence on the algebraic subtraction of integers by secondary students with learning disabilities. *Education and Treatment of Children*, *23*, 465–489.

MacGregor, M., & Stacey, K. (1997). Students' understanding of algebraic notation: 11–15. *Educational Studies in Mathematics*, *33*, 1–19.

MacKinnon, D. P., Fairchild, A. J., & Fritz, M. S. (2007). Mediation analysis. *Annual Review of Psychology*, *58*, 593–614.

Maftoon, P., & Sarem, S. N. (2012). The Realization of Gardner's Multiple Intelligences (MI) Theory in Second Language Acquisition (SLA). *Journal of Language Teaching and Research*, *3*(6), 1233–1241.

Malan, D. J., & Leitner, H. H. (2007). Scratch for budding computer scientists. *ACM SIGSCE Bulletin*, *39*(1), 223–227. https://doi.org/10.1145/1227504.1227388

Malara, N. A., & Navarra, G. (2003). *Aral project. Arithmetic pathways towards favouring pre-algebraic thinking*. Pitagora.

Malara, N. A., & Navarra, G. (2018). New words and concepts for early algebra teaching: Sharing with teachers' epistemological issues in early algebra to develop students' early algebraic thinking. In C. Kieran (Ed.), *Teaching and Learning Algebraic Thinking with 5- to 12-Year-Olds. ICME-13 Monographs.* (pp. 51–77). Springer. https://doi.org/10.1007/978-3-319-68351-5_3

Maloney, J., Peppler, K., Kafai, Y. B., Resnick, M., & Rusk, N. (2008). Programming by Choice: Urban Youth Learning Programming with

Scratch. *SIGCSE’08*, 367–371. https://doi.org/10.1007/s10639-019-09905-3

Margolis, J., Estrella, R., Goode, J., Holme, J. J., & Nao, K. (2008). *Stuck in the Shallow End: education, race and computing*. The MIT Press. http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:No+Title#0

Martinez, J. G. R. (2002). Building conceptual bridges from arithmetic to algebra. *Mathematics Teaching in the Middle School*, *7*(6), 326–331.

Mason, J., Burton, L., & Stacey, K. (2011). *Thinking Mathematically* (2nd Ed.). Pearson Education Limited.

Matthews, P., & Rittle-Johnson, B. (2009). In pursuit of knowledge: Comparing self-explanations, concepts, and procedures as pedagogical tools. *Journal of Experimental Child Psychology*, *104*, 1–21.

Maxwell, S. E., & Delaney, H. D. (1990). *Designing experiments and analyzing data: A model comparison approach*. Wadsworth Cengage Learning.

Mayer, R. E., & Hegarty, M. (1996). The process of understanding mathematical problem solving. In R. J. Sterberg & T. Ben-Zeev (Eds.), *The nature of mathematical thinking* (pp. 29–54). Lawrence Erlbaium Associates, Inc.

Mayfield, M. (2011). Creating training and development programs: Using the ADDIE method. *Development and Learning in Organisations*, *25*(3), 19–22. https://doi.org/10.1108/14777281111125363

Mayring, P. (2000). Quantitative Content Analysis. *Forum: Qualitative Social Research*, *1*(2), Art.20.

McCambridge, J., Witton, J., & Elbourne, D. R. (2014). Systematic review of the Hawthorne effect: New concepts are needed to study research participation effects. *Journal of Clinical Epidemiology*, *67*(3), 267–277.

McCarney, R., Warner, J., Iliffe, S., van Haselen, R., Griffin, M., & Fisher, P. (2007). The Hawthorne Effect: a randomised, controlled trial. *BMC Medical Research Methodology*, *7*, 30.

McNeil, N. M. (2008). Limitations to teaching children 2 + 2 = 4: Typical arithmetic problems can hinder learning of mathematical equivalence. *Child Development*, *79*, 1524–1537.

Meerbaum-Salant, O., Armoni, M., & Ben-Ari, M. (2013). Learning computer science concepts with scratch. *Computer Science Education*, *23*(3), 239–264.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook.* SAGE Publications.

Miller, G. A., & Chapman, J. P. (2001). Misunderstanding analysis of covariance. *Journal of Abnormal Psychology*, *110*(1), 40–48.

Mills, K. A. (2010). A review of the '"digital turn"' in the new literacy studies. *Review of Educational Research*, *80*(2), 246–271.

Millsap, R. E., & Maydeu-Olivares, A. (2009). *The SAGE Handbook of Quantitative Methods in Psychology*. Sage Publication Ltd.

