
Jamie Lee Taber

Follow this and additional works at: https://scholarcommons.sc.edu/etd

Part of the Curriculum and Instruction Commons

Recommended Citation


This Open Access Dissertation is brought to you by Scholar Commons. It has been accepted for inclusion in Theses and Dissertations by an authorized administrator of Scholar Commons. For more information, please contact dillarda@mailbox.sc.edu.
IMPLEMENTATION AND EVALUATION OF COMPUTER-ASSISTED SCIENCE VOCABULARY MODULES WITH STUDENTS WITH AN INTELLECTUAL DISABILITY AND AUTISM: AN ACTION RESEARCH STUDY

by

Jamie Lee Taber

Bachelor of Science
Ball State University, 2000

Master of Arts
Ball State University, 2004

Submitted in Partial Fulfillment of the Requirements

For the Degree of Doctor of Education in

Curriculum and Instruction

College of Education

University of South Carolina

2020

Accepted by:

Michael M. Grant, Major Professor
Tammi D. Kolski, Additional Major Professor
Anna C. Clifford, Committee Member
Fatih Ari, Committee Member
Lucas Vasconcelos, Committee Member
Cheryl L. Addy, Vice Provost and Dean of the Graduate School
DEDICATION

I dedicate this work to my family. To my boys, Ben and Kevin, thank you for believing in me and inspiring me to keep going. Follow your dreams and never give up! To my husband, Chris, thank you for your never-ending support. Thank you for giving me the time to work, the support to endure, and the faith to never quit. To my parents, thank you for always believing in me and supporting me through all I do. You will never know how much your faith in me has influenced this process. Lastly, to my niece, Madi, and my brother, Matt, thank you for the showing me the true meaning of grit, endurance, and fighting no matter what.

Finally, this research project is dedicated to all my students, past, present, and future. To all my students who we have lost along the way, thank you for blessing our world with your presence. My life is forever changed because of you and you will always live in my heart.
ACKNOWLEDGEMENTS

I would first like to acknowledge Dr. Michael M. Grant. Thank you for believing in me, keeping me reigned in, and giving me this amazing opportunity to grow in my profession. I truly appreciate your faith in me and guidance throughout this process. Next, I would like to acknowledge Dr. Tammi D. Kolski. Thank you for keeping me off the struggle bus, your huge heart, and for all your amazing guidance. I would also like to acknowledge my dissertation committee, Dr. Ari, Dr. Vasconcelos, and Dr. Clifford. I appreciate your expertise and time used to help me improve my practice. Also, to the University of South Carolina professors and staff, thank you for an amazing educational experience. To my school staff, participants, and the participants’ families, I deeply appreciate your time and willingness to assist me in this dissertation project. Finally, to my X-factor cohort members, namely my writing group partners, thank you for the support, advice, and friendship along the way.
ABSTRACT

Students with disabilities are struggling to meet expectations in science at the national and local level. Many studies have linked difficulties with science content to difficult and technical vocabulary, and this has been evident at the local level, too. To try to improve science instruction for students with disabilities, the purpose of this study was to evaluate the implementation of computer-assisted science vocabulary modules with students with an intellectual disability and autism in an adapted environmental science class. This study aimed to answer how the implementation of computer-assisted vocabulary modules, which adhere to evidence-based practices of special education vocabulary instruction, affected the acquisition and application of science vocabulary terms with students with an intellectual disability and autism in an adapted environmental science class, as well as how the students were engaged in the computer-assisted instruction activities.

This study implemented an action research design. The participants in this study included three students (n = 3) who were diagnosed with a moderate intellectual disability, autism, and a speech/language impairment who attended a weekly adapted environmental science class at their self-contained school. The students participated in computer-assisted vocabulary modules which included computer-assisted instruction features, vocabulary strategies including keyword mnemonics and graphic organizers, and the special education evidence-based practice of explicit instruction. The modules were developed surrounding the topic of photosynthesis, using Gagne’s nine events of
instruction, psycholinguistic/schema theory, and dual coding theory, as well as South Carolina-Alt performance level descriptors. The effectiveness of the computer-assisted vocabulary modules was measured through data collection which included a pre- and posttest, formative assessments in each module, the Classroom Measurement of Achievement Engagement, and a researcher’s journal. The data collected were analyzed using a convergent parallel mixed methods design. The findings of this study suggested the use of computer-assisted instruction and evidence-based explicit vocabulary instruction could improve science vocabulary acquisition and active engagement in instruction for students with an intellectual disability and autism.
# TABLE OF CONTENTS

Dedication ........................................................................................................................................ iii

Acknowledgements ........................................................................................................................ iv

Abstract ............................................................................................................................................... v

List of Tables ......................................................................................................................................... x

List of Figures ......................................................................................................................................... xiii

Chapter 1: Introduction ....................................................................................................................... 1

National Context ................................................................................................................................. 1

Local Context ....................................................................................................................................... 4

Statement of the Problem .................................................................................................................... 8

Statement of Research Subjectivities and Positionality ........................................................................ 9

Definition of Terms .............................................................................................................................. 14

Chapter 2: Literature Review .............................................................................................................. 21

Introduction .......................................................................................................................................... 21

Theoretical Underpinnings of Explicit, Special Education Vocabulary Instruction ................................ 23

Teaching and Learning Science Vocabulary in Special Education ..................................................... 29

Educational Implications of Active Engagement ............................................................................... 66

Chapter Summary ............................................................................................................................... 75

Chapter 3: Method ............................................................................................................................. 78

Research Design ................................................................................................................................. 79
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setting</td>
<td>...........................................................................................................</td>
<td>82</td>
</tr>
<tr>
<td>Participants</td>
<td>.......................................................................................................</td>
<td>91</td>
</tr>
<tr>
<td>Innovation</td>
<td>.........................................................................................................</td>
<td>92</td>
</tr>
<tr>
<td>Data Collection</td>
<td>........................................................................................................</td>
<td>112</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>..........................................................................................................</td>
<td>128</td>
</tr>
<tr>
<td>Procedures and Timeline</td>
<td>.................................................................................................</td>
<td>133</td>
</tr>
<tr>
<td>Rigor and Trustworthiness</td>
<td>.............................................................................................</td>
<td>137</td>
</tr>
<tr>
<td>Plan for Sharing and Communicating Findings</td>
<td>....................................................................................</td>
<td>141</td>
</tr>
<tr>
<td>Chapter 4: Analysis and Findings</td>
<td>..................................................................................</td>
<td>144</td>
</tr>
<tr>
<td>Quantitative Methods and Findings</td>
<td>..................................................................................</td>
<td>145</td>
</tr>
<tr>
<td>Qualitative Methods and Findings</td>
<td>..................................................................................</td>
<td>159</td>
</tr>
<tr>
<td>Converged Findings: Individual Experiences</td>
<td>.............................................................................</td>
<td>174</td>
</tr>
<tr>
<td>Chapter Summary</td>
<td>.........................................................................................</td>
<td>229</td>
</tr>
<tr>
<td>Chapter 5: Discussion, Implications, and Limitations</td>
<td>........................................</td>
<td>231</td>
</tr>
<tr>
<td>Discussion</td>
<td>.......................................................................................................</td>
<td>231</td>
</tr>
<tr>
<td>Implications</td>
<td>.......................................................................................................</td>
<td>241</td>
</tr>
<tr>
<td>Limitations</td>
<td>.........................................................................................................</td>
<td>249</td>
</tr>
<tr>
<td>Closing Thoughts</td>
<td>..............................................................................................</td>
<td>253</td>
</tr>
<tr>
<td>References</td>
<td>.........................................................................................................</td>
<td>255</td>
</tr>
<tr>
<td>Appendix A: Consent to be a Research Subject</td>
<td>........................................................................</td>
<td>295</td>
</tr>
<tr>
<td>Appendix B: Research and Information Sharing Agreement</td>
<td>................................</td>
<td>298</td>
</tr>
<tr>
<td>Appendix C: Institutional Review Board Approval</td>
<td>..................................................</td>
<td>314</td>
</tr>
<tr>
<td>Appendix D: Pre- and Posttest Questions &amp; Answers and Scoresheet</td>
<td>.......................</td>
<td>315</td>
</tr>
</tbody>
</table>
Appendix E: Formative Assessment Questions and Scoresheet.................................317
Appendix F: Classroom Measure of Active Engagement Observation Protocol .......321
Appendix G: Link for Table G.1..............................................................................324
Appendix H: Link for Table H.1..............................................................................325
LIST OF TABLES

Table 1.1. SC-Alt 2017 State Level Science Test Results ......................................................... 6
Table 1.2. 2017 SC-Alt Results for the Local School District ...................................................... 6
Table 2.1. Elements and Teaching Function of Explicit Instruction ......................................... 40
Table 3.1. Theories and Influenced Elements of the Computerized Science Vocabulary Modules .......................................................... 93
Table 3.2. Evidence-Based Instructional Practices in the Computerized Science Vocabulary Modules .......................................................... 97
Table 3.3. Reasoning for Specific Vocabulary Strategies Used .............................................. 100
Table 3.4. Vocabulary Terms Included in the Computerized Science Vocabulary Modules .......................................................... 101
Table 3.5. State Standard Addressing Photosynthesis .......................................................... 107
Table 3.6. SC-Alt Performance Level Descriptors Related to Photosynthesis ................................. 107
Table 3.7. Alternative Testing Standards Related to Photosynthesis ........................................... 108
Table 3.8. Comparison of Planned Modules and Actual Modules ........................................... 109
Table 3.9. Summary of Terms, Topics, Alternative Standard Levels, and a Timeline of the Computerized Science Vocabulary Modules .......................................................... 111
Table 3.10. Data Sources for Research Questions .......................................................... 113
Table 3.11. Alignment of Pre- and Posttest Questions and SC-Alt Performance Level Descriptors and Research Questions .......................................................... 115
Table 3.12. Alignment of Formative Assessment Questions to SC-Alt Performance Descriptors and Research Questions .......................................................... 117
Table 3.13. The Classroom Measure of Active Engagement .................................................... 123
Table 3.14. Correlations between Standardized Tests, Teacher Report Measures, and the Classroom Measure of Active Engagement ..............124

Table 3.15. Alignment of Observation Codes and Research Questions .....................................................................................................................126

Table 3.16. Alignment of Research Questions, Data Sources, and Data Analysis Methods ........................................................................................................129

Table 3.17. Data Collection Procedures and Timeline .................................................................................................................................134

Table 4.1. Descriptive Statistics of the Pre- and Posttest................................................................................................................................146

Table 4.2. Pre- and Posttest Questions and Vocabulary Words Assessed .................................................................................................................148

Table 4.3. Summary of Location of the Correct Answers and Attempts to Answer on the Pre- and Posttest and Formative Assessment .............153

Table 4.4. Summary of Qualitative Data Sources, Codes Applied, and Word Count .........................................................................................................160

Table 4.5. Evidence Examples from the Coding Process ........................................................................................................................165

Table 4.6. Charlie’s Performance on Module 8.........................................................................................................................................178

Table 4.7. Breakdown of Module 8 Components and Charlie’s Performance on Each ..................................................................................................182

Table 4.8. Charlie’s Performance on Module 2.........................................................................................................................................183

Table 4.9. Summary of Charlie’s Performance During Instruction Using Mnemonics .................................................................................................187

Table 4.10. Summary of Charlie’s Performance During Instruction Using Graphic Organizers .............................................................................188

Table 4.11. Summary of Charlie’s Performance During Computer-Assisted Instruction Components ..................................................................189

Table 4.12. Summary of Charlie’s Performance During Instruction Using Special Education Specific Methods ..................................................................190

Table 4.13. Peyton’s Performance on Module 2.........................................................................................................................................201

Table 4.14. Peyton’s Performance on Module 9 .........................................................................................................................................203
Table 4.15. Summary of Peyton’s Performance During Instruction Using Mnemonics ................................................................. 205

Table 4.16. Summary of Peyton’s Performance During Instruction Using Graphic Organizers ......................................................... 206

Table 4.17. Summary of Peyton’s Performance During Computer-Assisted Instruction Components .................................................... 207

Table 4.18. Summary of Peyton’s Performance During Instruction Using Special Education Specific Methods ........................................ 209

Table 4.19. Riley’s Performance on Module 11 ........................................................................................................................................ 216

Table 4.20. Riley’s Performance on Module 6 .................................................................................................................................... 218

Table 4.21. Summary of Riley’s Performance During Instruction Using Mnemonics ..................................................................................220

Table 4.22. Riley’s Performance During Instruction Using Graphic Organizers ..................................................................................... 221

Table 4.23. Riley’s Performance During Computer-Assisted Instruction Components .................................................................................. 222

Table 4.24. Riley’s Performance During Instruction Using Special Education Specific Methods ..................................................................... 223

Table 4.25. Joint Display Table for Converged Findings .......................................................................................................................... 228

Table G.1. Formative Assessment Questions, Type of Questions, and Students’ Score ......................................................................... 325

Table H.1. Summary of Classroom Measure of Active Engagement Findings ......................................................................................... 326
LIST OF FIGURES

Figure 2.1 Example of a keyword mnemonic for oxalis………………………………………………..43

Figure 2.2 Example of a picture-based cognitive/word map for
students with intellectual disability and autism .................................................................46

Figure 2.3 Example of a Frayer model ..................................................................................48

Figure 2.4 T-chart sample showing the use of words and picture symbols .........................49

Figure 3.1 Photographs of my classroom and outside greenhouse and garden area………83

Figure 3.2 Example of lesson plans for one week ................................................................87

Figure 3.3 Low-tech tools and communication devices regularly
used in the classroom ...........................................................................................................89

Figure 3.4 Examples of tactile models used in classroom lessons .....................................90

Figure 3.5 Photosynthesis mnemonic ................................................................................101

Figure 3.6 Example of a web shaped cognitive/word map used in
the computerized science vocabulary module .................................................................102

Figure 3.7 Example of a flow map used to show the process of making sugar ..............103

Figure 3.8 Example of a Frayer model used the computerized
science vocabulary module ..............................................................................................104

Figure 3.9 Example of the t-chart used in the computerized science
vocabulary module ..............................................................................................................104

Figure 3.10 Photosynthesis unit picture symbols ..............................................................106

Figure 3.11 Touch-the-model question example ...............................................................116

Figure 3.12 Example of a multiple-choice formative assessment question ..................117

Figure 3.13 Example of an errorless instruction practice question ..................................119
Figure 3.14 Sample page from my researcher’s journal .......................................................... 122
Figure 4.1 Sample of posttest Question 4 and the brightly colored blocks answer ......... 147
Figure 4.2 Sample of an errorless instruction question ......................................................... 150
Figure 4.3 Formative assessment questions from Module 9 ................................................... 152
Figure 4.4 Example of coding completed in Delve ............................................................... 161
Figure 4.5 Sample of codes laid out according to the type of coding process used ......... 162
Figure 4.6 Example of codes in stacks with similar codes ................................................. 163
Figure 4.7 Sample of the list of codes organized by categories and analytic memos ..... 163
Figure 4.8 Example of labeling code stacks with the category .......................................... 163
Figure 4.9 Module 8 simulation slides .................................................................................. 179
Figure 4.10 Module 8 Frayer model ..................................................................................... 179
Figure 4.11 Module 8 adapted reading passage ................................................................. 180
Figure 4.12 Module 2 Frayer model ..................................................................................... 183
Figure 4.13 Screenshot of the educational song in Module 2 .............................................. 184
Figure 4.14 Charlie’s answering patterns on the pre- and posttest .................................. 193
Figure 4.15 Screenshot of me holding Charlie’s completed photosynthesis model ...... 197
Figure 4.16 Screenshot of the Module 9 simulation ............................................................. 203
Figure 4.17 Peyton’s answering patterns on the pre- and posttest .................................. 211
Figure 4.18 Screenshot of the *Photosynthesis* video from Module 11 ......................... 216
Figure 4.19 Example of linear cognitive/word map from Module 6 ................................. 218
Figure 4.20 Riley’s answering patterns on the pre- and posttest .................................. 226
Figure 5.1. Question 2 from the pre- and posttest .............................................................. 252
Figure 5.2. Question 4 from the pre- and posttest .............................................................. 252
Figure A.1 Consent to be a research subject, page one .............................................295
Figure A.2 Consent to be a research subject, page two .............................................296
Figure A.3 Consent to be a research subject, page three .........................................297
Figure B.1 Research and data sharing agreement, page one .......................................298
Figure B.2 Research and data sharing agreement, page two .......................................299
Figure B.3 Research and data sharing agreement, page three .....................................300
Figure B.4 Research and data sharing agreement, page four .......................................301
Figure B.5 Research and data sharing agreement, page five .......................................302
Figure B.6 Research and data sharing agreement, page six ........................................303
Figure B.7 Research and data sharing agreement, page seven ....................................304
Figure B.8 Research and data sharing agreement, page eight .....................................305
Figure B.9 Research and data sharing agreement, page nine ......................................306
Figure B.10 Research and data sharing agreement, page 10 .......................................307
Figure B.11 Research and data sharing agreement, page 11 .......................................308
Figure B.12 Research and data sharing agreement, page 12 .......................................309
Figure B.13 Research and data sharing agreement, page 13 .......................................310
Figure B.14 Research and data sharing agreement, page 14 .......................................311
Figure B.15 Research and data sharing agreement, page 15 .......................................312
Figure B.16 Research and data sharing agreement, page 16 .......................................313
Figure C.1 Institutional review board approval .............................................................314
Figure D.1 Pre- and posttest questions and answers ...................................................315
Figure E.1 Formative assessment questions and answers, page one ..........................317
Figure E.2 Formative assessment questions and answers, page two ..........................318
Figure E.3 Formative assessment questions and answers, page three .................319
Figure E.4 Picture choices for formative assessment answers ................................320
Figure E.5 Sample of formative assessment recording sheet .................................320
Figure F.1 Classroom measure of active engagement observation protocol, page one .................................................................321
Figure F.2 Classroom measure of active engagement observation protocol, page two .................................................................322
Figure F.3 Classroom measure of active engagement observation protocol, page three ......................................................................323
CHAPTER 1

INTRODUCTION

National Context


Along with the call for science reform, national educational laws such as the Individuals with Disabilities Education Act (IDEA) and NCLB required access to all areas of the general education curriculum for students with disabilities (Courtade, 2006; Kahn, Wild, Woolsey, & Haegele, 2014; Knight, Spooner, Browder, Smith, & Wood, 2013; National Science Teachers Association [NSTA], 2004; U.S. DOE, 1997, 2001). During the 2014-2015 school year, there were 6.6 million or 13% of United States public school students, ages 3-21, receiving special education services (National Center for Education Statistics [NCES], 2017). These students included 35% with learning disabilities, 20% with speech/language disabilities, 13% with other health impairments, 9% with autism, 6% with intellectual disabilities 6% with developmental disabilities, 5% with emotional disabilities, 2% with multiple disabilities, 1% with hearing impairments, and 1% with orthopedic impairments (NCES, 2017). The Nation’s Report Card (2017)
reported the achievement levels for students with disabilities on the fourth grade 2015 National Assessment of Educational Progress (NAEP) science assessment results as 47% of students at below basic, 35% of students at basic, and 18% of students at proficient or advanced. This gap continued to widen as 66% of students with disabilities were below basic in eighth grade and 71% were below basic in the twelfth grade (The Nation’s Report Card, 2017). Only 5% of students with disabilities enter the workforce in a science or technology related field (Leddy, 2010).

As these statistics demonstrate, students with disabilities often struggle in the content area of science (Mutch-Jones, Puttick, & Minner, 2012; Villanueva, Taylor, Therrien, & Hand, 2012). The reasons reported for this underperformance in science include difficult vocabulary requirements (Rice & Deshler, 2013; Zoski, Nellenbach, & Erickson, 2018), focus on abstract concepts, complex expository texts, the teachers’ focus on the scientific method, and the limitation of time due to school schedules (Israel, Maynard, & Williamson, 2013). Students with disabilities also underperform in science due to factors such the science teachers’ science knowledge base (Smith, Spooner, Jimenez, & Browder, 2013), limited time, lack of materials, and students’ ability levels (Melber, 2004).

Nationally, students with disabilities are struggling to meet expectations about basic science concepts (Bybee, 1995/2005; National Academy of Sciences [NAS], 1996). Students who receive their instruction in the separate school setting and/or a self-contained classroom require modifications to their curriculum, which should include inquiry-based instruction and intensive vocabulary instruction (Courtade, 2006; Israel et al., 2013; Leddy, 2010; Mutch-Jones et al., 2012; Villanueva et al., 2012).
Another area of importance in science instruction is the use of educational technology. Using Internet resources have been found by science teachers to make students more motivated to learn, become more active in class, and likely to communicate with peers and teachers (Kim, Grabowski, & Song, 2003). In order to continue to improve and increase the implementation of technology in classrooms, school districts need to focus on (a) increasing access to educational technology for all students (e.g., one-to-one computing initiatives), (b) increasing instructional technology use (e.g., professional development, addressing ethical issues such as accessibility), (c) increasing the effective use of technology, and (d) addressing the need for technology-enabled assessment (Davies & West, 2014).

Additionally, computer-based technologies play an important role for students with disabilities and have increased in use in recent years. The focus on technology with people with intellectual disability started in 1982 when the Association for Retarded Citizens launched a bioengineering program, which focused on technology development for people with an intellectual disability (Wehmeyer & Smith, 2004). In 1988, Public Law 100-407, the technology-related assistance for individuals with disabilities act of 1988 (Tech Act), was created (Public Law 100-407, 1988). The findings in the Tech Act report stated assistive technology was imperative for people with disabilities because they have greater control over their lives and can participate in and contribute to their communities (Public Law 100-407, 1988). The Tech Act was reauthorized in 2004, and is still active today, because of the importance of the use of technology with students with disabilities (Okolo & Diedrich, 2014).
Technologies can meet a variety of needs for all students across the spectrum of disabilities to allow equal access to the general education curriculum (Braddock, Rizzolo, Thompson, & Bell, 2004; Burgstahler, 1994, 2003; Hasselbring & Glaser, 2000). These technologies have been found to provide many positive outcomes such as: (a) promoting positive postsecondary and career outcomes, (b) increasing access to education and careers in science fields (Burgstahler, 1994, 2003), (c) the ability to reach across a variety of educational domains (Wehmeyer, Smith, Palmer, & Davies, 2004), and (d) the application of computer-assisted instruction (CAI) in reading, writing, and math (Edyburn, 2003).

Specific to science vocabulary instruction, CAI offers promise for addressing gaps for students with disabilities. Science vocabulary has been especially problematic for students with disabilities. Some specific methods that have the potential to increase vocabulary knowledge acquisition for students with special needs include keyword mnemonics, cognitive strategies, direct instruction, and CAI (Rice & Deshler, 2018). CAI may be effective because it leverages effective teaching methods with the use of technology for students with disabilities.

Local Context

The need for improved science instruction for students with disabilities is apparent in the state of South Carolina, as well as the local school district, based on local assessment scores on the South Carolina Palmetto Assessment of State Standard (SCPASS) and the South Carolina Alternative Assessment (SC-Alt).
State of South Carolina: 2017-2018 Test Scores

The South Carolina state assessment for science is called the SCPASS and students in fourth, sixth, and eighth grades are administered this test. In the state of South Carolina, the students scoring does not meet expectations were 22.8% of the 60,327 fourth graders, 31.3% of the 58,415 sixth graders, and 26.0% of the 55,982 eighth graders (SC DOE, 2018a). The students scoring approaches expectations were 27.4% of fourth graders, 21.0% of sixth graders, and 25.2% of eighth graders (SC DOE, 2018a). The disabled category included 8,653 fourth graders with 55.0% scoring does not meet expectations and 27.0% scoring approaches expectations (SC DOE, 2018a). Of the 8,383 sixth graders with 71.9% scoring does not meet expectations and 15.9% scoring approaches expectations (SC DOE, 2018a). The disabled category included 7,173 eighth graders with 67.5% scoring does not meet expectations and 21.6% scoring approaches expectations (SC DOE, 2018a).

The SC-Alt is an alternative assessment for students with significant intellectual disabilities who are unable to participate in the general education curriculum, even with accommodations (SC DOE, 2018b). Students are scored on a level one through four, with one being the lowest. In 2017, students in grades four through eight and grade 11 were tested in the area of science. Table 1.1 shows the results of the state level testing on the SC-Alt.

The Local School District: 2017-2018 Test Scores

In the local school district, 6,156 fourth grade students participated in SCPASS and 16.1% of these students scored does not meet expectations, while 24.4% scored approaches expectations (SC DOE, 2018a). Of the 5,792 sixth graders tested in science,
28.0% scored *does not meet expectations* and 19.5% scored *approaches expectations* and of the 5,589 eighth graders, 24.6% scored *does not meet expectations* and 22.8% scored *approaches expectations* (SC DOE, 2018a). There were 1,011 fourth-grade students who were in the disabled category with 44.0% who scored *does not meet expectations* and 32.3% who scored *approaches expectations* (SC DOE, 2018a). Of the 5,792 sixth graders in the disabled category, 69.5% scored *does not meet expectations* and 17.4% scored *approaches expectations* (SC DOE, 2018a). There were 5,589 eighth grade students in the disabled category testing and 65.7% scored *does not meet expectations* and 22.5% scored *approaches expectations* (SC DOE, 2018a). There were 326 students in grades four through eight and grade 11 who were administered the SC-Alt test in the local school district. See Table 1.2 for the results.

Table 1.1. *SC-Alt 2017 State Level Science Test Results*

<table>
<thead>
<tr>
<th>Grade</th>
<th>Number Tested</th>
<th>Not Tested</th>
<th>% Level 1</th>
<th>% Level 2</th>
<th>% Level 3</th>
<th>% Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>592</td>
<td>1</td>
<td>11.1</td>
<td>12.3</td>
<td>27.2</td>
<td>49.3</td>
</tr>
<tr>
<td>5</td>
<td>513</td>
<td>4</td>
<td>6.4</td>
<td>7.0</td>
<td>25.0</td>
<td>61.6</td>
</tr>
<tr>
<td>6</td>
<td>499</td>
<td>1</td>
<td>9.4</td>
<td>21.2</td>
<td>21.6</td>
<td>47.7</td>
</tr>
<tr>
<td>7</td>
<td>510</td>
<td>2</td>
<td>9.4</td>
<td>18.0</td>
<td>19.4</td>
<td>53.1</td>
</tr>
<tr>
<td>8</td>
<td>515</td>
<td>1</td>
<td>9.3</td>
<td>18.3</td>
<td>20.2</td>
<td>52.2</td>
</tr>
<tr>
<td>11</td>
<td>425</td>
<td>1</td>
<td>15.5</td>
<td>28.5</td>
<td>13.9</td>
<td>42.1</td>
</tr>
<tr>
<td>All</td>
<td>3054</td>
<td>10</td>
<td>10.1</td>
<td>17.1</td>
<td>21.6</td>
<td>51.2</td>
</tr>
</tbody>
</table>

Table 1.2. *SC-Alt 2017 Results for the Local School District*

<table>
<thead>
<tr>
<th>Grade</th>
<th>Number Tested</th>
<th>% Level 1</th>
<th>% Level 2</th>
<th>% Level 3</th>
<th>% Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>60</td>
<td>8.3</td>
<td>8.3</td>
<td>41.7</td>
<td>41.7</td>
</tr>
<tr>
<td>5</td>
<td>37</td>
<td>5.4</td>
<td>5.4</td>
<td>27.0</td>
<td>62.2</td>
</tr>
<tr>
<td>6</td>
<td>49</td>
<td>10.2</td>
<td>26.5</td>
<td>22.4</td>
<td>40.8</td>
</tr>
<tr>
<td>7</td>
<td>42</td>
<td>0.0</td>
<td>9.5</td>
<td>31.0</td>
<td>59.5</td>
</tr>
<tr>
<td>8</td>
<td>50</td>
<td>4.0</td>
<td>18.0</td>
<td>20.0</td>
<td>58.0</td>
</tr>
<tr>
<td>11</td>
<td>34</td>
<td>2.9</td>
<td>52.9</td>
<td>17.6</td>
<td>26.5</td>
</tr>
<tr>
<td>All</td>
<td>272</td>
<td>5.5</td>
<td>18.8</td>
<td>27.6</td>
<td>48.2</td>
</tr>
</tbody>
</table>
About South Center School

This action research project will take place at South Center School (SCS) in South Carolina (a pseudonym for the school name was used). SCS is a separate school facility where students ages 3-21 with severe or profound intellectual disability attend. A few students with mild and moderate intellectual disability who also have severe behavioral and/or health conditions also attend. SCS currently has 123 students enrolled with 20 being served in their homes due to their medical needs (SCS: Sped K-12, 2018). There is a diverse population of students at SCS with ethnic backgrounds of Caucasian (47%), African American (33%), Hispanic (16%), and Asian (3%) (SCS: Sped K-12, 2018).

Every student has an individualized education plan (IEP) and receives additional services such as nursing, speech/language therapy, physical therapy, and/or occupational therapy.

SCS has many unique programs including adapted environmental science, daily living, adapted music, adapted art, sensory room time, and adapted physical education. Many community partners, such as local high school beta clubs and teacher cadets, volunteer their time and services to SCS. The local neighborhood has a garden club who sponsors our gardens, and a local woman-strong philanthropic is a large supporter.

During the 2018-2019 school year, SCS opened an American with Disabilities Act (ADA) accessible nature trail so that the students can access the outdoors in a safe manner.

South Center School: 2017 test scores. A total of 43 students at SCS were administered the 2017 SC-Alt science test. Of these 43 students 13 were in the fourth grade, seven were in fifth grade, four in sixth grade, one in seventh grade, six in eighth grade, and 12 in eleventh grade (SC DOE, 2018b). Scores were not reported when less
than 10 students were administered the test. Of the 13 fourth grade students who took the science test, 38.5% (five students) scored at level one, 15.4% (two students) scored at level two, 46.2% (six students) scored at level three, and 0.0% scored at level four (SC DOE, 2018b). Of the 12 eleventh grade students who took the science test, 0.0% scored at level one, 83.3% (10 students) scored at level two, 8.3% (one student) scored at level three, and 8.3% (one student) scored at level four (SC DOE, 2018b).

Statement of the Problem

The need for effective science instruction for students with disabilities is demonstrated by data at the national, state, and local levels. Inquiry-based activities and vocabulary instruction are crucial to the improved science instruction for students with disabilities (Courtade, 2006; Israel et al., 2013; Leddy, 2010; Melber, 2004; Mutch-Jones et al., 2012; Villanueva et al., 2012). The self-contained, special education teachers at SCS have also expressed the desire to improve their science instruction, but currently lack the time and materials to effectively do so. Students with an intellectual disability and autism at SCS have difficulty accessing and retaining grade level science content, so innovation strategies are needed to address students with an intellectual disability and autism science content instruction.

Purpose Statement

The purpose of this action research was to evaluate the implementation of computer-assisted science vocabulary modules with students with an intellectual disability and autism in an adapted environmental science class on their acquisition and application of vocabulary words and their active engagement in the modules.
Research Questions

Two research questions guided this research:

RQ1. How does the implementation of computer-assisted vocabulary modules, which adhere to evidenced-based practices of special education vocabulary instruction, affect the acquisition and application of science vocabulary terms with students with an intellectual disability and autism in an adapted environmental science class?

RQ2. How are the students with an intellectual disability and autism engaged in computer-assisted instruction activities?

Statement of Research Subjectivities and Positionality

I was an adapted environmental science teacher. I served all students who attended SCS once weekly for 45 minutes each class. While in my class, the students participated in science lessons, pet care activities, and gardening activities. We cared for a rabbit, a guinea pig, fish, two Russian tortoises, a bearded dragon, two cockatiels, two fire belly toads, and many feeder insects. We also ran a school-based farmers’ market where many of my students assisted me, outside of class time, with making, growing, and selling salads, microgreens, and other produce and plants. I also often pulled students during times outside of their typical class time to work on their areas of interest. My first year at this position was in 2018. Previously, I worked for 13 years as an elementary special education teacher for students with orthopedic impairments and other health impairments. Before my orthopedic impairments position, I taught for four and a half years as a middle school moderate disabilities teacher. I have an extensive background in special education, including multiple degrees from Ball State University, and my
National Board Certification in special education. Through my experiences as a teacher and as a learner, I have deepened my passion for the field of special education, as well as the subject of science.

My love of science has grown with the growth of my family. My husband was a former science teacher and was a pre-engineering teacher, and I have two boys. As I watched my boys grow and learn about the world around them, I realized that inquiry-based science learning is crucial for all students. Because I never learned how to properly teach science, I started participating in science professional development sessions offered by our district. After a professional development session about science kits, I developed a relationship with our science specialist. That relationship led to state-level trainings, writing science curriculum for the local and state levels, writing state science standards, providing professional development sessions, and assisting with the state of South Carolina’s Science Participatory Learning, Understanding, and Sharing Institute (Science PLUS) training program for teachers. After one year of assisting at Science PLUS, a colleague and I asked if we could start a Science PLUS program for special education teachers. This idea was met with much enthusiasm by the coordinator of Science PLUS and success has continued each summer.

The chain of events in the last few years has led me to pursue my doctoral degree, so I could continue to learn how to improve science instruction and curriculum for students who have special needs. The desire to take action in order to solve the problem of low science achievement in students with special needs led me to align with the pragmatic paradigm (Lodico, Spaulding, & Voegtle, 2010). I also aligned with the pragmatic worldview because I wanted to make science instruction for students with
special needs better by using real-world practices, researching, and using different methods to discover a way to solve the problem of low science interest and achievement (Creswell, 2012; Lodico et al., 2010; Mackenzie & Knipe, 2006). Technology was a promising solution to this problem because students with special needs have made many gains through video game learning (Marino et al., 2014; Marino, Israel, Beecher, & Basham, 2013).

Because I aligned with the pragmatic view, I conducted action research. As an action researcher, my positionality was that of an insider because I recorded and analyzed my own practice (Herr & Anderson, 2005; Zeni, 1998). I kept open lines of communication with the parents of my students by taking the role of an outsider; therefore, different modes of ethical protection applied to my research (Zeni, 1998). I needed this transparency with my students’ parents because I collected data to determine if the CSVM affected the understanding of science concepts with my students. I needed to earn the parents’ trust that I was protecting their child’s privacy and well-being when I conducted my research and reported my findings.

Finally, my values and biases needed to be monitored. SCS was a very small school, and we all became very much like family. I wanted my students to be successful, so I needed to be very aware of my actions while designing my study, conducting my research, and interpreting the results. In order to keep my values and biases in check, I needed to use sincerity, which is “achieved through self-reflexivity, vulnerability, honesty, transparency, and data auditing” (Tracy, 2010, p. 841). Specifically, I used bracketing. Bracketing is a method used by researchers to set aside personal beliefs, experiences, and influences by bringing awareness to presuppositions in order to prevent
harmful effects on data (Chan, Fung, & Chien, 2013; Fischer, 2009; Gearing, 2004; Tufford & Newman, 2010). There were three general phases to bracketing: (1) abstract formulation, which was orientating the research and developing a theoretical framework, (2) research praxis, which involved developing a foundational focus, suspending suppositions, and assigning starting and ending points, and (3) reintegration, which was analyzing the bracketed data and entering it into the body of data (Gearing, 2004). Bracketing was achieved by writing memos about presuppositions and keeping a reflexive journal to practice self-reflexivity (Chan et al., 2013; Fischer, 2009; Tufford & Newman, 2010).

Through the practice of self-reflexivity, I was honest about my strengths and shortcomings, ensured that I was ready to begin the research process, and used first person voice so readers remember I was a presence in the study (Tracy, 2010). I ensured I used self-reflexivity by including notes about my feelings and making sensemaking comments (Emerson, Fretz, & Shaw, 1995) and “weaving [my] reactions or reflexive considerations of self-as-instrument throughout the research report” (Tracy, 2010, p. 842). I also showed sincerity by creating an audit trail, or creating a paper trail of the steps I took, so that anyone could retrace my steps (Guba, 1981; Mertler, 2017; Shenton, 2004; Tracy, 2010). I also used journaling to record my thoughts that arose during data collection so that I am sure my biases were not reflected later in reporting results (Chenail, 2011). In addition to the audit trail, I was transparent by disclosing my practices, using detail in transcriptions, giving credit to those who deserve it, sharing how the phenomenon changed and developed over time, and sharing the challenges that I encountered (Tracy, 2010).
In addition to self-reflexivity, I ensured credibility, resonance, and ethical considerations were followed to continually monitor the effects of my biases and values (Tracy, 2010). Credibility was established through the reporting of rigor and trustworthiness of qualitative methods and reliability and validity of quantitative methods (Merriam, 2009; Shenton, 2004; Tracy, 2010). Resonance referred to my “ability to meaningfully reverberate and affect an audience … through aesthetic merit, evocative writing, and formal generalizations as well as transferability” (Tracy, 2010, p. 844). Specifically, I used situational ethics to continually reflect on and critique my decisions to ensure they were guided by what was right and not by what my values and biases guided me to do (Tracy, 2010). Finally, I used exiting ethics by reporting what was actually there and not allow my personal feelings to affect my writing, as well as anticipate how others may have viewed what I wrote (Fine, Weis, Weseen, & Wong, 2000; Tracy, 2010).

Furthermore, additional ethical considerations were made to ensure the protection of my participants. It was especially important for me to consider the protection of my students due to their intellectual disability. As shared by Fain (2017), “special education relies on justice, toleration and beneficence as it seeks the equal treatment of equals” (p. 41). To accomplish this, I promoted equal treatment of my students and was tolerant of my students’ differences (Fain, 2017). Also, I practiced beneficence by keeping my students’ best interests in mind throughout the study (Fain, 2017). Additionally, I protected my students by keeping their names and identifying information, including the setting, anonymous by assigning gender-neutral pseudonyms and omitting identify information (Flewitt, 2005). I also protected the students by obtaining confidentiality,
using data findings as outlined, and omitting any happenings that do not relate to the study (Flewitt, 2005). Finally, I practiced reciprocity by asking the parents and the students’ primary teachers to review my observation videos and analysis of these videos to ensure I was accurately interpreting the students’ actions (Harrison, MacGibbon, & Morton, 2001). These methods allowed me to keep my students’ best interests and protection in mind.

**Definition of Terms**

**Action Labels:** The term *action labels* referred to the labeling of words that represented actions.

**Active Engagement:** The term *active engagement* for students with ASD was defined, based on Sparapani, Morgan, Reinhardt, Schatschneider, and Wetherby’s (2016) conceptualization of active engagement, as the student’s ability to participate in class activities in a well-regulated state while also demonstrating social connectedness, communication, and flexibility.

**Adapted Environmental Science:** The term *adapted environmental science* referred to my science class. The class was specially designed for students with severe to profound intellectual disabilities. The students attended my class once weekly as a related arts/special class, as well as special pull-out sessions for further instruction.

**Computer-Assisted Instruction (CAI):** The term *computer-assisted instruction* (CAI) referred to the evidence-based practice of using technology tools as a learning medium for cognitive skills-based instruction.
Computer-Assisted Science Vocabulary Modules (CSVM): The term *computer-assisted science vocabulary modules* (CSVM) referred to the computer modules I create for students with special needs. The activities included in the CSVM will be based on SC state standards, as well as SC-Alt standards and performance descriptors.

**Errorless Learning:** The term *errorless learning* was defined as “systematic instruction using response-prompting procedures that results in less than 20% incorrect responses by learners because the opportunity to make errors is minimized by providing the level of assistance needed to make correct response” (Collins, 2012, p. 207).

**Evidence-Based Practices:** The term *evidence-based practices* meant that a teaching practice met the five criteria as outlined by Horner et al. (2005). Overall, the practice was confirmed to be effective, valid, and reliable through research studies.

**Explicit Instruction:** The term *explicit instruction* referred to the teacher’s intentional focus of direct vocabulary instruction on developing students’ knowledge of word meaning by targeting specific words (Wanzek, 2014).

**Formative Assessment:** The term *formative assessment* was defined as the process of judging the evidence of students’ learning up to a given point, which required feedback to indicate an existence of a gap in performance and the standard and how that work could be improved to meet the standard (Taras, 2005).

**Graphic Organizers:** The term *graphic organizers* was defined as “a visual and graphic display that depicts the relationships between facts, terms, and or ideas within a
learning task” (Hall & Strangman, 2008, p. 2). The specific graphic organizers in this study included Frayer models, t-charts, and cognitive/word maps.

**Intellectual Disabilities and Autism:** The term *intellectual disabilities and autism* referred to students who were categorized with a moderate to profound intellectual disability, autism, and a speech/language impairment. This meant that students had an IQ score ranging from less than 19 (profound) to 35 (severe) to 51 (moderate).

**Mnemonics:** In this study, the term *mnemonics* referred to the keyword mnemonic strategy which used a familiar word that sounds similar to the targeted word and also presents an image for association (Mastropieri & Scruggs, 2016).

**Scripting:** The term *scripting* was defined as a type of delayed echolalia, or the meaningless repetition of another person’s speech from a previously heard conversation, song, movie, commercial, or other auditory source, that was delayed and repeated at later times (Ross, 2002; Shield, Cooley, & Meier, 2017; Silla-Zaleski & Vesloski, 2010).

**Self-Contained Classroom/School:** The term *self-contained* meant that a majority or all students in the particular setting were students with disabilities. For the purpose of my study, self-contained meant that all students in my class and school had a severe to profound intellectual disability and served only with their peers receiving special education services.

**Simulation:** The term *simulation* referred to the modeling of science concepts via video or computerized animations of the science process.
**Stimming (Stim):** The term *stimming* or *stim* referred to repetitive or ritualistic motor movements that had a purpose of self-soothing and/or communicating intense emotion (Kapp et al., 2019; Mintz, 2009).
CHAPTER 2
LITERATURE REVIEW

Introduction

The purpose of this action research study was to evaluate the implementation of CSVM with students with an intellectual disability and autism in an adapted environmental science class. In order to answer how the implementation of CSVM, which adhere to the evidenced-based practices of special education instruction, affect acquisition and application of science vocabulary terms with students with an intellectual disability and autism in an adapted environmental science class, I conducted a literature search on vocabulary and science instruction with students with an intellectual disability and autism, as well as CAI and how it relates to students with an intellectual disability and autism, and with vocabulary instruction. In order to answer how students with an intellectual disability and autism are engaged in CAI activities, I also searched the types of engagement and how they are difficult for students with an intellectual disability and autism, related to CAI, and how to measure each type.

I searched Academic Search Complete, Dissertations and Theses at the University of South Carolina, OpenDissertations, and Education Sources and ERIC using the search terms severe disabilities, vocabulary instruction, and disabilities. When I used the term severe disabilities there were not any results; however, using just the term disabilities provided more findings. Next, I searched the University of South Carolina Catalog using combinations of the following terms: computer-assisted instruction, vocabulary, science,
science vocabulary, vocabulary instruction, autism, academic engagement, intellectual disabilities, science instruction, active engagement, and engagement. As my research progressed, I continued to add to these search terms to fill any gaps in my research, such as articles related to theoretical underpinnings of the study. All searches were limited to scholarly, peer-reviewed articles published between 2013 and 2019. Finally, I mined all articles for additional references that applied to this research study. When reading the articles, I found several books mentioned often, so I accessed books by Collins (2012), Beck, McKeown, and Kucan (2013), and Archer and Hughes (2011) for further information about vocabulary instruction.