Ministry of Education Malaysia. (2013). *Malaysia Education Blueprint 2013-2025: Preschool to Post-Secondary Education*. https://www.moe.gov.my/muat-turun/penerbitan-dan-jurnal/dasar/1207-malaysia-education-blueprint-2013-2025/file

Ministry of Education Malaysia (MOE), & Malaysia Digital Economy Corporation (MDEC). (2022). *Kempen Hour of Code*. https://www.moe.gov.my/en/pemberitahuan/announcement/kempen-hour-of-code

Mladenovic, M., Boljat, I., & Zanko, Z. (2018). Comparing loops misconceptions in block-based and text-based programming languages at the k-12 level. *Education and Information Technologies*, *23*, 1483–1500. https://doi.org/10.1007/s10639-017-9673-3

Mohamedi, H., Bensebaa, T., & Trigano, P. (2012). Developing adaptive intelligent tutoring system based on item response theory and metrics. *International Journal of Advanced Science and Technology*, *43*, 1–14.

Molenda, M. (2015). In search of the elusive ADDIE model. *Performance Improvement*, *54*(2), 40–42. https://doi.org/10.1002/pfi.21461

Monroy-Hernández, A., & Resnick, M. (2008). Empowering kids to create and share programmable media. *Interactions*, *15*(2), 50–53. https://doi.org/10.1145/1340961.1340974

Montague, M., & Applegate, B. (1993). Mathematical problem- solving characteristics of middle school students with learning disabilities. *Journal of Special Education*, *27*, 175–201.

Mordechai, B. (2001). Constructivism in computer science education. *Journal of Computers in Mathematics and Science Teaching*, *20*(1), 45–73.

Moreno-Leon, J., & Robles, G. (2015). Dr. Scratch: a Web Tool to Automatically Evaluate Scratch Projects. *WiPSCE '15: Proceedings of the Workshop in Primary and Secondary Computing Education*, 132–133.

Muller, O., & Haberman, B. (2008). Supporting abstraction processes in problem solving through pattern-oriented instruction. *Computer Science Education*, *18*(3), 187–212.

Mullis, I. V. S., Martin, M. O., & Foy, P. (2008). *TIMSS 2007 International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*. https://timssandpirls.bc.edu/timss2007/mathreport.html

Mullis, I. V. S., Martin, M. O., Foy, P., & Hooper, M. (2016). *TIMSS 2015 International Results in Mathematics*.

Napaphun, V. (2012). Relational Thinking: Learning Arithmetic in Order to Promote Algebraic Thinking. *Journal of Science and Mathematics Education in Southeast Asia*, *35*(2), 84–101.

Nathan, M. J., Kintsch, W., & Young, E. (1992). A theory of algebra-word-problem comprehension and its implications for the design of learning environments. *Cognition and Instruction*, *9*(4), 329–389. https://doi.org/10.1207/s1532690xci0904_2

Nathan, M. J., & Koedinger, K. R. (2000). Teachers' and researcher's beliefs about the development of algebraic reasoning. *Journal for Research in Mathematics Education*, *31*(2), 168–190.

National Council of Teachers of Mathematics Commission on Standards for School Mathematics (NCTM). (1989). *Curriculum and evaluation standards for school mathematics*. https://doi.org/. http://www.standards.nctm.org/index.htm

National Council of Teachers of Mathematics Commission on Standards for School Mathematics (NCTM). (2000). *Principles and Standards for School Mathematics*. https://www.nctm.org/uploadedFiles/Standards_and_Positions/PSSM_ExecutiveSummary.pdf

National Governors Association Center for Best Practices Council of Chief State School Officers (NGA Center and CCSSO). (2010). *Common Core State Standards for Mathematics*. http://www.corestandards.org/

National Mathematics Advisory Panel. (2008). *Foundations for Success: The Final Report of the National Mathematics Advisory Panel*. https://www2.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf

National Research Council (NRC). (2001). *Adding It Up: Helping Children Learn Mathematics* (J. Kilpatrick, J. Swafford, & B. Findell (eds.)). National Academy Press.

Navarrete, C. C. (2013). Creative thinking in digital game design and development: A case study. *Computers & Education*, *69*, 320–331.

Ng, W. (2012). Can we teach digital natives digital literacy? *Computers & Education*, *59*(3), 1065–1078.

Noss, R. (1987). Children's Learning of Geometrical Concepts through Logo. *Journal for Research in Mathematics Education*, *18*(5), 343–362.

Noyes, A., & Adkins, M. (2016). Reconsidering the rise in A-level mathematics participation. *Teaching Mathematics and Its Applications*, *35*(1), 1–13. https://doi.org/10.1093/teamat/hrv016

Nunes, T., Bryant, P., Barros, R., & Sylva, K. (2012). The relative importance of two different mathematical abilities to mathematical achievement. *British Journal of Educational Psychology*, *82*(1), 136–156. https://doi.org/10.1111/j.2044-8279.2011.02033.x

Nunes, T., Schliemann, A. D., & Carraher, D. W. (1993). *Street mathematics and school mathematics*. Cambridge University Press.