This review of the literature is broken into three main sections: (a) theoretical underpinnings, (b) science vocabulary instruction in special education, and (c) active engagement. The first section will cover the theoretical underpinnings that address vocabulary instruction with special education students and that support this study by examining schema/psycholinguistic theory, dual coding theory, and Gagné’s nine events of instruction. The second section will discuss implications for teaching vocabulary in the science content area, using errorless instruction and explicit instruction with students with an intellectual disability and autism, and how CAI is used for vocabulary instruction. Finally, the third section will address active engagement of students with an intellectual disability and autism by further exploring how active engagement is defined, five factors of active engagement, how CAI impacts engagement, and how to assess active engagement.
Theoretical Underpinnings of Explicit, Special Education Vocabulary Instruction

Theories that support word-learning strategies and guide vocabulary instruction include social constructivism/sociocultural theory, schema/psycholinguistic theories, reading motivation theory, and dual coding theory (Moody et al., 2018). Schema and dual coding theories are used the most for science specific vocabulary instruction (Wright, Franks, Kuo, McTigue, & Serrano, 2015). Students with an intellectual disability and autism benefit from explicit instruction (Archer & Hughes, 2011; Hughes, Morris, Therrien, & Benson, 2017; Kendorski & Fisher, 2018); therefore, Gagné’s nine events of instruction will be explored as a theoretical base for designing lessons. This section will explore the three theoretical underpinnings of this research study: (a) schema and psycholinguistic theories, (b) dual coding theory, and (c) Gagné’s nine events of instruction.

Schema and Psycholinguistic Theories

Schema and psycholinguistic theories are types of constructivist theories (Unrau & Alvermann, 2013; Yang, Kuo, Ji, & McTigue, 2018). Constructivist theorists believe that people learn via their interactions with other people and with objects that activate prior knowledge in order to build new knowledge (Unrau & Alvermann, 2013). Vygotsky, a well-known constructivist, believed this was especially true in the acquisition of language (Unrau & Alvermann, 2013). Schema theory provides the basis for the concept that more than one interpretation is possible because people have different experiences that they bring to their learning (Anderson, 2013).

Schema theory can be defined as how people structure and represent knowledge in their memory (Unrau & Alvermann, 2013). Students’ schema affects what they learn
and remember from the information they read (Anderson, 2013; McVee, Dunsmore, & Gavelek, 2005; Yang et al., 2018). The six functions of a student’s schema include to (a) scaffold what is learned from the text, (b) facilitate what gains the student’s attention, (c) allow the creation of inferences, (d) allow for the appropriate recall of information, (e) allow the production of summaries, and (f) allow students to draw conclusions about what was read (Anderson, 2013). In turn, schema theory provides an explanation of how students comprehend text (McVee et al., 2005; Yang et al., 2018) through the focus on students’ prior knowledge (Sadoski, Paivio, & Goetz, 1991).

Schema theory foundations can be found in several classroom applications. First, schema theory is most often used in science when instruction is focused on vocabulary acquisition (Wright et al., 2015). Next, graphic organizers help students organize information and activate their schema (Dye, 2000). Schema theory is present when students make inferences or predictions about a text because their schemata guides these actions (Sheridan, 1981; Zhang, 2010). Finally, schema theory is relevant to vocabulary instruction because teachers need to help students go beyond just the definitions of words and develop concepts with examples and nonexamples (Sheridan, 1981).

Psycholinguistic theory, founded by Chomsky, provided an explanation for how individuals construct or comprehend language (Unrau & Alvermann, 2013), which means that readers use their knowledge of syntax, semantics, and phonics to predict the meaning of text (Sheridan, 1981). Psycholinguistic theory also explains that reading is an inferencing process because readers try to comprehend the text through predictions (Yang et al., 2018). Psycholinguistic theory also views reading errors as the key to understanding problems that may occur when attempting to comprehend a text (Unrau &
Alvermann, 2013; Yang et al., 2018). The psycholinguistic theory specifically relates to vocabulary acquisition because individuals use semantics to comprehend texts (Sheridan, 1981).

**Dual Coding Theory**

Paivio proposed dual coding theory as an alternative theory to schema theory (McVee et al., 2005) because schema theory neglected the importance of imagery in cognition (Sadoski et al., 1991). Dual coding theory is a cognitive theory that explains that cognition and comprehension developed from processing both verbal and nonverbal information to create a memory (Paivio, 2014; Sadoski et al., 1991; Unrau & Alvermann, 2013). The premise of dual coding theory is that the use of the two different information processing systems, or dual coding, result in a deeper understanding of the concept (Yang et al., 2018).

There are many educational implications of dual coding theory. First, multimodal sources should be incorporated into all aspects of learning science content (Thompson, 2008; Wright et al., 2015). Multimodal methods should be used because there is less chance for cognitive overload and more benefits to memory retrieval when verbal and nonverbal channels are used (Sadoski, McTigue, & Paivio, 2012). Dual coding theory places a strong emphasis on the use of images in everyday instruction (Moody et al., 2018; Wright et al., 2015). When using images in instruction, it may be beneficial to use animated images along with sound because they have been found to help students learn significantly more vocabulary words than static images (Kassim, 2018). Often students with more severe disabilities are not able to access their environments and participate in real-world events; therefore, simulations of scientific interactions in the world can be
used to help make the connections that provide prior knowledge and allow for connections that lead to cognition (Wright et al., 2015).

**Gagné’s Nine Events of Instruction**

Gagné’s nine events of instruction (Gagné & Briggs, 1974) is considered a micro theory because it is a set of procedures for teachers to use to focus the delivery of a lesson to make it more interactive (Carnahan & Mensch, 2014; Sangswang, 2015; Ullah, Rehman, & Bibi, 2015). Gagné designed nine events of instruction that allow a learner to proceed from their current state to the level outlined by the learning objective of the lesson (Gagné & Briggs, 1974). While these events were originally designed for adult education, they have been used to instruct younger students to use concepts and solve problems (Zhu & St. Amant, 2010). These nine events should be deliberately arranged, but do not have to be in the exact order nor used in every lesson (Gagné & Briggs, 1974). The nine events together reflect a direct instructional model (Cronjé, 2006; Moallem, 2001); however, they are flexible enough to integrate more constructivist activities (Carman, 2005; Hirumi, 2002). The nine events of instruction include (a) gaining attention, (b) informing the learner of the objective, (c) stimulating the recall of prior learning, (d) presenting stimulus material, (e) providing guidance, (f) eliciting performance, (g) providing feedback, (h) assessing performance, and (i) enhancing retention and transfer (Carnahan & Mensch, 2014; Driscoll, 2000; Gagné & Briggs, 1974; Sangswang, 2015; Ullah et al., 2015; Zhu & St. Amant, 2010).

**Gaining attention.** The *gaining attention* event is a change in stimulus that appeals to the students’ interests (Driscoll, 2000; Gagné & Briggs, 1974) and is provided by the instructor (Zhu & St. Amant, 2010). This change in stimulus activates receptors in
the students’ brains (Zhu & St. Amant, 2010) to allow them to be interested and receptive to the information in order to learn (Carnahan & Mensch, 2014; Driscoll, 2000).

Strategies for gaining attention include using media or animated video clips with a familiar experience (Carnahan & Mensch, 2014) or showing relevant pictures and asking motivating questions (Ullah et al., 2015). This event is crucial to learning because it promotes the transfer of information to short-term memory, preventing the loss of information (Ullah et al., 2015).

**Informing the learner of the objective.** The informing the learner of the objective event is providing a simple statement of the instructional goals so that the learners know what is expected and/or the goals and purpose of the lesson (Carnahan & Mensch, 2014; Driscoll, 2000; Gagné & Briggs, 1974; Sangswang, 2015; Ullah et al., 2015; Zhu & St. Amant, 2010). This event also allows the teacher to plan for the activation of prior knowledge (Ullah et al., 2015). The instructor should use easy to understand words or pictures to convey the objective to the learners (Gagné & Briggs, 1974).

**Stimulating recall of prior learning.** The stimulating the recall of prior learning event stimulates prior knowledge (Carnahan & Mensch, 2014; Ullah et al., 2015). Stimulating prior knowledge prompts the retrieval of information stored in the brain and moves that information into short-term memory for use (Zhu & St. Amant, 2010). These quick reviews of previously learned material are especially important for younger students (Driscoll, 2000).

**Presenting stimulus material.** The presenting stimulus material event is the delivery of the content (Carnahan & Mensch, 2014) using the proper stimuli needed to
engage the students in learning (Gagné & Briggs, 1974). For a student to learn, the teacher must “prominently display distinctive features of the concept or rule to be learned” (Driscoll, 2000, p. 367). This new content should be presented piece by piece, using summaries and chunking to help aid retention of information (Sangswang, 2015).

**Providing learning guidance.** The *providing learning guidance* event involves the use of semantic encoding strategies to move information into the students’ long-term memory (Carnahan & Mensch, 2014; Driscoll, 2000; Gagné & Briggs, 1974; Sangswang, 2015; Ullah et al., 2015; Zhu & St. Amant, 2010). The level and amount of learning guidance is determined by the students’ needs (Driscoll, 2000; Gagné & Briggs, 1974). Learning guidance can involve the use of direct and indirect prompting to assist students in their learning (Gagné & Briggs, 1974). Examples of providing learning guidance include the use of questioning, charts, graphs, mnemonics, and repeated practice (Carnahan & Mensch, 2014; Driscoll, 2000; Gagné & Briggs, 1974; Sangswang, 2015; Ullah et al., 2015; Zhu & St. Amant, 2010).

**Eliciting the performance.** The *eliciting the performance* event is when the students attempt to complete what is required to show their learning (Carnahan & Mensch, 2014; Driscoll, 2000; Gagné & Briggs, 1974; Sangswang, 2015; Ullah et al., 2015; Zhu & St. Amant, 2010). The first attempt at eliciting the performance should be the same or similar to what was practiced, but the second attempt should be different and more real-life in nature (Gagné & Briggs, 1974; Sangswang, 2015). These practice performances allow information to have prolonged storage in long term memory (Sangswang, 2015) and enhances encoding of the stored information (Zhu & St. Amant, 2010).
Providing feedback. The *providing feedback* event is typically referred to as formative assessment, or the informative feedback about the correctness of responses that reinforces ideas and helps the instructor decide if the learner needs more practice (Carnahan & Mensch, 2014; Driscoll, 2000; Gagné & Briggs, 1974; Zhu & St. Amant, 2010). The overall goal of this feedback is to correct student errors (Driscoll, 2000; Gagné & Briggs, 1974). This feedback can be more formal, like answering questions and providing the answers, or can be as simple as a nod, smile, or spoken word (Gagné & Briggs, 1974).

Assessing performance. The *assessing performance* event is typically referred to as formal or summative assessment (Carnahan & Mensch, 2014; Driscoll, 2000; Gagné & Briggs, 1974; Zhu & St. Amant, 2010). This event is important for reinforcing the students’ final understanding of the information presented in the lesson (Zhu & St. Amant, 2010). These assessments should align to the learning objective and can include projects, quizzes, and tests (Carnahan & Mensch, 2014).

Enhancing retention and transfer. The *enhancing retention and transfer* event is when the teacher provides the students with opportunities to apply what they learned to new tasks (Carnahan & Mensch, 2014; Driscoll, 2000; Gagné & Briggs, 1974; Zhu & St. Amant, 2010). This event is important because students are required to retrieve the information they stored in their long term memory to apply it to the new situation presented (Carnahan & Mensch, 2014).

Teaching and Learning Science Vocabulary in Special Education

This section of the literature review will address the (a) need for vocabulary instruction in science, (b) challenges with science and vocabulary instruction, (c) types of
vocabulary words, (d) assessment of vocabulary learning for students with an intellectual disability and autism, and (e) evidence-based practices of vocabulary instruction with students with an intellectual disability.

Need for Vocabulary Instruction in Science

Vocabulary acquisition has shown to be imperative for the success of every student in every subject. First, vocabulary is a prerequisite to understanding content material (Wannarka, 2013) and comprehending academic content (Harmon & Wood, 2018). Additionally, students need to be able to communicate their science learning, so they need to accurately know vocabulary terms to do so appropriately (Spooner, Browder, & Jimenez, 2011). Another need for vocabulary instruction is that it builds the background knowledge that is extensively required in the content area of science (Knight et al., 2015). Specific to students with an intellectual disability and autism, vocabulary instruction helps to increase students’ significantly lower achievement levels (Harmon & Wood, 2018; Knight, Wood, Spooner, Browder, & O’Brien, 2015; Smith, Spooner, Jimenez, & Browder, 2013; Spooner et al., 2011; Villanueva et al., 2012; Wannarka, 2013). Finally, the need for vocabulary instruction in science is especially important for students with an intellectual disability and autism because research has demonstrated that even students with a severe intellectual disability and autism can learn grade-level science concepts from explicit instruction on science vocabulary (Smith, Spooner, Jimenez, & Browder, 2013). So, vocabulary instruction in science can increase students with an intellectual disability and autism’s background knowledge, science content comprehension, and overall science achievement levels.
Challenges with Science and Vocabulary Instruction for Students with Intellectual Disability and Autism

Students with an intellectual disability and autism have faced many challenges when participating in science and vocabulary instruction. Kennedy, Rodgers, Romig, Lloyd, and Brownell (2017) analyzed the vocabulary subsections of the National Assessment of Educational Progress and found that students with disabilities scored lower than the 25th percentile of students without disabilities. The first challenge students with an intellectual disability and autism face is understanding the technicality of science vocabulary words (Rice & Deshler, 2018). These technical terms are even more difficult because they rely on one another for comprehension (Rice & Deshler, 2018). Science vocabulary words are also multimorphemic (e.g., photosynthesis has five syllables, three morphemes, and 14 letters), have unfamiliar spelling patterns (e.g., muscle and muscular), are nominalized (e.g., changing magnify to magnification; Zoski et al., 2018), and have multiple meanings (e.g., matter can mean “to care or to find important any substance that occupies space”; Rice & Deshler, 2018, p. 48). One reason students with an intellectual disability and autism may have difficulty with science vocabulary acquisition is the difficult types of words that make up science content vocabulary.

Additionally, researchers have connected several other reasons students with an intellectual disability and autism may have difficulty with science vocabulary acquisition and comprehension. First, difficulties may lie within teachers’ instruction because teachers may not understand the concept well enough to accurately simplify the concept (Smith, Spooner, Jimenez, & Browder, 2013). Additionally, science instruction typically involves open-ended inquiry which lacks the systematic instruction that students with an
intellectual disability and autism need (Smith, Spooner, Jimenez, & Browder, 2013). Next, difficulties students with an intellectual disability and autism experience are often due to problems in other academic areas, such as reading and math (Villanueva et al., 2012). Further, students with an intellectual disability and autism have difficulty recalling information and need to be explicitly taught the big ideas of science (Villanueva et al., 2012). Therefore, science concepts and vocabulary terms can be difficult for students with an intellectual disability and autism to learn because of the lack of appropriate instruction and the effects of the students’ intellectual disability.

Students with autism have specific challenges in learning vocabulary due to their communication difficulties and cognitive processing skills. Children with communication delays have difficulty labeling stimuli in their environment, especially actions, often due to a lack of prior exposure and lack of vocabulary to describe scientific phenomena (Knight, Smith, Spooner, & Browder, 2012; Schebell, Shepley, Mataras, & Wunderlich, 2018; Zoski et al., 2018). In addition, children with autism acquire vocabulary and learn to communicate differently, and therefore, require more deliberate teaching of vocabulary terms (Dzulkifli, Wahdi, & Rahman, 2016). For example, Dzulkifli et al. (2016) found in their research that students with autism do not independently use strategies to learn new words; therefore, they require explicit teaching of vocabulary words and their meanings.

**Types of Vocabulary Words**

Before deciding on the type of vocabulary instruction to use, teachers must be aware of the types of vocabulary words. Beck et al., 2013 introduced three tiers of vocabulary words: (1) tier one words are the most basic words (e.g., book, run, girl, boy, dog) and do not need separate instruction; (2) tier two words are most commonly found
in instruction, are general academic terms, and are found across domains (e.g. measure, directions, describe) and (3) tier three words are technical words that are concept loaded and apply to the subject being taught (e.g., quadrilateral, economics, photosynthesis).

Tier two and tier three words are important to know to be successful in content areas (Baumann & Graves, 2010). Science vocabulary words typically fall into tier three (Beck et al., 2013; Reutzel & Cooter, 2019).

Furthermore, several researchers have included suggestions for selecting the correct words in their studies. When selecting the specific words to use in lessons, researchers suggest using curriculum materials (Vannest, Soares, Smith, & Williams, 2012), state standards (Browder et al., 2012; Ford, Conoyer, Lembke, Smith, & Hosp, 2018; Vannest et al., 2012), frequently appearing words (Beck et al., 2013; Rice & Deshler, 2018; Roberts, Torgesen, Boardman, & Scammacca, 2008; Vannest et al., 2012; Wannarka, 2013), and/or words crucial to understanding the text or topic being taught (Beck et al., 2013; Rice & Deshler, 2018; Roberts et al., 2008; Vannest et al., 2012; Wannarka, 2013). Beck et al. (2013) and Reutzel and Cooter (2019) also stressed the importance of teachers developing student-friendly explanations of tier two and tier three words. Student-friendly explanations can be developed by following Beck et al.’s procedures: (1) give a general description of the word and its use, (2) model how the word is used in everyday language, and (3) ask students to help explain the word.

Teachers can improve science vocabulary learning by selecting the appropriate terms for instruction and by creating student-friendly explanations for instruction.
Assessment of Vocabulary Instruction with Students with Intellectual Disability and Autism

Using formative assessment is an important aspect of any special education instruction (Kendorski & Fisher, 2018). Formative assessment can be defined as the process of judging the evidence of students’ learning up to a given point, which requires feedback to indicate an existence of a gap in performance and the standard and how that work can be improved to meet the standard (Taras, 2005). Formative assessments allow teachers to capture small changes in learning (Kendorski & Fisher, 2018). The assessments that will be explored in this section will include (a) curriculum-based measurements and (b) teacher-created assessments.

Curriculum-based measurements of vocabulary. Curriculum-based measurement assessments provide instructors with an overview of student growth by collecting samples of student work on a frequent basis and graphing the results (Espin et al., 2013). Several studies report the use of curriculum-based measurements involving a five-minute vocabulary matching assessment (e.g., Espin et al., 2013; Ford et al., 2018; Kennedy, Thomas, Meyer, Alves, & Lloyd, 2014). Espin et al. (2013) used the vocabulary matching curriculum-based measurements with 198 seventh grade students, 17 of whom had a learning disability. Kennedy et al. (2014) used it with 32 students with a learning disability and 109 without a learning disability in a high school setting. Both Espin et al. and Kennedy et al. concluded that the students were able to learn vocabulary at a faster rate due to adjusting instruction from the data the curriculum-based measurements provided. Additionally, Ford et al. (2018) used the vocabulary matching curriculum-based measurements along with a sentence verification technique to assess
vocabulary knowledge in 25 eighth-grade students, one of whom had an IEP, and found that vocabulary matching was a better predictor of more formal assessment scores. Finally, Vannest et al. (2012) used a different curriculum-based measurement called the Science Key Vocabulary Assessment, which was a free online program that allowed teachers to select vocabulary words to assess. Vannest et al. reported that the students were motivated by the online assessment probes because they were able to track their progress on the graphs the program created. The curriculum-based measurement was effective because teachers were able to “self-evaluate teaching practices and rapidly target struggling students who may have previously ‘fallen through the cracks’” (Vannest et al., 2012, p. 69). Curriculum-based measurement assessments allow teachers to collect data on a frequent basis in order to quickly adjust instruction to meet the students’ learning needs.

**Teacher-created vocabulary assessments.** Blachowicz and Fisher (2002) explained that teacher-constructed vocabulary assessments typically include students choosing synonyms, antonyms, the classification of an item, how items are used, a definition, a picture, and/or a word to complete a sentence. In addition, Blachowicz and Fisher provided four guidelines for creating teacher-made assessments: (1) use the same expectations that are used in class, (2) avoid repetition that leads to rote memorization and requires students to think more deeply, (3) use word knowledge activities that are useful to the content of the class, and (4) use a test format matches the instructional format. Smith, Spooner, and Wood (2013) successfully used CAI to assess three middle school students with an intellectual disability and autism by showing a photo and a choice of four words to label the photo. McMahon, Cihak, Wright, and Bell (2016) also used a
multiple-choice form with four choices, as well as provided a diagram for students to label to assess the use of augmented reality to teach science vocabulary to three college students with autism. Finally, Browder et al. (2012) created a science vocabulary test that required 21 students, ages 14-21, with autism or an intellectual disability to identify vocabulary from an array of four using three phases: (1) word only, (2) picture symbol only, and (3) matching the word to the symbol. Teacher-created assessments for students with an intellectual disability and autism are commonly multiple-choice and involve matching words, definitions, and/or picture symbols, and can be an easy-to-create and accurate measurement of student performance when teachers follow guidelines for creating assessments.

Evidence-Based Practices of Vocabulary Instruction for Students with Intellectual Disabilities and Autism

Students with an intellectual disability and autism require many strategies and methods of instruction to reach their unique learning requirements, and the strategies and methods should be evidence-based. A practice is considered evidence-based when (a) the practice and its context are defined, (b) conducted with fidelity, and (b) research results document a functional relationship in dependent measures and the findings are generalizable (Horner et al., 2005). Stevenson, Flynn, and Test (2016) conducted a literature review to find evidence-based practice for students with disabilities and discovered constant-time delay, mnemonic strategies, and visual displays, like graphic organizers, were successful evidence-based practices and strategies to use. Jitendra, Edwards, Jacks, and Jacobson (2004) extended Stevenson et al.’s findings to include direct instruction and CAI as effective instructional evidence-based practices for
vocabulary instruction. This section will discuss the evidence-based practices of (a) errorless learning procedures, (b) explicit instruction of teaching science vocabulary, and (c) CAI in the special education setting.

**Errorless learning procedures for instruction in special education.** Errorless learning procedures have been found to be evidence-based practices of special education instruction. An errorless learning procedure can be defined as “systematic instruction using response-prompting procedures that results in less than 20% incorrect responses by learners because the opportunity to make errors is minimized by providing the level of assistance needed to make correct response” (Collins, 2012, p. 207).

**Explicit instruction of teaching science vocabulary for students with intellectual disability and autism.** There are three types of evidence-based practices specific to vocabulary instruction: (a) text-based vocabulary instruction, (b) morphology-based instruction, and (c) explicit instruction. Text-based vocabulary instruction involves embedding vocabulary instruction into texts read aloud to students (Archer & Hughes, 2011). Morphology-based instruction is when the structure of words and morphemes are taught in order to help students use context clues and parts of words to understand the word’s meaning (e.g., identifying prefixes and suffixes; Archer & Hughes, 2011; Zoski et al., 2018). Explicit instruction is a method of vocabulary instruction that has been found to be effective with students with an intellectual disability and autism (Archer & Hughes, 2011; Hughes et al., 2017; Kendorski & Fisher, 2018).

First, text-based vocabulary instruction was found to be successful with general education students, students with learning disabilities, and language learners (Pham & Nguyen, 2017; Solis, Scammacca, Barth, & Roberts, 2017). There is a gap in the research
using text-based instruction with students with an intellectual disability and autism. Morphology-based vocabulary instruction has been effective for students in general education (Spies & Dema, 2014; Zoski et al., 2018); however, Swanson, Vaughn, and Wexler (2017) found that morphology-based instruction does not make substantial improvements in content knowledge with students with an intellectual disability and autism. Additionally, Lucas, Thomas, and Norbury (2017) found students with autism learned more from instruction on explicit definitions of vocabulary words than learning from phonological and semantic aspects. Since there is a gap in the research for text-based instruction and morphology-based instruction has not shown promise for students with an intellectual disability and autism (Swanson et al., 2017; Lucas et al., 2017), this section of the literature review will focus on explicit instruction. This section on explicit instruction will include (a) the definition of explicit instruction, (b) benefits and challenges of explicit instruction, and (c) explicit instruction strategies for vocabulary learning.

**Defining explicit instruction.** Explicit instruction is not exploratory but is a direct teaching method using research-based, systematic instruction with clear language and purpose, which reduces students’ cognitive load (Archer & Hughes, 2011; Hughes et al., 2017; Kendorski & Fisher, 2018). In addition, explicit instruction promotes learning through student engagement with frequent varied response opportunities that are followed by feedback and promotes generalization of skills via practice strategies (Hughes et al., 2017). A definition specific to vocabulary instruction and that will be used for the purpose of this study is that explicit vocabulary instruction is the teacher’s intentional
focus of direct vocabulary instruction on developing students’ knowledge of word meaning by targeting specific words (Wanzek, 2014).

Explicit instruction is made up of several smaller practices developed by Archer and Hughes (2011). The 16 elements and six teaching functions are summarized in Table 2.1. The first element, focus instruction on critical content, involves identifying the students’ needs and matching instruction to those needs to teach “skill, strategies, vocabulary terms, concepts, and rules” (Archer & Hughes, 2011, p. 2). Elements two through eight include: (a) sequence skills logically, (b) break down complex skills and strategies, (c) design organized and focused lessons, (d) begin lessons with a statement of the lesson’s goals, (e) review prior skills, (f) provide step-by-step demonstrations, (g) use clear and concise language, and (h) provide examples and non-examples (Archer & Hughes, 2011). The tenth element, provide guided and supported practice, is the regulation of the difficulty of practice opportunities throughout the lesson (Archer & Hughes, 2011). Elements 11-15 include: (a) require frequent responses, (b) monitor student performance closely, (c) provide immediate affirmative and corrective feedback, (d) use a brisk pace to deliver the lesson, and (e) help students organize knowledge (e.g., use graphic organizers; Archer & Hughes, 2011). Finally, the 16th element is to use distributed practices, or multiple opportunities, and cumulative practices, or providing practice opportunities that include previously learned skills (Archer & Hughes, 2011).

Rosenshire (1997) and Rosenshine and Stevens (1986) grouped the 16 teaching elements into six teaching functions as seen in Table 2.1. The six teaching functions of an explicit instruction lesson include: (a) review, (b) presentation, (c) guided practice, (d) corrections and feedback, (e) independent practice, and (f) weekly and monthly reviews
These six teaching functions can be compared to Gagne’s nine events of instruction (Gagné & Briggs, 1974) because they provide systematic methods for teaching by breaking down the process into smaller steps (Archer & Hughes, 2011; Rosenshine, 1997). These steps are important because students with special needs require scaffolded instruction which provides the supports for the students’ unique learning needs (Archer & Hughes, 2011).

Table 2.1. *Elements and Teaching Functions of Explicit Instruction*

<table>
<thead>
<tr>
<th>Elements of Explicit Instruction</th>
<th>Teaching Function of Explicit Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Focus instruction on critical content</td>
<td>1. Review</td>
</tr>
<tr>
<td>2. Sequence skills logically</td>
<td>2. Presentation</td>
</tr>
<tr>
<td>3. Break down complex skills and strategies into smaller instructional units</td>
<td>3. Guided practice</td>
</tr>
<tr>
<td>4. Design organized and focused lessons</td>
<td>4. Corrections and feedback</td>
</tr>
<tr>
<td>5. Begin lessons with a clear statement of the lesson’s goals and teacher expectations</td>
<td>5. Independent practice</td>
</tr>
<tr>
<td>6. Review prior skills and knowledge before beginning instruction</td>
<td>6. Weekly and monthly reviews</td>
</tr>
<tr>
<td>7. Provide step-by-step demonstrations</td>
<td></td>
</tr>
<tr>
<td>8. Use clear and concise language</td>
<td></td>
</tr>
<tr>
<td>9. Provide an adequate range of examples and nonexamples</td>
<td></td>
</tr>
<tr>
<td>10. Provide guided and supported practice</td>
<td></td>
</tr>
<tr>
<td>11. Require frequent responses</td>
<td></td>
</tr>
<tr>
<td>12. Monitor student performance closely</td>
<td></td>
</tr>
<tr>
<td>13. Provide immediate affirmative and corrective feedback</td>
<td></td>
</tr>
<tr>
<td>14. Deliver the lesson at a brisk pace</td>
<td></td>
</tr>
<tr>
<td>15. Helps student organize knowledge</td>
<td></td>
</tr>
<tr>
<td>16. Provide distributes and cumulative practice</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Elements and function from Archer and Hughes (2011) and Riccomini, Morano, and Hughes (2017).

In addition to the elements and teaching functions, explicit instruction requires that skills are taught using a scaffold assistance design (Archer & Hughes, 2011;
Kendorski & Fisher, 2018). The purpose of scaffolding is to provide support to complete a task that otherwise could not be completed without the support (Archer & Hughes, 2011; Larkin, 2001; Radford, Bosanquet, Webster, & Blatchford, 2015; Stone, 1998; Vygotsky, 1978). Scaffolding is successful with students with disabilities because it provides the needed confidence and support to fill in the gap of skills, such as reading ability, that are missing in order to complete the task (Archer & Hughes, 2011; Larkin, 2001; Radford, et al., 2015; Stone, 1998). The scaffolds are eventually faded so that the student can perform the task independently (Archer & Hughes, 2011; Larkin, 2001; Radford et al., 2015; Stone, 1998). The 16 teaching elements, six functions, and scaffolded design of explicit instruction allow teachers to make the general education curriculum accessible for students with special needs (Archer & Hughes, 2011; Larkin, 2001; Radford et al., 2015; Rosenshine, 1997; Stone, 1998).

**Benefits and challenges of explicit instruction.** Explicit instruction effectively and efficiently promotes learning for students with learning difficulties in comparison to methods, such as inquiry-based learning (Riccomini, Morano, & Hughes, 2017). Kaldenberg, Watt, and Therrien (2015) compared studies that explicitly taught science vocabulary \( n = 11 \) or did not \( n = 9 \) to students with learning disabilities and found that the vocabulary studies \( (ES = 1.25) \) had a greater impact on comprehension of science texts than for the non-vocabulary instruction intervention \( (ES = 0.64) \).

While the specific meaning of the words is crucial, instruction should also extend past the core meaning of the words (Spies & Dema, 2014). Cuticelli, Coyne, and Ware (2015) suggested that teachers focus intently on the following principles for at-risk
students: direct, explicit with teacher modeling, scaffolding of levels of difficulty, and many chances to practice while receiving feedback that is both timely and specific.

**Explicit instruction strategies for vocabulary learning.** In addition to the practices of explicit instruction, there are specific instructional strategies that can be used to promote vocabulary learning. Vocabulary instruction in the area of science is often left to rote memory or requiring students to recall and define words from memorization, which is not effective for many students (Archer & Hughes, 1997; Douglas, Klentschy, Worth, & Binder, 2006; Goldstein et al., 2017). Using vocabulary strategies instead of memorizing definitions of the words allows students to build a deeper understanding of words (Douglas et al., 2006). There are two strategies which have shown promise for students with an intellectual disability and autism: (a) mnemonics and (b) graphic organizers.

**Mnemonics.** Mnemonic strategies are memory aid devices that are used as prompts to assist students with different skills (Haydon, Musti-Rao, & Alter, 2017; Lubin & Polloway, 2016; Mastropieri, Scruggs, & Mushinski Fulk, 1990). The keyword strategy (See Figure 2.1), which is a type of linguistic mnemonic (Lubin & Polloway, 2016), uses a similar, known word and an image to help students connect the meaning of the term to the word (Haydon et al., 2017; King-Sears, Brawand, Jenkins, & Preston-Smith, 2014; Mastropieri et al., 1990). Tier three vocabulary terms, as described above, are the type of words that should be used in the keyword strategy (King-Sears et al., 2014). More specifically, King-Sears et al. (2014) developed the three Rs which makeup the keyword mnemonic strategy: “recording an unfamiliar word using a keyword, relating the keyword to the unfamiliar word’s definition, and retrieving the definition of the
previously unfamiliar word by using the keyword’s relation to the new word’s definition” (p. 23). Mastropieri et al. (1990) provided an example of the keyword strategy used with 25 middle school students with learning disabilities for learning the word *oxalis* by creating a keyword mnemonic that related the word *ox* by showing an ox eating clover. Mastropieri et al. shared that similar mnemonics resulted in high levels of recall and comprehension for concrete and abstract words. The overall goal of using mnemonics is to provide memory tools and graphic support (Dzulkifli et al., 2016) to help students remember facts and concepts (Lubin & Polloway, 2016) by pairing the mnemonics with effective direct instruction (Bryant, Goodwin, Bryant, & Higgins, 2003).

![Figure 2.1. Example of a keyword mnemonic for oxalis. Picture symbols from SymbolStix®, Copyright 2019, SymbolStix, LLC. All rights reserved. Used with permission.](image)

While there is a gap in the research with the use of mnemonics with students with an intellectual disability and autism, there is research supporting its use with various populations of students served in general and special education settings. Rice and Deshler...
(2018) completed a content analysis of two online earth science courses to determine the level of vocabulary support for students with disabilities and discovered that keyword mnemonic strategies are successful because students form associations with sound and imagery links with the vocabulary words. Therrien, Taylor, Watt, and Kaldenberg (2013) conducted a literature review of 11 articles about science instruction for students with emotional and behavioral disorders and found “evidence is strongest for the use of mnemonics to increase the acquisition and retention of … factual knowledge” (p. 25). Condus, Marshall, and Miller (1986) provided four different treatments including keywords mnemonics, picture context, sentence context, or choose your own method for 64 students, age 12 with a learning disability, and students who received the keyword treatment outperformed the other students who received the other treatments. Therefore, while the research has not yet generalized the use of mnemonic strategies to students of all ability levels, there is potential for using mnemonics to assist students with an intellectual disability and autism in participating in tasks that require higher-order thinking skills (Haydon et al., 2017).

*Graphic organizers.* Graphic organizers have been found to be a successful strategy to use for explicit vocabulary instruction. Kim, Vaughn, Wanzek, and Wei (2004) conducted a meta-analysis from 21 studies and determined visual displays of information provided by graphic organizers helped students organize the verbal information and improve their recall. The visual representations that a graphic organizer provides helps students with an intellectual disability and autism form a concrete picture out of abstract information (Browder, Spooner, & Meyer, 2011; Dexter & Hughes, 2011). This organization is needed because students with disabilities have difficulty recalling
large amounts of information from memory and need big ideas to connect vocabulary and concepts (Villanueva et al., 2012). Graphic organizers provide key information to be represented in visual displays that organize the information for students with an intellectual disability and autism who need this assistance for learning.

A seminal study conducted by Knight et al. (2013) reviewed key implications for the use of graphic organizers in the special education classroom with three middle school students with an intellectual disability and autism, ages 13-14. First, students needed explicit instruction on how to use graphic organizers (Knight et al., 2013). Knight et al. found that when explicit instruction was combined with the use of graphic organizers, scores on exams were higher. Knight et al. also found that using multiple exemplar training and modeling examples versus nonexamples with the use of systematic instruction and constant time delay can provide even more support for the use of graphic organizers. The researchers found a functional relationship of use between intervention and correct steps of task analysis of the science concept convection when graphic organizers were used (Knight et al, 2013).

Overall, graphic organizers make relationships between facts and concepts using visual displays to facilitate the learning of abstract concepts (Dexter & Hughes, 2011). There are many different types of graphic organizers that can be implemented in the classroom. Three types of graphic organizers are described below: (a) cognitive/word mapping strategies, (b) Frayer models, and (c) t-charts.

Cognitive or word mapping, also known as semantic maps (See Figure 2.2), strategies make relationships between concepts by using images, words, lines, and arrows to create a visual display of the concept (Dexter & Hughes, 2011; McKenzie, 2014;
Word mapping activities can align with the psycholinguistic theory when the focus is on semantics (Sheridan, 1998) and with dual coding theory when images are used (Moody et al., 2018; Wright et al., 2015). These maps also help students relate new information to prior knowledge, or schema (Reutzel & Cooter, 2019). Word mapping strategies including images, keywords, or simple drawings can be used to brainstorm ideas or assess prior knowledge about vocabulary terms (Dexter & Hughes, 2011; Spies & Dema, 2014). Word maps are appropriate to use any time during instruction, but they have been especially helpful for students with disabilities when used before reading (Reutzel & Cooter, 2019).

Figure 2.2. Example of a picture-based cognitive/word map for students with intellectual disabilities and autism. Picture symbols from SymbolStix®, Copyright 2019, SymbolStix, LLC. All rights reserved. Used with permission.

The second type of graphic organizers are Frayer models (See Figure 2.3). Frayer models are successful for instruction of tier two and three vocabulary words (Reutzel &
Frayer models are especially helpful for nonfiction words because examples and nonexamples are used (Reutzel & Cooter, 2019). Frayer models align with the dual coding theory when images are used (Moody et al., 2018; Wright et al., 2015) and schema theory when examples and nonexamples are used (Sheridan, 1981). The success of Frayer models is due to the ability to examine a concept by going beyond definitions (Thomas, 2016). Frayer models can be adapted to include definitions and characteristics, sentences, synonyms and antonyms, pictures/sketches of the vocabulary term, and examples and nonexamples (Reutzel & Cooter, 2019; Thomas, 2016). Thomas (2016) studied 47 general education students, ages 11-12, to determine if the use of a Frayer model improved word wall instruction. Thomas found that the Frayer model did make the instruction more effective because it helped to activate prior knowledge, as the gain of content knowledge was evident from pre- and posttest scores. While there are not specific studies that address the use of Frayer models with students with an intellectual disability and autism, they show promise in helping students connect their prior knowledge to the concept and go beyond the memorization of a definition to understanding of a concept.

A final type of graphic organizer is the t-chart (See Figure 2.4). T-charts can be used in numerous ways (Browder et al., 2011), but are commonly used to compare two items and could be used to show examples and nonexamples (Reutzel & Cooter, 2019). T-charts align with schema model because they allow teachers to determine students’ prior knowledge (Dye, 2000; McKenzie, 2014; Sadoski et al., 1991). Grids that compare information, such as t-charts, help simplify abstract concepts and help connect new vocabulary to their meanings and related concepts (Brown & DiRanna, 2012; Reutzel &
Cooter, 2019). A t-chart is essentially the same as a Venn diagram, but does not include the overlapped circles for similarities, but rather contrasts the two topics (Campbell & Rivas, 2012; McKenzie, 2014). T-charts can provide students with a visual representation of what does and does not represent a specific vocabulary term.

![Figure 2.3. Example of a Frayer model. Pictures from SymbolStix®, Copyright 2019, SymbolStix, LLC. All rights reserved. Used with permission.](image)

**Computer-assisted instruction in special education.** This section of the literature review will explore the (a) definition of CAI, (b) use of CAI with students with an intellectual disability and autism, (c) components of CAI, and (d) difficulties with CAI.
Figure 2.4. T-chart sample showing the use of words and picture symbols. Picture symbols from SymbolStix®, Copyright 2019, SymbolStix, LLC. All rights reserved. Used with permission.

**Defining computer-assisted instruction.** CAI has been defined in terms of (a) its description, (b) an evidence-based practice, and (c) its types and uses. CAI has been described in the literature as technology-aided (Root, Stevenson, Davis, Geddes-Hall, & Test, 2017), the use of computers or other technology used for educational purposes (Anohina, 2005; McKissick, Davis, Spooner, Fisher, & Graves, 2018; Sigafoos et al., 2014), and “an approach to teaching that is intended to promote learning and address related educational objectives” (Sigafoos et al., 2014, p. 78). McKissick, Diegelmann, and Parker (2017) described CAI as a way to provide “instruction on a specific skill or
concept like solving a mathematical problem or identifying key science vocabulary” (p. 155). CAI is also described as instruction provided solely by the technology tool, which means there is not a need for a teacher or paraprofessional for the lesson instruction (McKissick et al., 2017). In summary, CAI can be described as the use of a technology tool to provide instruction on a specific skill or concept.

Additionally, CAI has been described in terms of being an evidence-based practice in education. Pennington (2010) conducted a meta-analysis of 52 studies and found that CAI was an effective intervention when used with students with autism. Root et al. (2017) also conducted a meta-analysis and compared studies with the National Technical Assistance Center on Transition’s (NTACT) (2015) requirements for an evidence-based practice. Root et al. found that when CAI is used to teach academics to students with autism, it met NTACT’s criteria as an evidence-based practice. Therefore, CAI can be considered an evidence-based practice for academic instruction for students with autism.

Furthermore, CAI has been described in terms of its types and uses. CAI can be applied to the school setting in several ways: (a) to support academic learning (Kagohara et al., 2013; Pennington, 2010; Sigafoos et al., 2014), (b) drill and practice, (c) simulation, (d) to evaluate performance (e) to compliment teacher-directed instruction, (f) to reduce challenging behavior (Sigafoos et al., 2014), and (g) enhancing communication and life skills (Fletcher-Watson, 2014; Kagohara et al., 2013). Weng, Maeda, and Bouck (2014) categorized CAI for students with disabilities into the following categories: (a) visual, (b) auditory, (c) mobile, and (d) cognitive skills-based CAI. Additionally, Kagohara et al. (2013) reported the five domains of CAI when used with students with an
intellectual disability and autism as (a) academic, (b) communication, (c) employment, (d) leisure, and (e) transitioning. CAI was found to be an effective instructional method for academic skills with students with autism (McKissick et al., 2017). In summary, CAI is effective for academic, or cognitive skills-based, instruction for students with an intellectual disability and autism which can be applied to the classroom in multiple ways.

Further, one main purpose of CAI is to increase academic skills. Academic, or cognitive skills-based tasks, include “perception, attention, memory, orientation, knowledge presentation, problem solving, and language” (Weng et al., 2014, p. 167). Pennington (2010) found that students with autism usually received CAI that is focused on literacy due to the students’ difficulties with communication. Weng et al. (2014) conducted a meta-analysis of cognitive skills-based CAI and found that CAI increased cognitive skills by using text, pictures, and audio to present the information to be learned by the students. Finally, Weng et al. reported that interactive channels were used in correlation with the multiple modalities to present the lesson. These interactive channels included controlling the pace of learning or how the students engage with the materials (Weng et al., 2014). Through the utilization of CAI students, especially those with autism, benefit from cognitive skills-based instruction that is delivered via multiple modalities and interactive channels.

In summary, CAI has been found to be an effective and evidence-based method of instruction for the improvement of academic skills for students with an intellectual disability and autism. For the purposes of this study, CAI will be defined as the evidence-based practice of using technology tools as a learning medium for cognitive skills-based instruction.
Benefits of using computer-assisted instruction for students with an intellectual disability and autism. There have been many benefits to using CAI for students with an intellectual disability and autism reported in the literature. These benefits include: (a) improving academic achievement, (b) making the general education curriculum accessible, (c) gaining independence, (d) programming lessons easily, and (e) gaining attention and providing motivation.

Improving academic achievement. One of the most common findings of the use of CAI with students with disabilities has been an improvement in academic achievement. This section will explore (a) why academic achievement is improved, (b) general academic achievement findings, (c) academic achievement findings in the area of vocabulary learning, and (d) the promotion of generalization and maintenance.

There have been many reasons reported for why academic achievement is improved using CAI with students with an intellectual disability and autism. The first reason is CAI was found to be less aversive to students with autism because of the lack of social interactions, the greater predictability of student expectations (Sigafoos et al., 2014), the reduction of complex student-teacher interactions (Ramdoss, Mulloy, et al., 2011), and the removal of social anxiety from the expectation of responding (Whitby, Leininger, & Grillo, 2012). Next, the ease of programming allows the teacher to decrease distractions that are present in typical teacher-led instruction and incorporate visually appealing elements into the CAI lesson (Ramdoss, Machalicek, et al., 2012). Ozen, Ergenekon, and Ulke-Kurkcuoglu (2017) found that students with a mild to moderate intellectual disability and Down syndrome were able to focus on the relevant stimuli in the lesson because the teachers were able to reduce distractions via CAI lessons.
Furthermore, Wakeman, Karvonen, and Ahumada (2013) shared how they were able to tier the abstractness of text used in their lessons by incorporating photographs, picture symbols, and line drawings into the CAI lessons. Finally, Whitby et al. (2012) found in their meta-analysis that technology supports the receptive and expressive language and attention difficulties which students with disabilities often experience. CAI promotes academic achievement in students with an intellectual disability and autism because it is less aversive than teacher-led instruction, has reduced distractions, can be programmed to change the abstractness of text, and supports language and attention difficulties.

Furthermore, while research on teaching academic content to students with an intellectual disability and autism is limited (Barnett, Trillo, & More, 2018), there are a few studies that have provided positive findings when using CAI with students with autism and/or an intellectual disability across several academic areas. First, several researchers reported overall findings of increased academic achievement when CAI and/or computer-based tablets were used with students with autism and/or an intellectual disability (Kagohara et al., 2013; McKissick et al., 2017; Rivera, Hudson, Weiss, & Zambone, 2017; Root et al., 2017). More specifically, a systematic review of 11 studies conducted by Ramdoss, Lang, et al. (2012) found that 39 of the 42 participants in the combined studies acquired daily living skills via CAI. In another narrative review conducted by Ramdoss, Lang et al. (2011), the researchers found that all 10 studies reported improvements in the communication skills of students with autism when participating in CAI.

Additionally, Ramdoss, Machalicek, et al. (2012) found that there were correlations between the frequency of CAI and targeted skills and behaviors when CAI
was implemented with students with autism. Ramdoss, Machalicek, et al. continued to explain that CAI “can be as effective as face-to-face instruction” (p. 133). Özgüç and Cavkaytar (2016) found that technology had a positive effect on all 11 sixth grade students with an intellectual disability and their academic achievement and behavior, as well as allowed teachers to discover the students’ true potential that was not observed in teacher-led instruction. Finally, when researching the use of rewards in CAI, Constantin, Johnson, Smith, Lengyel, and Brosnan (2017) found that students with a severe intellectual disability and communication skills were able to participate in the same lessons as their same-age peers. The use of CAI with students with disabilities has been shown to lead to academic achievement in a variety of academic areas, and has even shown teachers skills the students had not yet displayed during teacher-led instruction.

In addition to the general academic achievement, many studies report findings specific to the increase in vocabulary learning using CAI with students with an intellectual disability and autism. Dzulkifli et al. (2016) conducted a meta-analysis and found that while several deficit areas can be addressed via CAI, vocabulary instruction was especially important to remediate deficits in language for students with autism. While Basoz and Cubukcu (2014) studied 52 college freshmen without disabilities, they also found that vocabulary teaching and learning is important subject matter to use in CAI. Yang et al. (2018) conducted a narrative review of 70 studies of using CAI with all academic levels of students and found that using technology in vocabulary lessons allowed students to make text-to-self connections that expedited vocabulary acquisition.

Several studies specific to the use of CAI and students with an intellectual disability and/or autism confirmed the importance of CAI for vocabulary instruction. In a
study conducted by Moore and Calvert (2000), 14 students with autism were taught vocabulary words through CAI or teacher-only instruction, and the students had 74% accuracy of target nouns with the CAI instruction and 41% with the teacher-only instruction. Bosseler and Massaro (2003) found that nine students, ages 7 through 12, with autism were able to improve their vocabulary recall to 85% accuracy up to 30 days after learning vocabulary from an animated talking tutor. Coleman-Martin, Heller, Cihak, and Irvine (2005) found that all three participants with severe speech impairments and a physical disability or autism were able to reach the criterion of 80% for two consecutive sessions in three to 14 sessions in the CAI instruction, and it took longer for the students to learn the vocabulary words in the teacher-only condition. Additionally, Smith, Spooner, Wood (2013) reported a functional relationship in the number of science term assessment items answered correctly in three middle school students with an intellectual disability and autism. McKissick et al. (2018) expanded on the Smith, Spooner, and Wood (2013) study by including instruction in the application of the vocabulary words, as well as the acquisition of the words. They found there was a functional relationship between the CAI instructional package and the increase in the number of correct responses on the assessment (McKissick et al., 2018). The findings in these studies confirm that using CAI with students with an intellectual disability and autism can result in increased accuracy of vocabulary acquisition and application.

Not only do students with an intellectual disability and autism need to learn new academic skills, but they also need to generalize and maintain what they have learned. Generalization is the application of newly acquired information and/or skills to other settings or occurrences (Prizant, Wetherby, Rubin, Laurent, & Rydell, 2006).
Maintenance is when the students can maintain the learned skill in a variety of settings over an extended period of time (Collins, 2012). The use of CAI has been found to promote both generalization and maintenance because it can accommodate for instruction across multiple settings (Coleman-Martin et al., 2005). Positive results in generalization and maintenance after implementing CAI with students with autism and/or an intellectual disability were reported in studies by Mazzotti, Test, Wood, and Richter (2010), McKissick, Spooner, Wood, and Diegelmann (2013), Ozen et al., (2017), Özgüç and Cavkaytar (2016), Riesen, McDonnell, Johnson, Polychronis, and Jameson (2003), and Smith, Spooner, and Wood (2013). Overall, using CAI with students with an intellectual disability and autism can help promote generalization and maintenance of skills learned during CAI lessons.

Making the general education curriculum accessible. Additionally, the use of CAI with students with an intellectual disability and autism has been found to make it easier to adapt the general education curriculum and make it accessible for the students’ special learning needs. Students with an intellectual disability and autism have difficulties with processing information; therefore, they require a series of lessons that fully address one content standard (Wakeman et al., 2013). One of the benefits of using CAI with students with an intellectual disability and autism is that it makes the general education curriculum accessible (McKissick et al., 2013) by providing students access to a series of lessons that allow them to learn new information (Wakeman et al, 2013). Additionally, the flexibility of CAI allows students to work independently and at their own pace on curriculum designed for their unique learning abilities (Fernández-López, Rodríguez-Fórtiz, Rodríguez-Almendros, & Martínez-Segura, 2013; Sigafoos et al., 2014). In summary, the
flexibility of CAI allows teachers to design lessons that address small parts of a larger curriculum standard that students can work through at their own pace, in turn making the general education curriculum accessible.

*Gaining independence.* In addition, the flexibility of CAI programming has been found to be beneficial because it promotes independence in students with disabilities who participate in CAI lessons. Teachers have been able to adjust instruction to meet their students’ unique learning needs using CAI programming (Mazzotti et al., 2010). CAI is provided solely by the technology tool so there is no need for a teacher or paraprofessional to work directly with the student (McKissick et al., 2017), which allows the students to control their learning, have autonomous achievement (Bouck, Savage, Meyer, Taber-Doughty, & Hunley, 2014; Sigafoos et al., 2014), work at their own pace (Saad, Dandashi, Aljaam, & Saleh, 2015; Sigafoos et al., 2014), and build independence skills (Mazzotti, Wood, Test, & Fowler, 2012). CAI is beneficial to students with an intellectual disability and autism because they are able to work independently, without any adult assistance, which is a rare occurrence in their educational program.

*Programming lessons easily.* The ease of programming lessons has been found to be a benefit of using CAI with students with an intellectual disability and autism. Wakeman et al. (2013) found that they were able to present content in an interactive way because they could program for the manipulation of different items within the lesson. Several other studies noted that the teacher can easily customize the CAI lesson to cater to the learners’ strengths and preferences, provide scaffolds, and set the pacing of the lesson (Mize, Park, & Moore, 2018; Ozen et al., 2017; Rivera, Mason, Moser, & Ahlgrim-Delzell, 2014; Sigafoos et al., 2014; Weng et al., 2014). Further, Coleman-
Martin et al. (2005) found that the use of CAI with students with severe speech impairments and/or autism provided a consistency in the presentation of the material and allowed for repetition that is needed for the students to learn targeted vocabulary words. Finally, several studies found that teachers can program personalized, attention-getting features, such as sounds and actions, that elicit the students’ visual attention which is needed to focus on a lesson (Moore & Calvert, 2000; Ramdoss, Machalicek, et al., 2012; Saad et al., 2015). Students with an intellectual disability and autism have unique learning needs that require interaction with the learning materials, individualized lesson planning and pacing, scaffolding of lessons, and repetition of the learning material, all of which can be easily programmed by teachers in CAI lessons.

**Gaining attention and providing motivation.** Furthermore, the use of CAI with students with learning disabilities has been found to gain the attention of the students and motivate them to participate in lessons. The first step in working with students with an intellectual disability and autism is to gain their visual attention (Moore & Calvert, 2000). Whitby et al. (2012) reviewed literature and found that technology devices support difficulties with attention in students with different levels of disabilities. Ramdoss, Mulloy, et al. (2011) found that there was a high responsiveness to the use of computers in their study with students with autism. Likewise, Fernández-López et al. (2013) found that students who received special education services were interested in the attention-getting multimedia contents of CAI.

Once students’ attention is on the task, they must be motivated to work and continue to work through the entire lesson. An advantage of CAI is the motivation of students with speech/ language impairments, autism, and an intellectual disability
(Coleman-Martin et al., 2005; Moore & Calvert, 2000; Ozen et al., 2017; Özőgüş & Cavkaytar, 2016; Pennington, 2010; Zein et al., 2016). Coleman-Martin et al. (2005) studied three students with severe speech impairments and physical impairments and/or autism and concluded that all students found the CAI lessons highly motivating when compared to teacher-only instruction lessons. Moore and Calvert (2000) studied 14 elementary-aged students with autism on their vocabulary acquisition through the use of CAI and reported that students were attentive 97% of time with CAI instruction compared to 57% with teacher-only instruction, and 57% of the students wanted to continue the CAI lesson compared to 0% of students wanting to continue the teacher-only instruction lesson. Similarly, Zein et al. (2016) compared teacher-directed instruction versus Apple® iPad® instruction and found that both reduced task refusal, but the Apple® iPad® instruction trials had fewer occurrences of challenging behaviors in students with autism.

Likewise, Pennington (2010) reviewed 15 studies and found that students with autism displayed more appropriate behavior when CAI was used versus teacher instruction. Özőgüş and Cavkaytar (2016) conducted an action research study with 11 sixth-grade students with a mild intellectual disability who attended a special education middle school and found that all students in the study increased their participation in class with the use of CAI. Finally, Ozen et al. (2017) studied four 5-year-old students with a mild to moderate intellectual disability and Down syndrome and found that CAI provided predictable instruction through prompting and consistent response which might have been the reason the students showed an increase in motivation. In summary, students with an intellectual disability and autism are more likely to improve their attention and are more
motivated to work by the unique components that teachers can program into CAI, than to
teacher-only directed instruction.

**Components of computer-assisted instruction that impact the education of**
**students with disabilities.** CAI has been found to be successful with students with
disabilities because of the components that can be programmed into CAI lessons. Rivera
et al., (2017) found that using multicomponent inventions, such as CAI, resulted in
students with a variety of disabilities to be better prepared for learning. Furthermore,
McKissick et al. (2017) reported that effective CAI should include the components of
systematic instruction as discussed in the first section of this literature review. This part
of the literature review will explain how CAI can enhance the components of systematic
instruction by examining CAI and its (a) controlled and structured environment, (b)
multimodal format, and (c) feedback, and (d) rewards.

**Controlled and structured environment.** One of the features of CAI that makes it
successful for students with an intellectual disability and autism is the controlled and
structured environment it provides for students (Dzulkifli et al., 2016). This controlled
and structured environment has been achieved by a few researchers using Microsoft®
PowerPoint®. Coleman-Martin et al. (2005) used Microsoft® PowerPoint® slides to
introduce and teach the decoding of new words without teacher instruction with three
students with severe speech impairments and physical disabilities and/or autism.
Coleman-Martin et al. reported that the teachers in their study stated that the slides were
as effective or somewhat more effective than teacher instruction of decoding new words.
McKissick et al. (2018) used Microsoft® PowerPoint® to create successful CAI lessons to
teach three students with an intellectual disability and autism science vocabulary.
Additionally, McKissick et al. (2017) provided a do-it-yourself guide to creating successful Microsoft® PowerPoint® lessons. In this guide, McKissick et al. (2017) suggested using the animation features to embed response prompting and to highlight correct options to create errorless instruction. The researchers also suggested including examples and nonexamples as multiple exemplars so that students generalize what was learned (McKissick et al., 2017). In summary, the features of the Microsoft® PowerPoint® software allows teachers to design a controlled and structured environment for students with an intellectual disability and autism to be successful in their learning.

**Multimodal format.** Multimodal formats have been found to be the key element in the success of CAI with students with an intellectual disability and autism. Multimodal formats can be defined as “an electronic means of linking various media in new and different ways in activities that can facilitate fundamental learning and thinking” (Hasselbring & Glaser, 2000, p. 109). Weng et al. (2014) completed a meta-analysis of studies about cognitive-based CAI and found there was a need to present information through multiple modalities. The need for multimodal formats was also true for students with an intellectual disability and autism as they “learn best with methods that engage senses, such as images, sounds, and clips (Saad et al., 2015, p. 366) and it directs their attention to the task (Whitby et al., 2012). In fact, Bosseler and Massaro (2003) found in their study with nine students with autism, ages 7 through 12, that a computer-animated talking tutor was successful in vocabulary acquisition because “seeing and hearing spoken language can better guide language learning than either modality alone” (p. 666). A final benefit of multimodal learning is it allows students who are unable to write to express their knowledge in different formats (Hasselbring & Glaser, 2000). Overall, the
multimodal format of CAI lessons provides students with an intellectual disability and autism with the best methods to engage all of their senses, which, in turn, improves their learning.

Moreover, a large part of the multimodal format are the visual supports. Visual supports have been found to be an evidence-based practice to promote engagement in students with high-functioning autism (Barnett et al., 2018). Visual supports are successful because they address learning and behavioral characteristics associated with autism by highlighting relevant information and removing irrelevant stimuli that could be distracting (Sigafoos et al., 2014). CAI was found to be an effective technique to teach literacy skills because teachers can customize the visual displays for their students’ needs (Ramdoss, Mulloy, et al., 2011).

Additionally, in a review of 13 studies focusing on CAI vocabulary instruction for students with disabilities, Mize et al. (2018) found visual supports should be added to the directions of the CAI lesson and that the supports were more commonly found in content vocabulary word instruction than in sight word instruction. Mize et al. (2018) also reported the positive outcomes for visual support (e.g. images, animations, etc.) with a percentage of nonoverlapping data (PND) of 91.81%. In summary, when using CAI teachers should use visual supports that highlight crucial information along with auditory supports.

Consequently, auditory supports are a crucial support for students with an intellectual disability and autism. Since most students with an intellectual disability and autism are nonreaders, auditory supports are a critical component of CAI (McKissick et al., 2017). Mize et al. (2018) found that the PND metric for auditory supports was
95.72% showing its importance for inclusion in CAI for students with disabilities. A common example of an auditory support in CAI is when the directions are automatically read aloud when the student advanced slides (Dzulkifli et al., 2016).

Furthermore, videos often combine the visual and auditory supports that students with an intellectual disability and autism need to be successful. While images help to promote a deeper learning than words alone (Mayer, 2005), videos better facilitate actions or models of actions (Schebell et al., 2018). McKissick et al. (2018) used free video clips from the Internet in their study with three middle school students with an intellectual disability and autism and found the videos that matched the learners’ preferences positively reinforced the students to continue working. King-Sears et al. (2014) used adapted video clips with six adults with an intellectual disability. They adapted the video clips by altering the narration and providing captions for the videos (King-Sears et al., 2014). King-Sears et al. also shared that the videos paired with captions and interactive features allowed students to create mental models and improve comprehension. Despite the successes with video use, Özgüç and Cavkaytar (2016) warned that they observed inattentiveness and/or behavior problems with sixth grade students with a mild intellectual disability when videos exceeded three minutes. Overall, the use of videos can provide students with an intellectual disability and autism with auditory and visual supports, especially when they are paired with captions and interactive features, that improve behavior, motivation, and comprehension.

Finally, simulations are additional components of CAI that can improve student learning. Simulations can be defined as computational models that “allow users to observe and interact with representations of processed that would otherwise be invisible”
(National Research Council, 2011, p. 9). Israel et al. (2013) shared in their review of science teaching procedures, that students needed to see abstract concepts and by manipulating the components of a simulation, students with disabilities gained conceptual understanding. Mechling, Pridgen, and Cronin (2005) included simulations in CAI for three 17- through 20-year-old students with a moderate to severe intellectual disability and the results indicated that students learned to complete the task of ordering food at fast-food restaurants. Additionally, Mechling, Gast, and Barthold (2003) used simulations to teach three students with a moderate intellectual disability to use a debit card and found that the students were able to complete and generalize the act of using a debit card, only struggling with the actual swiping of the card because it was difficult to simulate in the practice sessions. Overall, simulations can help students with an intellectual disability and autism see abstract concepts and manipulate them to gain an overall understanding of the concept being taught.

**Feedback.** Additionally, feedback should be given to students with an intellectual disability and autism for both correct and incorrect responses. Feedback should be given immediately and should provide reinforcement and error correction for positive results in cognitive skill acquisition in students with an intellectual disability and autism (Sigafoos et al., 2014; Weng et al., 2014). Feedback that is corrective needs to be delivered immediately and focus on what the student needs to do to answer correctly (Whitby et al., 2012). It is also important to ensure that the corrective feedback is informative and not reinforcing so that the students do not answer incorrectly on purpose (Sigafoos et al., 2014). However, feedback for correct answers should always be reinforcing (Sigafoos et al., 2014) and delivered close to the targeted behavior (Whitby et al., 2012). In summary,
feedback that is reinforcing for correct answers and are informative, but not reinforcing for incorrect answers is an important part of CAI for students with an intellectual disability and autism that encourages students to participate by answering correctly.

**Rewards.** Furthermore, several studies have reported students with an intellectual disability and autism enjoy CAI due to embedded extrinsic rewards which are catered to the students’ preferences (Constantin et al, 2017; Humphry 2011 as cited in Constantin et al., 2011; Weng et al., 2014). Humphry (2011 as cited in Constantin et al., 2017) reported that the three students with autism in her study were not motivated by social rewards. Instead, the students demonstrated the highest level of motivation, focus, and accuracy when their favorite type of reward was embedded into the CAI program (Humphry, 2011 as cited in Constantin et al., 2017). Consequently, Constantin et al. (2011) reported that students with autism preferred the ability to choose their embedded reward and found that the nature of the sound, animation, etc. of the reward was important. Overall, students with an intellectual disability and autism have been found to benefit from extrinsic rewards that they prefer or can choose and that are embedded into CAI programs.

**Difficulties implementing computer-assisted instruction for students with an intellectual disability and autism.** There have been very few difficulties or negative aspects reported for using CAI with students with an intellectual disability and autism and a majority of the difficulties lie in the actual development of CAI. Only Sigafoos et al. (2014) contradicted the benefit of affordability and ease of use by stating that CAI can be expensive and difficult to set up. While the actual development may not be difficult, depending on the specific activity being developed, CAI can take a substantial amount of time to create (Coleman-Martin et al., 2005; McKissick et al., 2018). Finally, teachers
need to be ready to use the tools that were developed so that they do not hinder the lesson (Özgüç & Cavkaytar, 2016). In summary, the main difficulties teachers incur when developing CAI are the actual use of the development programs and tools and the time it takes to develop such lessons.

Educational Implications of Active Engagement

This section of the literature review will address (a) how to define active engagement for students with an intellectual disability and autism, (b) descriptions of active engagement in students with an intellectual disability and autism, (c) the impact of CAI on student engagement, and (d) how to assess active engagement in students with an intellectual disability and autism.

Defining Active Engagement for Students with Intellectual Disability and Autism

Engagement in students with and without disabilities has been defined differently and in many ways throughout the years. Engagement for students with an intellectual disability and autism can be very difficult to define because of their challenges with communication, processing skills, cognitive skills, and emotions (Hollingshead, Williamson, & Carnahan, 2018). Engagement is defined differently for students with a severe intellectual disability than for students with a mild intellectual disability to no disability (Hollingshead, Carnahan, Lowrey, & Snyder, 2017), as well as for students with autism (Sparapani et al., 2016). Despite the definition used, engagement should be the facilitator for learning and the overall outcome of the students’ performance should be the measure of engagement (Hollingshead et al., 2017). This section discusses (a) the definition for engagement for general education students and (b) how the definition differs for students with disabilities.
Defining engagement for general education students. The general definition for students’ engagement, or active engagement, has changed over the years. Engagement was measured in early years in terms of the students’ eye contact but was determined an unsatisfactory measure (Bender, 2017; cf. Bender, 1985). The most recent and common definition of engagement is the “student’s cognitive investment in, active participation with, and emotional commitment to learning particular content” (Bender, 2017, p. 2). Several researchers added to this definition by finding that engagement involves components of the emotional, cognitive, and behavioral domains (Dearden, Emerson, Lewis, & Papp, 2017; Fredricks, Blumenfeld, & Paris, 2004; Hollingshead et al., 2017). Overall, a clear definition of engagement has been developed for students in general education.

Defining engagement for students with disabilities. The research on engagement for students with disabilities varies greatly in terms of what engagement encompasses. Several studies have found that definitions of engagement for students with disabilities often refer only to behavioral domains, such as on-task behaviors (Hollingshead et al., 2017; Hollingshead et al., 2018; Sparapani et al., 2016), participation, or the duration of attention (Hollingshead et al., 2017; Hollingshead et al., 2018). An example definition of active engagement for students with an intellectual disability is “interacting with the learning environment appropriately by manipulating materials or vocalizing. The child does not demonstrate repetitive and/or inappropriate behaviors” (Kishida & Kemp, 2006, p.113). However, these definitions did not account for all engagement domains and/or deficit areas of students with an intellectual disability and autism (Steinbrenner & Watson, 2015; Hollingshead 2018; Sparapani et al., 2016).
In contrast, some studies have called for additional domains to be added to the behavioral characteristics of engagement. Steinbrenner and Watson (2015) called for the inclusion of joint engagement, or “the ability to interact with materials and people simultaneously” (p. 2393) to be included in definitions of engagement for students with autism because the students had higher expressive communication assessment scores when they had high levels of joint engagement. Hollingshead et al. (2018) found cognitive engagement (e.g., academic responding, choice making, body language, etc.) and emotional engagement (e.g., self-determination, self-regulation, affect, etc.) were important elements to address for engagement in students with a severe intellectual disability.

Further, a seminal study conducted by Ruble and Robson (2007) called for the importance of a definition of active engagement for students with more significant disabilities. In this study, Ruble and Robson examined four boys with autism and four boys with Down syndrome, ages 6 through 10, to determine the characteristics of engagement. Ruble and Robson’s first finding was that there are three reasons a meaningful and measurable definition of engagement is important. The first reason is interventions and services for students with disabilities can be advanced once a true understanding of engagement is developed (Ruble & Rubson, 2007). Second, when researchers can understand the influences on engagement, they can identify the outcomes that are influenced by environmental and child-specific factors (Ruble & Rubson, 2007). Third, once an understanding of engagement is developed, researchers can identify evidence-based practices for specific disabilities (Ruble & Rubson, 2007). Additionally, the main finding by Ruble and Robson was the child’s internal factors and “external
environmental factors influenced the type of engagement. This finding suggests engagement is a state construct, influenced by external events, but also mediated by trait or internal factors” (p. 1463). Finally, because engagement is a state construct, it was found to be influenced by variables such as a student’s disability diagnosis (Ruble & Robson, 2007). In summary, an accurate definition of active engagement is crucial for students with disabilities, so they receive the services to support engagement according to the students’ specific learning requirements.

Furthermore, Sparapani et al. (2016) expanded on Ruble and Robson’s (2007) study by developing a definition specific to students with autism. These researchers examined literature and studied 196 kindergarten through second-grade students with autism (57% high-functioning autism) to discover the challenges in engagement for students with autism, and to create a tool to measure engagement in terms of those deficits (Sparapani et al., 2016). Sparapani et al. found that there were five factors that influenced active engagement in students with autism, which included (1) emotional regulation, (2) classroom participation, (3) social connectedness, (4) initiating communication, and (5) flexibility. For the purposes of this study, active engagement for students with autism will be defined, based on Sparapani et al.’s (2016) conceptualization of active engagement, as the student’s ability to participate in class activities in a well-regulated state while also demonstrating social connectedness, communication, and flexibility.
Description of Active Engagement in Students with Intellectual Disability and Autism

Students with an intellectual disability and autism have been noted to have low engagement in their educational environment. Moreira et al. (2015) studied 388 students with \( n = 150 \) and without \( n = 238 \) special needs to define the dimension of engagement and found that students with an intellectual disability and developmental disability had low levels of global school engagement. Further, Ruble and Robson (2007) studied four boys with autism and four boys with Down syndrome and found that students with autism are able to appear to be displaying behaviors as their general education peers; however, the students with autism are not actually engaged with sustained attention in the activity. Additionally, Sparapani et al. (2016) determined that students with autism demonstrated “limited overall active engagement in classroom activities” (p. 790). Sparapani et al. reported the low engagement of students with autism in terms of the five factors of engagement: (a) less than 50% of students with autism were in a well-regulated state, (b) less than 50% were productively and independently participating, (c) approximately 50% were engaged in responses to verbal bids for interaction, (d) students infrequently directed communication and rarely used generative language, and (e) approximately 75% of students were flexible with changes in materials and approximately 50% were flexible in the shift of attentional focus. These findings demonstrate the need for instruction that is tailored toward students’ weaknesses and needs in the area of active engagement.
Impact of Computer-Assisted Instruction on Student Engagement

The use of CAI has been shown to improve active engagement in students with an intellectual disability and autism. Moore and Calvert (2000) studied 14 children with autism, ages 3 through 6, and found that 97% of the students attended to instruction in the CAI condition compared to 62% in the teacher-only instruction condition. They also found that 57% of the students wanted to continue the CAI lesson compared to 0% who wanted to continue the teacher-only instruction lesson (Moore & Calvert, 2000). Stasolla et al. (2016) found that students with an intellectual disability and autism ages 8 through 10 increased on-task behavior, independence, self-determination, and participation, while preventing “withdrawal, isolation, passivity, and repetitive behaviors” (p. 172) when CAI was delivered via a computer-based tablet. Additionally, Chen, Wang, Zhang, Wang, and Liu (2019) studied 40 children with autism and 51 typically developing children, ages 2 to 6. They found that the children with autism did not perform as well as the typically developing children, but the computerized game successfully taught the students with autism new skills (Chen et al., 2019). These studies demonstrated that students with an intellectual disability and autism can benefit from CAI due to increased attention, willingness to participate, ability to learn new skills, and decreased negative behaviors.

Furthermore, CAI has been shown to improve active engagement because negative behaviors are less prevalent when students with an intellectual disability and autism are exposed to CAI due to the removal of aversive elements. One of the most aversive elements for students with autism is social interactions with other people, which are removed using CAI (Chen et al., 2019). Stasolla et al. (2016) found that students with severe autism and a mild intellectual disability engaged in significantly less stereotypic
behavior, such as repetitive behaviors (e.g., rocking, noise making, arm flapping).

Additionally, Neely, Rispoli, Camargo, Davis, and Boles (2013) found that two students with autism and challenging behaviors had decreased behaviors and higher levels of engagement when a tablet was used versus traditional materials. Neely et al. continued to explain that these results could be due to a possible aversiveness to traditional learning materials, a preference for technology, and the possibility that tablets were previously used as reinforcers. In addition, Bock and Erickson (2015) found that students with moderate to severe disabilities, ages 8 to 21, benefited from student-centered teaching and displayed high levels of engagement when teachers released control over communication. Steinbrenner and Watson (2015) confirmed Bock and Erickson’s finding and added that elementary and middle school students with autism had lower engagement with larger groups with an average of 8% engagement in large groups, 23% in small groups, and 42% with one-to-one instruction. Overall, these findings show that students with an intellectual disability and autism benefit from CAI because it removes elements of instruction that are aversive to the students and provides student-centered and individualized instruction to promote active engagement.

Finally, researchers have provided many recommendations to ensure CAI positively affects the engagement of students with an intellectual disability and autism. First, teachers need to supply well-planned activities that can be easily modified and include systematic teacher intervention (Kishida & Kemp, 2006). Teachers also need to ensure that stimuli are actively presented for longer periods of time to increase the alertness of students (Ten Brug, Munde, Van der Putten, & Vlaskamp, 2015). Additional recommendations are to allow for choice making and academic responding (Hollingshead
et al., 2018) and to use verbal and auditory cues together to enrich participation in students with an intellectual disability and autism (Stasolla et al., 2016). Finally, Dearden et al. (2017) studied a 10-year-old girl with autism and severe communication impairment and found she benefited from enticement, reinforcement, interesting and challenging activities, and modeling of the correct engagement behavior. In summary, teachers need to plan CAI that includes stimuli that supports the active engagement needs of students with an intellectual disability and autism.

**Difficulties with Computer Assisted Instruction and Students with Intellectual Disability and Autism**

Researchers have addressed difficulties that can occur specifically with students with autism. First, students with autism can choose to opt out of social interactions when using CAI, which can lead to a restriction on the students’ social development (Moore & Calvert, 2000). However, this difficulty can be avoided if the teacher has a dialogue with the student while engaging in CAI (Ramdoss, Mulloy, et al., 2011). Ramdoss, Mulloy, et al. (2011) added to this difficulty by stating that the students in their study had few opportunities for practice communication, social skills, joint attention, and eye contact. Additional difficulties in instruction can occur if the feedback given is not appropriate (Humphry as cited in Constantin, et al., 2017; Sigafoos, et al., 2014). For example, some students with autism are only motivated to continue using technology when they can choose their own reward (Humphry as cited in Constantin et al., 2017). CAI designers need to be sure that the feedback provided for incorrect answers is not reinforcing (Sigafoos et al., 2014); in other words, the designer needs to ensure the students do not choose the incorrect answer to engage with the feedback given. These negative aspects of
using CAI with students with an intellectual disability and autism should be considered by teachers when they design and use CAI so that there are not negative effects on the students’ achievement.

Assessing Engagement in Students with Intellectual Disability and Autism

Literature involving the assessment of active engagement in students with an intellectual disability and autism is sparse. Bender (2017) explained that “engagement is very hard to measure in an academic setting” (p. 3) for all students. Several researchers used engagement measures such as the Student Engagement Instrument (Appleton & Christenson, 2004), which measured cognitive and psychological engagement (Appleton, Christenson, Kim, & Reschly, 2006); the Behavioral Observation of Students in Schools (Shapiro, 2003), which measured on-task behavior (Sparapani et al., 2016); and chronologs that gave behavioral descriptions of engagement (Ruble & Robson, 2007). However, none of these measures accounted for the deficit areas related to autism that are required for accurately describing active engagement in students with an intellectual disability and autism (Sparapani et al., 2016). Sparapani et al. (2016) answered the need for a tool that measures the deficit areas in active engagement for students with autism with the creation of the Classroom Measure of Active Engagement (CMAE). Sparapani et al. used a five-factor model to address nine variables that are “core learning challenges for students with [autism]: emotional regulation, productivity, independence, responding, eye gaze, directed communication, generative language, flexible behavior, and flexible attention” (p. 787). Overall, the CMAE is the most appropriate measure for active engagement in students with an intellectual disability and autism because it accounts for the challenges that students with autism encounter (Sparapani et al., 2016).
Chapter Summary

In order to evaluate the implementation of CSVM, it is imperative to understand the theoretical underpinnings of vocabulary instruction, science vocabulary instruction for students with an intellectual disability and autism, CAI in special education, and active engagement in students with an intellectual disability and autism. First, the theoretical underpinnings of vocabulary instruction can assist teachers in developing strong lessons that meet their specific learning needs (Moody et al., 2018). Schema theory and psycholinguistic theories, which are constructivist, explain that comprehension is based on prior knowledge/schemata and components of language (Anderson, 2013; McVee et al., 2005; Unrau & Alvermann, 2013; Yang et al., 2018). A promising theory to use for students with an intellectual disability and autism is dual coding theory because it involves the use of nonverbal information as well as verbal information (Paivio, 2014; Sadoski et al., 1991; McVee et al., 2005; Unrau & Alvermann, 2013). Students with an intellectual disability and autism often respond well to the use of images, sounds, etc. that allow them to use dual processes to code the information they are learning. A final theory to use to plan instruction is Gagné’s nine events of instruction which provides a set of procedures to organize lessons (Gagné & Briggs, 1974; Zhu & St. Amant, 2010).

Explicit instruction of science vocabulary is vital for students’ overall science literacy (Wannarka, 2013). Science vocabulary terms are considered tier three words (Beck et al., 2013) and require explicit instruction, which is an evidence-based practice of special education vocabulary instruction (Baumann & Graves, 2010). Explicit instruction is a direct teaching method using systematic and scaffolded instruction (Archer &
Hughes, 2011; Hughes et al., 2017; Kendorski & Fisher, 2018). There is a total of 16 elements and six teaching functions of explicit instruction (Archer & Hughes, 2011). Explicit instruction strategies include keyword mnemonic strategy and graphic organizers. Specific graphic organizers which are effective with students with an intellectual disability and autism include cognitive/word mapping, Frayer models, and t-charts. Vocabulary instruction can be assessed through formative assessments such as curriculum-based measures and teacher-created assessments.

CAI is beneficial to the education of students with an intellectual disability and autism because the teacher can customize learning to the specific needs of the students (Wakeman et al., 2013; Weng et al., 2014). The multimodal focus of CAI lends itself well to vocabulary instruction and allows students with an intellectual disability and autism to receive visual representations that they need to be successful in learning new words (Hasselbring & Glaser, 2000; Saad et al., 2015; Weng, 2014). Difficulties associated with CAI may include the time to create, teacher knowledge of the technology tools, the lack of social interaction for students with autism, and the inappropriate use of feedback (Coleman-Martin et al., 2005; McKissick et al., 2018; Özguç & Cavkaytar, 2016). Overall, the benefits to CAI instruction with students with an intellectual disability and autism for vocabulary acquisition far outweigh any negative aspects.

A final area of importance in instruction of students with an intellectual disability autism is active engagement. The definition of active engagement for students with autism is based on the five factors of active engagement which include emotional regulation, class participation, social connectedness, initiating communication, and flexibility (Sparapani et al, 2016). CAI has been shown to have a positive influence on
active engagement (Chen et al., 2019; Steinbrenner & Watson, 2015; Moore & Calvert, 2000; Neely et al., 2013; Stasolla et al., 2016). Active engagement of students with an intellectual disability and autism can be assessed using the CMAE (Sparapani et al., 2016).
CHAPTER 3
METHOD

Because I needed to solve why my students at South Center School (SCS) were struggling with accessing and retaining science content, I used action research. Action research was used to solve educational problems (Creswell, 2012). Action research also required working with other members of the school community “to develop a deep understanding of a problem, implement an appropriate action, systematically investigate the effects of that action, and decide on next steps” (Buss & Zambo, 2014, p. 4). The purpose of this action research was to evaluate the implementation of computer-assisted science vocabulary modules with students with an intellectual disability and autism in an adapted environmental science class on their acquisition and application of vocabulary words and their active engagement in the modules. The research questions for my study were:

RQ1. How does the implementation of computer-assisted vocabulary modules, which adhere to evidenced-based practices of special education vocabulary instruction, affect the acquisition and application of science vocabulary terms with students with an intellectual disability and autism in an adapted environmental science class?

RQ2. How are the students with an intellectual disability and autism engaged in computer-assisted instruction activities?
Research Design

Action research was most appropriate for my study because I needed to work with the parents of my students, administrators, other special education teachers, and paraprofessionals in order to properly implement my study. Action research is defined as systematic inquiry procedures carried out by teachers or other school personnel to collect data about teaching and learning in their specific environment and using that data to make improvements at the local level (Creswell, 2012; Lodico et al., 2010; Merriam, 2009; Mertler, 2017; Patton, 2002). The specific benefits of action research to my study were numerous.

The first benefit of action research to my study was that action research focused on a small-scale action at the local level (Creswell, 2012; Lodico et al., 2010; Patton, 2002). This aspect was important to this study because I was studying a very select group of students who were served in a separate school special education setting, or a school for only students with severe disabilities, and who have unique learning and medical needs. I was the best person for understanding my students’ needs and they felt comfortable with me, so I needed to be active in the implementation phase. Next, action research required immediate and continual action to solve specific educational problems (Creswell, 2012; Lodico et al., 2010; Patton, 2002). Due to the unique and intensive needs of my students, I needed immediate results that would quickly improve how they accessed content and participated in class. Finally, action research was very appropriate because I needed to take additional steps after I studied the effects of the CSVM implemented with my students. I found that I would need to develop a new intervention if the CSVM did not work, or I would need to share the modules with the other special education teachers if
they did show positive results. Overall, action research allowed me to work toward a practical solution on a very specific problem in my classroom and school district (Lodico et al., 2010).

When compared to other types of research such as basic research, applied research, summative evaluation, and formative evaluation, action research differed greatly. The main differences were that action research was action oriented, followed a cyclical pattern, and was collaborative in nature (Buss & Zambo, 2014; Hatch, 2002; Rudestam & Newton, 2007). Action research also focused on problems within organizations or the local community instead of the larger, global society (Lodico et al., 2010; Patton, 2002). Another major difference in research types was found in the desired results of the study because action research aimed to solve problems with immediate action, whereas other types of research were adding to a theory, generalizing possible interventions, or making recommendations for improvements (Patton, 2002).

The research design used in my study was a mixed methods design, meaning both quantitative and qualitative methods were used (Creswell & Plano Clark, 2018; Rudestam & Newton, 2007). There were seven primary dimensions to consider when using a mixed methods design: (1) purpose, (2) theoretical drive, (3) timing, (4) point of integration, (5) typological versus interactive design approach, (6) planned versus emergent design, and (7) complexity (Schoonenboom & Johnson, 2017). First, the purpose of using mixed methods research was that it would help to answer my research questions (Schoonenboom & Johnson, 2017) because my questions required both quantitative and qualitative data. Mixed methods design also provided a “breadth and depth of understanding and corroboration” (Schoonenboom & Johnson, 2017, p. 108). Second,
mixed methods was an appropriate design for my study because it aligned with the pragmatic worldview that stated that any kind of data is good data (Lodico et al., 2010), research methods could be mixed (Schoonenboom & Johnson, 2017), and mixed methods were required because of the number of choices that needed to be made in my study (Morgan, 2014). The timing that was used in my mixed methods study was concurrent but independent, meaning both qualitative and quantitative data were collected together, but the data did not depend on one another for further data collection (Rudestam & Newton, 2007; Schoonenboom & Johnson, 2017). A typological approach, specifically the convergent design, was implemented (Schoonenboom & Johnson, 2017). The design was planned or fixed, which meant the methods were determined before the data collection began and followed through with as planned throughout the study; however, if it was determined that more data was needed it would have been collected (Creswell & Plano Clark, 2018; Schoonenboom & Johnson, 2017). Finally, the design was complex because the data were merged at multiple points (Schoonenboom & Johnson, 2017), including merging the quantitative and qualitative data for each student individually and then merging that data for all three students.

The specific mixed methods design that was used was the convergent parallel mixed methods design. The convergent parallel mixed methods design gave equal emphasis to the qualitative and quantitative data, which was collected at the same time, analyzed separately, and then converged (Creswell, 2012; Creswell & Plano Clark, 2018; Mertler, 2017). The results were converged to formulate a deep understanding of how the CSVM impacted my students (Creswell & Plano Clark, 2018; Mertler, 2017). The convergent parallel mixed methods design was appropriate for my study because I was
able to combine the quantitative scores from the formative assessment, pre- and posttest, and quantitative portions of the CMAE with the qualitative description of the students’ engagement in the CSVM (Schoonenboom & Johnson, 2017). To complete the convergent parallel mixed methods design, I collected quantitative and qualitative data at the same time, analyzed the data separately, merged the results and made a joint display table, and combined and interpreted the data (Creswell & Plano Clark, 2018).

Setting

My class was called adapted environmental science and was a related arts class, meaning the students attended once for 45 minutes each week. My classroom was a very large, warehouse-like room (see Figure 3.1 for photos) and housed our classroom pets which consist of a rabbit, guinea pig, bearded dragon, two cockatiels, two Russian tortoises, two fire belly toads, and fish, as well as planting stations and grow lights. I also had a greenhouse and several garden beds just outside of my classroom. During the 2018-2019 school year, SCS opened an ADA compliant nature trail which I often utilized for outdoor class lessons. In this section, the (a) types of classes, (b) type of instruction, (c) description of curriculum, and (d) use of technology is described.

Types of Classes

Each class I taught had very different dynamics, but the classes could be grouped into three general areas. The first type of class was made up of students with severe health needs and/or profound intellectual disability who required the most assistance. Students in these rooms were typically wheelchair users, required significant health care (e.g. tube feeds, ventilation machines, rescue medications for seizures, etc.), and had nurses on staff in
their classrooms. There were four classes that fell into this area. The students in these four classrooms required significant modifications and accommodations made to the general education curriculum. These students required full adult assistance to access the curriculum.

Figure 3.1. Photographs of my classroom and outside greenhouse and garden area.
The second type of class was considered a behavior class. These classes had students with a moderate to severe intellectual disability as well as some type of challenging behavior (e.g. severe autism, aggressive behaviors, self-abusive behaviors, etc.). Many of the students in these classes had behavior intervention plans that had to be implemented by every teacher. There were seven classes in this area. While these students needed significant modifications and accommodations to the grade level standards, they were more able to partially or fully participate in the modified lessons with limited adult assistance when compared to the other types of classes.

The third type of class was made up of students with a more severe intellectual disability who have orthopedic impairments (i.e. they may use wheelchairs, walkers, walk with assistance, etc.), but their intellectual, physical, and/or health disabilities or impairments were not as severe as the first group of students, and they did not have impeding behaviors as did the second group of students. There were five classes in this area. The students in that group usually needed more adult assistance to participate in the modified lessons.

**Type of Instruction**

Most of the instruction during the 2018-2019 school year was whole group instruction. A typical class session included welcoming the students, introducing the topic of the day, presenting a brief video, song, or book; completing the daily science notebook task, answering questions about the lesson as a whole group, completing the assessment individually (typically answering a question about the topic of the day out of a choice of three), and then practicing animal care or planting seeds. When completing the daily task, the students were seated around a U-shaped table and I was seated on a
rolling stool so that I could easily move to each student. The paraprofessionals who
attended with the students sat within or slightly behind the students who required the
most attention. The students participated to their fullest ability which could range from
hand-over-hand assistance (most restrictive) to assisted work with prompting to
independent work with prompting (least restrictive). When the students were required to
answer questions, they would answer by hand-over-hand assistance to touch the correct
answer (most restrictive) to choosing a tactile symbol or real item to choosing a picture
symbol or photo representation to using a speech device or speech to state the answer
(least restrictive). The students were typically given a choice of two or three answer
choices, depending on their specific needs. Students in one class did not answer the same
way so all items needed to be prepared and organized before each class.

My class often involved hands-on activities with our classroom pets and
gardening. Both activities involved step-by-step procedures, so picture symbol task
analyses/schedules were used to help the students know what they needed to do. The
students learned how to care for each of our pets. The students assisted with cleaning out
the habitats, feeding the animals, and learning how to use gentle touching to pet the
animals. It was noted that grade-appropriate vocabulary was used (e.g., *animal home* for
the younger students, *animal habitat* for the older students). The students participated in
gardening activities by filling pots with soil, sowing seeds repotting plants, and watering
plants. I obtained many adapted gardening tools through grants so that almost every
student could physically use a shovel. The few students who were not able to use a shovel
used a measuring cup that was set to a switch. The student pressed on the switch to make
the measuring cup turn which dumped the soil into the pot. The students sowed seeds by
pushing them off an adult’s hands or by shaking a saltshaker of small seeds over the pot. Many plants were repotted with the assistance of students pulling the plant and placing it into a larger pot and covering it with soil. Finally, the students watered plants using squirt bottles, watering cans, and different attachments to the hose which they could manipulate.

The 2018-2019 school year, was my first year in the adapted environmental science teacher position, and since I had a better understanding of my position, I changed the overall format of my lessons for the 2019-2020 school year into small group stations so that one adult worked with one or two students at a time on a different task. These stations included an animal care station, a gardening activity station, and a specific lesson of the week that was completed with me. These stations allowed the students to receive more adult attention while being more active during the class period. The stations also allowed the students to get more practice with the class pets and gardening activities.