O'Brien, T. C., Shapiro, B. J., & Reali, N. C. (1971). Logical thinking—Language and context. *Educational Studies in Mathematics, 4*(2), 201–219.

Olive, J., Makar, K., Hoyos, V., Kor, L. K., Kosheleva, O., & Straber, R. (2009). Mathematical knowledge and practices resulting from access to digital technologies. In C. Hoyles & J. B. Lagrange (Eds.), *Mathematics education and technology – Rethinking the terrain* (pp. 133–177). Springer.

Oostermeijer, M., Boonen, A. J. H., & Jolles, J. (2014). The relation between children's constructive play activities, spatial ability, and mathematical word problem-solving performance: A mediation analysis in sixth-grade students. *Frontiers in Psychology*, *5*, 782.

Organisation for Economic Co-operation and Development (OECD). (2010). *The High Cost of Low Education Performance: The Long-Run Economic Impact of Improving PISA Outcomes*. www.oecd.org/publishing/corrigenda.

Organisation for Economic Co-operation and Development (OECD). (2012). *Programme for International Student assessment (PISA): Results from PISA 2012*. http://www.oecd.org/pisa/keyfindings/PISA-2012-results-US.pdf

Organisation for Economic Co-operation and Development (OECD). (2014a). *PISA 2012 Results: Creative Problem Solving: Students' Skills in Tackling Real-Life Problems (Volume V)*. OECD Publishing. https://www.oecd.org/pisa/keyfindings/pisa-2012-results-volume-V.pdf

Organisation for Economic Co-operation and Development (OECD). (2014b). *PISA 2012 results in focus: What 15-year-olds know and what they can do with what they know*. https://www.oecd.org/pisa/keyfindings/pisa-2012-results-overview.pdf

Othman, M. (2001). *Thesis Writing in Applied Social Science.* Universiti Putra Malaysia.

Pallant, J. (2020). *SPSS Survival Manual: A Step by Step Guide to Data Analysis using IBM SPSS* (7th Ed.). Open University Press.

Panasuk, R. M., & Beyranevand, M. L. (2010). Algebra students' ability to recognize multiple representations and achievement. *International Journal for Mathematics Teaching and Learning*, 1–21.

Panhuizen, M. v. d. H., Kolovou, A., & Robitzsch, A. (2013). Primary school students' strategies in early algebra problem solving supported by an online game. *Educational Studies in Mathematics*, *84*(3), 281–307.

Papert, S. (1972a). Teaching Children Thinking. *Programmed Learning and Educational Technology*, *9*(5), 245–255. https://doi.org/10.1080/1355800720090503

Papert, S. (1972b). Teaching children to be mathematicians versus teaching about mathematics. *International Journal of Mathematical Education in Science and Technology*, *3*(3), 249–262. https://doi.org/10.1080/0020739700030306

Papert, S. (1980). *Mindstorms: Children, Compuers, and Powerful Ideas*. Basic Books Inc.

Papert, S. (1988). A critique of technocentrism in thinking about the school of the future. *Children in the Information Age*, 3–18.

Papert, S. (1996). An exploration in the space of mathematics educations. *International Journal of Computers for Mathematical Learning*, *1*(1), 95–123.

Peel, A., Fulton, J., & Pontelli, E. (2015). DISSECT: An experiment in infusing computational thinking in a sixth grade classroom. *2015 IEEE Frontiers in Education Conference (FIE)*. https://doi.org/10.1109/FIE.2015.7344240

Perkins, D. (2010). *Making Learning Whole: How Seven Principles of Teaching Can Transform Education* (1st Ed.). Jossey-Bass.

Peterson, D. J. (2016). The Flipped Classroom Improves Student Achievement and Course Satisfaction in a Statistics Course: A Quasi-Experimental Study. *Teaching of Psychology*, *43*(1), 10–15.

Phumeechanya, N., & Wannapiroon, P. (2014). Design of problem-based with scaffolding learning activities in ubiquitous learning environment to develop problem-solving skills. *Procedia - Social and Behavioral Sciences*, *116*, 4803–4808. https://doi.org/10.1016/j.sbspro.2014.01.1028

Phye, G. D. (1997). Learning and remembering: The basis for personal knowledge construction. In *Handbook of academic learning: Construction of knowledge* (pp. 47–64). Academic Press.

Piaget, J. (1969). *The origins of intelligence in children*. International University Press.

Piaget, J. (1970a). *Genetic epsitemology*. Norton & Company, Inc.

Piaget, J. (1970b). *Structuralism*. Basic Books Inc.

Piaget, J. (1973). *To understand is to invent*. Grossman.