Description of Curriculum

I did have a specific curriculum that I was required to teach because I was the only adapted environmental science teacher in the district. I always addressed our state standards and typically pulled from the life or Earth science standards across kindergarten through 12th grade. I occasionally used the Attainment curriculum (Attainment Company, 2018) that our school had obtained, but I typically designed my own activities. During the 2018-2019 school year, I was required to include reading, math, and social studies lessons at least once per quarter; however, this requirement was removed during the 2019-2020 school year. During the 2019-2020 school year, I tiered my lessons into two overall levels and assigned a tier to each class (see Figure 3.2 for an example of the
weekly lesson plans). As my class was considered a related arts class, it was supplemental for the students, and they did not make up any work that they missed due to absences or school events. The only data I typically recorded on the students was for our student learning outcome goals. This data was collected three times a year on one elementary, one middle, and one high school level class (in 2018-2019) and one high school class (in 2019-2020). Even though the curriculum was mandated, it was important for the students to learn important life skills, personal management skills, and academic skills that were aligned with the topics in my class.

![In-Person Lesson](image)

**Learning Target:** The students will use their five senses (touch) and tools to learn about objects’ properties by participating in a variety of investigations involving hearing and then show what they know by identifying things they can feel.

**Vocabulary:** touch, skin, hands, feel, like, yes/no

**Procedures:**
1. Review the senses of hearing, taste, smell, and sight. Introduce the sense of touch.
2. Listen to "I can feel" read aloud (linked to PDF).
3. Explore different textures using their sense of touch.
4. The students will choose one of my sound books to listen to.
5. Read the Wonder Wally story for the week and then complete the workbook pages. Poole and Kennedy’s class will glue pictures of things that feel hard/soft, bumpy/rough/smooth.

**Assessment:** Older elementary: completion of Attainment questions in the workbook. Younger elementary/pk: identify photos of items that are hard/soft and bumpy/rough/smooth.

**In-Person Lesson**

**Standards:** Linked

**Learning Target:** The students will identify that items can be recycled SCI.6-8.MG 39 by listening to resources (books, videos, songs) about recycling and then show what they know by sorting recyclable items.

**Vocabulary:** recycle, reuse, work

**Procedures:**
1. Use books, videos, and songs about recycling (see virtual PDF) to instruct students about recycling.
2. Demonstrate how to sort aluminum, paper, and plastic into the three recycling bags. Allow students a turn to practice.
3. Complete the attainment workbook page about recycling.

**Assessment:** TO of students sorting recycling as independently as possible.

Figure 3.2. Example of lesson plans for one week.
Use of Technology

I used a variety of technology in my class on a daily basis. Much of the technology I used was *low-tech*; however, I had a few *high-tech* devices. Low-tech devices are usually inexpensive and “do not have complex or mechanical features” (Georgia Tech, 2019, para. 1). In contrast, high-tech devices are complex, “have digital or electronic components, [and] may be computerized” (Georgia Tech, 2019, para. 3). In my class, I used technology (a) for communication, (b) for physical assistance, and (c) for instruction.

**Technology for communication.** Technology was mostly used as a means for my students to communicate. This technology ranged from low-tech items such as picture symbols, tactile symbols, and paper grids to speech buttons called BIGmacks (AbleNet, 2020) to high-tech devices like speech generating devices (see Figure 3.3 for an example of these speech devices). I had one Apple® iPad® that I used in my class. The most common use of the Apple® iPad® was to use the Doceri app (SP Controls, 2018) which projected what was on my computer. With the Doceri app (SP Controls, 2018), I was able to allow the students to manipulate what was on my computer without them touching my computer. The Doceri app (SP Controls, 2018) was beneficial because I could enlarge one specific area of the screen (i.e. create errorless instruction by filling the whole Apple® iPad® screen with the correct answer) and hold the Apple® iPad® in any position for the students to properly view.

**Technology for physical assistance.** The main low-tech devices we used for physical assistance were adapted tools for gardening activities. I had shovels, trowels, rakes, etc. that had long and short handles, as well as the capability to add an arm brace
(see Figure 3.3). I also often made manipulatives for the students to use, such as large cardboard dice to play a game. Higher-tech items included the measuring cup on a switch for filling pots with soil (see Figure 3.3). Once I knew my students’ needs better, I started making more devices that could be activated by switches to assist the students in physical activities.

Figure 3.3. Low-tech tools and communication devices regularly used in the classroom.

**Technology for instruction.** I used a variety of low-tech tools and devices in my classes. I created large, tactile models of what the students were learning about (see Figure 3.4). These models were created with different textures to meet sensory needs and to provide a way for students with visual impairments and/or blindness to interact and better participate in class. Other items included interactive books where the students placed a matching picture in the book to promote engagement, picture symbols, and task analysis schedules (e.g., how to feed the guinea pig).
I did not use high-tech devices in instruction as much as I would have liked during the 2018-2019 school year due to getting to know the students and I did not have access to a Promethean® board until January. Once I received the Promethean® board, I was able to better implement high-tech activities. I created interactive flipcharts that required the students to click on answers, drag items to sort them, etc. I usually taught through exposure to nature and real-life items but implemented technology as much as possible. One way I found to incorporate both technology and outdoor education was to use apps like GooseChase (2019) to create scavenger hunts for items in nature. I was able to embed academic skills in the scavenger hunts (e.g., find something red, find two leaves, find an animal that lives in trees, etc.). Overall, I incorporated technology as much as possible, but I tried to maintain a balance of hands-on activities that involved the senses and technology use.

Figure 3.4. Examples of tactile models used in classroom lessons.
Participants

The criteria for inclusion in this study are that the student must

- be a South Center School (SCS) student,
- attend my adapted environmental science class,
- be in at least sixth grade,
- and have a primary disability categorization of a moderate intellectual disability and autism, and a secondary categorization of a speech or language impairment.

Students had to be in at least the sixth grade because that is when photosynthesis was first addressed in SC standards. Students with qualifications in any other primary category than moderate intellectual disability and autism, and a secondary categorization of a speech or language impairment were excluded so that the participants had similar educational needs.

Of the 117 students in my adapted environmental science class, 97 SCS students were considered as possible participants. Twenty students were eliminated because they were from our neighboring school and an additional 26 SCS students did not attend my class because they were homebound students or missed my class due to an abbreviated schedule. First, I reviewed the students’ eligibility to find students who had classifications of only autism, a moderate intellectual disability, and speech/language impairment. Next, I eliminated any students who were in grades kindergarten to fifth grade. This elimination process resulted in four participants being selected for the study. One of the four participants was placed on homebound instruction early in the 2019-2020 school year, so this student was eliminated from the study and three students remained.
Consent for participation in this research study was obtained by all participants’ parents (see Appendix A), and the consent form detailed that the participants would be videotaped during the research process. While assent is typically appropriate for students ages 12 and under (Office of Research Compliance [ORC], n.d.), because of the severity of the participants’ intellectual disability, only parental consent was obtained.

**Innovation**

The innovation in this study was CSVM that were teacher created. Vocabulary terms were targeted in the modules because several researchers have found that learning science vocabulary has helped to close the gap in science instruction and increase the students’ participation in inquiry-based activities for students with learning disabilities (Browder et al., 2012; Jimenez, Browder, Spooner, & Dibiase, 2012; Kennedy & Ihle, 2012; Kennedy et al., 2017). CAI modules, including interactive portions, were used because students with disabilities are able to better access science curriculum through repetitive games integrated in the curriculum due to controlled feedback (Marino et al., 2014; Marino et al., 2013; National Research Council, 2011).

The specific topic addressed in the innovation was photosynthesis. The main ideas that were explored in the CSVM were: (1) plants perform photosynthesis, (2) plants make food out of sunlight, CO₂, and water/H₂O, (3) plants need sunlight to make food and grow, and (4) photosynthesis is a chemical reaction (Bastain, 2018). This section addresses the (a) theoretical influences, (b) description of the CSVM, and (c) stages of implementation.
Theoretical Influences

Several theoretical influences informed the development of the CSVM. These theories included (a) schema and psycholinguistic theories, (b) dual coding theory, and (c) Gagne’s nine events of instruction. See Table 3.1 for a summary of the theory and how it was integrated into the CSVM.

Table 3.1. *Theories and Influenced Elements of the Computerized Science Vocabulary Modules*

<table>
<thead>
<tr>
<th>Theory</th>
<th>Influenced Elements of the CSVM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schema Theory</td>
<td>• Graphic organizers</td>
</tr>
<tr>
<td></td>
<td>• Use of examples and nonexamples</td>
</tr>
<tr>
<td>Psycholinguistic Theory</td>
<td>• Providing definition of terms</td>
</tr>
<tr>
<td>Dual Coding Theory</td>
<td>• Use of imagery</td>
</tr>
<tr>
<td></td>
<td>• Use of videos</td>
</tr>
<tr>
<td></td>
<td>• Use of songs</td>
</tr>
<tr>
<td></td>
<td>• Use of simulations</td>
</tr>
<tr>
<td></td>
<td>• Use of mnemonics</td>
</tr>
<tr>
<td>Gagne’s Nine Events of Instruction (Gagne &amp; Briggs, 1916, p. 123)</td>
<td>• Order of elements presented</td>
</tr>
<tr>
<td></td>
<td>1. Gaining attention</td>
</tr>
<tr>
<td></td>
<td>2. Informing the learner of objective</td>
</tr>
<tr>
<td></td>
<td>3. Stimulating recall of prerequisite learnings</td>
</tr>
<tr>
<td></td>
<td>4. Presenting the stimulus material</td>
</tr>
<tr>
<td></td>
<td>5. Providing learning guidance</td>
</tr>
<tr>
<td></td>
<td>6. Eliciting the performance</td>
</tr>
<tr>
<td></td>
<td>7. Providing feedback about performance correctness</td>
</tr>
<tr>
<td></td>
<td>8. Assessing the performance</td>
</tr>
<tr>
<td></td>
<td>9. Enhancing retention and transfer</td>
</tr>
<tr>
<td></td>
<td>• Types of elements presented</td>
</tr>
<tr>
<td></td>
<td>Feedback &amp; error correction</td>
</tr>
<tr>
<td></td>
<td>Formative &amp; summative assessment</td>
</tr>
<tr>
<td></td>
<td>Attention getters</td>
</tr>
</tbody>
</table>
The use of graphic organizers (Dye, 2000) and examples and nonexamples in the Frayer model (Sheridan, 1981) were influenced by schema theory, while the psycholinguistic theory influenced activities that promoted semantic learning (Sheridan, 1981; Unrau & Alvermann, 2013). The use of graphic organizers and examples and nonexamples were included to help the participants organize the information they were learning, activate prior knowledge, and go beyond just memorizing definitions (Dye, 2000; Sheridan, 1981).

Dual coding theorists posited that imagery was needed along with verbal and nonverbal information to remember the information presented (Paivio, 2014; Sadoski et al., 1991; Unrau & Alvermann, 2013). Multimodal methods were consistently used in the CSVM because, according to dual coding theory, they decreased the chance of cognitive overload (Sadoski & Paivio, 2013). Also, simulations were used to help students experience interactions in the world which led to better connections with vocabulary terms and their meanings (Wright et al., 2015).

The overall sequencing of events in the CSVM were based on Gagne’s nine events of instruction. The first event, gaining attention, was established by using an attention getting sound or visual to bring the students’ attention to the task. Specifically, a picture symbol showing look and listen and my voice stating, “It’s time to look and listen,” was used. Next, the participants were informed of the daily objective through a statement of the targeted term and its definition. The third event, stimulating recall of prerequisite knowledge, was completed by including a slide that reminds the student of any previously learned science content that applies to the current term. A picture symbol of review was also used to signal the students that this information was learned in the
previous module. Learner guidance was provided through the use of special education strategies, specifically explicit instruction. The sixth event, eliciting the performance, was conducted via the interactive sections of the CSVM when the students were tasked with showing what they had learned. Next, feedback was provided by using an applause sound for correct answers and error correction procedures for incorrect answers. The eighth event, assessing performance, was conducted through the interactive formative assessment sections of the CSVM and through the pre- and posttest. Finally, retention and transfer were enhanced by requiring the students to participate in whole group activities using the terms learned, making models, and completing labs during their regularly scheduled adapted environmental science class time.

**Description of the CSVM**

The three students worked each day individually with me to complete the CSVM. The participants came to the adapted environmental science room for approximately 10 minutes each day to complete their daily module. Due to the cancellation of school and student absences, some students had to complete two modules in one session to catch-up. The participants completed the modules individually so that all distractions of group work were removed; however, one student also participated in Module 12 of the CSVM during the time their entire class participated so that any differences in engagement could be noted (two students were absent for their whole-class lesson).

The CSVM was an interactive digital slideshow, created on Microsoft® PowerPoint® that the students could have potentially completed without adult assistance. The CSVM were completed by using the Doceri app (SP Controls, 2018) to project the modules from the laptop onto an Apple® iPad®. The first part of each CSVM included
instruction, where the student engaged in learning activities by watching videos, listening to songs, watching graphic organizers become completed, or clicking where requested to complete a simulation. The second part of the CSVM was an interactive, practice and formative assessment section where the students actively engaged by answering questions, and completing graphic organizers or simulations, etc. Each learning section of the module lasted approximately five minutes, unless it was a few minutes longer due to the inclusion of a video or song. The length of the interactive or assessment part of the modules depended on the students’ response times. Overall, the CSVM was designed using research-based (a) computer-assisted instruction features, (b) vocabulary strategies, and (c) special education instruction strategies (see Table 3.2).

**Computer-assisted instruction features.** A major advantage of using CAI was the ease of programming (Mize et al., 2018; Ozen et al., 2017; Rivera, et al., 2014; Sigafoos et al., 2014; Weng et al., 2014). The specific features of CAI that were programmed into the CSVM included: (a) feedback and (b) attention getting features.

**Feedback.** Students with autism have been found to prefer extrinsic rewards (Constantin et al., 2017; Weng et al., 2014) which could easily be embedded into the CSVM. The extrinsic reward used in the CSVM was a sound clip of applause that played when the students answered correctly. Another type of feedback that was used was immediate feedback that provided reinforcement and error correction (Sigafoos et al., 2014; Weng et al., 2014). Correct answers were reinforced with the applause sound immediately after the students chose the correct answer. To prevent the students from answering incorrectly on purpose, immediate reinforcement was not used after incorrect answers. Instead, incorrect answers led to the question being posed again and the
elimination of one answer choice. A subsequent incorrect answer eliminated two of the three answer choices, resulting in errorless instruction, meaning the student could only answer correctly and receive the applause feedback.

Table 3.2. Evidence-Based Instructional Practices in the Computerized Science Vocabulary Modules

<table>
<thead>
<tr>
<th>EBP Area</th>
<th>Specific Strategy</th>
<th>Description</th>
<th>Innovation Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer-assisted instruction feature</td>
<td>Feedback</td>
<td>• Extrinsic rewards (Constantin et al., 2017; Weng et al., 2014)</td>
<td>• The student answered correctly, and an applause sound was played</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Immediate feedback that provides reinforcement and error correction (Sigafoos et al., 2014; Weng et al., 2014)</td>
<td>• When the student answered incorrectly, they were provided the correct answer and given another opportunity to answer correctly</td>
</tr>
<tr>
<td>Computer-assisted instruction feature</td>
<td>Attention-getting features</td>
<td>• Sound or action to elicit student’s visual attention (Moore &amp; Calvert, 2000)</td>
<td>• There was a picture symbol with my voice stating “It’s time to look and listen”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Video for sequences of actions (Israel et al., 2013)</td>
<td>• Actions will be used to introduce pictures, terms, etc.</td>
</tr>
<tr>
<td>Vocabulary Strategy</td>
<td>Mnemonic</td>
<td>• Assist participants in remembering definitions (Haydon et al., 2017; Stevenson et al., 2016)</td>
<td>• Videos showing the process of photosynthesis and growth will be used</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• A mnemonic was created for photosynthesis using a sun with a camera (photo = light) and two trees with puzzle pieces in between them</td>
</tr>
<tr>
<td>EBP Area</td>
<td>Specific Strategy</td>
<td>Description</td>
<td>Innovation Examples</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Vocabulary strategy</td>
<td>Cognitive/word mapping</td>
<td>- Cognitive/word mapping strategies create a visual display of concepts (Dexter &amp; Hughes, 2011; Reutzel &amp; Cooter 2019)</td>
<td>- Illustrated the process of photosynthesis</td>
</tr>
<tr>
<td></td>
<td>strategies</td>
<td></td>
<td>- The students watched the maps being completed during the instruction sections and completed them during the interactive portions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocabulary strategy</td>
<td>Frayer model</td>
<td>- For use with tier two and three vocabulary words (Reutzel &amp; Cooter, 2019)</td>
<td>- A four-part Frayer model was used to include a definition, examples, non-examples, and picture of the term</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Students watched a Frayer model being completed in the learning portions and completed one in the interactive portions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocabulary strategy</td>
<td>T-chart</td>
<td>- Used to show examples and non-examples (Browder et al., 2011)</td>
<td>- A t-chart was used to label what a plant needs and what it does not need</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- The students watched the t-chart being completed during the instruction section and completed it during the interactive sections</td>
</tr>
<tr>
<td>Special education EBP</td>
<td>Explicit instruction</td>
<td>- The intentional focus of instruction on the targeted vocabulary words (Wanzek, 2014)</td>
<td>- Each vocabulary term had a dedicated module with specific strategies planned for that word’s instruction</td>
</tr>
</tbody>
</table>

*Note. EBP = evidence-based practice*
**Attention-getting features.** One type of attention-getting feature was the use of sounds or actions to elicit the students’ visual attention (Moore & Calvert, 2000). These sounds and actions were easily embedded into the CSVM. Other attention-getting features included pictures, simulations, songs, and videos. While photographs and pictures were appropriate for any type of instructional item, videos were better for abstract concepts like actions or sequences of interactions (Israel et al., 2013). While pictures were used for all of the terminology, videos were used to show the process of photosynthesis and how the specific parts of the plants function. The video sections were limited to clips or short videos because behavioral problems have been reported in students with intellectual disability and autism when videos were over three minutes long (Özgüç & Cavkaytar, 2016).

**Vocabulary strategies.** There were several vocabulary strategies found to be effective when used with students with intellectual disability and autism. These vocabulary strategies were embedded into both the instruction and interactive portions of the CSVM. The vocabulary strategies used included (a) mnemonics, (b) cognitive word mapping strategy, (c) Frayer models, and (d) t-charts. A summary of why of specific vocabulary strategies were selected for use can be found in Table 3.3 and a list of the vocabulary words can be found in Table 3.4.

**Mnemonics.** A keyword strategy mnemonic device was used for the word *photosynthesis* to assist the students in remembering its definition (Haydon et al., 2017; Stevenson et al., 2016). The definition, using light to put together, and word parts used in the mnemonic are from the Dr. Binocs Show’s *Photosynthesis* YouTube video (Peekaboo Kidz, 2015). The first part of the mnemonic was a sun holding a camera (see Figure 3.5).
This image was selected because *photo* means light (Peekabo Kidz, 2015). The camera was used to make the association with the word photo and the sun was the light. The second part of the mnemonic was two hands holding trees which are put together by puzzle pieces (see Figure 3.5). This image was selected because the puzzle pieces represented *putting together* and the plants helped remind students that photosynthesis happens in plants.

<table>
<thead>
<tr>
<th>Vocabulary Strategy</th>
<th>Modules and Vocabulary Words Used</th>
<th>Reasoning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cognitive Word Mapping Strategy</strong></td>
<td>Module 4: Defining chloroplast</td>
<td>Relationships between concepts could be formed by creating a visual display (Dexter &amp; Hughes, 2011; Reutzel &amp; Cooter, 2019).</td>
</tr>
<tr>
<td></td>
<td>Module 6: Mapping how CO2, H2), and sunlight enter the leaf</td>
<td></td>
</tr>
<tr>
<td><strong>Frayer Model</strong></td>
<td>Module 2: Describing what plants are</td>
<td>Successful with tier two and three vocabulary words (convert, chemical reaction) as well as nonfiction words (plant) (Reutzel &amp; Cooter, 2019).</td>
</tr>
<tr>
<td></td>
<td>Module 7: Defining what convert means</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Module 8: Describing what a chemical reaction is</td>
<td></td>
</tr>
<tr>
<td><strong>T-Chart</strong></td>
<td>Module 3: Sorting plant needs</td>
<td>T-charts show examples and nonexamples for one concept (Browder et al., 2011)</td>
</tr>
</tbody>
</table>
Table 3.4. *Vocabulary Terms Included in the Computerized Science Vocabulary Modules*

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Definition’s Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plants</td>
<td>Mostly green organisms that make their own food</td>
<td>(Bastain, 2018)</td>
</tr>
<tr>
<td>Photosynthesis</td>
<td>The process of using light to put together plant’s food</td>
<td>(Bastain, 2018; Peekabook Kidz, 2015)</td>
</tr>
<tr>
<td>Sunlight</td>
<td>Energy that comes from the sun as light</td>
<td>(Bastain, 2018)</td>
</tr>
<tr>
<td>Chloroplast</td>
<td>The organelle that performs photosynthesis</td>
<td>(Bastain, 2018)</td>
</tr>
<tr>
<td>Leaf</td>
<td>A flat, usually green, part of a plant</td>
<td>(Bastain, 2018)</td>
</tr>
<tr>
<td>Growth</td>
<td>Increase in size</td>
<td>(Bastain, 2018)</td>
</tr>
<tr>
<td>Convert</td>
<td>To make something change</td>
<td>(Bastain, 2018)</td>
</tr>
<tr>
<td>Sugar</td>
<td>A sweet substance made of carbohydrates that gives organisms energy</td>
<td>(Bastain, 2018)</td>
</tr>
</tbody>
</table>

Figure 3.5. Photosynthesis mnemonic. The images used in the mnemonic were a licensed product purchased from CanStockPhoto (2019).
**Cognitive word mapping strategy.** The cognitive word mapping strategy was used in the CSVM to map concepts related to photosynthesis (see Table 3.3). Cognitive word mapping strategy was appropriate for these topics because it allowed relationships between concepts to be formed by creating a visual display (Dexter & Hughes, 2011; Reutzel & Cooter, 2019). Two different cognitive word maps were used in the CSVM. The first was web shaped and can be seen in Figure 3.6. The second cognitive word map (seen in Figure 3.7) was used across two slides to map the process plants use to make food. The students were able to watch the development of the cognitive word maps during the instruction parts of the modules and then were tasked with filling in the maps during the interactive portions.

![Figure 3.6](image)

Figure 3.6. Example of a web shaped cognitive map used in the computerized science vocabulary modules. Pictures from SymbolStix®, Copyright 2019, SymbolStix, LLC. All rights reserved. Used with permission.
Frayer model. Frayer models were found to be successful with tier two and three vocabulary words as well as nonfiction words (Reutzel & Cooter, 2019). Frayer models were easily adaptable to the specific needs for defining the targeted word. The Frayer models used in the CSVM included a definition, pictures of the vocabulary terms, examples, and non-examples (as seen in Figure 3.8). A Frayer model was used specifically for the words and terms chemical reactions, plants, and convert.

T-chart. A t-chart is commonly used to show examples and non-examples (Browder et al., 2011). A t-chart was used to assess the students’ knowledge of what plants need and do not need to live (as seen in Figure 3.9).
Figure 3.8. Example of a Frayer model used in the computerized science vocabulary modules. Pictures from SymbolStix®, Copyright 2019, SymbolStix, LLC. All rights reserved. Used with permission.

Figure 3.9. Example of the t-chart used in the computerized science vocabulary modules. Pictures from SymbolStix®, Copyright 2019, SymbolStix, LLC. All rights reserved. Used with permission.
**Special education instruction strategies.** There was one specific special education instructional strategy embedded in the CSVM. Explicit instruction, or direct instruction, involved the intentional focus of instruction on targeted vocabulary terms (Wanzek, 2014).

I programmed the CSVM so that several vocabulary terms and definitions were explicitly taught. Each term had a separate module and was reviewed during one or more additional modules. The terms, their definitions, and the sources of the definitions can be found in Table 3.4 above. Each term had a dedicated picture symbol that was used throughout the modules. The students in this study were familiar with symbols from SymbolStix Prime® (News-2-You, 2019) so they were used in the modules. Figure 3.10 presented the symbols for each vocabulary term.

**State and alternative standards addressed.** The intervention included standards from the sixth-grade state standards, as well as alternative testing standards. The state standards that addressed photosynthesis, including the conceptual understanding and performance indicators, can be found in Table 3.5. The alternative assessment performance level descriptors included the prioritized standard from the state standard which was then broken down into four levels: (a) foundational, (b) emerging, (c) meets standard, and (d) exceeds standard (SC-Alt Assess, 2018; see Table 3.6). Finally, the science support guide for instruction with students on the alternative testing track provided a breakdown of standards from most complex to least complex on three levels (SC-Alt support guide, n.d.). The alternative standards addressing photosynthesis can be found in Table 3.7. In summary, the CSVM fully addressed only one content standard.
through a series of shorter lessons because of the participants’ difficulties with processing
information (Wakeman et al., 2013).

Figure 3.10. Photosynthesis unit picture symbols. Pictures from SymbolStix®,
Copyright 2019, SymbolStix, LLC. All rights reserved. Used with permission.
Table 3.5. *State Standard Addressing Photosynthesis*

<table>
<thead>
<tr>
<th>Standard</th>
<th>Conceptual Understanding</th>
<th>Performance Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard 6.L.5: The student will demonstrate an understanding of the structures, processes, and responses that allow protists, fungi, and plants to survive and reproduce.</td>
<td>The Plant Kingdom consists of organisms that primarily make their own food (autotrophs) and are commonly classified based on internal structures that function in the transport of food and water. Plans have structural and behavioral adaptations that increase the chances of reproduction and survival in changing environments.</td>
<td>6.L.5B.2 Analyze and interpret data to explain how the processes of photosynthesis, respiration, and transpiration work together to meet the needs of plants.</td>
</tr>
</tbody>
</table>

*Note.* Adapted from South Carolina Department of Education [SCDOE] (2014).

Table 3.6. *SC-Alt Performance Level Descriptors Related to Photosynthesis*

<table>
<thead>
<tr>
<th>Prioritized Standard</th>
<th>Level 1: Foundational</th>
<th>Level 2: Emerging</th>
<th>Level 3: Meets Standard</th>
<th>Level 4: Exceeds Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.L.5B.2 Plants must perform the processes of photosynthesis and respiration in order to survive.</td>
<td>Can understand that plants need light and water to survive.</td>
<td>Can identify that light and water are necessary for green plants’ survival to make food (photosynthesis)</td>
<td>Can interpret a model of the processes of photosynthesis and respiration (getting energy for growth), which are necessary for plant survival.</td>
<td>Can explain how the process of photosynthesis and respiration work together to meet the need of plants.</td>
</tr>
</tbody>
</table>

*Note.* Adapted from SC-Alt Assess (2018).
Table 3.7. Alternative Testing Standards Related to Photosynthesis

<table>
<thead>
<tr>
<th>Most Complex</th>
<th>Middle Level</th>
<th>Least Complex</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.L.5B.2 (a) Interpret a model of the process of photosynthesis and respiration (getting energy for growth), which are necessary for plant survival.</td>
<td>6.L.5B.2 (b) Identify the components of photosynthesis: light (sun or artificial), water, and air (for carbon dioxide), which are necessary for plant survival.</td>
<td>6.L.5B.2 (c) Recognize that light and water are necessary for green plants’ survival to make food (photosynthesis).</td>
</tr>
</tbody>
</table>

*Note.* Adapted from SC-Alt support guide (n.d.).

**Stages of Implementation**

Originally, there were going to be 27 modules presented over one month; however, the students demonstrated progress on the formative assessments which resulted in the reorganization and elimination of several modules (see Table 3.8 for a comparison of the planned and actual modules). Essentially, the elements that were in the least complex and middle level descriptors were combined and the numerous review modules were omitted because the students demonstrated the ability to work at the most complex level. The final CSVM were presented over a total of three weeks. There were 12 modules developed; therefore, there were three days allotted for missed sessions due to absences, school events, etc. The innovation phases included (a) the overview, (b) all about plants, (c) energy, (d) chemical reactions, (e) photosynthesis, and (f) the review (see Table 3.9 for a summary of the timeline, focus terms, topics, and level of alternative standard addressed).
<table>
<thead>
<tr>
<th>Mod</th>
<th>Planned Topics</th>
<th>Actual Topics</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduce mnemonic and definition of photosynthesis</td>
<td>Introduce mnemonic and definition of photosynthesis</td>
<td>Same</td>
</tr>
<tr>
<td>2</td>
<td>Describing features of a plant</td>
<td>Describing features of a plant</td>
<td>Same</td>
</tr>
<tr>
<td>3</td>
<td>Review of plant, structures, needs, and processes</td>
<td>Plant growth</td>
<td>I combined the review of what they have learned previously to talk about plant growth.</td>
</tr>
<tr>
<td>4</td>
<td>Introduce the overall structure of a leaf</td>
<td>The leaf and chloroplast</td>
<td>I decided to combine the leaf with chloroplast because of their relationship in the photosynthesis process.</td>
</tr>
<tr>
<td>5</td>
<td>Define chloroplast</td>
<td>Review of Modules 1-4</td>
<td>I wanted to be sure the students were progressing well, so I added a review to check progress.</td>
</tr>
<tr>
<td>6</td>
<td>Define chlorophyll</td>
<td>Sunlight, Energy, and Sugar</td>
<td>After reviewing the photosynthesis concepts, I decided I did not need to include chlorophyll and stomata because I needed the students to focus on chloroplast and leaf. I also decided to combine sunlight, energy, and sugar to show their relationship instead of showing each separately. I then added a review to ensure these difficult concepts were being understood.</td>
</tr>
<tr>
<td>7</td>
<td>Define stomata</td>
<td>Convert</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Plant Review</td>
<td>Chemical reaction</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Explain how sunlight helps plants</td>
<td>Carbon Dioxide and Oxygen</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Food energy for plants</td>
<td>Review of Modules 6-9</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Sugars and carbohydrates</td>
<td>Review Photosynthesis (Repeat of Module 1)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Define a chemical reaction</td>
<td>Photosynthesis</td>
<td>This concept remained the same but was moved to Module 8.</td>
</tr>
<tr>
<td>13</td>
<td>Define convert</td>
<td>N/A</td>
<td>This concept remained the same but was moved to Module 7.</td>
</tr>
<tr>
<td>Mod</td>
<td>Planned Topics</td>
<td>Actual Topics</td>
<td>Notes</td>
</tr>
<tr>
<td>-----</td>
<td>----------------------------------------</td>
<td>---------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>14</td>
<td>Explain carbon dioxide formula</td>
<td>N/A</td>
<td>I made the decision that completing the formulas was not an important part of the photosynthesis process for the participants. I combined CO2 and O2 into module 9.</td>
</tr>
<tr>
<td>15</td>
<td>Explain oxygen formula</td>
<td>N/A</td>
<td>I initially thought the students would need a lot of review to be successful with the topics. After seeing their success, I combined the reviews into modules 11 and 12. Module 11 was a repeat of module one and module 12 put everything learned together into an overview of photosynthesis.</td>
</tr>
<tr>
<td>16</td>
<td>Explain water formula</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Chemical reaction formula</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Review mnemonic</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Photosynthesis song</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Photosynthesis model</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Photosynthesis simulation</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Review photosynthesis</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Review plant parts</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Review energy</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Review chemical reactions</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Review photosynthesis</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Review photosynthesis</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>
Table 3.9. *Summary of Terms, Topics, Alternative Standard Levels, and a Timeline of the Computerized Science Vocabulary Modules*

<table>
<thead>
<tr>
<th>Day</th>
<th>Focus Term</th>
<th>Topics</th>
<th>Alt-Standard Level</th>
<th>Strategies Used to Instruct</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Modules</td>
<td></td>
<td>All Modules</td>
<td></td>
<td>Feedback, gain attention, pacing, explicit instruction, Mnemonics</td>
</tr>
<tr>
<td>1</td>
<td>Photosynthesis</td>
<td>Introduce mnemonic and definition of photosynthesis</td>
<td>MC</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Plant</td>
<td>Describing features of a plant</td>
<td>LC</td>
<td>Frayer model</td>
</tr>
<tr>
<td>3</td>
<td>Growth</td>
<td>Review of plant structures, needs, and processes</td>
<td>LC</td>
<td>T-chart</td>
</tr>
<tr>
<td>4</td>
<td>Chloroplast</td>
<td>Define chloroplast</td>
<td>MC</td>
<td>Cognitive/word mapping strategy</td>
</tr>
<tr>
<td>5</td>
<td>Plant Review</td>
<td>Review of Modules 1-4</td>
<td>LC to MC</td>
<td>Mnemonics, Frayer model, Cognitive/word mapping strategy</td>
</tr>
<tr>
<td>6</td>
<td>Sunlight, Energy, and Sugar</td>
<td>Describing the process using sunlight to turn water and oxygen into sugar</td>
<td>MC</td>
<td>Cognitive/word mapping strategy</td>
</tr>
<tr>
<td>7</td>
<td>Convert</td>
<td>Define and identify convert</td>
<td>MC</td>
<td>Frayer model</td>
</tr>
<tr>
<td>8</td>
<td>Chemical Reaction</td>
<td>Define a chemical reaction</td>
<td>MC</td>
<td>Frayer model</td>
</tr>
<tr>
<td>9</td>
<td>Carbon Dioxide and Oxygen</td>
<td>Explain how each gas is related to the process of photosynthesis</td>
<td>MC</td>
<td>N/A (simulation used)</td>
</tr>
<tr>
<td>10</td>
<td>Review</td>
<td>Review of modules 6-9</td>
<td>MC</td>
<td>Frayer model, cognitive/word mapping strategy</td>
</tr>
<tr>
<td>11</td>
<td>Repeat of Module 1</td>
<td>Repeat of Module 1</td>
<td>MC</td>
<td>Mnemonics</td>
</tr>
<tr>
<td>12</td>
<td>Overview of the process of photosynthesis</td>
<td></td>
<td>MC</td>
<td>N/A (simulation used)</td>
</tr>
</tbody>
</table>

*Note.* Alt-Standard = Alternative standard; MC = most complex; LC = least complex.

The overview included a one-day session that familiarized the participants with the format of the CSVM and introduced the concept of photosynthesis through the
explanation of the mnemonic. The *all about plants* section included three days of modules that addressed (a) describing the plant, (b) defining *growth* and a review of the previously learned plant structures and processes, and (c) chloroplast. The *energy* section included one module about sunlight, energy, and sugar. The *chemical reaction* section included three modules that addressed (a) definition of the word *convert*, (b) what a chemical reaction is, and (c) carbon dioxide and oxygen. The photosynthesis section was a total of two instructional days. This section included (a) a review of the photosynthesis mnemonic and (b) a presentation of a photosynthesis song and simulation. Finally, the students reviewed the CSVM by completing review modules (Modules 5 and 10).

**Data Collection**

My data collection involved several different methods so that in-depth information was collected, and meaning was developed via multiple perceptions (Bloomberg & Volpe, 2015). The data collection methods included qualitative and quantitative methods that had equal emphasis in the study as outlined in Table 3.10. Before any data were collected, parental consent for participation was obtained for all three students (see Appendix A), as well as permission from the school district (see Appendix B) and the University of South Carolina’s Institutional Review Board (see Appendix C).

There was a total of four data collection instruments used. The quantitative data collection instruments included a pre- and posttest and formative assessments embedded in the CSVM. The qualitative methods included a researcher’s journal and document analysis. Finally, the CMAE developed by Sparapani et al. (2016) combined with anecdotal notes provided both qualitative and quantitative data. This section describes the
(a) pre- and posttest, (b) formative assessments, (c) researcher’s journal, (d) the CMAE, and (e) document analysis.

Table 3.10. *Data Sources for Research Questions*

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Data Sources</th>
</tr>
</thead>
</table>
| RQ1. How does the implementation of computer-assisted vocabulary modules, which adhere to evidenced-based practices of special education vocabulary instruction, affect the knowledge and application of science vocabulary terms with students with intellectual disability and autism in an adapted environmental science class? | • Pre- and Posttest  
• Formative Assessments in the CSVM  
• Researcher’s Journal |
| RQ2. How are the students with an intellectual disability and autism engaged in computer-assisted instruction activities? | • Researcher’s Journal  
• Classroom Measurement of Active Engagement (CMAE) |

**Pre- and Posttest**

All three students were administered the test before and after the CSVM were implemented so that the effect of the CSVM could be determined through the comparison of the two testing sessions (Wiersma & Jurs, 2009). The photosynthesis pre- and posttest was composed of ten questions with three answer choices for each question. The maximum score for the assessment was 30 points with three points given for the correct answer on the first try, two points given for the correct answer on the second try, and one point given for participating in the errorless instruction question. If the student answered incorrectly on the first attempt, one answer choice was eliminated. If the student answered incorrectly a second time, an errorless instruction question (only the correct
answer was presented) was given. An annotated copy of the test with correct answers highlighted in blue and the answer choice that were eliminated, if needed, highlighted in pink can be found in Appendix D. It is important to note that this assessment was only used to describe if any changes occurred in the test scores after the implementation of the CSVM.

The overall test was based on the SC science standard 6.L.5B.2: “Analyze and interpret data to explain how the processes of photosynthesis, respiration, and transpiration work together to meet the needs of plants” (SC DOE, 2014, p. 52). I created the test based on the four SC-Alt performance level descriptors, with two questions for each SC-Alt performance level descriptor, as well as two additional questions to review the definition of photosynthesis. See Table 3.11 for an alignment of the test questions to the performance level descriptors and research questions.

The content of the pre- and posttest was validated by sending a copy of the assessment to a science academic specialist and a special education instructional coach. The science academic specialist stated that the content in the pre- and posttest was aligned with the standards being used and was appropriate for the population of students being assessed. The special education instructional coach stated that some questions may be very difficult for the population of students being studied but felt they were appropriate to gauge which level of questions the students could answer. The science academic specialist and special education instructional coach found the pre- and posttest to be a valid measure for students with an intellectual disability and autism.
Table 3.11. Alignment of Pre and Posttest Questions and SC-Alt Performance Level Descriptors and Research Questions

<table>
<thead>
<tr>
<th>Research Question</th>
<th>SC-Alt Performance Level Descriptor</th>
<th>Test Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1. How does the implementation of computer-assisted vocabulary modules, which adhere to evidenced-based practices of special education vocabulary instruction, affect the knowledge and application of science vocabulary terms with a student with intellectual disability and autism in an adapted environmental science class?</td>
<td>Level 1: Can understand that plants need light and water to survive.</td>
<td>1. What does a plant need to live?</td>
</tr>
<tr>
<td></td>
<td>Level 2: Can identify that light and water are necessary for green plants’ survival to make food (photosynthesis).</td>
<td>2. What else does a plant need to live?</td>
</tr>
<tr>
<td></td>
<td>Level 3: Can interpret a model of the processes of photosynthesis and respiration (getting energy for growth), which are necessary for plant survival.</td>
<td>1. What does a plant need to make food?</td>
</tr>
<tr>
<td></td>
<td>Level 4: Can explain how the process of photosynthesis and respiration work together to meet the need of plants.</td>
<td>2. What color are most plants?</td>
</tr>
<tr>
<td></td>
<td>N/A – Definition Review</td>
<td>1. Which picture shows photosynthesis?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. What part of the plant is food made in?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. What type of air does a plant need?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. What does a plant need to grow?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. What is photosynthesis?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. How does a plant make food?</td>
</tr>
</tbody>
</table>

Formative Assessments in the Computerized Science Vocabulary Modules

The formative assessments in the CSVM included at least three questions in each of the 12 modules for a total of 60 questions. The questions required students to answer a multiple-choice or fill-in-the-blank question (46 questions) or touch a part of a model as requested (14 questions; see Figure 3.11 and Figure 3.12 for an example of the questions). Of these questions five were questions that reviewed science content taught before the implementation of the CSVM or addressed definitions needed for the
understanding of the concept of photosynthesis. The remainder of the questions aligned to the SC-Alt performance level descriptors (SC-Alt support guide, n.d.) with two questions addressing level one, seven questions addressing level two, eight questions addressing level three, and 13 questions addressing level four. Students with intellectual disability and autism benefit from repetition of instruction (Collins & Ludlow, 2018); therefore, all of the questions were repeated in at least one other review module. See Table 3.12 for the alignment of the formative assessment questions to the SC-Alt performance level descriptors and research questions.

The formative assessment scores were used for descriptive purposes only. The scores allowed me to determine how many questions the students were able to answer correctly and how many attempts were needed to obtain a correct answer. I developed a score sheet to use while the students are answering the formative assessment questions. I was seated next to the students while they answered the questions on the Apple® iPad®, and I recorded the students’ performances on the data sheet (see Appendix E for the formative assessment questions and the data sheet).

Figure 3.11. Touch-the-model question example. Picture symbols from SymbolStix®, Copyright 2019, SymbolStix, LLC. All rights reserved. Used with permission.
Figure 3.12. Example of a multiple-choice formative assessment question. Picture symbols from SymbolStix®, Copyright 2019, SymbolStix, LLC. All rights reserved. Used with permission.

Table 3.12. Alignment of Formative Assessment Questions to SC-Alt Performance Descriptors and Research Questions

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Level or Definition Review</th>
<th>Questions on the Formative Assessment</th>
</tr>
</thead>
</table>
| N/A               | Review previously learned material or definitions | 1. If something grows it gets…  
2. Which picture shows something growing.  
3. Energy is the ability to do…  
4. Convert means something…  
5. Which picture shows convert? |
| RQ1. How does the implementation of computer-assisted vocabulary | Level 1: Can understand that plants need light and water to survive | 1. What picture shows a plant?  
2. What does a plant need to grow? |
modules, which adhere to evidenced-based practices of special education vocabulary instruction, affect the knowledge and application of science vocabulary terms with a student with intellectual disability and autism in an adapted environmental science class?

<table>
<thead>
<tr>
<th>Level 2: Can identify</th>
<th>1. What does a plant need to put together food?</th>
</tr>
</thead>
<tbody>
<tr>
<td>that light and water are necessary for green plants’ survival to make food (photosynthesis).</td>
<td>2. What color are most plants?</td>
</tr>
<tr>
<td>3. What is photosynthesis?</td>
<td></td>
</tr>
<tr>
<td>4. Sunlight helps a plant make…</td>
<td></td>
</tr>
<tr>
<td>5. Sugar gives plants…</td>
<td></td>
</tr>
<tr>
<td>6. Plants convert light, water, and CO₂ into…</td>
<td></td>
</tr>
<tr>
<td>7. Which picture shows how we can remember what photosynthesis means?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level 3: Can interpret a model of the processes of photosynthesis and respiration (getting energy for growth), which are necessary for plant survival.</th>
<th>1. Touch the leaf.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Touch the sunlight.</td>
<td></td>
</tr>
<tr>
<td>3. Touch the water.</td>
<td></td>
</tr>
<tr>
<td>4. Touch where the plant makes its food.</td>
<td></td>
</tr>
<tr>
<td>5. Touch the leaf.</td>
<td></td>
</tr>
<tr>
<td>6. Touch the stem.</td>
<td></td>
</tr>
<tr>
<td>7. Touch the roots.</td>
<td></td>
</tr>
<tr>
<td>8. Touch the flower</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level 4: Can explain how the process of photosynthesis and respiration work together to meet the need of plants.</th>
<th>1. Which picture shows how we can remember what photosynthesis means?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. The organelle in a plant is called…</td>
<td></td>
</tr>
<tr>
<td>3. What does chloroplast do?</td>
<td></td>
</tr>
<tr>
<td>4. Chloroplast is in a…</td>
<td></td>
</tr>
<tr>
<td>5. What does photosynthesis make for plants?</td>
<td></td>
</tr>
<tr>
<td>6. What does photosynthesis happen in?</td>
<td></td>
</tr>
<tr>
<td>7. Putting together light, carbon dioxide, and water to make food is called…</td>
<td></td>
</tr>
<tr>
<td>8. A chemical reaction is when two things are…</td>
<td></td>
</tr>
<tr>
<td>9. Photosynthesis is… (chemical reaction)</td>
<td></td>
</tr>
<tr>
<td>10. Which picture shows a chemical reaction?</td>
<td></td>
</tr>
<tr>
<td>11. What does do plants take in?</td>
<td></td>
</tr>
<tr>
<td>12. What gas do plants give out?</td>
<td></td>
</tr>
<tr>
<td>13. What gas do people breathe in?</td>
<td></td>
</tr>
</tbody>
</table>
The formative assessments implemented the errorless instruction strategy during a practice session by first presenting the question with a green outline around the correct answer choice (see Figure 3.13 for an example). The module would not advance until the student touched the correct answer. After the practice session, the students were administered the formative assessment questions in the same order as the practice questions. The formative assessment questions did not have the green outline around the correct answers. If the student answered incorrectly there was not any sound, instead the student was then presented with two answer choices. If the student answered incorrectly again, only the correct answer was shown on the next screen.

![What does photosynthesis happen in?](image)

Figure 3.13. Example of an errorless instruction practice question. Picture symbols from SymbolStix®, Copyright 2019, SymbolStix, LLC. All rights reserved. Used with permission.

The formative assessment questions, along with sample questions to show formatting, were sent to a science academic specialist and a special education instructional coach for content review. The elementary science academic specialist found
the assessment to appropriately assess the content standards. The special education instructional coach was concerned about the presence of three answer choices and how they appeared on an Apple® iPad®; however, after viewing a sample question and receiving an explanation of how the answer choices would be presented, she found the assessment to be a valid measure for students with an intellectual disability and autism. Both the science academic specialist and the special education instructional coach found the assessment questions to be valid measures of the learning standards for students with an intellectual disability and autism.

**Researcher’s Journal**

I used journals to take notes before, during, and after the implementation of the CSVM. The purpose of the journals was to “maintain narrative accounts of [my] professional reflections on practice” (Mertler, 2017, p. 138). My students did not write; therefore, they were not asked to keep their own journals but may have been asked to create artifacts showing what they have learned (i.e. label a model of a flower). Notes about these artifacts and the participants were kept in my journal. Information that was not recorded in the anecdotal notes of the CMAE was recorded in my journal (i.e. absences, emergency drills, etc.). I used the researcher’s journal (see Figure 3.14) to record and reflect on my feelings, perceptions, and interpretations of the students’ actions as they participated in the CSVM (Lodico et al., 2010). My journals also included diagrams of the setting, memos, and data recording and analyses (Lodico et al., 2010).

**Classroom Measurement of Active Engagement**

The CMAE was used to measure the students’ active engagement in lessons before, during, and after the implementation of the CSVM. The CMAE consisted of nine
descriptors within the five factors of active engagement as outlined by Sparapani et al. (2016). The five factors of active engagement included (a) emotional regulation, (b) classroom participation, (c) social connectedness, (d) initiating communication, and (e) flexibility. Classroom participation was further broken into the descriptors of (b1) productivity and (b2) independence; social connectedness was broken into (c1) responding and (c2) eye gaze; initiating communication was divided into (d1) directed communication and (d2) generative language; and flexibility was made up of (e1) flexible behavior and (e2) flexible attention (Sparapani et al., 2016). The CMAE provided coding definitions, examples, and the data yields for the nine descriptors as found in Table 3.13; however, there was not a specific format for recording this data so I created my own recording chart (see Appendix F).

The CMAE was originally developed “as an observational research tool to measure and document change in student active engagement” (Sparapani et al., 2016, p. 787). Sparapani et al. (2016) chose these nine descriptors because their research found the descriptor items included the major challenges students with autism present in terms of classroom engagement. Sparapani et al. established interrater reliability by using multiple coders for 20% of the data. The interrater reliability average scores were “at or above 80% for each of the CMAE variables [except for] flexible attention (76%)” (Sparapani et al., 2016, p. 787). Eighty percent is typically the standard for minimal acceptable interrater reliability (McHugh, 2012); therefore, all descriptors could be deemed as reliable except for flexible attention.

Correlation coefficients for the descriptors of the CMAE were calculated by Sparapani et al. (2016) using the Pearson product-moment correlation coefficients
measure. The correlation coefficients for the CMAE were reported as a range from 0.74 to 0.99, which demonstrated strong correlation (Sparapani et al., 2016). The researchers also found “good consistency across the coders for each behavior” (Sparapani et al., 2016, p. 787). The validity of the CMAE was also checked by Sparapani et al. (2016) and reported as valid in measuring active engagement in students with autism through the use of the five themes and nine descriptors.

Figure 3.14. Sample page from my researcher’s journal.
Table 3.13. *The Classroom Measure of Active Engagement*

<table>
<thead>
<tr>
<th>Themes and Variables</th>
<th>Definition</th>
<th>Data Yields</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emotional Regulation</td>
<td>The student’s ability to manage emotional states to match the demands of the physical and social environment.</td>
<td>The duration of time the student spends in a well-regulated state.</td>
</tr>
<tr>
<td>Emotional Regulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classroom Participation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity</td>
<td>The student is actively performing roles within an activity and using materials in an appropriate manner – roles can be motoric or social.</td>
<td>Productivity yields the duration of time spent in a productive state</td>
</tr>
<tr>
<td>Independence</td>
<td>Self-initiated management of materials and participation within classroom activities.</td>
<td>The number of instances the student looks at the faces of others</td>
</tr>
<tr>
<td>Social Connectedness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Responding</td>
<td>The student’s physical and social responses following clear expectant language. Response do not need to demonstrate comprehension or compliance.</td>
<td>The percentage of times that the student responds to expectant language</td>
</tr>
<tr>
<td>Eye Gaze</td>
<td>Each instance of clear eye gaze directed toward a communicate partner’s face. The partner’s face does not have to be showing, but enough of the partner’s body must be showing to confirm that the student is looking at the partner’s face.</td>
<td>The number of instances the student looks at the faces of others</td>
</tr>
<tr>
<td>Initiating Communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Directed Communication</td>
<td>A vocalization, verbalization, or communicative gesture directed toward another person to serve a communicative function.</td>
<td>The number of instances the student directs clear communication toward others</td>
</tr>
<tr>
<td>Generative Language</td>
<td>The student’s production of spoken, written, and gestural language that is used in a flexible and creative manner.</td>
<td>The number of instances the student exhibits generative language</td>
</tr>
<tr>
<td>Themes and Variables</td>
<td>Definition</td>
<td>Data Yields</td>
</tr>
<tr>
<td>----------------------</td>
<td>------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Flexibility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexible Behavior</td>
<td>The student’s ability to change in response to classroom changes including activity changes, location changes, and material changes.</td>
<td>The percentage of time that the student exhibits flexible behavior</td>
</tr>
<tr>
<td>Flexible Attention</td>
<td>The student’s ability to shift attentional focus when presented with opportunities to change.</td>
<td>The percentage of time that the student exhibits flexible attention</td>
</tr>
</tbody>
</table>

*Note.* The Classroom Measure of Active Engagement (CMAE) by Sparapani et al. (2016). Permission granted.

Table 3.14. Correlations between Standardized Tests, Teacher Report Measures, and the Classroom Measure of Active Engagement

<table>
<thead>
<tr>
<th>Descriptors</th>
<th>Standardized Test</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generative Language</td>
<td>ABIQ: Receptive Vocabulary</td>
<td>($r = 0.32, p &lt; 0.0001$) Positive significance</td>
</tr>
<tr>
<td>Generative Language</td>
<td>ABIQ: Expressive Vocabulary</td>
<td>($r = 0.17, p &lt; 0.05$) Positive significance</td>
</tr>
<tr>
<td>Productivity</td>
<td>PPVT-4: Receptive Vocabulary</td>
<td>($r = 0.18, p &lt; 0.05$) Positive significance</td>
</tr>
<tr>
<td>Responding</td>
<td>PPVT-4: Receptive Vocabulary</td>
<td>($r = 0.16, p &lt; 0.05$) Positive significance</td>
</tr>
<tr>
<td>Directed Communication</td>
<td>PPVT-4: Receptive Vocabulary</td>
<td>($r = 0.15, p &lt; 0.05$) Positive significance</td>
</tr>
<tr>
<td>Emotional Regulation</td>
<td>TRF: Externalizing Behavior</td>
<td>($r = -0.18, p &lt; 0.05$) Negative significance</td>
</tr>
<tr>
<td>Flexible Behavior</td>
<td>TRF: Externalizing Behavior</td>
<td>($r = -0.19, p &lt; 0.01$) Negative significance</td>
</tr>
</tbody>
</table>

A score sheet (see Appendix F) was developed to measure the students’ performance on the nine descriptors of active engagement as defined by the CMAE (Sparapani et al., 2016). In order to measure emotional regulation, productivity, and independence, the start and end time of the correct behavior(s) were documented.
Recording a + for every instance in which there was a correct response and a – for incorrect responses will be used for responding, flexible behavior, and flexible attention. Because the opportunities for responding, flexible behavior, and flexible attention varied for each student, the possible opportunities were also documented. Finally, a tally of occurrences was used to record eye gaze, directed communication, and generative language. Due to the quick behavior changes of the students, time was recorded in seconds.

In addition to the CMAE scores, anecdotal notes were recorded on the right side of the form using codes for features of the CSVM, behaviors, and description versus reflective notes. I looked for the students’ reactions to the CSVM features which included watching an educational video, watching a simulation, applause sound, listening to an educational song, answering practice and formative assessment questions, Frayer model, cognitive/word maps, t-charts, listening to a reading passage, and reactions to interruptions. It should be noted that codes were added as needed. The behavior codes consisted of two parts. The first part recorded if there was a reaction and if it was negative or positive. The second part recorded the type of reaction, which included verbal sounds, verbal speech, gestures, facial expressions, stimming (repetitive movements such as arm flapping), echolalia (repeating speech), elopement (leaving the area of instruction), preservation (becoming stuck on one thing and repeating it over and over), and preoccupation (appearing to be in their own world). Finally, the data in blue represented the description of activities and the data in red represented reflective notes. See Table 3.15 for the alignment of the observation codes and research questions.
<table>
<thead>
<tr>
<th>Research Question</th>
<th>CSVM Features Codes</th>
<th>Behavior Engagement Codes</th>
<th>Color Codes</th>
</tr>
</thead>
</table>
| RQ2. How are the students with an intellectual disability and autism engaged in computer-assisted instruction activities? | EV = watching educational video  
WS = watching simulation  
ES = educational song  
P = practice  
FA = formative assessment  
TC = t-chart  
FM = Frayer model  
CM = cognitive/word map  
RP = reading passage | N = Negative  
P = Positive  
NR = No  
Reaction  
V = Verbal  
Sound  
VS = Verbal  
Speech  
G = Gesture  
FE = Facial Expression  
St = Stimming  
E = Echolalia  
El = Elopement  
P = Perseverates  
PO = Preoccupied | Blue =  
Red =  
Description of Activities  
Reflective Notes |

The students were videotaped while completing the pre- and posttest and while accessing the CSVM. The length of all sessions was approximately five minutes each, except for the review sessions which averaged 10 minutes each. The purpose of these videotapes was to “allow for holistic interpretation of the phenomenon being investigated” (Merriam, 2009, p. 136). The participants were videotaped before, during, and after the intervention. First, the participants were videotaped once during class activities, which were not technology-based before the CSVM intervention. The students were also observed once in their primary classroom during an academic task and once during a different related arts class. The students were also going to be observed in a whole class lesson about photosynthesis after the implementation of the CSVM; however, only one student was present for this lesson. I used thick, rich descriptions including
verbatim transcription of their spoken communication (if verbal), as well as subtle factors such as facial expressions and gestures (Hatch, 2002; Merriam, 2009). By recording their responses and reactions before and after implementation, I was able to note differences in their active engagement.

Next, the participants were videotaped interacting with and accessing the CSVM. The students were recorded each time they used the CSVM, rather in whole group or during independent practice. My students struggled with their expressive language skills and were mostly nonverbal, so it would have been difficult to ask them why they liked or disliked the CSVM. For this reason, I recorded my students as they interacted with the CSVM so that I could record their amount of engagement and signs of interest. I recorded details, including the amount of time actively engaged in the module, facial expressions and gestures, direct quotes of any comments they made (if verbal), and any other notable events that occurred during their participation (Hatch, 2002; Merriam, 2009). The students did not necessarily know they were being recorded during these sessions, which allowed for unobtrusive data collection (Hatch, 2002).

The observation videotapes also allowed me to be a full participant and directly observe for a better understanding of the context of my study, use inductive methods for analysis, and discover things no one else had previously observed (Hatch, 2002; Merriam, 2009; Patton, 2002). I developed an observation protocol based on the CMAE to record the students’ reactions to the CSVM (Wiersma & Jurs, 2009). Finally, using videotapes could have been intrusive because of the equipment (Hatch, 2002); however, the students did not seem to notice the video camera during the implementation sessions.
Document Analysis

School documents such as IEPs, psychological reports, and students’ permanent records were reviewed before the implementation to obtain demographic information. These documents were only helpful for demographic data because they usually do not contain accurate, revealing information such as verbatim quotations from the student or the family (Bogdan & Biklen, 2007). The IEPs and psychological reports helped to paint a picture about the special education services and the specific educational needs of each student. If the students had functional behavior assessments or behavior intervention plans, they were reviewed to learn about what positively reinforces the students, as well as any special behavior needs that needed to be considered. Understanding the students’ unique learning needs helped me describe any successes or complications with the implementation of the vocabulary modules. The review of permanent records provided the students’ ages, ethnicity, primary language, absences, and any other pertinent background information. Medical information pertaining to the students’ disabilities may also have been present. This information was kept confidential through a coding process, by creating gender-neutral pseudonyms for each student, and a pseudonym for the school’s name.

Data Analysis

The data were organized, and I made sense of this data through data analysis (Merriam, 2009). Because my study was a convergent, mixed methods design, I completed four major steps when analyzing the data: (a) collected both quantitative and qualitative data, (b) analyzed both types of data separately, (c) merged the results of both types of data, and (d) interpreted the data (Creswell & Plano Clark, 2018). I implemented
the parallel-databases variant of the convergent design, which means I brought together the qualitative and quantitative data during the interpretation phase to look at different aspects of the same phenomenon and develop a more complete picture of what happened when the CSVM was implemented (Creswell & Plano Clark, 2018). See Table 3.16 for the alignment of research questions, data sources, and the data analysis methods. This section will present (a) quantitative data analysis methods, (b) qualitative data analysis methods, (c) integration of the data analyses, and (d) presenting the findings.

Table 3.16. Alignment of Research Questions, Data Sources, and Data Analysis Methods

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Data Sources</th>
<th>Data Analysis Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1. How does the implementation of computer-assisted vocabulary modules, which adhere to evidenced-based practices of special education vocabulary instruction, affect the knowledge and application of science vocabulary terms with a student with intellectual disability and autism in an adapted environmental science class?</td>
<td>• Pre- and posttest&lt;br&gt;• Formative Assessments&lt;br&gt;• Researcher’s Journal</td>
<td>• Descriptive statistics&lt;br&gt;• Inductive analysis&lt;br&gt;• Inductive analysis</td>
</tr>
<tr>
<td>RQ2. How is the student with an intellectual disability and autism engaged in computer-assisted instruction activities?</td>
<td>• Classroom Measure of Active Engagement (CMAE) with anecdotal notes about engagement observations&lt;br&gt;• Researcher’s Journal</td>
<td>• Descriptive statistics for CMAE and inductive analysis for anecdotal notes&lt;br&gt;• Inductive analysis</td>
</tr>
</tbody>
</table>

129
Quantitative data were analyzed using descriptive statistics. The goal of descriptive statistics was to summarize data and show patterns (Lodico et al., 2010). Descriptive statistics were used to collect information from the (a) pre- and posttest and formative assessments and (b) CMAE observation protocol.

**Pre- and posttest and formative assessments.** The pre- and posttest and formative assessments were scored by creating a summed score or counting how many questions were answered correctly out of the ten questions (Creswell, 2012). I calculated a percentage correct from the summed scores. The formative assessment summed scores included scores for the individual modules and all the CSVM together (a total of 81 questions).

**Classroom Measure of Active Engagement.** Descriptive statistics were calculated for the CMAE. The duration of time was calculated for emotional regulation, productivity, and independence (Sparapani et al., 2016). In addition, the percentage of time for emotional regulation, productivity, and independence were also calculated because the total amount of possible time was different for each student. The percentage of times the student correctly completed the specific behavior was calculated for responding, flexible behavior, and flexible attention (Sparapani et al., 2016). The number of instances of eye gaze, directed communication, and generative language were also totaled (Sparapani et al., 2016).

**Qualitative Data Analysis**

The qualitative data were analyzed according to the type of data collected. Qualitative data analysis was conducted for (a) behavioral observation data and (b) narrative data.
Behavioral observation data. Behavioral observation data was collected from observational notes recorded on the CMAE. The observational notes were recorded using \textit{a priori} codes as found above in Table 3.15, as well as any other codes that emerged during the data collection process. These data were organized by participants so that an overall picture of the participants’ interactions with the CSVM could be developed. The data were analyzed by creating frequency counts for each positive, negative, or no-response occurrence. For example, I found the frequency of each positive gesture while watching an educational video or each negative verbal sound while listening to an adaptive story being read aloud. The frequency counts were, converted into percentages to show the amount of time engaged in the specific CMAE descriptor, organized into tables and/or graphs, and accompanied by a narrative explanation.

Narrative data. Narrative data were collected via my researcher’s journal. This narrative data included how the students’ interactions with the CSVM changed over time, details about the students’ days (e.g., change in medication, had a major schedule change, did not sleep the previous night, etc.), major events that may happen during implementation (e.g., fire drill), observational notes that are not related to the CMAE (e.g., the homeroom teacher used a different reward system), and/or notes about the research procedures used (Bogdan & Biklen, 2007).

The narrative data collected were analyzed using inductive analysis. Inductive analysis could be defined as “a systematic procedure for analyzing qualitative data in which the analysis is likely to be guided by specific evaluation objects” (Thomas, 2006, p. 238). The purpose of inductive analysis was to condense data into smaller parts and create themes from those parts (Leech & Onwuegbuzie, 2007; Mertler, 2017; Thomas,
The qualitative data from my researcher’s journal entries were analyzed by (a) organizing and preparing data, (b) coding the data, (c) generating categories and themes from the data, and (d) presenting the findings (Creswell, 2012, 2014; Thomas, 2006).

**Organizing and preparing the data.** The first step in preparing data was to clean it by formatting all data into a similar format (Thomas, 2006). I formatted my data by preparing a document for each student and in my researcher’s journal to include the date, time, module number, and overall notes from each CSVM implementation session. This step also included a general reading of the data to gain an overall sense of the information collected (Creswell, 2012, 2014).

**Coding the data.** The second step in the analysis process was coding the data that entailed (a) completing a close reading, (b) categorizing data into codes, and (c) using memos (Stuckey, 2015; Thomas, 2006). I used several different coding lenses to perform a critical analysis reading of the cleaned data (Thomas, 2006). The coding process occurred using Delve software (n.d.). Finally, memos were created in Delve (n.d.) in order to “write ideas or thoughts of how [I] arrived at the codes, and how [I am going to use] them to explain” (Stuckey, 2015, p. 9) my findings. Using these memos enhanced my audit trail because I showed the reader how I made decisions and reached conclusions (Stuckey, 2015).

**Generating categories and themes.** Categories were developed by finding repetitions, similarities and differences, and/or missing data in the codes (Thomas, 2006). Each of the codes were sorted into one or more categories by creating sticky note piles that “produce similarity data” (Thomas, 2006, p. 113). Next, memos were created to describe the meaning of each category (Thomas, 2006). A similar process was used.
through the second cycle coding process to develop themes (Saldaña, 2015). The developed themes were used to develop an assertion (Saldaña, 2015) and present and interpret the findings.

**Presenting the Findings**

The overall quantitative and qualitative findings were presented separately. The quantitative and qualitative findings for each student were then converged and used to create a whole picture of what occurred for each student during the CSVM implementation. The findings for each student were then reviewed for similarities and differences, displayed in a joint display table, and then compared for an overall picture of how the CSVM implementation affected the students.

The joint display table showed the integration of the data in one table and/or graph (Creswell & Plano Clark, 2018). The joint display merged the data findings for each of the participants in order to compare how each student responded to the CSVM implementation. This display also helped demonstrate if the students made increases in academic areas as well as in active engagement. The final display helped determine if the CSVM needed to be revised to better address the content instruction, tools to increase active engagement, or both. The joint display was accompanied by a narrative that addressed how the data for each participant converged and/or demonstrated divergence (Creswell & Plano Clark, 2018).

**Procedures and Timeline**

The procedures for my study were divided into three phases. Phase I was the preparation, phase II was the implementation of the CSVM, and phase III was the data
analysis phase. Each phase is explained in Table 3.17 according to the participant, parent, or researcher’s role, as well as the length of time for each phase.

### Table 3.17. Data Collection Procedures and Timeline

<table>
<thead>
<tr>
<th>Timeline and Roles</th>
<th>Phase I: Preparation</th>
<th>Phase II: Implementation</th>
<th>Phase III: Data Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Participant’s Role</strong></td>
<td>Two Weeks</td>
<td>Three Weeks</td>
<td>Six Weeks</td>
</tr>
<tr>
<td></td>
<td>Attend practice sessions</td>
<td>Complete the pretest</td>
<td>Participate in typical class activities</td>
</tr>
<tr>
<td></td>
<td>Participate in typical class activities</td>
<td>Complete the 12 CSVM modules</td>
<td></td>
</tr>
<tr>
<td><strong>Parent’s Role</strong></td>
<td>Discuss study with the researcher</td>
<td>Communicate with researcher about important changes with child (e.g. medication changes, etc.)</td>
<td>Complete member check with researcher</td>
</tr>
<tr>
<td></td>
<td>Sign consent forms</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Researcher’s Role</strong></td>
<td>Select participants</td>
<td>Administer and score the pretest</td>
<td>Prepare all data</td>
</tr>
<tr>
<td></td>
<td>Discuss study with parents</td>
<td>Video record students participating in the CSVM</td>
<td>Complete descriptive statistics on pre- and posttests, CMAE, and formative assessments</td>
</tr>
<tr>
<td></td>
<td>Add student preferences to CSVM (feedback, reward, etc.)</td>
<td>Watch recording and complete CMAE and observational data</td>
<td>Analyze observational data and record frequencies</td>
</tr>
<tr>
<td></td>
<td>Administer practice sessions</td>
<td>Record formative assessment data on scoring sheets</td>
<td>Conduct inductive analysis on researcher’s journal</td>
</tr>
<tr>
<td></td>
<td>Complete two observations in another classroom environment and one observation in the adapted</td>
<td>Administer and score the posttest</td>
<td></td>
</tr>
<tr>
<td>Timeline and Roles</td>
<td>Phase I: Preparation</td>
<td>Phase II: Implementation</td>
<td>Phase III: Data Analysis</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------</td>
<td>--------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>environmental science room</td>
<td>• Prepare and start researcher’s journal</td>
<td>• Continue researcher’s journal</td>
<td>• Integrate data for both participants separately and then compare both in a joint display</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Observe students in two typical class activities about photosynthesis</td>
<td>• Share findings and complete member checks with parents</td>
</tr>
</tbody>
</table>

**Phase I: Preparation**

The first phase included preparation for the study. First, the participants’ parents were contacted to set up a time to discuss the study. Since my students’ have significant disabilities, I met with the parents in-person to review the study, review and sign the consent forms, and answer any questions they had. The parents were encouraged to keep open lines of communication with me throughout the study so that I could be aware of any major changes the students experienced. Once consent was obtained, I started creating the CSVM. I also arranged a time and place for the students to participate in the CSVM sessions. We completed one practice session with a similar layout, but unrelated module content. This session allowed the students to get used to the CSVM work as part of their daily schedule. I also completed pre-observations including one per student in my adapted environmental science class, in another related arts class (art or library), and in their primary class. I started a researcher’s journal which was used throughout the entire process.
Phase II: Implementation

The implementation phase commenced with the administration and scoring of the pretest. The original plan was to have the students complete one module per day across 27 days; however, the students were demonstrating positive performances on the formative assessments so the module topics were condensed and combined to fit the students’ current levels of performance. I also omitted the week of review at the end because it was clear from the formative assessment scores that the students were making adequate progress and this time could be used for instruction on other topics. The result was a total of 12 modules that spanned across three weeks.

The modules took approximately five minutes each to complete and were scheduled at a time that was best for the student and the primary teacher. My researcher’s journal was used to collect any notes while the students were completing the modules. The students’ performance on formative assessments were recorded on the scoring sheet (see Appendix E) while they completed the assessment. The CMAE and observational notes (see Appendix F) were completed while viewing the recorded CSVM sessions on the same day that the students completed the module. I completed the initial reviews on the same day so that I did not confuse events that occurred on separate days. It should be noted that I returned to these videos later in phase III because I had focused so much on the quantitative data, I needed more rich, thick descriptions that came from a second viewing. It should also be noted that we experienced extreme weather, including tornadoes and snow, which impacted the students’ attendance at school. Once all 12 modules were completed, the participants were administered the posttest (see Appendix D), and it was scored. The implementation phase concluded with one classroom
observation using the CMAE (see Appendix F) in my adapted environmental science class when the students were completing activities about photosynthesis; however, only one of the three participants was present for this lesson.

**Phase III: Data Analysis**

The data analysis phase started with the preparation and organization of all the data. I analyzed the pre- and posttest scores, formative assessments, and the CMAE, and completed descriptive statistics. Next, I analyzed the observational data from the CMAE and created frequencies from the findings. Then, my researcher’s journal was analyzed using inductive analysis. All the data was then integrated for each student separately. Once the data was integrated for each student, I again merged the data for an overall comparison and completed a joint display. This phase concluded with sharing the findings and completing member checks with the parents to ensure the findings accurately represented their children.

**Rigor and Trustworthiness**

Rigor and trustworthiness methods ensured that the findings of the study were accurate, believable, and consistent with the collected data (Merriam, 2009; Shenton, 2004). The validity of the pre- and posttest and formative assessments were validated by experts in the field, and an explanation of this validation process can be found in the data collection and sources section above. The qualitative measures of rigor and trustworthiness included (a) thick, rich descriptions; (b) methodological triangulation; (c) member checking; (d) peer debriefing; and (e) an audit trail.
Thick, Rich Descriptions

As I wrote descriptions of the setting, activities, and participants, I went through great lengths to provide numerous and precise details. Creswell (2014) called this process “rich, thick description” (p. 202) and asserted that it allows the reader to share the experience. In addition, thick, rich descriptions contextualized the study allowing readers to connect their own situations to those of the study (Merriam, 2009). I accomplished this by painting a vivid picture of my students and their specific learning needs, the details of the CSVM and how it was accessed, describing my observations in great detail, using verbatim responses (when possible), and collecting detailed field notes.

Thick, rich descriptions were accomplished in my study in several ways. First, I wrote detailed descriptions of my students’ experiences as they were administered the pre- and posttest. I described their body language, engagement in the assessment, attempts at taking the test (e.g. trying to answer questions versus just touching answers without looking), and other important factors (e.g. medication changes, a change in the schedule, etc.) that influenced their performance on the pre- and posttest. Thick, rich descriptions about the students’ engagement in and reaction to the CSVM and the embedded formative assessments were achieved through anecdotal notes on the CMAE recording sheet. This process led me to an unexpected finding that greatly influenced my study. I used the codes to find patterns in engagement and behavior and their relation to elements of the CMAE and wrote in detail about these patterns. These patterns were also presented in tables and/or graphs for an overall understanding of what occurred. All descriptions included specific examples of reactions, verbal comments (when possible), difficulties, and successes.
Methodological Triangulation

Triangulation is a method utilizing both qualitative and quantitative data to justify emerging themes (Creswell, 2014; Guba, 1981; Shenton, 2004; Yin, 2018). Triangulation allowed qualitative methods to compensate for the limitations and supports the findings of quantitative methods, and vice versa (Mertler, 2017; Shenton, 2004). I triangulated data by converging data from the formative assessment scores, CMAE, and pre- and posttest with data from my qualitative methods including anecdotal notes on the CMAE and researcher’s journal.

Member Checking

Member checking is discussing the accuracy of data and findings collected via interviews and observations with the participants of the study (Lodico et al., 2010; Mertler, 2017). Member checking can be the most important way of ruling out my misinterpretations or misunderstandings, as well as recognizing biases that emerge in my interpretations (Guba, 1981; Maxwell, 2005). In fact, Guba (1981) stated that member checking “is the single most important action inquirers can take, for it goes to the heart of the credibility criterion” (p. 85). Due to the nature of my students’ intellectual disability, their parents were asked to act on their behalf. I also consulted the students’ primary teachers for clarification of questionable behaviors and/or reactions. Before I publicly shared my final product, I shared my major findings or themes with the parents of the students so they could review them for accuracy (Creswell, 2014; Mertler, 2017; Shenton, 2004; Yin, 2018). I shared my findings by sending the parents the completed sections about their particular child. I asked the parents to read my interpretations in
order to determine that what I wrote matches what they think truly portrays their child (Shenton, 2004). I made comments in my document that contained their responses.

**Peer Debriefing**

According to Mertler (2017), “peer debriefing is the act of using other professionals ... who can help you reflect on the research by reviewing and critiquing your processes of data collection, analysis, and interpretation” (p. 143). The questions and input that I received during peer debriefing sessions allowed me to ensure outsiders understand my research, as well as allowed me to separate from my own biases (Guba, 1981; Mertler, 2017; Shenton, 2004). Peer debriefing occurred with my dissertation chair to ensure all data analyses were exhausted. These debriefings with my dissertation chair helped to correct any flaws or answer critical questions (Shenton, 2004). The peer debriefing process occurred at least every other week with my dissertation chair. During that time, I was asked questions that challenged my thinking and assisted me in assuring I was not adding my personal bias into my data analysis.

I also requested my colleagues at SCS to offer feedback since they are detached from the project (Shenton, 2004). Specifically, I asked my colleagues to review data and determine the plausibility of my findings. I sent my colleagues my final draft to review my findings via an emailed document before was published. The students’ primary teachers were specifically requested to participate because they knew the students best in the classroom setting.

**Audit Trail**

An audit trail is a type of documentation that a researcher uses to create a path of evidence detailing how the research was conducted and how data were analyzed and
interpreted (Guba, 1981; Mertler, 2017; Shenton, 2004). I accomplished an audit trail by keeping a researcher’s journal. In my journal, I kept a running account of my actions that included detailed descriptions of data collection, decisions during data analysis, tentative interpretations, as well as my reflections, thoughts, questions, fears, frustrations, victories, and decisions (Guba, 1981; Hatch, 2002; Merriam, 2009).

**Plan for Sharing and Communicating Findings**

Sharing the findings of an action research project is what “helps bridge the divide between research and application” (Mertler, 2017, p. 259). I can share the findings both informally and formally in the local, regional, and/or national contexts (Mertler, 2017). Before I share my research, all information about teachers and students will be protected by following the alternative approach to confidentiality that provides “guidelines to reduce the uncertainty surrounding the use of detailed data that might lead to deductive disclosure” (Kaiser, 2009, para. 22), or when the descriptions of the participants make them identifiable. These guidelines will include a consideration of the audience to which I will present my findings and will consider my participants as part of the audience (Kaiser, 2009). The alternative approach is important to my study because I will not be able to guarantee confidentiality when I present the information at SCS because everyone knows all the students so well; however, I can better guarantee confidentiality when presenting to anyone outside of the school (Kaiser, 2009). I will also protect the participants’ identities by using pseudonyms (Wiles, Crow, Heath, & Charles, 2006). Finally, during the informed consent process, I will discuss my possible audiences and my confidentiality process with the students’ parents so that they understand how I will protect their identities and the identities of the students (Kaiser, 2009).
I plan to share my results with the parents of the participants, as well as other professionals. First, I will create a presentation about my action research project which includes the background information, purpose of my study, a description of the methodology I used, the findings, the conclusions I reached, an action plan, and questions and answers (Mertler, 2017). I will share my presentation with the participants’ parents via a Google Classroom link so they can be comfortable with what I present to others. I will ask the parents if they feel any of the information I have in my presentation could lead to the breach of confidentiality of their children. After I edit the presentation and it is approved by the parents, I will share my results with other professionals.

A presentation will also be shared with both the science and special education departments in my school district. The presentation will include my findings, as well as a how-to session, so teachers can create similar modules. This presentation will also be shared at my district’s summer academy professional development sessions, the Upstate Technology Conference, South Carolina EdTech conference, and South Carolina’s Science PLUS Institute. I will also locate national forums, such as the Association for Educational Communications and Technology (AECT website, 2019), National Association of Special Education Teachers (NASET website, 2007), the Council for Exceptional Children (Council for Exceptional Children website, 2017), and the Journal of Special Education Technology (Sage Journals website, n.d.) in order to further share the findings of my research. At the conclusion of each presentation, I will provide attendees with a Google Classroom link that includes an interactive area where teachers who use the CSVM in their classrooms can provide feedback. I can edit and improve my modules based on this input and republish them to the teachers in the group, as well as
continue in reflection about my work. By engaging in this collaborative and reflective practice, I will be able to give more meaning to my practice, “as well as a heightened level of empowerment” (Mertler, 2017, p. 276) to myself and other teachers.
CHAPTER 4

ANALYSIS AND FINDINGS

The purpose of this action research project was to evaluate the implementation of CSVM with three students with an intellectual disability and autism in an adapted environmental science class to assess their acquisition and application of science vocabulary terms and their engagement in the modules. Two research questions guided this research:

RQ1. How does the implementation of computer-assisted vocabulary modules, which adhere to evidenced-based practices of special education vocabulary instruction, affect the acquisition and application of science vocabulary terms with students with an intellectual disability and autism in an adapted environmental science class?

RQ2. How are the students with an intellectual disability and autism engaged in computer-assisted instruction activities?

This action research study used a convergent parallel mixed methods design to merge quantitative and qualitative findings. To create a clear picture of how the implementation of the CSVM affected the students’ engagement and their knowledge and application of science vocabulary, observations recorded on the CMAE, a pretest and posttest, formative assessment questions, and my researcher’s journal were analyzed. This chapter includes
(a) quantitative methods and findings, (b) qualitative methods and findings, (c) converged findings: individual experiences, and (d) the chapter summary.

**Quantitative Methods and Findings**

The quantitative measures used in my study included the pre- and posttest, formative assessment questions, and observations recorded on the CMAE. This section will provide the overall results from the (a) pre- and posttest, (b) formative assessments, and (c) CMAE. Due to the small number of participants, the internal reliability of the pre- and posttest and formative assessments were not calculated.

**Pre- and Posttest**

I created 10 photosynthesis unit questions to assess the students’ acquisition and application of photosynthesis-related vocabulary terms. The 10 questions were presented via Microsoft® PowerPoint® slides by showing three picture symbol answer choices and having the text read aloud. The pre- and posttests were scored by assigning a 3 if the student answered a question correctly on the first attempt, a 2 if the student needed one choice removed, and a 1 if the student required errorless instruction (when only the correct answer was shown). A total of 30 points was possible for each test. To test the hypothesis that the implementation of the CSVM would affect the knowledge and application of science vocabulary terms with students with intellectual disability and autism in an adapted environmental science class, a descriptive statistical analysis was conducted. The outcomes of the pre- and posttest scores of conceptual knowledge can be found in Table 4.1.
Table 4.1. *Descriptive Statistics of the Pre- and Posttest*

<table>
<thead>
<tr>
<th>Question</th>
<th>Charlie Pre-test</th>
<th>Charlie Posttest</th>
<th>Peyton Pre-test</th>
<th>Peyton Posttest</th>
<th>Riley Pre-test</th>
<th>Riley Posttest</th>
<th>M (SD) Pre-test</th>
<th>M (SD) Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2.00 (1.00)</td>
<td>2.33 (1.16)</td>
</tr>
<tr>
<td>Q2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2.00 (1.00)</td>
<td>2.67 (0.58)</td>
</tr>
<tr>
<td>Q3</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2.00 (1.00)</td>
<td>2.33 (1.16)</td>
</tr>
<tr>
<td>Q4</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1.67 (0.58)</td>
<td>1.67 (0.58)</td>
</tr>
<tr>
<td>Q5</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2.33 (0.58)</td>
<td>2.67 (0.58)</td>
</tr>
<tr>
<td>Q6</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1.33 (0.58)</td>
<td>2.67 (0.58)</td>
</tr>
<tr>
<td>Q7</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2.00 (0.58)</td>
<td>2.67 (0.58)</td>
</tr>
<tr>
<td>Q8</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2.33 (1.00)</td>
<td>3.00 (0.00)</td>
</tr>
<tr>
<td>Q9</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2.00 (1.16)</td>
<td>2.67 (0.58)</td>
</tr>
<tr>
<td>Q10</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2.33 (1.00)</td>
<td>3.00 (0.00)</td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>27</td>
<td>19</td>
<td>23</td>
<td>18</td>
<td>27</td>
<td>20.00 (2.65)</td>
<td>25.67 (2.31)</td>
</tr>
</tbody>
</table>

*Note.* Q = question.
All three students improved their scores from the photosynthesis pretest to the photosynthesis posttest. Peyton improved from 63.33% on the pretest to 76.67% on the posttest, Riley improved from 60.00% on the photosynthesis pretest to 90.00% on the photosynthesis posttest, and Charlie improved from 76.67% on the photosynthesis pretest to 90.00% on the photosynthesis posttest. When looking at the individual test questions, Question 4 (see Figure 4.1) on the posttest was the most problematic for the students. This question asked what a plant needs to make food and had the answer choices of sun, blocks, and sticks. The correct answer was sun; however, the picture symbol of blocks was in the middle and was bright and multi-colored.

![What does a plant need to make food?](Figure 4.1. Sample of posttest Question 4 and the brightly colored blocks answer. Picture symbols from SymbolStix®, Copyright 2019, SymbolStix, LLC. All rights reserved. Used with permission.)

There were not any questions on the pretest answered correctly by all three students. However, all three students answered Questions 8 and 10 correctly on the posttest (see Table 4.2 for the questions and vocabulary words assessed). These questions
asked the students to identify what a plant needs to grow and in what part of the plant the food is made. When analyzing the formative assessment questions in the modules these topics were presented, the students scored all 2s and 3s with percentages of 88.89% (Questions 11 and 26; Modules 3 and 5 respectively) and 100% (Question 55; Module 12) which demonstrated acquisition of these concepts. The CSVM covered these topics in multiple modules, using several modalities such as educational videos and songs, models, and simulations.

Table 4.2. Pre- and Posttest Questions and Vocabulary Words Assessed

<table>
<thead>
<tr>
<th>Number</th>
<th>Question</th>
<th>Vocabulary Word(s) Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What does a plant need to live?</td>
<td>Plant</td>
</tr>
<tr>
<td>2</td>
<td>What else does a plant need to live?</td>
<td>Plant</td>
</tr>
<tr>
<td>3</td>
<td>What type of air does a plant need?</td>
<td>Carbon Dioxide</td>
</tr>
<tr>
<td>4</td>
<td>What does a plant need to make food?</td>
<td>Plant, Food</td>
</tr>
<tr>
<td>5</td>
<td>What is photosynthesis?</td>
<td>Photosynthesis</td>
</tr>
<tr>
<td>6</td>
<td>A chemical reaction is when two things…</td>
<td>Chemical Reaction</td>
</tr>
<tr>
<td>7</td>
<td>Which picture shows photosynthesis?</td>
<td>Photosynthesis</td>
</tr>
<tr>
<td>8</td>
<td>What does a plant need to grow?</td>
<td>Plant, Growth</td>
</tr>
<tr>
<td>9</td>
<td>How does a plant make food?</td>
<td>Photosynthesis</td>
</tr>
<tr>
<td>10</td>
<td>What part of the plant is food made in?</td>
<td>Leaf, Food</td>
</tr>
</tbody>
</table>

Three questions on the pre- and posttest specifically asked about photosynthesis, while the other questions examined knowledge of vocabulary terms needed to understand the photosynthesis process. Of the photosynthesis questions (Question 5, Question 7, Question 9), Riley answered all three of the questions correctly on the posttest, while Charlie answered two correctly on the first attempt and one on the second attempt, and Peyton answered one correctly on the first attempt and the other two with second attempts. Comparing the pretest to the posttest for these three photosynthesis questions, Riley made the most improvement in answering questions 5, 7, and 9 about
photosynthesis, by increasing their total score for those questions from 5 to 9. Peyton’s score for these three questions remained the same from the pretest to the posttest with a total score of 7. Charlie improved one point by increasing their total from 7 on the pretest to 8 on the posttest. Overall, these scores showed that the CSVM positively impacted the students’ knowledge of photosynthesis when they were engaged in lessons about vocabulary words related to the topic.

**Formative Assessments**

The formative assessments were made up of questions that were presented at the end of each CSVM module. Before the students answered the formative assessment questions, they were given the identical questions using errorless instruction during a practice session. The term *errorless learning* has been defined as the use of response-prompting procedures that limit errors and incorrect responses (Collins, 2012; Fish, Manly, Kopelman, & Morris, 2015). Errorless instruction was used because it had been found by multiple researchers to be an effective method to eliminate guessing and improve retention of information for students with disabilities (Cohen et al., 2010; Fish et al., 2015; Jones & Eayrs, 1992). In this study, errorless instruction was used by placing a large green box around the correct answer and not allowing the screen to advance or change until the student touched the correct answer choice (see Figure 4.2 for an example). Some of the formative assessment questions involved touching a part of a model when asked, while the others involved making a choice from a field of three picture symbols to answer a question or fill in a blank. The formative assessment provided data on (a) further educational planning, (b) areas of need, and (c) areas of success.
Further educational planning. The results of the formative assessment questions were used to make educational decisions about the upcoming modules. As shared by Black and Wiliam (2009), formative assessment allows a teacher to determine where the students are, where they are going, and what needs to be done to get the students where they need to be. According to Wiliam and Leahy (2015), the decision to make these changes were justified because formative assessment should have instant feedback, benefit the students immediately, and change instruction if it helps the students learn. While obtaining true feedback from students who are not able to verbalize their learning can be difficult, Aidonopoulou-Read (2019) found body language to be an indication of the students’ learning and engagement in learning.

Originally, I had planned to do a month’s worth of modules, but the students were progressing well, so I significantly cut the number of modules used from 27 to 12. I combined topics into modules instead of having a module for each individual topic and
combined five modules of review into two modules. Overall, this decision was confirmed valid based on the body language of the students (Aidonopoulou-Read, 2019). As the students completed more modules, I observed they were not as enthusiastic during the last few modules. This lack of enthusiasm was also reflected by how quickly they left the work area when finished, when compared to when they first started the modules. The decision to cut modules was also supported by the students’ positive performance on the posttest.