Piaget, J. (1977). *The development of thought: Equilibration of cognitive structures*. Viking.

Piaget, J., & Cook, M. T. (1952). *The origins of intelligence in children*. Norton & Company, Inc.

Polya, G. (1973). *How To Solve It Mathematical Method*. Princeton University Press.

Powell, S. R. (2012). Equations and the equal sign in elementary mathematics textbooks. *The Elementary School Journal*, *112*, 627–648.

Powell, S. R. (2015). The Influence of Symbols and Equations on Understanding Mathematical Equivalence. *Intervention in School and Clinic*, *50*(5), 266–272. https://doi.org/10.1177/1053451214560891

Powell, S. R., Berry, K. A., & Barnes, M. A. (2019). The role of pre - algebraic reasoning within a word - problem intervention for third - grade students with mathematics difficulty. *ZDM*, *0123456789*. https://doi.org/10.1007/s11858-019-01093-1

Powell, S. R., Driver, M. K., & Julian, T. E. (2015). The effect of tutoring with nonstandard equations for students with mathematics difficulty. *Journal of Learning Disabilities*, *48*, 523–534.

Powell, S. R., & Fuchs, L. S. (2010). Contribution of equal-sign instruction beyond word-problem tutoring for third-grade students with mathematics difficulty. *Journal of Educational Psychology*, *102*(2), 381–394. https://doi.org/10.1037/a0018447

Powell, S. R., & Fuchs, L. S. (2014). Does Early Algebraic Reasoning Differ as a Function of Students' Difficulty with Calculations versus Word Problems? *Learning Disabilities Research & Practice*, *29*(3), 106–116. https://doi.org/10.1111/ldrp.12037.

Prather, R. W., & Alibali, M. W. (2009). The development of arithmetic principle knowledge: How do we know what learners know? *Developmental Review*, *29*, 221–248.

Price, G. R., & Ansari, D. (2013). Dyscalculia: Characteristics, causes, and treatments. *Numeracy*, *6*(1), 2–16. https://doi.org/10.5038/1936-4660.6.1.2

Psycharis, S., & Kallia, M. (2017). The effects of computer programming on high school students' reasoning skills and mathematical self-efficacy and problem solving. *Instructional Science*, *45*(5), 583–602. https://doi.org/10.1007/s11251-017-9421-5

Raghavan, J., Sena, L., Liu, H., & Bethelmy, D. (2008). Problem solving experience through light dose computational mathematical modules for Engineering students. *2008 Annual Conference & Exposition*, 1–11. https://doi.org/10.18260/1-2--4408

Rahbarnia, F., Hamedian, S., & Radmehr, F. (2014). A Study on The Relationship Between Multiple Intelligences and Mathematical Problem Solving Based on Revised Bloom Taxonomy. *Journal of Interdisciplinary Mathematics*, *17*, 109–134.

Rakes, C. R., Valentine, J. C., McGatha, M. B., & Ronau, R. N. (2010). Methods of Instructional Improvement in Algebra: A Systematic Review and Meta-Analysis. *Review of Educational Research*, *80*(3), 372–400.

Ratcliff, C. C., & Anderson, S. E. (2011). Reviving the turtle: Exploring the use of logo with students with mild disabilities. *Computers in the Schools*, *28*(3), 241–255.

Rendas, A., Pinto, R. P., & Gamboa, T. (1999). A computer simulation designed for problem-based learning. *Medical Education*, *33*, 47–54.

Resnick, M. (2013). *Learn to Code , Code to Learn*. EdSurge. https://www.edsurge.com/n/2013-05-08-learn-to-code-code-to-learn

Resnick, M., Maloney, J., Monroy-Hernandez, A., Rusk, N., Eastmond, E., & Brennan, K. (2009). Scratch:Programming for all. *Communications of the ACM*, *52*(11), 60–67.

Reusser, K. (1993). Tutoring systems and pedagogical theory: representational tools for understanding, planning and reflection in problem solving. In S. P. Lajoie & S. J. Derry (Eds.), *Computers as Cognitive Tools* (pp. 143–177). Lawrence Erlbaum Associates, Inc.

Reusser, K., Kampfer, A., Sprenger, M., Staub, F., Stebler, R., & Stussi, R. (1990). *Tutoring mathematical word problems using solution trees. Research Report No.8*.

Rich, K. M., & Yadav, A. (2020). Applying Levels of Abstraction to Mathematics Word Problems. *TechTrends*. https://doi.org/10.1007/s11528-020-00479-3

Rich, P. J., Leatham, K. R., & Wright, G. A. (2013). Convergent cognition. *Instructional Science*, *41*(2), 431–453.

Richey, R. C., & Klein, J. D. (2007). *Design and Development Research: Methods, Strategies, and Issues* (R. C. Richey & J. D. Klein (eds.); 1st Ed.).