**Areas of need.** Table A.1 located in Appendix G shows an outline of the questions, the modules the questions appeared, the type of questions, the students’ scores, and the overall total score for all participants. Of the 60 formative assessment questions, only four questions proved problematic for all three participants. The most problematic question (55.56% accuracy) appeared in Module 9 and asked, “What gas do plants give out?” with the correct answer on the left. Peyton scored 1, while Riley and Charlie scored 2 on this question. Interestingly, all three students answered the other two questions in this module with 100% accuracy. Due to this discrepancy, I examined the order of the answers and the placement of the correct answers (see Figure 4.3). Both Peyton and Riley chose CO₂ for their answer first (Charlie chose H₂0), which could lead one to believe they were simply choosing the answer in the middle for all three questions. It should also be noted the correct answer was on the left and the students only answered correctly on 18 of 86 (20.93%) first attempts, four of 30 (13.33%) second attempts, and nine of 17 (52.94%) third attempts when the correct answer was located on the left (see Table 4.3).
Figure 4.3. Formative assessment questions from Module 9. Picture symbols from SymbolStix®, Copyright 2019, SymbolStix, LLC. All rights reserved. Used with permission.
Table 4.3. *Summary of Location of the Correct Answers and Attempts to Answer on the Pre- and Posttest and Formative Assessment*

| Source  | Attempt | Location | Charlie | | | Peyton | | | Riley | | | Total | | | M (SD) |
|---------|---------|----------|---------| | | | | | | | | | | | |
|         |         | A | % | A | % | A | % | A | % | A | % | M (SD) |
| Pretest | First   | Left | 1 | 20.00% | 2 | 66.67% | N/A | N/A | 3 | 27.27% | 2.00 (0.82) |
|         | Middle  | 2 | 40.00% | 1 | 33.33% | N/A | N/A | 3 | 27.27% | 1.50 (0.50) |
|         | Right   | 2 | 40.00% | N/A | N/A | 3 | 100% | 2 | 18.18% | 2.50 (0.50) |
|         | Left    | 2 | 50.00% | 2 | 66.67% | N/A | N/A | 4 | 44.44% | 2.00 (0.00) |
|         | Second  | Middle | 1 | 25.00% | 1 | 33.33% | 2 | 100% | 4 | 44.44% | 1.33 (0.47) |
|         | Right   | 1 | 25.00% | N/A | N/A | N/A | N/A | 1 | 11.11% | 1.00 (0.00) |
|         | Left    | 1 | 100% | N/A | N/A | 4 | 80.00% | 5 | 50.00% | 2.50 (0.50) |
|         | Third   | Middle | N/A | N/A | 1 | 25.00% | 1 | 20.00% | 2 | 20.00% | 1.00 (0.00) |
|         | Right   | N/A | N/A | 3 | 75.00% | N/A | N/A | 3 | 30.00% | N/A |
|         | Left    | 1 | 14.29% | 3 | 60.00% | 1 | 14.29% | 5 | 26.31% | 1.67 (0.94) |
|         | Second  | Middle | 3 | 42.86% | N/A | N/A | 3 | 42.86% | 6 | 31.58% | 3.00 (0.00) |
|         | Right   | 3 | 42.86% | 2 | 40.00% | 3 | 42.86% | 8 | 42.11% | 2.67 (0.47) |
|         | Left    | 3 | 100% | 1 | 33.33% | 2 | 100% | 6 | 75.00% | 2.00 (0.82) |
|         | Posttest | Second | Middle | N/A | N/A | 2 | 66.67% | N/A | N/A | 2 | 25.00% | N/A |
|         | Right   | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
|         | Left    | N/A | N/A | N/A | N/A | 1 | 100% | 1 | 33.33% | N/A |
|         | Third   | Middle | N/A | N/A | 1 | 50.00% | N/A | N/A | 1 | 33.33% | N/A |
|         | Right   | N/A | N/A | 1 | 66.67% | N/A | N/A | 3 | 27.27% | N/A |
Charlie

Peyton

Riley

Total

<table>
<thead>
<tr>
<th>Source</th>
<th>Attempt</th>
<th>Location</th>
<th>Charlie A</th>
<th>%</th>
<th>Peyton(^a) A</th>
<th>%</th>
<th>Riley A</th>
<th>%</th>
<th>Total A</th>
<th>%</th>
<th>M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left</td>
<td>First</td>
<td>4</td>
<td>14.29%</td>
<td>8</td>
<td>32.00%</td>
<td>6</td>
<td>18.18%</td>
<td>18</td>
<td>20.93%</td>
<td>6.00 (1.63)</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>First</td>
<td>11</td>
<td>39.29%</td>
<td>11</td>
<td>44.00%</td>
<td>16</td>
<td>48.48%</td>
<td>38</td>
<td>44.19%</td>
<td>12.67 (2.36)</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>First</td>
<td>13</td>
<td>46.43%</td>
<td>6</td>
<td>24.00%</td>
<td>11</td>
<td>33.33%</td>
<td>30</td>
<td>34.88%</td>
<td>10.00 (2.94)</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>Second</td>
<td>1</td>
<td>8.33%</td>
<td>1</td>
<td>14.29%</td>
<td>2</td>
<td>18.18%</td>
<td>4</td>
<td>13.33%</td>
<td>1.33 (0.47)</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>Second</td>
<td>9</td>
<td>75.00%</td>
<td>2</td>
<td>28.57%</td>
<td>4</td>
<td>36.36%</td>
<td>15</td>
<td>50.00%</td>
<td>5.00 (2.94)</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>Second</td>
<td>2</td>
<td>16.67%</td>
<td>4</td>
<td>57.14%</td>
<td>5</td>
<td>45.45%</td>
<td>11</td>
<td>36.67%</td>
<td>3.67 (1.25)</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>Third</td>
<td>6</td>
<td>100%</td>
<td>1</td>
<td>11.11%</td>
<td>2</td>
<td>100%</td>
<td>9</td>
<td>52.94%</td>
<td>3.00 (2.16)</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>Third</td>
<td>N/A</td>
<td>N/A</td>
<td>3</td>
<td>33.33%</td>
<td>N/A</td>
<td>N/A</td>
<td>3</td>
<td>17.65%</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>Third</td>
<td>N/A</td>
<td>N/A</td>
<td>5</td>
<td>55.56%</td>
<td>N/A</td>
<td>N/A</td>
<td>5</td>
<td>29.41%</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Note. A = actual number answered; % = percentage correct.

\(^a\) Peyton’s total number of formative assessment test questions was different due to missing Modules 11 and 12.
The next two most problematic questions (“Touch the roots.” “Which picture shows a plant?”) had an average of 61.11% accuracy and appeared in Modules 2 and 5. The methods used in Modules 2 and 5 included Frayer models and an educational song. It should be noted that Modules 5 was a review module, so it repeated what was in Module 2. These two questions each contained touch-the-model and multiple-choice questions, so it could be determined the type of question was not a factor. While the students struggled with these two questions, Charlie and Riley improved at least 1 point from Module 2 to Module 5. This finding could confirm that repetition is important for students with significant learning needs (Coleman-Martin et al., 2005). Overall, when looking at the Module 5 answers, only Charlie scored 1 for the question, “Which picture shows a plant?” The correct answer was on the left, and Charlie struggled with questions where the correct answer was on the left (11 questions total) as reflected by answering only four of 11 (36.36%) correctly on attempt one and one of 7 (14.29%) on attempt two; therefore, requiring six errorless instruction presentations (see Table 4.3).

**Areas of success.** When examining all formative assessment questions to determine if the implementation of CSVM affected the knowledge and application of science vocabulary terms with students with an intellectual disability and autism in an adapted environmental science class, a descriptive statistical analysis was conducted. Eight questions had a 100% average score, with one question appearing in two different modules. Of these eight questions, five were multiple-choice questions and three were touch-the-model questions. It should be noted that only two participants answered the touch-the-model questions and two of the five multiple-choice questions (Peyton was absent and therefore did not complete the module). The questions answered with 100%
accuracy by all three students were in Modules 7 and 9 and by two students in Module 12. The methods used in these modules included Frayer models (Module 7), simulations (Modules 9 and 12), video simulations (Module 12), and educational songs (Module 12). Of the five multiple-choice questions, four contained the correct answer in the middle. Only one question, “Which picture shows convert?” appeared in two modules.

Four questions had a 94.44% average score across participants. These four questions included three fill-in-the-blank questions and one touch the model question. The modules that contained these questions included Modules 2, 4, 5 (review module), 6, 7, and 10 (review module). These modules used Frayer models (Modules 2 and 7), an educational song (Module 2), an educational video (Module 4), and concept maps (Modules 4 and 6). The three fill-in-the-blank questions had the correct answer positioned in the middle (2) or left (1). All of the questions with 94.44% accuracy appeared in two modules, with one participant per module scoring a 2. Peyton improved from a 2 to a 3 on the fill-in-the-blank question asking, “Convert means something _.” Riley decreased from a 3 to 2 from the original module to the review module on the fill-in-the-blank question “The organelle in a plant is called __.” Charlie increased from a 2 to a 3 on two questions including “Touch the flower” and “Energy is the ability to do ___”

**Summary of formative assessment findings.** Based on the findings in my study, it could be concluded that simulations were the most successful with the students. My findings support previous research that simulations allowed students to see abstract concepts (Israel et al., 2013) and gain conceptual understanding (Mechling et al., 2003; Mechling et al., 2005). Previous research also found that multimodal formats have shown
great success for the acquisition of content knowledge for students with significant intellectual disability (Bosseler & Massaro, 2003; Hasselbring et al., 2000; Saad et al., 2015; Weng et al., 2014; Whitby et al., 2012). Based on the positive results from Module 12, my study could confirm these findings. It could be concluded that a combination of educational songs and simulations was the most successful; however, only two students completed this module.

Interestingly, Modules 2 and 6 had a mix of successful and unsuccessful formative assessment answers. Module 2 used a Frayer model and an educational song. Module 2 contained six questions, with accuracy ranging from 61.11% to 94.44% (see Table A.2 in Appendix H). Module 6 used a concept map. Module 6 contained three questions with one question averaging 94.44% accuracy, one averaging 77.78%, and one question averaging 66.67% accuracy (see Table A.2 in Appendix H). This finding could demonstrate the need to evaluate these two modules further by adding stronger instructional methods.

Another interesting finding was the students were most successful when the correct answer choice was in the middle (44.19% accuracy on the first attempt and 50.00% on the second attempt) and least successful when the answer choice was on the left (20.93% on the first attempt and 13.33% on the second attempt; see Table 4.3 above). According to their primary teachers, when presented with only two answer options, all three students usually choose the picture on their right first. Coincidentally, none of the questions with 100% or 94.44% accuracy had the correct answer positioned on the right. This finding may show the students were attempting to find the correct answer but were used to only two answer choices, so they answered in the middle.
Finally, the results demonstrated the type of question asked (multiple-choice, fill-in-the-blank, or touch-the-model) did not affect the students’ success in answering. The most and least successful questions in the formative assessment were made up of a mix of the three formats of questions; therefore, the question format did influence the students’ abilities to answer. This finding was surprising because the students had been exposed the most to multiple-choice questions in all of their classes.

**Classroom Measure of Active Engagement**

The CMAE was divided into five categories and nine descriptors. The authors of the CMAE provided three types of data yields including (a) the percentage of time, (b) the number of instances, and (c) the duration of time (Sparapani et al., 2016). This measure was used in conjunction with recorded observations because, according to Merriam (2009), videotapes allow for all-inclusive interpretation of students’ actions.

I used descriptive statistics including percentages and frequency counts because my goal was to summarize the data collected and determine patterns that emerged (Lodico et al., 2010). For the purposes of this study, the duration of time measurements were calculated using descriptive statistical analysis as percentages because the amount of time engaged in each CSVM component and module were different. To determine the mean number of seconds and the standard deviation for each emotional regulation, productivity, independence, responding, and flexible, a descriptive statistical analysis was conducted. Flexible behavior was calculated as the percentage for each student because there were not many opportunities for students to display flexible behavior. Finally, to determine the total amount of occurrences of eye gaze, directed communication, and
generative language, frequency counts were counted. A summary of these findings can be found in Table A.2 in Appendix H.

**Qualitative Methods and Findings**

I collected qualitative data from the anecdotal notes of the CMAE during CSVM observations, as well as from notes made in my researcher’s journal. This section includes descriptions of the (a) purpose of the qualitative data analysis, (b) first cycle coding, (c) code mapping, (d) second cycle focused coding, (e) themes and assertions developed, (f) findings, and (g) qualitative accuracy.

**Purpose of Qualitative Data Analysis**

The purpose of the qualitative data analysis was to develop outcomes that allowed me to share my students’ experiences while participating in the CSVM implementation. I started the process by typing the anecdotal notes from the CMAE into a document for each student and my researcher’s journal notes into another document. After realizing I had focused too much on the quantitative data parts of the CMAE, I completed a second review of the video taking more detailed anecdotal notes and adding these details to the previous anecdotal notes. I made sure to delineate the actual observations from my reflections by color-coding my notes with blue for observations and red for reflections. Before starting the coding process, I reviewed the typed documents for accuracy with my hand-written notes from my journal. These documents were then coded using two cycles.

**First Cycle Coding**

First, transcripts for each participant were loaded into Delve (n.d.) and I used a sentence by sentence unit of analysis for all of the coding methods. The first coding lens I used was *protocol coding* (Saldaña, 2016), which involved using the pre-established
codes, or a priori codes, in the CMAE to code my observations. The protocol codes included codes such as formative assessment, t-charts, responding, emotional regulation, etc. Next, I used process coding which coded all the action words in the transcripts, focusing on words ending in -ing (Bogdan & Biklen, 2007; Saldaña, 2016). The process codes included codes such as laughing, smiling, dancing, etc. Finally, I used structural coding to code the elements of instruction that were implemented (Saldaña, 2016). Examples of structural coding included teacher ignoring, teacher used stern voice, use of a model, etc. See Table 4.4 for a summary of the qualitative data sources used, codes applied, and word count, as well as Figure 4.1 for an example of coding completed in Delve (n.d).

Table 4.4. Summary of Qualitative Data Sources, Codes Applied, and Word Count

<table>
<thead>
<tr>
<th>Types of Qualitative Data Sources</th>
<th>Number</th>
<th>Total Number of Codes Applied</th>
<th>Word Count per Transcript</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMAE anecdotal notes</td>
<td>3</td>
<td>92</td>
<td>17,269</td>
</tr>
<tr>
<td>Researcher’s journal</td>
<td>1</td>
<td>10</td>
<td>963</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
<td>102</td>
<td>18,232</td>
</tr>
</tbody>
</table>

**Code Mapping**

After the first cycle of coding, I used code mapping to sort codes into categories (Saldaña, 2016), making analytic memos of my thoughts as I progressed (Stuckey, 2015; Thomas 2006). I created the code map using sticky notes to move codes into categories. I started by organizing the codes according to the coding process used (see Figure 4.5). I then moved the sticky notes into stacks of codes that were related (see Figure 4.6). During this process, I was careful to use inductive reasoning as the organization of the CMAE would pull me in the direction of deductive reasoning. To do so, I set aside all the
codes that applied to the CMAE organization (i.e. emotional regulation, productivity, etc.) and sorted them last. This process led me to a total of 102 codes.

Figure 4.4. Example of coding completed in Delve (n.d.).

**Second Cycle Focused Coding**

Next, I completed second cycle coding by using focused coding to revisit codes without being distracted by “their properties and dimensions” (Saldana, 2016, p. 240) to condense categories into themes. I completed this second cycle of coding by developing an outline in a Google document and using the comments feature for analytic memoing (see Figure 4.7). After completing the outline, I labeled each stack of sticky notes with the category in which they were subsumed (see Figure 4.8). Also, during this time, I contacted the students’ primary teachers to confirm my thinking on some of the codes I created. For example, the code *swatting at the teacher* was originally under the category
of negative emotional regulation but after talking with the teacher it was moved to the category of attention seeking.

Figure 4.5. Sample of codes laid out according to the type of coding process used.
Figure 4.6. Example of codes in stacks with similar codes.

Figure 4.7. Sample of the list of codes organized by categories and analytic memos.

Figure 4.8. Example of labeling code stacks with the category.
Themes and Assertion Developed

I originally had four themes including: (1) difficulties with instruction due to autism, (2) teaching methods used, (3) participation, and (4) communication. After reflecting and engaging in conversations with colleagues, I realized that communication is part of the learning challenges attributed to autism. I also struggled with the concept of participation and the fact that participation is part of the difficulties with autism but is also showing the overall picture of the students’ difficulties due to autism and its effect on the teaching methods used. After talking this out with others, I realized that participation needed to be separate because it was the big picture of what I wanted to measure. I then engaged in peer debriefing with my chairperson to determine the best wording for my themes. From this, three themes emerged including: (1) the students’ learning challenges attributed to autism, (2) instructional methods used in the CSVM and by the teacher, and (3) the students’ active engagement in the CSVM. Finally, I looked at how the themes fit together and developed the assertion that the students’ learning challenges attributed to autism and the instruction provided, affected the students’ active engagement in the CSVM.

Findings

The findings of the qualitative analysis resulted in one assertion and three themes (see Table 4.5 for evidence examples from the coding process). The assertion was that students’ learning challenges attributed to autism and the instructional methods used in the CSVM and by the teacher affected the students’ active engagement in the CSVM. This assertion subsumed the three themes: (1) students’ learning challenges attributed to
Table 4.5. Evidence Examples from the Coding Process

<table>
<thead>
<tr>
<th>Assertion</th>
<th>Themes</th>
<th>Categories</th>
<th>Evidence Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students’ learning challenges attributed to autism and the instructional</td>
<td>Students’ learning challenges attributed</td>
<td>Emotional regulation</td>
<td>• The module started, and Charlie leaned over watching and said, “Noooo, nooo, nooo.”</td>
</tr>
<tr>
<td>methods used in the CSVM and by the teacher affected the students’ active</td>
<td>to autism.</td>
<td></td>
<td>• Charlie answered the next question correctly, smiled, and then started to stim.</td>
</tr>
<tr>
<td>engagement in the CSVM.</td>
<td></td>
<td></td>
<td>• Peyton put head in their right hand and covered eyes.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flexibility of attention</td>
<td>• Peyton looked at their hands and moved their fingers on their left hand (stimming).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>when changes or distractions</td>
<td>• They got up and grabbed their shoes and shoved them in my face.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>occur</td>
<td>• When the model showing convert was being filled out, Riley was still at times and would only stim a little.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Charlie watched the simulation but looked across the hall a few times (the student across the hall was still being loud).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• During the simulation, Peyton looked from the Apple® iPad®, to the table, then around the room.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• A student in the hall was making loud whooping noises and eventually walked by the room, but Riley did not notice.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Communication</td>
<td>• During the last question, Charlie was teasing me by looking at me and pointing over and over to the hall.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Charlie said, “Jamie, get Lisa.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• On the second and third question, Peyton looked at me before they were supposed to answer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Peyton looked at me and I told them it was okay.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Riley acted like they were going to push something off the table and looked at me while they did it.</td>
</tr>
<tr>
<td>Assertion</td>
<td>Themes</td>
<td>Categories</td>
<td>Evidence Examples</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>-------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>the CSVM and by the teacher affected the students’ active engagement in</td>
<td>The instructional methods used in the CSVM and by the teacher</td>
<td>Instructional methods</td>
<td>• When it was time to complete the web, I had to prompt Peyton to click.</td>
</tr>
<tr>
<td>the CSVM.</td>
<td></td>
<td></td>
<td>• Peyton required prompts (pointing) to click on the pictures to complete the models/diagrams.</td>
</tr>
<tr>
<td>Students’ learning challenges attributed to autism and the instructional</td>
<td>The instructional methods used in the CSVM and by the teacher</td>
<td></td>
<td>• We completed the Frayer model with HOH. Riley was very cooperative while doing so.</td>
</tr>
<tr>
<td>methods used in the CSVM and by the teacher</td>
<td></td>
<td></td>
<td>• Riley laid their head down on the Apple® iPad® again during the reading passage – twice.</td>
</tr>
<tr>
<td>affected the students’ active engagement in the CSVM.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The instructional methods used in the CSVM and by the teacher</td>
<td>Teacher reactions</td>
<td></td>
<td>• Charlie answered the question correctly and I patted them on the back (during whole class lesson).</td>
</tr>
<tr>
<td>The instructional methods used in the CSVM and by the teacher</td>
<td></td>
<td></td>
<td>• I would not look at or make eye contact with Charlie because they were more likely to talk to me if I did.</td>
</tr>
<tr>
<td>Difficulties with technology</td>
<td></td>
<td></td>
<td>• I had to tell Peyton to click on the pictures on the Frayer model each time.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• I said, “Riley, please stop.”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Riley tried to swat at my face, but I ignored it.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• All the touch the model questions were hard to click (from researcher’s journal).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Charlie – the video would not connect through the Microsoft® PowerPoint® and I had to start the video from my</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>computer. This caused a pause because I had to search for the video and play it from YouTube (from researcher’s journal).</td>
</tr>
<tr>
<td>Assertion</td>
<td>Themes</td>
<td>Categories</td>
<td>Evidence Examples</td>
</tr>
<tr>
<td>-----------</td>
<td>--------</td>
<td>------------</td>
<td>-------------------</td>
</tr>
</tbody>
</table>
| Students’ learning challenges attributed to autism and the instructional methods used in the CSVM and by the teacher affected the students’ active engagement in the CSVM. | The students’ active engagement in the CSVM. | Productivity and Independence<sup>a</sup> (positive and negative examples) | • The module said to touch the picture of photosynthesis and Charlie did so immediately.  
• Charlie smiled and then continued to work.  
• During the FA section, Charlie needed slight assistance due to the Apple® iPad® not registering their touch on all the questions and prompts to answer when they were supposed to.  
• When asked which one shows a plant, Peyton immediately picked it and smiled – they seemed very sure of their answer.  
• Peyton required prompts to touch the pictures to make the chemical reaction simulation.  
• Riley needed prompts to touch the picture.  
• Riley would answer when I held my hand out for him to touch the Apple® iPad®.  
• Riley was still the rest of the video and leaned over and looked closely.  
• Riley tried very hard to answer independently on the last few questions.  

The students’ active engagement in the CSVM. | Patterns in answering | • Charlie – Module 6 – they were always picking right to left on the formative assessment.  
• Charlie – they always went directly to the green highlight on the practice questions.  
• Peyton – Module 5 – chose left to right on all but questions 8 and 11.  
• Riley – they always picked the answer on the right. |

<sup>a</sup> It should be noted that productivity and independence were very much alike. When scored quantitatively, independence was the time the students were independent in their productivity.

Note. Evidence is verbatim from my anecdotal notes with the exception of gender-neutral pronouns and the insertion of student names. HOH = hand-over-hand; FA= formative assessment.
autism, (2) the instructional methods used in the CSVM and by the teacher, and (3) the students’ active engagement in the CSVM.

**Theme one: Students’ learning challenges attributed to autism.** Sparapani et al. (2016) compiled previous research to identify the specific challenges students with autism experience when engaging in the school environment. Specifically, they found five factors including (1) emotional regulation, (2) classroom participation, (3) social connectedness, (4) initiating communication, and (5) flexibility. Because I used inductive reasoning to develop the themes, theme one did not encompass all five factors but instead included (a) emotional regulation, (b) flexibility, and (c) communication.

**Emotional regulation.** The codes that were used to describe situations in which the students were not well-regulated included: (a) covering eyes, (b) eloping, (c) grabbing teacher, (d) inappropriately touching items, (e) laying head down, (f) pushing chair, (g) taking shoes off, (h) swatting at the teacher, (i) throwing, (j) turning off, and (k) fist bump. Codes that demonstrated positive emotional regulation included (a) sat quietly and (b) stimming. It should be noted that stimming was included as a positive emotional regulation tool because the student was self-calming or self-soothing. Overall, the three participants remained in a well-regulated state during most the CSVM implementation demonstrating that the CAI-based CSVM had positive results on the students’ emotional regulation.

**Flexibility.** Flexible behaviors and flexible attention are two ways flexibility was referenced in this study. Flexible behaviors were how the students responded to distractions and changes in their environment. All three students continually exhibited flexible behavior during the CSVM implementation, meaning the students participated in
the CSVM tasks despite any changes in the setting, time of day, or overall schedule. On
the other hand, all three students struggled with flexible attention, meaning the students
would turn their attention away from the CSVM to attend to distractors. The distractions
included adults entering my classroom, the custodian cleaning my classroom, and adults
and students in the hallway.

**Communication.** For the purposes of this theme, I grouped eye gaze, responding
(to an adult directive), directed communication, and generative language because they
showed how the students used receptive and expressive language. As shared by Ramdoss,
Mulloy, et al. (2011), students have few opportunities to practice communication skills
while participating in CAI. This research finding was evident in the few codes generated
(16 of 120) from the observations. Of these 16 codes, 10 were included under generative
language including (a) *attention seeking*, (b) *clapping*, (c) *dancing*, (d) *kissing*, (e)
*laughing*, (f) *pretending*, (g) *smiling*, (h) *scratching*, (i) *touching the teacher*, and (j)
*yelling/noise making*. With two students being nonverbal and effective communication
overall being a challenge for students with autism (Sparapani et al., 2016), how
communication codes were experienced by the participants varied greatly. As found in
their individual experiences (see below), some types of communication were the students
showing their reactions to the CSVM components (i.e. *dancing to a song* to show
enjoyment) or seeking my assistance (i.e. *looking at me* to determine if it was time to
answer a question). Overall, the students’ eye gazes, responses, directed communication,
and generative language were used to describe the overall student experience.

**Theme two: Instructional methods used in the CSVM and by the teacher.**
Theme two, instructional methods used in the CSVM and by teacher, encompassed the
categories of (a) the components of the CSVM, (b) my reactions to the students’ wants and needs, and (c) technical difficulties.

**Components of the CSVM.** Research has shown that students with learning disabilities struggle with the acquisition of vocabulary words due to the terms being technical, multimorphemic, nominalized, and having multiple meanings (Rice & Deshler, 2018) and called for the direct and deliberate teaching of vocabulary terms (Dzulkifli et al., 2016). In this study, the direct and deliberate teaching of vocabulary terms was accomplished by using (a) evidence-based practices for vocabulary instruction, (b) graphic organizers, and (c) CAI components, which were encompassed in the components of the CSVM category. Specifically, this category was developed using multiple protocol codes. Evidence-based practices for vocabulary instruction were found to include errorless learning, mnemonic strategies, and graphic organizers (Stevenson et al., 2016), as well as direct instruction and CAI (Jitendra et al., 2004). The specific graphic organizers used in this study included (a) t-charts, (b) Frayer models, and (c) cognitive/word maps. The specific direct instruction method used included errorless learning. Finally, the CAI components included in the CSVM were (a) educational videos, (b) educational songs, and (c) applause feedback.

**Teacher reactions to students’ wants and needs.** Researchers suggested that a teacher should participate in dialogue with students while they participate in CAI to avoid restricting the students’ social development (Ramdoss, Mulloy, et al., 2011). Despite this suggestion, I attempted to remain unengaged from the students during the CSVM implementation so that I could best measure the students’ independence. Still, I did have to engage with the students’ wants and needs at times so they could complete the
modules. My engagement was coded as (a) *answering student questions*, (b) *no assistance*, (c) *prompting*, (d) *redirecting*, (e) *restating questions*, (f) *stern voice*, and (g) *teacher ignoring student*. These codes provided a lot of information about the students’ productivity and independence because I could determine how many times I had to prompt the students to attend to the CSVM tasks. I could also use these codes to determine the cause of a student’s emotional irregularity. Overall, my reactions to the students’ wants and needs and how they impacted the students’ behavior and engagement helped to provide a more detailed student experience.

*Technical difficulties.* Research found that the difficulties with using CAI with students with intellectual disability and autism were found to be the time to create (Coleman-Martin et al., 2005; McKissick et al., 2018) and the teachers’ readiness to use the tools that were developed (Ö zgüç & Cavkaytar, 2016). While not specifically researched, I did find that the CSVM took me considerable time to create and would be difficult to make in a typical class instruction planning session. The main difficulty experienced in this study was when the students’ *touches were not registered* and resulted in a pause in the CSVM. Two of three students struggled with their touch registering on the Apple® iPad®, which caused productivity and independence issues. I often had to click their answer on my laptop to get the module to advance forward. I even had to stop Charlie several times to wipe their fingers off, which was distracting from the CSVM. This also often interfered with the applause feedback as the feedback was not given immediately after the student touched their answer.

*Theme three: The students’ active engagement in the computerized science vocabulary modules.* Many studies have found that students with an intellectual
disability and autism have low engagement in their educational environment (Moreira et al., 2015; Ruble & Robson, 2007; Sparapani et al., 2016); however, additional studies have shown that the use of CAI improved active engagement (Chen et al., 2019; Moore & Calvert, 2000; Stasolla et al., 2016). Specifically, Chen et al. (2019) found that the use of CAI allowed students to be more engaged because it removed the aversiveness of social interactions. Theme three included the exploration of these findings through the lens of the students’ (a) productivity and independence, and (b) patterns in answering.

**Productivity and independence.** The students’ productivity was measured using the codes *positive productivity* and *negative productivity*, with related subcodes. The students were recorded as positively demonstrating productivity when they (a) answered questions, (b) appropriately touched items, (c) gluing, (d) listening to song, (e) making choices, and (f) watching. The students were recorded as negatively demonstrating productivity when they (a) were looking around, (b) staring off, (c) touching too soon, and (d) turning around. The students’ independence was noted by indicating the times the students did not require my assistance.

**Patterns in answering.** An unexpected finding in this study was the change in the students’ methods of answering questions. Often students with an intellectual disability and autism will have a positional preference, or make choices on the same side, so it is important to control for positional preference and analyze the participants’ patterns in answering (Fleming et al., 2010). When students abandon their positional preference, it could demonstrate true engagement in the task and application of knowledge acquired (Fleming et al., 2010).
While all three participants demonstrated a change in how they answered the questions, the changes in patterns were most notable for Riley from the pretest to the posttest (see below). The changes in the participants’ answering habits could suggest they were making an effort to answer questions correctly. These changes could also suggest that the students were actively engaged in the modules which resulted in more purposeful answering. It should be noted that other possible influences such as distractions, completing more than one module per session, or changes in schedules were not factored into these results. Further research could investigate whether the practice questions using a green outline for the correct answer taught the students to look for a correct answer.

**Qualitative Accuracy**

After completing the coding process, I participated in peer debriefing with my dissertation chair. During the debriefing, I explained my coding process and my thinking throughout the development of the codes, categories, and themes. I was asked reflective questions about what surprised and frustrated me. These reflective questions helped me to determine important findings to report. This process also helped me to stay focused on reporting what actually happened and not just what I wanted to happen. Also, due to the peer debriefing process I changed my original assertion wording of students’ behavioral characteristics attributed to autism to students’ learning challenges attributed to autism to make it clearer that I was looking at areas other than motoric responses. Overall, the peer debriefing process refined my thinking to better share my outcomes with others.

I also ensured accuracy and positionality by using member checking and an audit trail. I completed member checking by sending completed portions of my writing to the participants’ parents for their review. I also consulted the participants’ primary teachers
for their feedback about descriptions of behaviors, reports about absences, and other
details that were not clear in my observations (i.e. discussing Riley’s attention-seeking
behaviors). Finally, I completed an audit trail by keeping a researchers’ journal. In my
journal I wrote details about my actions and thoughts.

**Converged Findings: Individual Experiences**

In this section, I will identify the individual experiences of (a) Charlie, (b) Peyton,
and (c) Riley when they participated in the implementation of CSVM, as well as (d)
similar findings. It should be noted that all mean and standard deviation scores reported
in this section are the mean and standard deviation for the specific student’s performance
on all of the CSVM or all of the CMAE components. The percentages reported are the
percent of time the students were emotionally regulated, productive, and independent, as
well as the percent of time flexible attention, flexible behavior, and responding to adult
direction occurred. Finally, eye gaze, directed communication, and generative language
were not reported as percentages but as the number of times the students engaged in these
behaviors.

**Charlie’s Experience**

Charlie, 16-years-old, was in the 10th grade during the 2019-2020 school year.
Charlie was verbal and often very funny. Charlie had to be accompanied by a
paraprofessional to help with managing aggressive behaviors; however, the
paraprofessional never needed to intervene because Charlie worked so well. Charlie often
struggled with emotional regulation and would hit, kick, pull hair, etc. when frustrated or
triggered with a script in their head. Scripting can be described as a type of stimming that
involves a student reciting lines from something they heard or watched that was
imprinted in their memory (Ross, 2002; Shield et al., 2017; Silla-Zaleski & Vesloski, 2010). It could often be observed that Charlie had a script running in their head by their vocalizations and acting on the vocalizations. Charlie’s primary teacher explained that even though Charlie was classified as a student with a moderate intellectual disability, they struggled with academic skills and obtaining new skills. Charlie enjoyed verbal praise, food, being called a genius, and anything to do with a specific movie. Charlie often must have completed the script in their head before answering a question or completing their work and required a lot of guidance and redirection to complete assignments. Finally, Charlie could have a difficult time transitioning away from behavioral reinforcers and preferred academic and/or work tasks, so it was important to plan their use.

Before the implementation of the CSVM, Charlie was observed in the primary classroom, in the library, and in my adapted environment science classroom. Charlie was very distracted by my presence in the primary classroom and library and would often stare at me and call out my name using different vocal inflections. Charlie would attempt to gain my attention by staring at me and would eventually turn away if we did not make eye contact.

During my observations in these three classrooms, Charlie complied with adult directions and participated well in class. Charlie would sometimes become stuck on the script in their mind. For example, during the lesson in the primary classroom, Charlie continuously repeated, “Cuckoo cuckoo momma.” Charlie’s ability to make connections, as well as misconceptions, with what was being taught was made evident when Charlie started talking about spiders during a video about insects. It was observed that Charlie
very much enjoyed the videos that were played during the adapted environmental science and library classroom times; however, Charlie struggled to pay attention when stories were read aloud on the computer in comparison to a teacher reading them aloud.

Overall, Charlie enjoyed school and engaged in tasks well. Charlie sometimes needed assistance to stay on task and to work past the internal scripts. Charlie also required assistance and tools to help regulate emotions. What follows will detail Charlie’s experience when participating in the CSVM implementation by describing the student’s (a) performance by modules, (b) performance by CSVM component, (c) active engagement in the CSVM, and (d) demonstration of photosynthesis vocabulary acquisition.

**Performance by modules.** Charlie completed all 12 of the CSVM modules. Due to school cancellations caused by extreme weather and Charlie’s behavior difficulties in the primary class, Charlie missed one research session but made it up by completing Modules 4 and 5 on the same day. Charlie completed the modules first thing in the morning, which proved to be a difficult time due to a lot of disruptions that do not typically occur later in the day. Charlie’s performance by module can be seen in Table H.1 in Appendix H. The (a) least successful and (b) most successful modules were determined by the highest and lowest percentages of productivity and independence because these were the two measures of the CMAE that addresses classroom participation (Sparapani et al., 2016).

**Least successful module.** When looking at the overall data (see Table H.1 in Appendix H), Charlie demonstrated the least success with Module 8 (see Table 4.6). The topic in Module 8 was chemical reactions and included a simulation (see Figure 4.9),
Frayer model (see Figure 4.10), and an adapted reading passage (see Figure 4.11). As soon as Module 8 started, Charlie started moving both arms up and down and repeating, “Meena, meena, meena.” Charlie then leaned over and watched the module while continuing the arm motions. A student across the hall was screaming, and Charlie stopped the motion and started to bounce up and down in the chair while shaking their right hand back and forth. The screaming appeared to greatly disturb Charlie; however, Charlie returned attention to the module when the term *chemical reaction* was introduced. A few minutes later Charlie started to repeat my name and ask me to tickle them. I told Charlie we would talk when they were finished working and Charlie said, “Work, Lisa.” Charlie then started staring at something on their shirt and required multiple prompts to return to the task being presented. Next, Charlie tried to tickle me and repeatedly said, “Jamie, tickle.” At this time, the chemical reaction simulation started, and Charlie watched it intently. The student across the hall started to scream again, but it did not seem to bother Charlie this time. After the simulation ended, Charlie repeated Lisa’s name. The student across the hall again started to scream and Charlie shook their head *no* and put their right hand over their face and repeated, “Lisa, Lisa, a bad, bad, bad, baaaad, note.” The screaming soon stopped, and Charlie looked in the hall and smiled. When the screaming started again, Charlie repeated, “Lisa, Lisa, Lisa, Lisa coming,” and pointed both fingers up in the air while moving their arms up and down. At this time, I took Charlie’s hand and helped them complete the practice session with hand-over-hand assistance. Another student across the hall started to squeal loudly, and Charlie again called Lisa’s name and said, “Pop her, pop her.” Charlie continued to state the teacher’s name over and over. When the formative assessment section started, Charlie
continued to say Lisa’s name. It appeared Charlie was trying to get the noise to stop by stating Lisa’s name because when the noise stopped, Charlie stopped saying her name. Charlie completed the rest of the module with some stimming such as laughing and clapping.

Table 4.6. Charlie’s Performance on Module 8

<table>
<thead>
<tr>
<th>Components</th>
<th>Charlie’s Score</th>
<th>M&lt;sup&gt;b&lt;/sup&gt; (SD&lt;sup&gt;b&lt;/sup&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emotional Regulation</td>
<td>100%</td>
<td>98.37 (2.95)</td>
</tr>
<tr>
<td>Productivity</td>
<td>41.13%</td>
<td>70.32 (12.02)</td>
</tr>
<tr>
<td>Independence</td>
<td>39.18%</td>
<td>58.43 (12.61)</td>
</tr>
<tr>
<td>Flexible Attention</td>
<td>95.24%</td>
<td>50.24 (24.58)</td>
</tr>
<tr>
<td>Flexible Behavior</td>
<td>100%</td>
<td>100 (0.00)</td>
</tr>
<tr>
<td>Responding</td>
<td>100%</td>
<td>86.68 (13.08)</td>
</tr>
<tr>
<td>Eye Gaze&lt;sup&gt;a&lt;/sup&gt;</td>
<td>33</td>
<td>24.92 (23.81)</td>
</tr>
<tr>
<td>Directed Communication&lt;sup&gt;a&lt;/sup&gt;</td>
<td>22</td>
<td>11.00 (12.58)</td>
</tr>
</tbody>
</table>

Note. The full table of Charlie’s performance can be found in Table A.2 in Appendix H.  
<sup>a</sup> Eye gaze, directed communication, and generative language were measured by seconds of duration.  
<sup>b</sup> The mean and standard deviation include Charlie’s mean and standard deviation scores across all modules.

Even though Charlie was clearly distracted by the noises across the hall, Charlie remained emotionally regulated 100% of the time. Charlie was able to talk themselves through the difficult noises and did not demonstrate any aggressive or negative behaviors. However, the distractions clearly affected Charlie’s ability to be productive and independent. Charlie was only productive and independent during the chemical reaction simulation and the last two formative assessment questions. This was likely because Charlie seemed to enjoy watching the chemical reaction simulation and the noises had stopped for a few minutes once Charlie reached the last two questions. Even though there were a lot of distractions, Charlie was able to bring attention back to the module 95.24%
of the time. This score seemed high because there were not many instances requiring Charlie’s redirection of attention, but rather few distractions that lasted a longer period of time.

Figure 4.9. Module 8 simulation slides. These five photos were used to demonstrate how a chemical reaction occurs when we bake a cake. There were multiple ingredients behind the oil in photo one. There were many sound effects in this simulation. Picture symbols from SymbolStix®, Copyright 2019, SymbolStix, LLC. All rights reserved. Used with permission.

Figure 4.10. Module 8 Frayer model. Picture symbols from SymbolStix®, Copyright 2019, SymbolStix, LLC. All rights reserved. Used with permission.
When looking at social connectedness and communication for Module 8, I noted several interesting findings. The two students who were making the noise and Charlie were in Lisa’s primary class the previous school year. Charlie seemed to be calling Lisa to take care of the behaviors that were occurring, which was reflected in the 33 seconds of eye gaze and 22 seconds of directed communication that occurred. Charlie also used generative language for seven seconds when pointing out into the hall and shaking their head no. Finally, Charlie responded to any verbal directions I gave 100% of the time. These data showed that Charlie was extremely distracted by the noises and wanted them to stop.

Figure 4.11. Module 8 adapted reading passage. Copyright 2018, Attainment Company. All rights reserved. Used with permission.
While Charlie was overall very distracted during Module 8 (see Table 4.7 for a breakdown of Module 8), which explained chemical reactions, the simulation used in the module proved to be successful. Charlie was productive for 58 out of 74 seconds (78.38%), independent for 56 out of 74 seconds (75.68%), and displayed flexible attention 44 of 44 seconds (100%) of time during the simulation. Charlie’s attention was gained through the noises that occurred when the cake ingredients were added to the oven (see Figure 4.9 above for a sample of this simulation). In addition to the simulation, Module 8 included a Frayer model and an adapted reading passage from the Attainment Company (2018) curriculum. Charlie was productive for 27 of 71 (38.03%) seconds of the Frayer model instruction, 35 of 72 (48.61%) seconds of the Frayer model practice, and 0 of 37 seconds of the adapted reading passage. Charlie was independent 25 of 71 (35.21%) seconds of the Frayer model instruction, 32 of 72 (44.44%) seconds of the Frayer model practice, and 0 of 37 seconds of the adapted reading passage. There were not any distractors present while Charlie was participating in the Frayer model practice or instruction and adapted reading passage. These data could suggest the simulation was interesting enough to actively engage Charlie despite distractions; however, the Frayer model instruction and practice were not preferred enough to engage Charlie. The adapted reading passage was the least successful method for actively engaging Charlie, who did not engage in the passage at all. Overall, Module 8 was difficult for Charlie because of the extreme noise disruptions; however, the simulation with moving pictures and sounds was interesting enough to engage Charlie while still overtly distracted from the noises.
Table 4.7. Breakdown of Module Eight Components and Charlie’s Performance on Each

<table>
<thead>
<tr>
<th>Module Eight Component</th>
<th>P</th>
<th>I</th>
<th>FA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>P</td>
<td>%</td>
</tr>
<tr>
<td>Frayer Model – I</td>
<td>27</td>
<td>71</td>
<td>38.03%</td>
</tr>
<tr>
<td>Frayer Model - Practice</td>
<td>35</td>
<td>76</td>
<td>48.61%</td>
</tr>
<tr>
<td>Adapted Reading Passage</td>
<td>0</td>
<td>37</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

Note. A = actual seconds; P = possible seconds; I = instruction; % = percent of time engaged.

**Most successful module.** When looking at the overall data (see Table A.2 in Appendix H), Charlie demonstrated the most successes with active engagement on Module 2 (see Table 4.8). Module 2 addressed the features of plants and used a Frayer model (see Figure 4.12) and educational song (see Figure 4.13). During Module 2, Charlie immediately demonstrated interest in the module by leaning forward and looking toward the Apple® iPad® during the introduction. When the review started, Charlie pushed the chair back and looked around the room. Once the attention cue, “It’s time to look and listen,” was stated, Charlie smiled and returned attention to the module. It was difficult to determine if Charlie was watching the module when the Frayer model was being demonstrated. When the song started, Charlie scooted the chair back up to the table and watched intently. Charlie was then interrupted when Lisa entered my classroom. Charlie smiled big and repeated her name. Lisa greeted Charlie and asked if they were working hard. Charlie then pointed to her and said, “Hi!” Charlie ran over to her and gave her a big hug and then came immediately back to the seat and watched the song’s video. Charlie was praised by Lisa, the paraprofessional, and me for immediately returning to their seat without being directed. Charlie then started smiling and dancing along to the remainder of the song. Charlie then participated in the practice and formative assessment.
questions. Charlie would stim at times during the module by calling out the favorite
teacher’s name and laughing. Charlie would be answering even if stimming on all but one
occasion. While Charlie was completing the formative assessment questions, two other
adults entered the classroom. Both times, Charlie looked up when they entered, but
immediately returned to the task being presented.