Lawrence Erlbaium Associates, Inc.

Rittle-Johnson, B., Schneider, M., & Star, J. R. (2015). Not a One-Way Street: Bidirectional Relations Between Procedural and Conceptual Knowledge of Mathematics. *Educational Psychology Review*, *27*(4), 587–597. https://doi.org/10.1007/s10648-015-9302-x

Rivers, R. H., & Vockell, E. (1987). Computer simulations to stimulate scientific problem solving. *Journal of Research in Science Teaching*, *24*, 403–415.

Robinson, B. K., & Dearmon, V. (2013). Evidence-based Nursing Education: Effective Use of Instructional Design and Simulated Learning Environments to Enhance Knowledge Transfer in Undergraduate Nursing Students. *Journal of Professional Nursing*, *29*(4), 203–209.

Robinson, K. M., & Ninowski, J. E. (2004). Adults' Understanding of Inversion Concepts: How Does Performance on Addition and Subtraction Inversion Problems Compare to Performance on Multiplication and Division Inversion Problems? *Canadian Journal of Experimental Psychology*, *57*(4), 321–330.

Rocks, S., Carson, D., & Gilmore, A. (2007). Understanding small business enterprise networking: A qualitative case approach. In D. Hine & D. Carson (Eds.), *Innovative methodologies in enterprise research* (pp. 214–231). Edward Elgar.

Rosenzweig, C., Krawec, J., & Montague, M. (2011). Metacognitive strategy use of eighth-grade students with and without learning disabilities during mathematical problem solving: A think-aloud analysis. *Journal of Learning Disabilities*, *44*, 508–520.

Runco, M. A. (2007). Creativity: Theories and Themes: Research, Development, and Practice. In M. A. Runco (Ed.), *Creativity: Theories and Themes: Research, Development, and Practice*. Elsevier Academic Press. https://doi.org/10.1016/C2012-0-06920-7

Russell, J. D. (1974). *Modular Instruction: A Guide to the Design, Selection, Utilization and Evaluation of Modular Materials*. Burgess Publishing Co.

Saez-Lopez, J. M., Roman-Gonzalez, M., & Vazquez-Cano, E. (2016). Visual programming languages integrated across the curriculum in elementary school: A two year case study using "scratch" in five schools. *Computer & Education*, *97*, 129–141. https://doi.org/10.1016/j.compedu.2016.03.003

Saez-Lopez, J. M., & Sevillano-Garcia, M. L. (2017). Sensors, programming and devices in art education sessions. One case in the context of primary education. *Culture and Education*, *29*(2), 350–384.

Sands, P., Yadav, A., & Good, J. (2018). Computational thinking in K-12: In-service teacher perceptions of computational thinking. In M. Khine (Ed.), *Computational Thinking in the STEM Disciplines* (pp. 151–164). Springer.

https://doi.org/10.1007/978-3-319-93566-9_8

Savant, M. (1997). *The power of logical thinking*. St.Martin's Press.

Schank, R. (1997). *Virtual learning: A revolutionary approach to building a highly skilled workforce*. McGraw-Hill Education.

Schliemann, A. D., Carraher, D., & Brizuela, B. M. (2007). *Bringing out the algebraic character of arithmetic: From children's ideas to classroom practice*. Lawrence Erlbaium Associates.

Schliemann, A. D., & Carraher, D. W. (1992). Proportional reasoning in and out of school. In P. Light & G. Butterworth (Eds.), *Context and cognition* (pp. 47–73). Harvester-Wheatsheaf.

Schliemann, A. D., & Magalhaes, V. P. (1990). Proportional reasoning: From shopping, to kitchens, laboratories, and, hopefully, schools. In G. Booker, P. Cobb, & T. De Mendicuti (Eds.), *Proceedings of the XIV PME Conference Vol. III,* (pp. 67–73). Oaxtepec.

Schliemann, A. D., & Nunes, T. (1990). A situated schema of proportionality. *Journal of Developmental Psychology*, *8*, 259–268.

Schmidt, H. G. (1993). Foundations of problem-based learning: some explanatory notes. *Medical Education*, *27*(5), 422–432.

Schoenfeld, A. H. (2016). Learning to Think Mathematically: Problem Solving, Metacognition, and Sense Making in Mathematics (Reprint). *Journal of Education*, *196*(2), 1–38. https://doi.org/10.1177/002205741619600202

Schoenfeld, A. H., & Kilpatrick, J. (2013). A US perspective on the implementation of inquiry-based learning in mathematics. *ZDM Mathematics Education*, *45*, 901–909. https://doi.org/10.1007/s11858-013-0531-5

Schuman, L. A. (1987). *Plans and situated actions.* Cambridge University Press.

Seel, N. M. (2012). Experimental and Quasi-Experimental Designs for Research on Learning. In N. M. Seel (Ed.), *Encyclopedia of the Sciences of Learning*. Springer. https://doi.org/10.1007/978-1-4419-1428-6_716

Seels, B. B., & Richey, R. C. (1994). *Instructional Technology: The Definition and Domains of the Field*. Association for Educational Communications and Technology.

Sekaran, U., & Bougie, R. (2016). *Research Methods for Business: A Skill Building Approarch* (7th Editio). John Wiley & Sons Inc.

Sfard, A. (1991). On the dual nature of mathematical conceptions: reflections on processes and objects as different sides of the same coin. *Educational*

Studies in Mathematics, *21*, 1–36.

Sfard, A. (1995). The Development of Algebra: Confronting Historical and Psychological Perspectives. *Journal of Mathematical Behavior*, *14*, 15–39.

Sfard, A., & Linchevski, L. (1994). The Gains and Pitfalls of Reification – The Case of Algebra. *Educational Studies in Mathematics*, *26*, 191–228.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Houghton Mifflin Company.

Sharaz, M. S. (2009). *Statistical analysis of data using SPSS program*. Umm Al-Qura University.

Shelton, K., & Saltsman, G. (2008). Applying the ADDIE Model to Online Instruction. In L. Tomei (Ed.), *Adapting Information and Communication Technologies for Effective Education* (pp. 40–57). IGI Publishing.

Shin, S.-B. (2015). The Improvement Effectiveness of Computational Thinking through Scratch Education. *Journal of the Korea Society of Computer and Information*, *20*(11), 191–197. https://doi.org/10.9708/jksci.2015.20.11.191

Shute, V. J., Sun, C., & Asbell-Clarke, J. (2017). Demystifying computational thinking. *Educational Research Review*, *22*(October), 142–158. https://doi.org/10.1016/j.edurev.2017.09.003

Skadberg, Y. X., & Kimmel, J. R. (2004). Visitors' flow experience while browsing a web site: its measurement, contributing factors and consequences. *Computers in Human Behavior*, *20*, 403–422.

Skemp, R. R. (2006). Relational understanding and instrumental understanding. Mathematics Teaching in the Middle School. *Mathematics Teaching in the Middle School*, *12*(2), 88–95.

Smith, M. K., Jones, H. M., Gilbert, S. L., & Wieman, C. E. (2013). The Classroom Observation Protocol for Undergraduate STEM (COPUS): A New Instrument to Characterize University STEM Classroom Practices. *CBE-Life Sciences Education*, *12*(4), 618–627.

Southern Regional Education Board (SREB). (2002). *Getting students ready for Algebra I: What middle grades students need to know and be able to do*.

Stacey, K., & MacGregor, M. (1997). Ideas about symbolism that students bring to algebra. *Mathematics Teacher*, *90*(2), 110–113.

Stacey, K., & MacGregor, M. (1999). Learning the algebraic method of solving problems. *Journal of Mathematical Behavior*, *18*(2), 149–167.

Stanovich, K. E., West, R. F., & Toplak, M. E. (2016). *The rationality quotient: Toward a test of rational thinking.* MIT Press.

Starkey, P., & Gelman, R. (1982). The development of addition and subtraction abilities prior to formal schooling in arithmetic. In T. P. Carpenter, J. M. Moser, & T. A. Romberg (Eds.), *Addition and subtraction: A cognitive perspective*. Erlbaum.

Stein, M. K., Kaufman, J., Sherman, M., & Hillen, A. (2011). Algebra: A challenge at the crossroads of policy and practice. *Review of Educational Research*, *81*(4), 453–492.

Stephens, A. C. (2005). Developing students' understandings of variable. *Mathematics Teaching in the Middle School*, *11*(2), 96–100.

Stigler, J., & Hiebert, J. (2004). Improving mathematics teaching. *Educational Leadership*, *61*(5), 12–17.

Stocker, T. F., Qin, D., Plattner, G.-K., Tignor, M. M. B., Allen, S. K., Boschung, J., Nauels, A., Xia, Y., Bex, V., & Midgley, P. M. (2013). *Climate Change 2013 - The Physical Science Basis*. Cambridge University Press. https://doi.org/10.1017/CBO9781107415324.004

Strawhacker, A., Lee, M., & Bers, M. U. (2017). Teaching tools, teachers' rules: exploring the impact of teaching styles on young children's programming knowledge in ScratchJr. *International Journal of Technology and Design Education*, *28*, 5044. https://doi.org/10.1007/s10798-017-9400-9

Swafford, J. O., & Langrall, C. W. (2000). Grade 6 student's pre- instructional use of equations to describe and represent problem situations. *Journal for Research in Mathematics Education*, *31*, 89–112.