Table 4.8. Charlie’s Performance on Module 2

<table>
<thead>
<tr>
<th>Components</th>
<th>Charlie’s Score</th>
<th>$M^a$ (SD$^a$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emotional Regulation</td>
<td>100%</td>
<td>98.37 (2.95)</td>
</tr>
<tr>
<td>Productivity</td>
<td>84.70%</td>
<td>70.32 (12.02)</td>
</tr>
<tr>
<td>Independence</td>
<td>76.35%</td>
<td>58.43 (12.61)</td>
</tr>
<tr>
<td>Flexible Attention</td>
<td>49.06%</td>
<td>50.24 (24.58)</td>
</tr>
<tr>
<td>Flexible Behavior</td>
<td>100%</td>
<td>100 (0.00)</td>
</tr>
<tr>
<td>Responding</td>
<td>100%</td>
<td>86.68 (13.08)</td>
</tr>
<tr>
<td>Eye Gaze$^b$</td>
<td>7</td>
<td>24.92 (23.81)</td>
</tr>
<tr>
<td>Directed Communication$^b$</td>
<td>45</td>
<td>11.00 (12.58)</td>
</tr>
<tr>
<td>Generative Language$^b$</td>
<td>47</td>
<td>6.75 (12.60)</td>
</tr>
</tbody>
</table>

Note. The full table of Charlie’s performance can be found in Table A.2 in Appendix H.

$^a$ The mean and standard deviation include Charlie’s performance across all CSVM methods.

$^b$ Eye gaze, directed communication, and generative language were measured by the total
seconds of duration.

Figure 4.12. Module 2 Frayer model. Picture symbols from SymbolStix®, Copyright
2019, SymbolStix, LLC. All rights reserved. Used with permission.
During Module 2, Charlie demonstrated emotional regulation 100% of the time, as Charlie was happy and calm during the entire module. It should be noted that I did not count stimming against emotional regulation because it is the student’s method of self-soothing. When engaged in Module 2, Charlie was productive 84.70% of the total time and independent 76.35% of the total 11 minutes and 18 seconds it took to complete the module. The two minutes and 55 seconds Charlie was not productive included the times the interruptions occurred, and during the Frayer model. It should be noted that in Module 2, the Frayer model did not have an interactive portion, as interactive portions were added in subsequent modules after it was observed the students needed to be more engaged in the graphic organizers. Charlie’s level of independence was greatly impeded by their touch not registering on the Apple® iPad®. Charlie’s hands were often sweaty, so I would have to enter their answers on the laptop after they touched the answer. While
Charlie’s flexible attention score of 49.06% of time was not optimal, Charlie did a great job returning attention to the module after many classroom interruptions.

When looking at social connectedness and communication, Charlie used eye gaze for 7 seconds, directed communication for 45 seconds, generative language for 47 seconds, and responded to adult directives 100% of the time. Typically, when using CAI for an academic task such as the CSVM, eye gaze and directed communication scores would be lower because the student should be engaged with the CSVM and not with people. On the other hand, responding and generative language could range depending the specific situations. Charlie only used eye gaze for 7 seconds, which demonstrated a lack of interest in what I was doing and was focused on the CSVM instead. The directed communication score of 45 seconds was the highest Charlie had across the modules. While typically directed communication is not desired during the CSVM, this high score was due to the interruption of Charlie’s favorite teacher. Charlie also demonstrated 47 seconds of generative language, which was Charlie’s highest score over all the modules. The generative language score was so high because Charlie was being creative with expressive language (Sparapani et al., 2016) by smiling and dancing. Overall, despite the numerous interruptions experienced during Module 2, Charlie displayed excellent active engagement during this module.

The topic of Module 2, describing the features of a plant, was a review for the student as this was a topic I previously, and often, covered in my pedagogy. Module 2 included a Frayer model describing what plants are, the Parts of a Plant song by Harry Kindergarten (2015), and questions that required the students to touch the part of the plant that was named. While the topic was familiar, I had never previously used Frayer
models with the students. When looking at Frayer model data across the modules it was used, Charlie was productive 57.27% and independent 50.91% of the time. This data demonstrated that Charlie likely did so well in Module 2 due to the familiar topic and preferred song, and not the presentation method of a Frayer model.

**Performance by CSVM component.** Charlie’s performance on the CSVM varied according to the different components being accessed in the CSVM. A full table of Charlie’s performance across CSVM components can be found in Appendix H. The special education explicit instruction methods are broken into (a) mnemonics, (b) graphic organizers, (c) CAI in special education, and (d) special education specific methods.

**Mnemonics.** The photosynthesis mnemonic was introduced in Module 1 and reviewed in Modules 5 and 11. While the mnemonic was not used for specific instruction in every module, it was shown at the beginning of each module in the introduction. A formative assessment question asking, “Which picture shows how we can remember what photosynthesis means?” appeared in Modules 1, 5, and 11. Charlie scored 3s each time this question was presented, demonstrating that Charlie may have been able to successfully identify the photosynthesis mnemonic. Charlie’s success cannot be determined with full assurance because the correct answer was presented on the right, which was Charlie’s preferred side for choosing answers. As well, the mnemonic was not used on the pre-and posttest. When looking at the classroom participation portion of the CMAE, Charlie was productive 66.88% and independent 53.13% of the overall time the mnemonic was used, which demonstrated that Charlie participated close to their average performance in the CSVM (see Table 4.9). Overall, there was not strong evidence that the
mnemonic assisted Charlie in the acquisition of photosynthesis related vocabulary; however, the results were not discouraging either.

Table 4.9. Summary of Charlie’s Performance During Instruction Using Mnemonics

<table>
<thead>
<tr>
<th>Mnemonics Summary</th>
<th>Emotional Regulation</th>
<th>Productivity</th>
<th>Independence</th>
<th>Flexible Attention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mnemonics</td>
<td>100%</td>
<td>66.88%</td>
<td>53.13%</td>
<td>22.22%</td>
</tr>
<tr>
<td>M</td>
<td>99.62</td>
<td>67.88</td>
<td>54.75</td>
<td>49.15</td>
</tr>
<tr>
<td>SD</td>
<td>0.78</td>
<td>22.23</td>
<td>21.62</td>
<td>15.15</td>
</tr>
</tbody>
</table>

Note. The full table of Charlie’s performance can be found in Table A.2 in Appendix H. The mean and standard deviation include Charlie’s performance across all CSVM methods.

**Graphic organizers.** The graphic organizers used in the modules included t-charts, Frayer models, and cognitive/word maps. Each module included an instruction portion where the student watched the graphic organizer be completed, and a practice session in which the student completed the graphic organizer. Charlie’s performance can be found in Table 4.10. Charlie’s overall productivity (90.57%) and independence (83.02%) were the highest when engaged in the cognitive/word mapping practice maps. When compared to Charlie’s mean productivity (M = 67.88) and independence (M = 54.75) scores for all explicit instruction methods, Charlie demonstrated the most success with the cognitive/word mapping practices. The cognitive/word mapping practice was the second highest score overall when compared to all explicit instruction methods. When comparing the cognitive/word map instruction to the practice sessions, Charlie scored 62.86% of the time on both productivity and independence. These data demonstrated that Charlie had a positive response to interacting with and manipulating cognitive/word maps which used two different styles, web and linear progression, across the modules.
### Table 4.10. Summary Charlie’s Performance During Instruction Using Graphic Organizers

<table>
<thead>
<tr>
<th>Graphic Organizers</th>
<th>Emotional Regulation</th>
<th>Productivity</th>
<th>Independence</th>
<th>Flexible Attention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive/ Word Map Practice</td>
<td>100%</td>
<td>62.86%</td>
<td>62.86%</td>
<td>N/A</td>
</tr>
<tr>
<td>T-Chart Practice</td>
<td>100%</td>
<td>100%</td>
<td>72.22%</td>
<td>N/A</td>
</tr>
<tr>
<td>T-Chart Practice</td>
<td>100%</td>
<td>58.33%</td>
<td>69.64%</td>
<td>N/A</td>
</tr>
<tr>
<td>Frayer Model</td>
<td>100%</td>
<td>57.27%</td>
<td>50.91%</td>
<td>N/A</td>
</tr>
<tr>
<td>Frayer Model Practice</td>
<td>100%</td>
<td>59.57%</td>
<td>30.25%</td>
<td>100%</td>
</tr>
<tr>
<td>M&lt;sup&gt;a&lt;/sup&gt;</td>
<td>99.62</td>
<td>67.88</td>
<td>54.75</td>
<td>49.15</td>
</tr>
<tr>
<td>SD&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.78</td>
<td>22.23</td>
<td>21.62</td>
<td>15.15</td>
</tr>
</tbody>
</table>

Note. The full table of Charlie’s performance can be found in Table H.1 in Appendix H. The mean and standard deviation include Charlie’s performance across all CSVM methods.

Computer-assisted instruction in special education. The CAI methods used in the modules included educational songs and videos, simulations, and applause feedback. Charlie’s performance can be seen in Table 4.11. Interestingly, Charlie’s productivity and independence scores varied by CAI methods. Charlie was the most productive with the simulation practice sessions 94.14%; however, Charlie was the least independent 46.40% with this CAI method. It should be noted that there were some days that Charlie was very sweaty and had difficulty getting answers to register on the Apple® iPad® and this often decreased the independence score. Charlie’s highest level of independence was during the applause feedback 93.06%, followed by the educational videos 66.60%. While the applause feedback and educational videos did not require Charlie to complete a task, Charlie demonstrated the ability to independently attend to these items. Charlie’s only scores below the mean productivity (M = 67.88) were watching the simulations (61.31%), and below the mean independence (M = 54.75) were simulations (47.45%) and simulations practice (46.40%). These lowered productivity and independence scores were
not inferred to negatively influence Charlie’s CSVM experience. Overall, Charlie was most productive when able to interact with the CSVM during simulations and most independent when engaged in the applause feedback and educational videos.

Table 4.11. Summary Charlie’s Performance During Computer-Assisted Instruction Components

<table>
<thead>
<tr>
<th>Components</th>
<th>Emotional Regulation</th>
<th>Productivity</th>
<th>Independence</th>
<th>Flexible Attention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational Videos</td>
<td>98.79%</td>
<td>73.48%</td>
<td>66.60%</td>
<td>33.33%</td>
</tr>
<tr>
<td>Educational Songs</td>
<td>100%</td>
<td>73.59%</td>
<td>56.68%</td>
<td>30.43%</td>
</tr>
<tr>
<td>Simulations</td>
<td>100%</td>
<td>61.31%</td>
<td>47.45%</td>
<td>93.64%</td>
</tr>
<tr>
<td>Simulations – P</td>
<td>100%</td>
<td>94.14%</td>
<td>46.40%</td>
<td>N/A</td>
</tr>
<tr>
<td>Applause Feedback</td>
<td>100%</td>
<td>77.40%</td>
<td>93.06%</td>
<td>28.57%</td>
</tr>
<tr>
<td><em>M</em></td>
<td>99.62</td>
<td>67.88</td>
<td>54.75</td>
<td>49.15</td>
</tr>
<tr>
<td><em>SD</em></td>
<td>0.78</td>
<td>22.23</td>
<td>21.62</td>
<td>28.59</td>
</tr>
</tbody>
</table>

Note. P = practice; The full table of Charlie’s performance can be found in Table H.1 in Appendix H.  
*a The mean and standard deviation include Charlie’s performance across all CSVM methods.

**Special education specific methods.** The strategies encompassed in special education specific methods included errorless learning, formative assessment, an adapted reading passage, and breaks for extreme behaviors (see Table 4.12 for Charlie’s performance). Charlie did not require any breaks due to extreme behavior throughout the modules. Of these methods, the Attainment Company (2018) adapted reading passage about chemical reactions (Module 8) was the least successful of all methods used. Charlie scored 0% productivity and 0% independence on the adapted reading passage. During the adapted reading passage, Charlie remained 100% emotionally regulated and made eye contact (eye gaze) with me four times. These findings reflected the reading passage was not a successful method for engaging Charlie in instruction or communication.
opportunities. Charlie was the most productive (76.17%) with the formative assessment questions, which was above the overall mean score of 67.88%. The formative assessment questions required the students to answer before finishing, which forced student productivity. Charlie was also more productive during the formative assessment likely because they knew it was getting close to seeing their favorite teacher. Charlie struggled somewhat with independence with both the errorless learning (49.87%) and formative assessment (39.13%) questions, which was below the overall independence mean of 54.75. These lower independence scores were not due to an unwillingness to participate but were a direct result of Charlie’s touch not registering on the Apple® iPad® and the need for me to enter Charlie’s answers via the laptop. Overall, for Charlie, the most significant special education specific method outcomes were the negative response to the adapted reading passage and the positive response when continual, active interaction with the CSVM was present.

Table 4.12. Summary of Charlie’s Performance During Instruction Using Special Education Specific Methods

<table>
<thead>
<tr>
<th>Methods</th>
<th>Emotional Regulation</th>
<th>Productivity</th>
<th>Independence</th>
<th>Flexible Attention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Errorless Learning</td>
<td>97.80%</td>
<td>66.62%</td>
<td>49.87%</td>
<td>34.31%</td>
</tr>
<tr>
<td>Formative Assessment</td>
<td>97.76%</td>
<td>76.17%</td>
<td>39.13%</td>
<td>50.72%</td>
</tr>
<tr>
<td>Adapted Reading</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passage</td>
<td>100%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>N/A</td>
</tr>
<tr>
<td>Behavior Breaks</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>( M^a )</td>
<td>99.62</td>
<td>67.88</td>
<td>54.75</td>
<td>49.15</td>
</tr>
<tr>
<td>( SD^a )</td>
<td>0.78</td>
<td>22.23</td>
<td>21.62</td>
<td>28.59</td>
</tr>
</tbody>
</table>

Note. The full table of Charlie’s performance can be found in Table H.1 in Appendix H.

\( ^a \) The mean and standard deviation include Charlie’s performance across all methods.

\( ^b \) Eye gaze, directed communication, and generative language were measured by the total seconds of duration.
Active engagement in the computerized science vocabulary modules. Active engagement was measured using the CMAE and included observation of the participants’ emotional regulation, social connectedness, communication, classroom participation, and flexibility (Sparapani et al., 2016). Through the analysis of the CMAE, I was able to determine Charlie’s (a) areas of need and (b) areas of strength when using the CSVM for science vocabulary acquisition (see Table A.2 in Appendix H).

Areas of need. Charlie’s area of need regarding active engagement was flexible attention. Charlie demonstrated excellent flexible attention during the Frayer model practice (100%) and simulation instruction (93.64%) but struggled when having to shift attention away from a distraction to the task (Sparapani et al., 2016) during all other scored methods. This was evident with all other scores where Charlie displayed below the mean of 49.15 for flexible attention. It should be noted that there were not any distractions during the cognitive/word map instruction and practices, t-chart instruction and practices, Frayer model instruction, simulations practice, and adapted reading passage. Charlie demonstrated the least success with transferring attention back to the CSVM during the use of the mnemonic (22.22%) and the applause feedback (28.57%). Charlie had previously demonstrated a lack of interest in the mnemonic and the applause often resulting in a reminder that they would see Lisa soon; therefore, the mnemonic and applause were not attractive enough to bring Charlie’s attention back to the CSVM after a distraction. Overall, Charlie greatly struggled with maintaining attention to the task when it was not a highly preferred task.

Areas of strength. Charlie demonstrated excellent emotional regulation throughout all of the modules. Charlie was emotionally regulated 100% of the time for
nine of the modules. The three modules Charlie had less than 100% of regulated time included Modules 1 (91.58%), 4 (95.61%), and 5 (93.20%). Modules 4 and 5 occurred on the same day. After revisiting the observation data, I realized Charlie was distracted by Lisa in all three instances. In the first instance, Charlie saw Lisa in the hall and left the work area to try to exit the room. Charlie went through a script in their head by the door by pretending to talk to the favorite teacher and then kissing the door. After finishing the script, Charlie returned to the work area and completed the task presented. It was at this time I implemented the first, then Lisa.” Charlie would repeat this to me each day before working and followed this directive each time it was used. During Modules 4 and 5, which occurred back to back in the same day, Charlie was distracted when Lisa entered my classroom. I was extremely impressed that, though distracted, Charlie got up and spoke to her but then immediately returned to the work area without instruction. Charlie’s initiative to do so was unusual and could have demonstrated that the CSVM work was enjoyed. Charlie never had more than 46 seconds of unregulated time across the modules. It should also be noted that Charlie never displayed aggressive or angry behaviors, as the irregulated times were over excitement. This finding suggests that Charlie enjoyed participating in the CSVM, and it did not have any adverse effects on Charlie’s emotional regulation.

Demonstration of photosynthesis vocabulary acquisition. The students in this study were able to demonstrate photosynthesis vocabulary acquisition through the (a) the pre- and posttest, (b) their patterns in answering questions, and (c) whole class photosynthesis unit.
**Pre- and posttest.** Charlie demonstrated positive acquisition of photosynthesis related vocabulary after being administered the pre- and posttest (scores can be found in Table 4.1). Charlie scored 23 out of 30 (76.67%) on the pretest and improved to 27 out of 30 on the posttest (90.00%). Impressively, Charlie did not require errorless instruction during the posttest and scored 2s on only three questions. While Charlie did not seem to have a preference when answering questions with the correct answers on the left, it is interesting that the three incorrect posttest questions were answered in the middle first with the correct answer on the left (see Figure 4.14). It was noted that Charlie was able to answer Question 2 correctly on the pretest, but needed an answer removed for a correct answer on the posttest; however, this could have indicated a guess on the pretest. Overall, the positive performance on the posttest suggested that Charlie improved photosynthesis vocabulary acquisition after engaging in the 12 CSVM implementation.

![Figure 4.14. Charlie's answering patterns on the pre- and posttest.](image-url)
**Patterns in answering questions.** Charlie’s primary teachers from the last two years reported that Charlie did not have a positional preference when answering questions. This was confirmed in the pre-observations. During an insect sorting task in adapted environmental science, Charlie sorted four out of five insects correctly no matter which side they were presented. During the News-2-You (2019) lesson in their primary classroom, Charlie had a combination of correct and incorrect choices when they were presented on both the right and left. It was noted that Charlie chose the answer on the right when presented with picture symbols and on the left when answering at the board. Overall, it was noted in pre-observations that Charlie chose the answer on the right more than the left; however, a pattern of positional preference was not observed.

As seen in Figure 4.14 above, Charlie did not have a true pattern to choosing answers. Charlie answered 50% of the pretest questions on the first attempt, 80% on the second attempt, and required errorless instruction for one question. Charlie chose the answer on the right in six of 10 pretest questions, with only two of those answers being correct. On the posttest, Charlie answered 70% on the first attempt and the remaining three questions with two attempts. The three questions Charlie needed a second attempt at all had answer choices on the left and Charlie chose the middle picture. Charlie did answer one question correctly on the first attempt, with that picture being positioned on the left. Charlie answered four questions correctly on the pretest and posttest.

Charlie answered 28 of 46 (60.87%) of formative assessment questions correctly on the first attempt. Charlie answered correctly 13 of 18 (72%) of second attempt questions and required errorless instruction for five questions. Charlie only answered left first on four of 46 questions and was correct each time; however, the left answer choice
was correct on six of 18 questions that Charlie missed (two requiring errorless instruction for a correct answer). Charlie did not have any incorrect answers on Modules 1 and 11. Overall, this data demonstrated that Charlie did not have a preferred side or pattern to answering; however, Charlie was least likely to answer positively when the correct answer was on the left.

**Whole class lesson on photosynthesis.** Charlie was the only student out of the three participants present for the whole class lesson and was one of four students overall present for the lesson. The four students were seated around a u-shaped table facing the whiteboard. I presented Module 12 by projecting it both on the whiteboard and an Apple iPad using the Doceri app (SP Controls, 2018). The use of the Apple iPad allowed me to circulate around the table so the students could easily answer questions. Charlie had not yet completed Module 12 independently. Only qualitative data were collected on the whole class lesson.

Charlie was seated at one end of the table with a paraprofessional seated behind him, slightly off to one side. When Module 12 started, Charlie rotated between looking at the whiteboard, which was slightly to their right, to looking forward. When the song played, Charlie maintained attention to the whiteboard. When the photosynthesis simulation began, Charlie looked at the whiteboard and then looked at me, smiled, and said, “Jamie!” Charlie did not maintain attention to the module when other students were answering but quickly attended when it was their turn to answer. Charlie answered quickly and correctly, and I patted Charlie on the back, causing them to look at me and smile. During Charlie’s next turn to answer a question, he started to laugh and said, “Momma, momma [unintelligible], momma, momma,” answered correctly, smiled big,
and then repeated, “Momma, momma.” Charlie then started to stim by swaying, talking, watching their hands hit together, and laughing while the other students answered.

After completing Module 12, the students were tasked with creating a textured model of the photosynthesis process (see Figure 4.15). During this process, Charlie started to repeat “Daddy” continuously. Charlie would make choices and glue the pieces with assistance; however, Charlie became more and more agitated. Charlie suddenly started clapping repeatedly with their head titled back and repeating something unintelligible. Charlie then became very agitated and started bouncing forcefully up and down in the chair, repeating, “Daddy.” Charlie then rocked back and forth a few times and then stopped. Charlie attended to my directions about how to make their tissue paper flower but when I approached Charlie to help, Charlie slapped their own hand and yelled, “Ow!” I put the paper in Charlie’s hand and they crumbled as directed but continued to close their eyes and sway in circles. Charlie became agitated again and started to bounce and yell, “Daddy.” The paraprofessional seated next to Charlie tapped Charlie on the arm. Charlie opened their eyes and turned to the paraprofessional and cheerfully yelled his name several times and asked to, “Watch?” The paraprofessional told Charlie, “First work, then watch at home.” Charlie bounced up and down while laughing hysterically. When I circulated back to Charlie, Charlie moved their chair closer to the table and completed the model with assistance from me. For the remainder of the work session, Charlie smiled and giggled often. When I sat in front of Charlie to label the model, Charlie scooted close and yelled, “Jamie! Jamie! Fi-fi-five, fi-fi-fi-fi-fi-five minutes!” I asked Charlie, “Five minutes until what?” Charlie leaned back, smiled, waved their hands
in front of their face, scooted back up and said, “Jamie, Jamie, tickle,” while smiling big. Charlie then finished by yelling out Lisa’s name.

Figure 4.15. Screenshot of me holding Charlie’s completed photosynthesis model.

This observation suggested the success of the CSVM when used in the one-on-one setting, meaning one adult and one student. When comparing Charlie’s behaviors during the individual CSVM sessions, the whole group CSVM session, and the whole group model making, it was clear that Charlie had the most success during the individual CSVM sessions. Charlie was clearly emotionally regulated and mostly productive and independent during the CSVM instruction. However, Charlie was not emotionally regulated and required constant prompting during the model making lesson. Overall, Charlie’s performance during this observation provided support for the CSVM as a successful instructional method for Charlie.

**Summary of Charlie’s experience.** Charlie demonstrated the least participation with Module 8, which included a reading passage that resulted in 0% productivity and 0% independence. On the other hand, Charlie performed the best on Module 2, which
included a familiar topic and well-liked song. Charlie struggled with flexible attention and excelled with emotional regulation. Charlie did not engage well when a reading passage was presented; however, Charlie had high active engagement scores when cognitive/word maps and simulations were used. Overall, Charlie demonstrated active engagement and an increase in photosynthesis related vocabulary acquisition after participating in the 12 CSVM implementation.

**Peyton’s Experience**

Peyton, 20-years-old, was in the 11th grade during the 2019-2020 school year. Peyton was nonverbal but did make vocal sounds such as humming a song. According to the primary teacher, Peyton enjoyed independent activities or working one-on-one with a staff member to complete a multi-step task. Peyton required verbal redirection to stay on task and not be distracted and required gestural and verbal prompting to complete tasks. At times, Peyton could struggle with emotional regulation. These issues stemmed from frustration from hunger, noises, changes in schedule and result in extremely loud screaming and rocking in the face of adults. During the 2019-2020 school year, Peyton missed many days of school due to displaying aggressive behaviors at home which affected emotional regulation and academic skills. During the implementation period alone, Peyton was absent seven days and tardy one day. Peyton also attended outside therapy once a week and did not come to school after therapy. Peyton’s positive behavior and attention to work is reinforced by food, drinks, or taking walks around the school or nature trail.

Before the implementation of the CSVM, Peyton was observed in the primary classroom, an art classroom, and my adapted environment science classroom. During
these classes Peyton would sit quietly until she was asked to work. In all three settings, Peyton answered the questions asked of her and completed tasks as requested. It was often unclear if Peyton was simply staring blanking at the screen or actually processing the information being displayed. When I used a large model of a bee in my adapted environmental science class, Peyton became interactive by suddenly changing their view to the area of instruction and pretending to be scared. Initially, Peyton backed up a bit and then touched the bee, covered her eyes, gently touched my arm, and laughed. Peyton also demonstrated excitement when asked to pick the morning song and when being the weatherperson during the primary class calendar time. A final time Peyton demonstrated enjoyment was during art class. Peyton picked up a special adapted tool and pretended to use it, while smiling at the paraprofessional. My observation of this nonverbal response suggested Peyton to be stating, “Look, I can do this by myself” with their actions. Peyton was also very eager to do the artwork tasks and worked with a big smile.

Overall, Peyton loved any type of hands-on work, helping others, and completing jobs. While complying with academic tasks, Peyton does so less enthusiastically and with less effort (i.e. always choosing the photo on the right when completing an insect sorting task). Per Peyton’s primary teacher, Peyton is generally well-behaved and eager to please adults. What follows will detail Peyton’s experience when participating in the CSVM implementation by describing the participant’s (a) performance by modules, (b) performance by CSVM component, (c) active engagement in the CSVM, and (d) demonstration of photosynthesis vocabulary acquisition.

**Performance by modules.** Peyton only completed 10 of the 12 CSVM modules due to multiple absences and the inability to make up sessions because of time restraints.
Peyton completed Modules 2 and 5 in the same day, Modules 6 and 7 in the same day, and Modules 8, 9, and 10 in the same day. Modules 8, 9, and 10 were completed throughout the afternoon of the same day because we were held inside all morning due to a tornado warning. Due to the tornado warning, afternoon related arts classes were canceled so Peyton’s primary teacher asked me to keep Peyton during this time so they could have some structure. Peyton’s performance by module can be seen in Table A.2 in Appendix H. What follows outlines (a) Peyton’s least successful CSVM module performance and (b) Peyton’s most successful CSVM module performance.

**Least successful module.** When looking at the overall data (see Table A.2 in Appendix H), Peyton was least successful with Module 2 (see Table 4.13). The topic of Module 2 was describing features of a plant and it included a Frayer model (see Figure 4.12 above) and educational song (see Figure 4.13 above). Module 2 was completed after Module 5, due to missing this module after an absence. Peyton had the lowest productivity (41.74%), independence (34.28%), responding (72.73%), and flexible attention (32.43%) scores during this module. Peyton also had the second lowest emotional regulation score (98.93%) during Module 2. All of these scores were below Peyton’s mean scores as seen in Table H.1 in Appendix H.

Peyton was initially interested in Module 2 as demonstrated by Peyton’s touching of the Apple® iPad® and looking at me three times. These actions were confirmed by Peyton’s primary teacher to be their way of telling me they were ready to work. After Peyton started the module, there were many distractions because it had started snowing outside. All of the surrounding classes were going outside to play in the snow and Peyton watched as they all exited the building. Peyton continued to watch the classes going
outside instead of watching the video of the song. Peyton continued to require prompting to touch the part of the model as requested. When the movement in the hall settled, Peyton was able to answer two touch-the-model questions correctly and without assistance. When the movement in the hallways started again, Peyton again became distracted. When there were two questions left Peyton put their head in their heads and smiled at me. I responded by telling Peyton they were doing a good job. Peyton answered one more question and then held their hand out for a fist bump and put their thumb up. From observations of Peyton prior to starting this research, I recalled that Peyton will ask for fist bumps when starting to become unregulated; however, since there was only one question left, I ignored Peyton’s fist bump request. At this time, an adult opened the door and asked if we saw it was snowing. I quickly answered the adult and Peyton quickly answered the last question. After answering the last question, Peyton and I exchanged a high-five hand slap.

Table 4.13. *Peyton’s Performance on Module 2*

<table>
<thead>
<tr>
<th>Components</th>
<th>Peyton’s Scores</th>
<th>SDa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emotional Regulation</td>
<td>98.93%</td>
<td>0.67</td>
</tr>
<tr>
<td>Productivity</td>
<td>41.74%</td>
<td>12.31</td>
</tr>
<tr>
<td>Independence</td>
<td>34.28%</td>
<td>13.98</td>
</tr>
<tr>
<td>Flexible Attention</td>
<td>31.43%</td>
<td>15.02</td>
</tr>
<tr>
<td>Flexible Behavior</td>
<td>100%</td>
<td>0.00</td>
</tr>
<tr>
<td>Responding</td>
<td>72.73%</td>
<td>9.50</td>
</tr>
<tr>
<td>Eye Gazeb</td>
<td>29</td>
<td>19.15</td>
</tr>
<tr>
<td>Directed Communicationb</td>
<td>8</td>
<td>3.74</td>
</tr>
<tr>
<td>Generative Languageb</td>
<td>9</td>
<td>8.16</td>
</tr>
</tbody>
</table>

*Note.* The full table of Peyton’s performance can be found in Table H.1 in Appendix H.  
a The mean and standard deviation include Peyton’s performance across all CSVM methods.  
b Eye gaze, directed communication, and generative language were measured by the total seconds of duration.
While Peyton’s scores in Module 2 were the lowest, it was clear that the distractions going on outside of the classroom were the main cause of the low scores. Peyton attempted to work when there were no distractions occurring in the hallways. Initially, I was worried about Peyton completing two modules in one session; however, in later sessions Peyton completed multiple modules with better scores. Overall, had time permitted, this module could have been repeated with Peyton to determine if the true cause of struggle was the distractions or the content of the module.

**Most successful module.** When looking at the overall data (see Table A.2 in Appendix H), Peyton was most successful with Module 9 (see Table 4.14). Module 9 addressed carbon dioxide and oxygen and used a simulation (see Figure 4.16). Peyton scored well above the mean scores for productivity (85.13%), independence (81.34%), flexible attention (81.33%), and responding (100%). Module 9 involved the difficult and abstract concept of the process of carbon dioxide and oxygen which are connected between plants and animals. Module 9 involved the use of a simulation I created to show the movement of carbon dioxide and oxygen through plants and people.

The conditions in which Peyton completed Module 9 were different than the other modules. Earlier in the day, we had been held in our classrooms for several hours due to a tornado warning. The afternoon related arts classes were canceled due to lunch being delayed. Peyton’s primary teacher had contacted me to see if I wanted to make up work with Peyton during this class because Peyton needed structure. Therefore, Peyton completed Modules 8, 9, and 10 during different times throughout the afternoon. I did note that Peyton was excited as evidenced by their running to the door with a smile when I went to get them.
Table 4.14. *Peyton’s Performance on Module 9*

<table>
<thead>
<tr>
<th>Components</th>
<th>Peyton’s Scores</th>
<th>$M^a (SD^a)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emotional Regulation</td>
<td>100%</td>
<td>99.61 (0.67)</td>
</tr>
<tr>
<td>Productivity</td>
<td>85.13%</td>
<td>56.97 (12.31)</td>
</tr>
<tr>
<td>Independence</td>
<td>81.34%</td>
<td>53.27 (13.98)</td>
</tr>
<tr>
<td>Flexible Attention</td>
<td>81.33%</td>
<td>56.24 (15.02)</td>
</tr>
<tr>
<td>Flexible Behavior</td>
<td>100%</td>
<td>100 (0.00)</td>
</tr>
<tr>
<td>Responding</td>
<td>100%</td>
<td>94.15 (9.50)</td>
</tr>
<tr>
<td>Eye Gaze$^b$</td>
<td>9</td>
<td>32.00 (19.15)</td>
</tr>
<tr>
<td>Directed Communication$^b$</td>
<td>1</td>
<td>3.30 (3.74)</td>
</tr>
<tr>
<td>Generative Language$^b$</td>
<td>0</td>
<td>8.80 (8.16)</td>
</tr>
</tbody>
</table>

*Note.* The full table of Peyton’s performance can be found in Table H.1 in Appendix H.  
$^a$ The mean and standard deviation include Peyton’s performance across all CSVM methods.  
$^b$ Eye gaze, directed communication, and generative language were measured by the total seconds of duration.

![Figure 4.16. Screenshot of the Module 9 simulation.](image)

The observation anecdotal notes I made throughout Peyton’s time completing the CSVM were limited because Peyton completed the work so well. Also, there were not any distractions while Peyton was working during the afternoon. During Module 9, Peyton looked around the room often but would look back to the module without
prompting. However, during the other modules, Peyton required some prompting from me, such as, “Go ahead” or “Which one,” to answer questions. Peyton worked quickly and accurately throughout the modules and gave me a high-five when finished.

Overall, Peyton’s positive performance on Module 9 could have been due to the overall calm and quiet setting in which Peyton worked or it could have been the use of the simulation. It was surprising Peyton performed so well on such an abstract concept, as I expected this to be the most difficult module for all the students. It is noteworthy that even though Peyton performed well on Module 9, acquisition of this concept was not demonstrated on the posttest (76.67% posttest score). While it cannot be determined exactly what influenced Peyton to remain so engaged in this module, it could be inferred that Peyton did well because they were excited to work that afternoon, there were not any distractions, and the simulation was enjoyed.

**Performance by CSVM component.** Peyton’s performance on the CSVM varied according to the different components being accessed in the CSVM. A full tale of Peyton’s performance across CSVM components can be found in Table A.2 in Appendix H. This section will outline Peyton’s performance by (a) mnemonics, (b) graphic organizers, (c) CAI in special education, and (d) special education specific methods.

**Mnemonics.** The photosynthesis mnemonic was introduced in Module 1 and reviewed in Module 5. It should also be noted that Peyton missed Module 11 which addressed the mnemonic a third time. While the mnemonic was not used for specific instruction in every module, it was shown at the beginning of each module in the introduction. A formative assessment question which asked, “Which picture shows how we can remember what photosynthesis means?” appeared in Modules 1 and 5. Peyton
scored 1s each time this question was presented, demonstrating that Peyton was not successful with remembering the mnemonic. Peyton chose the picture with just the hands holding the tree both times it was presented. The mnemonic was not used on the pre-and posttest. When looking at the classroom participation portion of the CMAE, Peyton demonstrated a positive response to the use of mnemonics throughout the modules (see Table 4.15). Peyton remained 100% emotionally regulated and responded to adult directives 100% of the time while mnemonics were being used. Peyton also scored above the mean for productivity at 72.37% and independence at 68.42% when mnemonics were used. Overall, this data demonstrated that Peyton responded well to and enjoyed instruction including mnemonics; however, mnemonics instruction was not successful in the retention of further identification of the mnemonic picture.

Table 4.15. Summary of Peyton’s Performance During Instruction Using Mnemonics

<table>
<thead>
<tr>
<th>Mnemonics</th>
<th>Emotional Regulation</th>
<th>Productivity</th>
<th>Independence</th>
<th>Flexible Attention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mnemonics</td>
<td>100%</td>
<td>72.37%</td>
<td>68.42%</td>
<td>N/A</td>
</tr>
<tr>
<td>$M^a$</td>
<td>99.75</td>
<td>59.93</td>
<td>55.04</td>
<td>52.43</td>
</tr>
<tr>
<td>$SD^a$</td>
<td>0.54</td>
<td>20.52</td>
<td>19.76</td>
<td>16.21</td>
</tr>
</tbody>
</table>

*Note.* The full table of Peyton’s performance can be found in Table A.2 in Appendix H. N/A = no opportunities.

*a The mean and standard deviation include Peyton’s performance across all CSVM methods.

**Graphic organizers.** The graphic organizers used in the modules included t-charts, Frayer models, and cognitive/word maps. Each module included an instruction portion where the student watched the graphic organizer be completed, and a practice session in which the student completed the graphic organizer. Peyton’s performance can
be seen in Table 4.16. The least successful graphic organizer strategy for Peyton was the Frayer model instruction. Peyton scored well below the mean for productivity at 20.83%, independence at 20.83%, and flexible attention at 22.22% when Frayer models were used. On the other hand, Peyton was most successful with t-chart instruction and practice. Peyton scored at 96.00% on both productivity and independence during t-chart instruction, and at 75.00% flexible attention during t-chart practice. Peyton’s success on t-charts could be attributed to familiarity with this method, as I used it often during my class sessions. Also, Peyton may have had more success with the t-chart because it was visually simpler, with two columns compared to four squares, which was how a Frayer model was presented.

<table>
<thead>
<tr>
<th>Graphic Organizers</th>
<th>Emotional Regulation</th>
<th>Productivity</th>
<th>Independence</th>
<th>Flexible Attention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive-Word Map</td>
<td>100%</td>
<td>31.43%</td>
<td>31.43%</td>
<td>62.50%</td>
</tr>
<tr>
<td>Cognitive-Word Map Practice</td>
<td>100%</td>
<td>65.29%</td>
<td>48.76%</td>
<td>45.45%</td>
</tr>
<tr>
<td>T-Chart</td>
<td>100%</td>
<td>96.00%</td>
<td>96.00%</td>
<td>60.00%</td>
</tr>
<tr>
<td>T-Chart Practice</td>
<td>98.23%</td>
<td>84.96%</td>
<td>61.06%</td>
<td>75.00%</td>
</tr>
<tr>
<td>Frayer Model</td>
<td>100%</td>
<td>20.83%</td>
<td>20.83%</td>
<td>22.22%</td>
</tr>
<tr>
<td>Frayer Model Practice</td>
<td>100%</td>
<td>48.80%</td>
<td>40.00%</td>
<td>47.78%</td>
</tr>
<tr>
<td>(M^a)</td>
<td>99.75</td>
<td>59.93</td>
<td>55.04</td>
<td>52.43</td>
</tr>
<tr>
<td>(SD^a)</td>
<td>0.54</td>
<td>20.52</td>
<td>19.76</td>
<td>16.21</td>
</tr>
</tbody>
</table>

Note. The full table of Peyton’s performance can be found in Table H.1 in Appendix H. \(^a\) The mean and standard deviation include Peyton’s performance across all CSVM methods.

**Computer assisted instruction in special education.** The CAI methods used in the modules included educational songs and videos, simulations, and applause feedback. Peyton’s performance can be seen in Table 4.17. Of these, Peyton was the least
successful with the applause feedback. Peyton became less productive (48.64%) and independent (45.38%), as well as greatly increased eye gaze to 20 when the applause feedback was played. This finding aligned with the fact that, as reported by the primary teacher, Peyton did not enjoy certain sounds and the increased eye gaze could have been a request to make it stop. This finding also suggested that it may be beneficial to use feedback sounds specific to the students’ liking. Peyton was the most successful with the simulation. Peyton scored well above the mean in productivity at 71.86% during simulation practice and 70.21% during simulation instruction. Peyton also scored well above the mean in independence at 79.43% and in flexible attention at 80.58% during simulation instruction. Overall, these data outcomes demonstrated that Peyton was not influenced or encouraged to work when applause feedback was used; however, Peyton demonstrated great success with the simulations.

Table 4.17. Summary of Peyton’s Performance During Computer-Assisted Components

<table>
<thead>
<tr>
<th>Components</th>
<th>Emotional Regulation</th>
<th>Productivity</th>
<th>Independence</th>
<th>Flexible Attention</th>
<th>Eye Gaze(^{b})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational Videos</td>
<td>100%</td>
<td>69.86%</td>
<td>69.52%</td>
<td>67.65%</td>
<td>22</td>
</tr>
<tr>
<td>Educational Songs</td>
<td>100%</td>
<td>70.22%</td>
<td>68.89%</td>
<td>40.00%</td>
<td>0</td>
</tr>
<tr>
<td>Simulations</td>
<td>100%</td>
<td>70.21%</td>
<td>79.43%</td>
<td>80.58%</td>
<td>8</td>
</tr>
<tr>
<td>Simulations – Practice</td>
<td>100%</td>
<td>71.86%</td>
<td>56.71%</td>
<td>56.67%</td>
<td>2</td>
</tr>
<tr>
<td>Applause Feedback</td>
<td>100%</td>
<td>48.64%</td>
<td>45.38%</td>
<td>51.32%</td>
<td>20</td>
</tr>
<tr>
<td>(M^{a})</td>
<td>99.75%</td>
<td>59.93%</td>
<td>55.04%</td>
<td>52.43%</td>
<td>17.47</td>
</tr>
<tr>
<td>(SD^{a})</td>
<td>0.54</td>
<td>20.52</td>
<td>19.76</td>
<td>16.21</td>
<td>26.25</td>
</tr>
</tbody>
</table>

*Note. The full table of Peyton’s performance can be found in Table H.1 in Appendix H.*

\(^{a}\) The mean and standard deviation include Peyton’s performance across all CSVM methods.

\(^{b}\) Eye gaze, directed communication, and generative language were measured by the total seconds of duration.
**Special education specific methods.** The strategies encompassed in special education specific methods used in the CSVM included errorless learning, formative assessment, an adapted reading passage, and breaks for extreme behaviors (see Table 4.18 for Peyton’s performance). The least successful of these methods was the reading passage with Peyton scoring 27.50% productivity, 27.50% independence, and 27.50% flexible attention. The reading passage was from the Attainment Company (2018) curriculum and was used to help define a chemical reaction. It was clear that Peyton did not engage well with the reading passage as evidenced by my anecdotal notes that included, “Peyton looked at me and then looked around the room.” On the other hand, Peyton responded well to the errorless learning practice sessions as evidenced by anecdotal notes including their eagerness to answer (i.e. Peyton “looked at me, I nodded, and [they] quickly answered.”) and productivity and independence scores. While these sessions required the students to answer the question before moving on, Peyton was highly productive at 67.84% (M = 59.93%) and independent at 63.61% (M = 55.04%), demonstrating that Peyton was an active participant, with very little prompting being required, in these sessions. Overall, including the errorless instruction practice sessions improved Peyton’s overall independent participation in the lessons.

**Active engagement in the computerized science vocabulary modules.** Active engagement was measured using the CMAE and included observation of the participants’ emotional regulation, social connectedness, communication, classroom participation, and flexibility (Sparapani et al., 2016). Through the analysis of the CMAE, I was able to determine Peyton’s (a) areas of need and (b) areas of strength when using the CSVM for
science vocabulary acquisition. See Table A.2 in Appendix H for Peyton’s scores across the CSVM.

Table 4.18. Summary of Peyton’s Performance During Instruction Using Special Education Specific Methods

<table>
<thead>
<tr>
<th>Methods</th>
<th>Emotional Regulation</th>
<th>Productivity</th>
<th>Independence</th>
<th>Flexible Attention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Errorless Learning</td>
<td>98.77%</td>
<td>67.84%</td>
<td>63.61%</td>
<td>39.14%</td>
</tr>
<tr>
<td>Formative Assessment</td>
<td>99.21%</td>
<td>53.10%</td>
<td>48.12%</td>
<td>58.15%</td>
</tr>
<tr>
<td>Reading Passage</td>
<td>100%</td>
<td>27.50%</td>
<td>27.50%</td>
<td>27.50%</td>
</tr>
<tr>
<td>Behavior Breaks</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>( M^a )</td>
<td>99.75%</td>
<td>59.93%</td>
<td>55.04%</td>
<td>52.43%</td>
</tr>
<tr>
<td>( SD^a )</td>
<td>0.54</td>
<td>20.52</td>
<td>19.76</td>
<td>16.21</td>
</tr>
</tbody>
</table>

Note. The full table of Peyton’s performance can be found in Table H.1 in Appendix H. N/A = no opportunities.

\( a \) The mean and standard deviation include Peyton’s performance across all CSVM methods.

**Areas of need.** Peyton’s main areas of need included independence and flexible attention across CSVM modules. These scores aligned with Peyton’s typical participation in classes as described by the primary teacher and in pre-observations where Peyton required many prompts to stay engaged in work and maintain attention to the task they were directed to work on. The independence and flexible attention scores demonstrated the importance of finding methods, such as the simulations, that engaged Peyton enough to keep their attention to the task.