Swan, M. (2000). Making sense of algebra. *Mathematics Teaching*, *171*, 16–19.

Swanson, H. L., Lussier, C. M., & Orosco, M. J. (2015). Cognitive strategies, working memory, and growth in word problem solving in children with math difficulties. *Journal of Learning Disabilities*, *48*(4), 339–358.

Tall, D., Smith, D., & Piez, C. (2008). Technology and calculus. In M. K. Heid & G. M. Blume (Eds.), *Research on technology and the teaching and learning of mathematics, Volume I: Research syntheses* (pp. 207–258). Information Age Publishing.

The Royal Society. (2012). *Shut down or restart? The way forward for computing in UK schools*. https://royalsociety.org/~/media/education/computing-in-schools/2012-01-12-computing-in-schools.pdf

Tortop, H. S. (2013). A New Model Program for Academically Gifted Students in Turkey: Overview of the Education Program for the Gifted Students' Bridge with University (EPGBU). *Journal for the Education of the Young Scientist and Giftedness*, *1*(2), 21–31. https://files.eric.ed.gov/fulltext/ED553590.pdf

Trouche, L. (2005). An instrumental approach to mathematics learning in symbolic calculator environments. In D. Guin, K. Ruthven, & L. Trouche (Eds.), *The didactical challenge of symbolic calculators: Turning a computational device into a mathematical instrument* (pp. 137–162). Springer.

Tsai, F. H., Yu, K. C., & Hsiao, H. S. (2007). Designing constructivist learning environment in online game. *2007 First IEEE International Workshop on Digital Game and Intelligent Toy Enhanced Learning (DIGITEL'07)*, 212–214.

Tsukamoto, H., Oomori, Y., Nagumo, H., Takemura, Y., Monden, A., & Matsumoto, K. I. (2017). Evaluating algorithmic thinking ability of primary schoolchildren who learn computer programming. *In Frontiers in Education Conference (FIE)*, 1–8.

Tuckman, B. W., & Harper, B. E. (2012). *Conducting educational Research* (6th Ed.). Rowman & Littlefield Publishers.

Utsumi, M. C., & Mendes, C. R. (2000). Researching the Attitudes Towards Mathematics in Basic Education. *Educational Psychology*, *20*(2), 237–243. https://doi.org/10.1080/713663712

van Dijk, T. A., & Kintsch, W. (1983). *Strategies of discourse comprehension*. Academic Press.

van Merrienboer, J. J. G. (2013). Perspectives on problem solving and instruction. *Computers and Education*, *64*, 153–160.

Vergnaud, G. (1982). A classification of cognitive tasks and operations of thought involved in addition and subtraction problems. In T. P. Carpenter, J. M. Moser, & A. Romberg (Eds.), *Addition and subtraction: A cognitive perspective* (pp. 39–59). Lawrence Erlbaum.

Vergnaud, G. (1994). Multiplicative conceptual field: What and why? In G. Harel & J. Confrey (Eds.), *The development of multiplicative reasoning in the learning of mathematics* (pp. 41–59). State University of New York Press.

Verschaffel, L., & De Corte, E. (1997). Teaching realistic mathematical modeling in the elementary school: A teaching experiment with fifth graders. *Journal for Research in Mathematics Education*, *28*(5), 577–601.

Verschaffel, L., Depaepe, F., & Van Dooren, W. (2015). Individual differences in word problem solving. In R. C. Kadosh & A. Dowker (Eds.), *Oxford handbook of numerical cognition* (pp. 953–974). Oxford University Press.

Verschaffel, L., Greer, B., & de Corte, E. (2000). *Making sense of word problems*. Swetz and Zeitlinger Publishers.

von Glaserfeld, E. (1995). A constructivist approach to teaching. In L. P. Steffe

& J. Gale (Eds.), *Constructivism in education* (pp. 3–15). Lawrence Erlbaum Associates, Inc.

von Glaserfeld, E. (1996a). Introduction: Aspects of constructivism. In *Constructivism: Theory, perspectives, and practice* (pp. 3–7). Teacher College Press.

von Glaserfeld, E. (1996b). Learning and adaption in constructivism. In L. Smith (Ed.), *Critical Readings on Piaget* (1st Ed.). Routledge.

von Glaserfeld, E. (1998). The reluctance to change a way of thinking. *The Irish Journal of Psychology*, *9*(1), 83–90.

von Glaserfeld, E. (2006). A constructivist approach to experiential foundations of mathematical concepts revisited. *Constructivist Foundations*, *1*(2), 61–72.

Voskoglou, M. G., & Buckley, S. (2012). Problem Solving and Computational Thinking in a Learning Environment. *Egyptian Computer Science Journal*, *36*(4), 28–46. http://arxiv.org/ftp/arxiv/papers/1212/1212.0750.pdf

Voss, C., Tsikriktsis, N., & Frohlich, M. (2002). Case research in operations management. *International Journal of Operations & Production Management*, *22*(2), 195–219. https://doi.org/10.1108/01443570210414329

Vukovic, R. K., & Siegel, L. S. (2010). Academic and cognitive characteristics of persistent mathematics difficulty from first through fourth grade. *Learning Disabilities Research & Practice*, *25*, 25–38.

Wagner, T. (2008). *The global achievement gap: Why even our best schools don't teach the new survival skills our children need and what we can do about it.* Basic Books Inc.

Wang, S. K., & Hsu, H. Y. (2009). Using the ADDIE model to design second life activities for online learners. *TechTrends*, *53*(6), 76–81. https://doi.org/10.1007/s11528-009-0347-x

Wang, X. (2015). The Literature Review of Algebra Learning: Focusing on the Contributions to Students' Difficulties. *Creative Education*, *06*(02), 144–153. https://doi.org/10.4236/ce.2015.62013

Warren, E. (2003). The role of arithmetic structure in the transition from arithmetic to algebra. *Mathematics Education Research Journal*, *15*(2), 122–137.

Weinberg, A. D., Stephens, A. C., McNeil, N. M., Krill, D. E., Knuth, E. J., & Alibali, M. W. (2004). Students initial and developing conceptions of variable. *Annual Meeting Fo the American Educational Research Association*.

Welty, G. (2008). Strategy and Tactics for Pilot Implementation in the ADDIE Model. *Journal of GXP Compliance*, *12*(2), 12–19.

Weng, X. J., & Wong, K. W. (2017). Integrating computational thinking into english dialogue learning through graphical programming tool. *2017 IEEE 6th International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*, 320–325.

Wenger, E., Brown, J. S., & Greeno, J. (1987). *Artificial intelligence and tutoring systems: Computational and cognitive approaches to the communication of knowledge* (E. Wenger, J. S. Brown, & J. Greeno (eds.)). Elsevier Inc, Morgan Kaufmann Pub. https://doi.org/10.1016/0950-7051(88)90091-3

White, H., & Sabarwal, S. (2014). *Quasi-Experimental Design and Methods: Methodological Briefs Impact Evaluation No.8.* https://www.unicef-irc.org/KM/IE/img/downloads/Quasi-Experimental_Design_and_Methods_ENG.pdf.

Wilensky, U. (1991). Abstract meditations on the concrete and concrete implications for mathematical education. In I. Harel & S. Papert (Eds.), *Constructionism: Research reports and essays, 1985–1990* (pp. 193–203). Epistemology & Learning Research Group.

Wing, J. M. (2006). Computational Thinking. *Communications of the ACM*, *49*(3), 33–35. https://doi.org/10.1145/1118178.1118215

Wing, J. M. (2008). Computational thinking and thinking about computing. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *366*(1881), 3717–3725. https://doi.org/10.1098/rsta.2008.0118

Wing, J. M. (2010). *Computational Thinking : What and Why ?* (Issue November).

Wing, J. M. (2011). Research notebook: Computational thinking—What and why? *The Link Magazine*, June 23, 2015. http://www.cs.cmu.edu/link/research-notebook-computational-thinking-what-and-why

Wing, J. M. (2014). *Computational thinking benefits society.* Social Issues in Computing. http://socialissues.cs.toronto.edu/

Wolfram, C. (2016). *The Dark Side of Math Education*. EdCircuit.Com. https://www.edcircuit.com/the-dark-side-of-math-education/

Woodward, J., Carnine, D., & Gersten, R. (1988). Teaching problem solving through computer simulations. *American Educational Research Journal*, *25*(1), 72–86.

Wu, H. (2001). How to prepare students for algebra. *American Educator*, *25*(2), 10–17.

Xin, Y. P. (2012). *Conceptual model-based problem solving: Teach students with learning difficulties to solve math problems*. Sense Publishers.

Yadav, A., Hong, H., & Stephenson, C. (2016). Computational Thinking for All: Pedagogical Approaches to Embedding 21st Century Problem Solving in K-12 Classrooms. *TechTrends*, *60*(6), 565–568. https://doi.org/10.1007/s11528-016-0087-7

Yerushalmy, M. (2006). Slower algebra students meet faster tools: Solving algebraic word problems with graphing software. *Journal for Research in Mathematics Education*, *37*, 356–387.

Zazkis, R. (2011). *Relearning Mathematics: A Challenge for Prospective Elementary School Teachers*. Information Age Publishing, Inc.

Zohar, A., & Dori, Y. J. (2003). Higher order thinking skills and low-achieving students: Are they mutually exclusive? *Journal of the Learning Sciences*, *12*(2), 145–181.