**Areas of strength.** Peyton’s areas of strength included emotional regulation and responding throughout all the CSVM modules they completed. These scores also aligned with Peyton’s typical responses to instruction as described by the primary teacher and in pre-observations. While Peyton was often difficult to keep engaged, Peyton remained well regulated and responded to adult directives when provided. While these results did
not provide new information about Peyton, the data suggested that the CSVM can be used without negative effects on Peyton.

**Demonstration of photosynthesis vocabulary acquisition.** The students in this study were able to demonstrate photosynthesis vocabulary acquisition through the (a) pre- and posttest and (b) their patterns in answering questions. Peyton was absent during the whole class lesson on photosynthesis; therefore, I was not able to observe Peyton’s application of vocabulary acquisition to a typical classroom lesson.

**Pre- and posttest.** Peyton demonstrated positive acquisition of photosynthesis related vocabulary after being administered the pre- and posttest (scores can be found in Figure 4.17). Peyton scored 19 out of 30 (63.33%) on the pretest and improved to 23 out of 30 (76.67%) on the posttest. Peyton also decreased the amount of times errorless instruction was required to answer from four times to two times. Peyton struggled the most with Questions 1 and 3 which addressed what a plant needs to live and what type of air a plant needs to live. Question three was clearly a problem area for Peyton; however, it was surprising that errorless instruction was required for Question 1. It should be noted that two weeks passed between Peyton’s completion of Module 10 (Modules 11 and 12 were not completed) and the posttest due to Peyton’s absences. This could demonstrate that Peyton was able to retain the information acquired despite absences; however, it would have been interesting to see differences had Peyton completed Modules 11 and 12 and taken the posttest closer to the actual completion of the CSVM. Overall, these data outcomes demonstrated that Peyton successfully improved content knowledge and application of photosynthesis related vocabulary words to test questions through the implementation of the CSVM.
Patterns in answering questions. Peyton’s primary teacher reported that Peyton chooses the answer on the right most often. In pre-observations it was observed that when Peyton was given a choice of two items, the item on the right was selected when Peyton did not have prior experience with the task. For example, when sorting insects in adapted environmental science class, Peyton always chose the animal on the right whether it was an insect or not. In art class, Peyton chose all pieces for the snowman from the right but picked the colors they wanted in no particular order. Peyton also made choices during the daily calendar routine that did not present a preference; however, Peyton struggled to find picture symbols on a board with multiple options. These observations demonstrated that Peyton seemed to choose answers on the right when they do not have a personal preference or does not know the answer.

As seen in Figure 4.17 above, when Peyton was administered the pretest, they answered in an $AAABBB$ pattern, with $A$ being the left answer choice, and $B$ being the middle answer choice. While following this pattern, Peyton answered 20% of the pretest
questions on the first attempt (both answers on the left) and three of seven (42.86%) of questions on the second attempt. The remaining four questions were answered using errorless instruction. Peyton did not appear to use a pattern in answering the posttest questions. Peyton answered 50% of questions on the first attempt (three on the left and two on the right) and three of five (60%) questions on the second attempt. Peyton only required errorless instruction to answer two of the posttest questions. Peyton did answer one question correctly on the pretest but required two attempts on the posttest of the same question.

Peyton’s answers on the formative assessment questions appeared to be more random and targeted to the correct answer throughout the progression of the CSVM implementation. Peyton favored the middle and right answers in Modules 1 through 3 and the answers in the left position in Modules 4 through 5. Starting with Module 6, her first attempt at answers became more mixed and accurate. Overall, Peyton answered correctly on the first attempt in 26 of 42 questions (61.90%), on the second attempt in five of 14 questions (35.71%), and required errorless instruction for the remaining nine questions. In Modules 6 through 10, Peyton answered all but one question per module correctly on her first attempt (Module 10 had eight questions and the other modules had three each). Peyton did not have any errors in their answers on Module 8 questions.

**Summary of Peyton’s experience.** Overall, Peyton demonstrated an increased content knowledge and application of photosynthesis related vocabulary words through the increased test score from the pretest to the posttest. When the most and least successful modules were compared, it became clear that Peyton was more successful when there were not any distractions present, despite what the module presented. When
the types of graphic organizers were examined, Peyton responded best to the simpler and more concrete format that the t-charts provided over the more abstract Frayer model. Finally, true to Peyton’s overall learning characteristics, Peyton struggled with flexible attention and independence, but excelled with emotional regulation and responding.

**Riley’s Experience**

Riley, 18-years-old, was in the 11th grade during the 2019-2020 school year. Riley was nonverbal but often made vocal noises. Riley’s primary teacher shared that this participant enjoyed engaging with staff members in a playful manner and responded well to verbal praise. Riley’s primary teacher also reported that Riley often displayed attention-seeking behaviors such as dropping to the ground or going in other rooms when walking in the hall, swatting at adults, pushing items off the table, and taking shoes off. The primary teacher reported that Riley was able to answer questions without assistance when given a choice of two picture symbols but needed gestural and verbal prompting to respond when given a larger field. Riley required consistent monitoring and assistance to complete academic work. Riley did not struggle with transitions but required several verbal reminders to stay on track when moving from one location to another. Riley’s positive behavior and participation in academic/work tasks is reinforced by leisure time and sitting in a favorite camping chair.

Before the implementation of the CSVM, I observed Riley in the primary classroom, an art classroom, and my adapted environment science classroom. During these classes Riley sat crisscross in a chair and often rocked back and forth while making arm motions. In all three observations, Riley was told by the paraprofessional to sit up instead of laying their head down. Riley complied with directions but often needed hand-
over-hand assistance to complete tasks. Examples of these tasks included using sign language during calendar time, gluing small items on a snowman in art class, and creating an insect shape in my adapted environmental science. Riley was also observed trying to gain adult attention in art class. After completing a task in art, Riley would push a paper away and then was asked to stop. Riley would stop initially but then would slightly touch the paper and look at the paraprofessional to see if she noticed. The more Riley was ignored, the more the behavior occurred.

Overall, Riley required a lot of encouragement to complete academic tasks. Riley loved adult attention and would engage in behaviors to gain that attention. Riley would complete tasks and answer questions with adult assistance but preferred to have social and leisure time. What follows will detail Riley’s experience when participating in the CSVM implementation by describing the participant’s (a) performance by modules, (b) performance by CSVM component, (c) active engagement in the CSVM, and (d) demonstration of photosynthesis vocabulary acquisition.

Performance by modules. Riley completed all 12 CSVM modules. Due to missing two school days because of severe weather, Riley completed Modules 6 and 7 on the same day and Modules 8 and 9 on the same day. Riley had 15-minute breaks between the modules completed on the same day. Riley’s total performance by module can be seen in Table A.2 in Appendix H. What follows outlines (a) Riley’s least successful CSVM module performance and (b) Riley’s most successful CSVM module performance.

Least successful module. When looking at the overall data (see Table H.1 in Appendix H), Riley had the most difficulties when completing Module 11 (see Table
The topic of Module 11 was a review of photosynthesis which included an educational video (see Figure 4.18) and mnemonic instruction. According to Riley’s primary teacher, Riley had been displaying challenging behaviors prior to coming to my classroom to complete the modules. I noted this behavior in my researcher’s journal, stating, “[They] started swatting at me before we started.” When the module started, Riley took their shoes off and laid them on the table. I moved the shoes to the floor; however, when the video started, Riley started looking for the shoes and then picked them up and shoved them in my face. I moved the shoes and Riley attempted to get up to get them. I very sternly told Riley to stop and sit down. They sat down and started to self-regulate by stimming. Riley continued to alternate between swatting at me, attempting to turn the Apple® iPad® off, and stimming throughout the remainder of the video. During the last seconds of the video (the length of the video was approximately 3.5 minutes), Riley started to look around the table for things to grab and tried to grab my laptop. When the video was completed, Riley tried to turn the Apple® iPad® off and pushed it away.

During the remainder of Module 11, Riley had a few more instances of swatting at me or attempting to turn off the Apple® iPad®. While answering the second practice question, Riley increased the intensity of these behaviors, and I firmly said, “Stop. It’s enough.” Riley immediately stopped, looked down, and continued to answer the questions. Even though Riley began the research session very agitated, Riley was able to regain emotional regulation during the middle of the module and remained regulated for 93.35% of Module 11. For the remainder of the session, Riley swatted at the Apple® iPad® three more times but otherwise touched the answers when prompted by me. This
prompting included me holding Riley’s forearm so that I was not interfering with the answer by chosen by Riley.

Table 4.19. Riley’s Performance on Module 11

<table>
<thead>
<tr>
<th>Components</th>
<th>Riley’s Scores</th>
<th>$M^a (SD^a)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emotional Regulation</td>
<td>93.35%</td>
<td>92.68 (4.09)</td>
</tr>
<tr>
<td>Productivity</td>
<td>36.01%</td>
<td>60.28 (20.77)</td>
</tr>
<tr>
<td>Independence</td>
<td>57.61%</td>
<td>46.10 (17.36)</td>
</tr>
<tr>
<td>Flexible Attention</td>
<td>N/A</td>
<td>47.53 (24.66)</td>
</tr>
<tr>
<td>Flexible Behavior</td>
<td>100%</td>
<td>100 (0.00)</td>
</tr>
<tr>
<td>Responding</td>
<td>75.00%</td>
<td>90.76 (9.38)</td>
</tr>
<tr>
<td>Eye Gaze$^b$</td>
<td>26</td>
<td>23.08 (19.18)</td>
</tr>
<tr>
<td>Directed Communication$^b$</td>
<td>0</td>
<td>0.47 (0.64)</td>
</tr>
<tr>
<td>Generative Language$^b$</td>
<td>12</td>
<td>10.42 (8.24)</td>
</tr>
</tbody>
</table>

Note. The full table of Riley’s performance can be found in Table H.1 in Appendix H. N/A = no opportunities.

$^a$ The mean and standard deviation include Peyton’s performance across all methods.

$^b$ Eye gaze, directed communication, and generative language were measured by the total seconds of duration.

Figure 4.18. Screenshot of the Photosynthesis video from Module 11. Video from Peekaboo Kidz (2015).
Even though Riley was able to regain emotional regulation during the middle of Module 11, Riley struggled with productivity, independence, and responding. Riley did not have a flexible attention score during Module 11 because there were not any interruptions or distractions. Riley was productive 36.01%, independent 28.90%, and responsive 75.00% of the time during Module 11. These data suggested that Riley did not engage well with the educational video and mnemonic instruction in Module 11. Because Riley was already experiencing behavioral challenges before the research session started, it was difficult to determine if Riley’s mediocre performance on Module 11 was due to behaviors attributed to autism or a result of the methods used in the module.

Most successful module. When looking at the overall data (see Table H.1 in Appendix H), Riley was the most successful with Module 6 (see Table 4.20). The topic of Module 6 was sunlight, energy, and sugar and used a linear cognitive/word map to show the process of CO$_2$, water, and sunlight making sugar (see Figure 4.19). During Module 6, Riley was emotionally regulated 95.60%, productive 86.81%, independent 74.18%, and responsive 100% of the time. Module 6 required the students to interact and touch the Apple® iPad® constantly, which may have prompted Riley’s successful performance.

Despite the presence of many distractors during Module 6, Riley displayed flexible attention 91.45% of the time. During the first few seconds of Module 6, a student across the hall started to make high-pitched noises, and Riley was observed to display increased stimming. I reflected in my journal that, while it is difficult to determine if something was bothering Riley, they seemed agitated by the loud noise because as the noise became louder Riley started putting their hands over their head while making their own noises. It could be determined that the noises were bothering Riley because when the
noises stopped, Riley’s facial expression changed to a relieved look. I also noted that Riley did not notice several people walking by the classroom and was only distracted when another student working in the hall knocked on the classroom door. Even with this distraction, Riley continued to work through Module 6 with minimal prompting. The prompts utilized included verbal prompts from me, such as, “Which one?” or “Try again.” After the first minute, Riley was very calm and compliant during the remainder of Module 6.

Table 4.20. Riley’s Performance on Module 6

<table>
<thead>
<tr>
<th>Components</th>
<th>Riley’s Scores</th>
<th>$M^a (SD^a)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emotional Regulation</td>
<td>95.60%</td>
<td>92.68 (4.09)</td>
</tr>
<tr>
<td>Productivity</td>
<td>86.81%</td>
<td>60.28 (20.77)</td>
</tr>
<tr>
<td>Independence</td>
<td>74.18%</td>
<td>46.10 (17.36)</td>
</tr>
<tr>
<td>Flexible Attention</td>
<td>91.45%</td>
<td>47.53 (24.66)</td>
</tr>
<tr>
<td>Flexible Behavior</td>
<td>100%</td>
<td>100 (0.00)</td>
</tr>
<tr>
<td>Responding</td>
<td>100%</td>
<td>90.76 (9.38)</td>
</tr>
<tr>
<td>Eye Gaze$^b$</td>
<td>13</td>
<td>23.08 (19.18)</td>
</tr>
<tr>
<td>Directed Communication$^b$</td>
<td>0</td>
<td>0.47 (0.64)</td>
</tr>
<tr>
<td>Generative Language$^b$</td>
<td>1</td>
<td>10.42 (8.24)</td>
</tr>
</tbody>
</table>

*Note.* The full table of Riley’s performance can be found in Table H.1 in Appendix H.

$^a$ The mean and standard deviation include Peyton’s performance across all CSVM methods.

$^b$ Eye gaze, directed communication, and generative language were measured by the total seconds of duration.

*Figure 4.19.* Example of linear cognitive/word map from Module 6.
Overall, Module 6 seemed to be successful in engaging Riley due to the need to constantly touch the Apple® iPad®. Riley was able to work through a distraction that was bothersome and become emotionally regulated. Once regulated, Riley was able to ignore other distractors and successfully complete Module 6.

**Performance by CSVM component.** Riley’s performance on the CSVM varied according to the different components being accessed in the CSVM. A full table of Riley’s CSVM performance can be found in Table H.1 in Appendix H. This section will outline Riley’s performance by (a) mnemonics, (b) graphic organizers, (c) CAI in special education, and (d) special education specific methods.

**Mnemonics.** The photosynthesis mnemonic was introduced in Module 1 and reviewed in Module 5. While the mnemonic was not used for specific instruction in every module, it was shown at the beginning of each module in the introduction. A formative assessment question which asked, “Which picture shows how we can remember what photosynthesis means?” appeared in Modules 1, 5, and 11. Riley scored a 3, 2, and 3 respectively when this question was presented, demonstrating that Riley was successful in remembering the mnemonic. When mnemonic instruction was used, Riley struggled with productivity and independence (as seen in Table 4.21), however remained emotionally regulated and displayed positive flexible attention. Riley displayed the least amount time being productive 15.32% ($M = 61.59\%$) and second least amount of time demonstrating independence 16.94% ($M = 42.72\%$) during all of the CSVM components used. Even though Riley required much assistance to be productive and independent during mnemonic use, they remained emotionally regulated 96.04% ($M = 91.32\%$) of the time and displayed flexible attention 100% ($M = 91.37\%$) of the time. These data could
suggest that Riley liked the mnemonic enough to look at it, but it was not attractive enough to engage Riley to work independently. Overall, the use of mnemonics was not a successful engagement method for Riley.

Table 4.21. Summary of Riley’s Performance During Instruction Using Mnemonics

<table>
<thead>
<tr>
<th>Mnemonics</th>
<th>Emotional Regulation</th>
<th>Productivity</th>
<th>Independence</th>
<th>Flexible Attention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mnemonics</td>
<td>96.04%</td>
<td>15.32%</td>
<td>16.94%</td>
<td>100%</td>
</tr>
<tr>
<td>$M^a$</td>
<td>91.32</td>
<td>61.59</td>
<td>42.72</td>
<td>91.37</td>
</tr>
<tr>
<td>$SD^a$</td>
<td>12.26</td>
<td>26.46</td>
<td>22.51</td>
<td>14.66</td>
</tr>
</tbody>
</table>

*Note.* The full table of Riley’s performance can be found in Table H.1 in Appendix H. *$^a$* The mean and standard deviation include Riley’s performance across all CSVM methods.

**Graphic organizers.** The graphic organizers used in the CSVM included cognitive/word maps, t-charts, and Frayer models (Riley’s performance can be seen in Table 4.22). Each module included an instruction portion where the student watched the graphic organizer be completed, and a practice session in which the student completed the graphic organizer. Riley struggled when Frayer models were used in the modules. Riley displayed engagement 25.81% of the time for both productivity and independence when Frayer models were used. On the other hand, Riley was the most productive with t-chart practice at 95.83% and cognitive/word map instruction 95.12% of the time. Riley was also independent with cognitive/word map instruction 95.12% of the time. This data suggested that Riley required graphic organizers that were visually simpler, and which contained a smaller amount of details.

**Computer-assisted instruction in special education.** The CAI methods used in the CSVM included educational videos, educational songs, simulations, and applause.
feedback (Riley’s performance can be found in Table 4.23). Interestingly, Riley was least productive with educational videos at 26.95% productivity and the most successful with educational songs at 90.75% productivity. Riley required prompting from me to engage in both the educational videos and songs; however, the videos required more assistance as demonstrated by Riley’s independence score of 25.44%. Riley also demonstrated decreased emotional regulation at 89.13% of the time during educational videos. It is not clear if the cause of the decreased emotional regulation was a direct result of the educational videos or from extraneous factors such as noises from across the hall.

Table 4.22. Riley’s Performance on Graphic Organizers

<table>
<thead>
<tr>
<th>Graphic Organizers</th>
<th>Emotional Regulation</th>
<th>Productivity</th>
<th>Independence</th>
<th>Flexible Attention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Word Map</td>
<td>87.80%</td>
<td>95.12%</td>
<td>95.12%</td>
<td>NA</td>
</tr>
<tr>
<td>Cognitive Word Map Practice</td>
<td>94.74%</td>
<td>63.16%</td>
<td>24.56%</td>
<td>100%</td>
</tr>
<tr>
<td>T-Chart</td>
<td>100%</td>
<td>68.97%</td>
<td>68.97%</td>
<td>NA</td>
</tr>
<tr>
<td>T-Chart Practice</td>
<td>97.10%</td>
<td>95.83%</td>
<td>15.94%</td>
<td>100%</td>
</tr>
<tr>
<td>Frayer Model</td>
<td>94.19%</td>
<td>25.81%</td>
<td>25.81%</td>
<td>NA</td>
</tr>
<tr>
<td>Frayer Model Practice</td>
<td>90.18%</td>
<td>70.53%</td>
<td>34.39%</td>
<td>93.94%</td>
</tr>
<tr>
<td>(M^a)</td>
<td>91.32</td>
<td>61.59</td>
<td>42.72</td>
<td>91.37</td>
</tr>
<tr>
<td>(SD^a)</td>
<td>12.26</td>
<td>26.46</td>
<td>22.51</td>
<td>14.66</td>
</tr>
</tbody>
</table>

*Note.* The full table of Riley’s performance can be found in Table H.1 in Appendix H. *a* The mean and standard deviation include Riley’s performance across all CSVM methods.

Additionally, while not the highest rates, Riley demonstrated levels well above the mean during the simulation practice. Riley was emotionally regulated 96.40%, productive 80.80%, and independent 54.80% of the time during the simulation practice. Riley also demonstrated 100% flexible attention for all CAI components when distractors were present. Overall, these data suggested that Riley was most successful when they could touch the Apple® iPad® and actively engage with the modules.
Table 4.23. *Riley's Performance During Computer-Assisted Instruction Components*

<table>
<thead>
<tr>
<th>Components</th>
<th>Emotional Regulation</th>
<th>Productivity</th>
<th>Independence</th>
<th>Flexible Attention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational Videos</td>
<td>89.13%</td>
<td>26.95%</td>
<td>25.44%</td>
<td>NA</td>
</tr>
<tr>
<td>Educational Songs</td>
<td>97.31%</td>
<td>90.75%</td>
<td>51.94%</td>
<td>100%</td>
</tr>
<tr>
<td>Simulations</td>
<td>95.97%</td>
<td>61.41%</td>
<td>54.03%</td>
<td>100%</td>
</tr>
<tr>
<td>Simulations Practice</td>
<td>96.40%</td>
<td>80.80%</td>
<td>54.80%</td>
<td>100%</td>
</tr>
<tr>
<td>Applause Feedback</td>
<td>97.10%</td>
<td>71.21%</td>
<td>67.86%</td>
<td>100%</td>
</tr>
</tbody>
</table>

*Riley’s performance across all CSVM methods.*

*Riley’s performance can be found in Table H.1 in Appendix H.*

The mean and standard deviation include Riley’s performance across all CSVM methods.

**Special education specific methods.** The strategies encompassed in the special education specific methods used in the CSVM included errorless learning, formative assessment, an adapted reading passage, and breaks for extreme behaviors (see Table 4.24 for Riley’s performance). Riley was given a break to regulate their behavior when needed during Module 12. For Riley, the least successful special education method used was the adapted reading passage. Riley demonstrated their lowest percentage of emotional regulation (47.06%) during the adapted reading passage. Riley was only productive and independent 17.65% of time, which was far below the mean scores of time for productivity and independence. Most notable, Riley displayed 0% flexible attention during the adapted reading passage. These data suggested that Riley did not like listening to the reading passage, and this method had adverse effects on Riley’s performance in the CSVM implementation.

Riley performed well when errorless learning and formative assessments were presented. Riley remained emotionally regulated during both errorless learning (93.66%) and formative assessment (93.05%) tasks. Of these tasks, Riley was most independent.
with errorless learning tasks (42.70%). I noted in my observations several times that Riley performed well with errorless instruction because they seemed to notice the green box highlighting the answer. Riley’s attention to the green box was evident by their immediate and direct touch of the highlighted answer. The formative assessment was the most successful of the special education specific methods with Riley being productive 76.76% and independent 41.31% of the time. Riley’s independence scores were lower because they often required assistance for their touch to register (i.e. I would click the answer on my laptop when the Apple® iPad® did not register Riley’s touch). It should also be noted that, while not the lowest, Riley’s flexible attention scores were below the mean of 91.37% for errorless learning (68.15%) and formative assessment (82.31%).

Table 4.24. Riley’s Performance During Instruction Using Special Education Specific Methods

<table>
<thead>
<tr>
<th>Methods</th>
<th>Emotional Regulation</th>
<th>Productivity</th>
<th>Independence</th>
<th>Flexible Attention</th>
<th>Responding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Errorless Learning</td>
<td>93.66%</td>
<td>66.94%</td>
<td>42.70%</td>
<td>68.15%</td>
<td>94.29%</td>
</tr>
<tr>
<td>Formative Assessment</td>
<td>93.05%</td>
<td>76.76%</td>
<td>41.31%</td>
<td>82.31%</td>
<td>94.64%</td>
</tr>
<tr>
<td>Reading Passage</td>
<td>47.06%</td>
<td>17.65%</td>
<td>17.65%</td>
<td>0%</td>
<td>66.67%</td>
</tr>
<tr>
<td>Behavior Breaks</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>55.56%</td>
</tr>
<tr>
<td>$M^a$</td>
<td>91.32</td>
<td>61.59</td>
<td>42.72</td>
<td>91.37</td>
<td>91.37</td>
</tr>
<tr>
<td>$SD^a$</td>
<td>12.26</td>
<td>26.46</td>
<td>22.51</td>
<td>14.66</td>
<td>14.66</td>
</tr>
</tbody>
</table>

*Note. The full table of Riley’s performance can be found in Table H.1 in Appendix H. $^a$The mean and standard deviation include Riley’s performance across all CSVM methods.*

Overall, this data can be interpreted to show that Riley did not like, nor did they perform well, during the adapted reading passage. Riley also struggled with flexible attention during the errorless learning (68.15%), formative assessment (82.31%), and
adapted reading passage (0%) when compared to the mean of 91.37%, suggesting that Riley required a lot of prompting to attend to these tasks. However, Riley’s emotional regulation, productivity, and independence scores were close to the mean scores for errorless learning and the formative assessment, suggesting these special education specific methods seem to be positive strategies for keeping Riley engaged or on task.

Active engagement in the computerized science vocabulary modules. Active engagement was measured using the CMAE and included observation of the students’ emotional regulation, social connectedness, communication, classroom participation, and flexibility (Sparapani et al., 2016). Through the analysis of the CMAE, I was able to determine Riley’s (a) areas of need and (b) areas of strength when using the CSVM for science vocabulary acquisition. See Table H.1 in Appendix H for a summary of Riley’s CSVM scores.

Areas of need. Regarding active engagement, Riley struggled the most with independence and flexible attention. It should also be noted that Riley’s independence scores were often lower because of the assistance required for their answers to register on the Apple® iPad®. These findings were consistent with Riley’s primary teacher’s observations of Riley’s typical work habits. Riley craved adult attention, which often resulted in attention-seeking behaviors (i.e. swatting at adults, taking shoes off, playing with items on the table, etc.), affecting Riley’s independence and flexible attention scores.

Areas of strength. Throughout all of the CSVM modules, Riley’s areas of strength were in responding (91.37%) and emotional regulation (91.32%). This could suggest that Riley overall enjoyed the CSVM and uncharacteristically responded well to
adult direction and prompting while participating. I would like to note that Riley was productive 61.59% of the time, which is a high percentage when compared to their primary teacher’s description of typical classroom productivity. Overall, Riley demonstrated improved overall performance in the CSVM suggesting the research intervention to have been successful in keeping Riley engaged.

**Demonstration of photosynthesis vocabulary acquisition.** The students in this study were able to demonstrate photosynthesis vocabulary acquisition through the (a) pre- and posttest and (b) their patterns in answering questions. Riley was absent during the whole class lesson on photosynthesis; therefore, I was not able to observe Riley’s application of vocabulary acquisition to a typical classroom lesson.

**Pre- and posttest.** Of the three students, Riley demonstrated the most acquisition of photosynthesis related vocabulary from the pretest (60.00% accuracy) to the posttest (90.00% accuracy). Riley’s pre- and posttest answers can be found in Figure 4.20. Riley only required errorless instruction on Question 4 of the posttest, which asked, “What does a plant need to make food?” As discussed previously, Question 4 was difficult for all the students most likely due to the attractive picture symbol of the blocks; however, Riley also chose the picture of sticks before the correct answer of sun. Impressively, Riley only required a second attempt on Question 2 and Question 6. Overall, the pre- and posttest scores demonstrated that Riley improved their photosynthesis vocabulary acquisition after completing the 12 CSVM implementation.

**Patterns in answering.** Riley’s primary teacher reported that Riley always answered to the right, no matter the type of question and/or method being used. During the pre-observations, it was noted that Riley chose answers on the right when sorting
insects in my adapted environmental science class and choosing pieces for the art project. This positional preference was also noted during the lesson about seasons in Riley’s primary classroom. When they went to the board to choose the type of weather that usually occurs in spring, Riley continually touched snow which was located on the right. Overall, these observations confirmed that Riley used positional preference when answering questions.

Figure 4.20. Riley's answering patterns on the pre- and posttest.

Riley followed this pattern, answering right to left, on the pretest (this pattern can be seen in the above Figure 4.20). Riley scored 30% on the first attempt with all three correct answers being on the right. Riley required two attempts for two additional questions and required errorless instruction for the remaining five questions. Riley did not use patterns when answering questions on the posttest. Riley’s score for the first attempt was 70% and required two attempts for two questions and errorless instruction.
for only one question. Riley answered one question to the left correctly the first time; however, the three questions that required additional attempts were on the left.

Riley’s answers on the formative assessment questions did not seem to follow any patterns. Riley answered correctly on the first attempt in 33 of 46 questions (71.74%), on the second attempt in 11 of 13 questions (84.62%), and only required errorless instruction for two questions. Riley answered all of the questions in Modules 4, 11, and 12 with 100% accuracy on the first attempt. It could be inferred that the practice questions before the formative assessment questions helped Riley to locate answers in different positions.

**Summary of Riley’s experience.** Riley struggled the most with Module 11 likely due to behaviors issues they experienced prior to starting the research session. Riley did not respond well to the adapted reading passage, Frayer models, mnemonic, or educational videos. The areas of need for Riley were independence and flexible attention. Riley performed the best during Module 6 and when t-chart, cognitive/word maps, educational songs, and simulations were used. Riley’s areas of strength were emotional regulation and responding, as well as notable performance in productivity. Overall, Riley demonstrated many of their typical behaviors when participating in the academic tasks of this research; however, Riley demonstrated many positive performances resulting in an improved posttest score and decreased patterns in answering.

**Converged Findings**

A joint display table for the converged findings can be found in Table 4.25. Overall, the implementation of the CSVM was not successful in improving flexible attention when distractions and interruptions were present. This means that all components of the CSVM were not engaging enough for the students to ignore the
distractions and interruptions that occurred. Regarding the components of the CSVM, the adapted reading passage and Frayer models were not successful with the students and would likely be eliminated in future modules. On the other hand, all the students were successful with emotional regulation and responding. The students were also successful with the cognitive/word maps and t-chart graphic organizers, as well as the simulations. Finally, all three students achieved increased scores from the pretest to the posttest, demonstrating their increased acquisition of photosynthesis vocabulary after the implementation of the CSVM.

Table 4.25. Joint Display Table for Converged Findings

<table>
<thead>
<tr>
<th>Findings</th>
<th>Quantitative Findings</th>
<th>Qualitative Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Similarities/Differences</strong></td>
<td><strong>Similarities</strong></td>
<td><strong>Similarities</strong></td>
</tr>
<tr>
<td></td>
<td>- Increased posttest scores</td>
<td>- Difficulty with flexible attention</td>
</tr>
<tr>
<td>Similarities</td>
<td></td>
<td>- Success with emotional regulation and responding</td>
</tr>
<tr>
<td>Differences</td>
<td></td>
<td>- High engagement with simulations</td>
</tr>
<tr>
<td></td>
<td>- Peyton and Riley changed patterns in answering</td>
<td>- Low engagement with the adapted reading passage and Frayer model</td>
</tr>
<tr>
<td>Differences</td>
<td></td>
<td>- Peyton and Riley difficulties with independence</td>
</tr>
<tr>
<td>Integrated Statement</td>
<td>All three students also improved their scores from the pretest to the posttest.</td>
<td>All three students demonstrated difficulties with flexible attention and success with emotional regulation and responding. All three students demonstrated low engagement with the adapted reading passage and Frayer models. The students had the highest engagement in cognitive/word maps (Charlie and Riley) and t-charts (Peyton and Riley). The modules in which the students were the most and least engaged were different for all three students.</td>
</tr>
</tbody>
</table>
Chapter Summary

Chapter four presented the findings and analysis of this study including the quantitative findings, the qualitative findings, Charlie’s experience, Peyton’s experience, Riley’s experience, and converged findings between students. The quantitative findings from the pre- and posttest confirmed that the implementation of CSVM with students with intellectual disability and autism was successful in their acquisition and application of photosynthesis related vocabulary terms for all three students. The quantitative findings from the formative assessment were used throughout the implementation process to inform me where the students were in the learning process and where they needed to improve, resulting in the adjustment of the number of modules and combining content in those modules.

The qualitative findings from the CMAE and my researcher’s journal were coded, and three themes and one assertion were developed. The themes and assertion were used to describe how the overall CSVM implementation affected the students’ active engagement in an academic task. The qualitative findings were then converged with the quantitative findings to create an overall picture of the students’ experiences with the CSVM. While each student had unique experiences with the CSVM implementation, there were several findings that could be converged.

The converged findings confirmed that flexible attention was an area of concern for all students during the CSVM implementation. When looking at the specific components of the CSVM, it was found that Frayer models and an adapted reading passage were not successful, but cognitive/word maps, t-charts, and simulations were successful at actively engaging the students. Finally, all three students improved their
scores on posttest from the pretest, confirming the acquisition of photosynthesis related vocabulary after the implementation of the CSVM.
CHAPTER 5
DISSCUSSION, IMPLICATIONS, AND LIMITATIONS

The purpose of my study was to evaluate the implementation of CSVM with students with an intellectual disability and autism in an adapted environmental science class. The implementation of the CSVM was evaluated using quantitative measures (i.e. pre- and posttest, formative assessments, and CMAE) and qualitative measures (i.e. anecdotal notes on the CMAE and my researcher’s journal). Through the collection of data, I was able to assert that the students’ learning challenges attributed to an intellectual disability and autism and the instructional methods used in the CSVM and by the teacher affected the students’ active engagement in the CSVM. This section includes (a) a discussion, (b) the implications, and (c) the limitations of my study.

Discussion

To answer the two research questions of this study, the students were administered a pre- and posttest, formative assessments in each module, and observed and scored using the CMAE. It should be noted that my researcher’s journal was used to support the data sources for both research questions; however, my researcher’s journal did not provide enough data to be a standalone source. The data collected from these methods were analyzed and findings were explained for each student’s personal experience and then converged to report similar findings. This section includes a discussion of the findings for (a) RQ 1 and (b) RQ 2.
Research Question 1: How does the implementation of the computer-assisted vocabulary modules, which adhere to evidence-based practices of special education vocabulary instruction, affect the acquisition and application of science vocabulary terms with students with an intellectual disability and autism in an adapted environmental science class?

RQ 1 was answered through the analysis of the photosynthesis pre- and posttest scores and formative assessment questions from the CSVM. These findings support that implementing the CSVM with three students with an intellectual disability and autism in an adapted environmental science class was very successful in the students’ acquisition of science vocabulary terms. The findings in my study are consistent with the findings that the use of explicit instruction (Kalenberg et al., 2015) along with vocabulary strategies such as graphic organizers (Douglas et al., 2006) with students with an intellectual disability and autism effectively promotes science vocabulary learning (Riccomini et al., 2017). In addition, the use of CAI with students with an intellectual disability and autism has been found to improve academic achievement (Ozen et al., 2017; Ramdoss, Machalicek, et al., 2012; Ramdoss, Mulloy, et al., 2011; Sigafoos et al., 2014) make the general education curriculum accessible, (Fernández-López et al., 2013; McKissick et al., 2013; Wakeman et al., 2013) increase students’ independence (Bouck, et al. 2014; Mazzotti et al., 2012; McKissick et al., 2017; Saad et al., 2015; Sigafoos et al., 2014), and assist in gaining students’ engagement (Coleman-Martin et al., 2010; Moore & Calvert, 2000; Özgüç & Cavkaytar, 2016; Ramdoss, Mulloy, et al., 2011; Whitby et al, 2012).

Further analysis of the photosynthesis CSVM outcomes provided insight to (a) the implication of the pre- and posttest scores, (b) how the formative assessments were used
to improve instruction, (c) how the CAI and special education vocabulary instruction methods influenced the students’ vocabulary acquisition, and (d) application of science vocabulary terms.

**Implication of the pre- and posttest results.** The photosynthesis pre- and posttest results were a powerful indicator that Charlie, Peyton, and Riley greatly improved their science vocabulary acquisition after participating in the CSVM. The most notable difference was Riley’s increase from 60.00% on the photosynthesis pretest to 90.00% on the photosynthesis posttest, followed by Charlie’s increase from 76.67% on the photosynthesis pretest to 90.00% on the photosynthesis posttest and Peyton’s increase from 63.33% on the photosynthesis pretest to 76.67% on the photosynthesis posttest. The primary teachers were very excited about these scores and expressed that the increase of scores over a short time-period was not typical of the three students. The pre- and posttest results were also supported by the unexpected finding that, during the posttest, the students abandoned their typical patterns in answering questions. This abandonment from their typical patterns in answering could suggest the students were attempting to make more purposeful attempts to answering the questions (Bourret, 2012); however, research in this area is sparse. Most current research on the positional preference for students with an intellectual disability and/or autism addresses the students’ choice of preferred activities (e.g. Lohrmann-O’Rourke & Browder, 1998) or the effects of reinforcement on choice (e.g. Lerman et al., 1997; Yuan, 2018) and not specifically answering academic questions. Overall, the notable increase in pre- and posttest scores was a very promising result implying programs such as the CSVM could be successful with students with an intellectual disability and autism.
The use of formative assessments to improve instruction. According to Kendorski and Fisher (2018), using formative assessment is an important part of any type of special education instruction because they allow teachers to capture small changes in the students’ learning. Following Blachowicz and Fisher’s (2002) suggested guidelines, I used teacher-created vocabulary formative assessments. The students were administered at least three formative assessment questions in each module. There were three types of questions including multiple choice, touch-the-model, and fill-in-the-blank. The data gathered from the formative assessment questions were used to adjust the CSVM timeline and components. Such adjustments included combining topics into fewer overall modules due to good progress early in the implementation phase, creating practice sessions for the graphic organizers so the students could interact with the modules more and adding more sound effects to the simulations. These adjustments allowed the students to successfully complete the modules with the cognitive load level that led to successful vocabulary acquisition. My findings support that formative assessments were successful with adjusting the curriculum to meet these three students’ needs. The findings also aligned with the outcomes of Browder et al. (2012), McMahon et al. (2016), and Smith, Spooner, and Wood (2013) who all used formative assessments to measure the students with intellectual disability and/or autism current vocabulary learning and used the results to adjust instruction. The success of formative assessments was also determined by the increased scores across the modules, with Modules 11 and 12 containing the highest average scores. Overall, adjusting the instruction according to the formative assessment scores was successful in increasing my three students’ vocabulary acquisition at a pace that met their unique learning needs.
The influence of computer-assisted instruction and special education vocabulary instruction on the students’ science vocabulary acquisition. SCS is in a school district which uses a 10-point grading scale, with anything above 70% being above average (10 point grading scale, n.d.). I used this scale as a basis for interpreting above average scores for my three students’ performances. Two modules had formative assessment average scores above 80.00%. These modules were Module 11 (100%) and Module 12 (93.33%). Module 11 was a repeat of Module 1 and contained an educational video and mnemonic instruction. Module 12 used a simulation and educational song. Only three modules had formative assessment average scores below 80.00%. These modules were Modules 2 (70.37%), 3 (77.78%), and 6 (77.78%) which used an educational song (Module 3), t-chart (Module 3), linear cognitive/word map (Module 6), educational video (Module 2), and Frayer model (Module 2).

Since all formative assessment average scores were above 70.00% and the CAI and special education vocabulary instruction methods varied from the highest and lowest formative assessment score averages, it could not be determined that one method of instruction used better influenced the students’ vocabulary acquisition. However, because Module 11 was a repeat of Module 1 and had an increase of mastery to 100%, it could be inferred that the CSVM altogether, with the combination of all methods, was why the students were able to greatly increase their acquisition of science vocabulary. This finding is supported by previous research that the use of multimodal formats with students with an intellectual disability and autism are best because they engage the senses (Saad et al., 2015), direct student attention to the task (Whitby et al., 2012), provide visual (Barnett et al., 2018; Mize et al., 2018; Sigafoos et al., 2014) and auditory supports
(Dzulkifli et al., 2016; McKissick et al., 2017; Mize et al., 2018), and allow students to express their knowledge in different formats (Hasselbring & Glasser, 2000). It is also supported by previous research findings that students with an intellectual disability and autism need repetition to learn targeted vocabulary terms (Coleman-Martin et al., 2005; Collins & Ludlow, 2018).

**Application of science vocabulary terms.** The students’ application of the science vocabulary terms was planned to be measured by the three students’ participation in a whole class lesson about photosynthesis. Instead, only Charlie was present for this application lesson. While Charlie was successful during the CSVM portion of the whole class lesson, they did not seem to be engaged; resulting in the difficulty of accurately measuring the application of the science vocabulary terms. In summary, findings of this research could suggest that the students’ increased acquisition of science vocabulary was due to the use of multimodal CAI and special education vocabulary instruction methods and the repetition of content across modules, and not one specific component or method.

**Research Question 2: How are the students with an intellectual disability and autism engaged in computer-assisted instruction activities?**

The students’ engagement in the CAI activities was measured using the CMAE. The students’ engagement was calculated for the percentage of time they were emotionally regulated, productive, independent, demonstrating flexible attention, demonstrating flexible behavior, and responsive to adult direction. Frequency counts were recorded each time the students’ displayed eye gaze with another person, directed communication, and used generative language. Anecdotal notes were also recorded to further describe how the three students were engaged in the CSVM. These data collection
methods were validated by Sparapani et al. (2016) who created the CMAE based on the areas of deficit for students with autism and completed a confirmatory factor analysis to ensure the factors were significant contributors to students’ active engagement.

The CSVM included CAI activities that were based on evidence-based practices of special education vocabulary instruction, as well as specific CAI components. CAI was chosen because for this innovation because it has been found to improve academic achievement (Ozen et al., 2017; Ramdoss, Machalicek, et al., 2012; Ramdoss, Mulloy, et al., 2011; Sigafoos et al., 2014; Wakeman et al., 2013; Whitby et al., 2012), more specifically vocabulary instruction (Bosseler & Massaro, 2003; Coleman-Martin, et al. 2005; McKissick et al., 2018; Moore & Calvert, 2000; Smith, Spooner & Wood, 2013) in students with an intellectual disability and autism. CAI was also found to help students with disabilities improve independence (Fernández-López et al. 2013; Mazzotti et al., 2010; McKissick et al., 2017; Özgüç & Cavkaytar, 2016; Saad et al., 2015; Sigafoos et al., 2014) by gaining their attention and providing motivation (Moore & Calvert, 2000; Ramdoss, Mulloy, et al., 2011; Whitby et al., 2012). The areas of these CAI activities included mnemonics, graphic organizers, and special education methods, while the specific CAI components included multimodal formats, simulations, and applause feedback. The major areas of the CMAE that I focused on in the CSVM included emotional regulation, productivity, independence, flexible behavior, and flexible attention. While I recorded data, I did not focus as much on responding, eye gaze, directed communication, and generative language because these areas described times the students were engaging with people and not engaging solely with the CSVM.
Overall, the students’ engagement in the CSVM was positive with most scores averaging above 50.00% engagement; however, they were mixed between the three students and there was diversity in the length of their engagement with the CSVM based on the students’ preferences. Only the adapted reading passage findings for engagement were consistent across all three students’ outcomes. Further analysis of the CMAE areas provided insight to the CAI components and special education vocabulary instruction methods that had (a) negative effects on students’ engagement and (b) positive effects on the students’ engagement.

**Negative effects on students’ engagement.** The quantitative analysis of the CMAE score revealed that the adapted reading passage and Frayer model instruction and practice had negative effects on the students’ engagement. Further research about why these items could have had negative effects would need to be conducted because the use of Frayer models has not been researched with students with an intellectual disability and autism and the adapted reading passage is part of a research-based program that has been found to be successful with students with disabilities (Attainment Company, 2018). The adapted reading passage had the lowest mean scores for emotional regulation (M = 82.35), productivity (M = 15.05), independence (M = 15.05), and flexible attention (M = 13.75). In fact, of the three students, Riley demonstrated the most emotional regulation (47.06% of the time), yet demonstrated flexible attention 0.00% of the time during the adapted reading passage. Also, Charlie was productive and independent 0.00% of the time during the adapted reading passage. These findings were also supported by my observations of the students looking away and/or around the room during the adapted reading passage. This finding was surprising because the adapted reading passage was
from the science curriculum our school uses. This could suggest that the students preferred the multimodal material on the CSVM over the curriculum materials typically used in my school’s science instruction.

Frayer model instruction and practice also had some negative effects on the students’ engagement in the CSVM. While the students displayed emotional regulation (M = 98.06 for instruction and M = 96.73 for practice) and flexible attention (instruction for Charlie only = 22.22% and M = 80.57 for practice), they struggled with productivity (M = 34.64 for instruction and M = 59.63 for practice) and independence (M = 32.52 for instruction and M = 34.88 for practice). Current research on the use Frayer models with students with a moderate to profound intellectual disability and autism was not found and was exploratory in nature in my study. Based on these findings, Frayer models may have contained too much information in one viewing and more simplistic graphic organizers, such as t-charts, may be more successful with students with an intellectual disability and autism.

Positive effects on the students’ engagement. Recent researchers have discovered that students with an intellectual disability and autism benefit from multiple modalities (Saad et al., 2015) and CAI components like simulations that make the real-world accessible and interactive (Israel et al., 2013; Mechling et al., 2003; Mechling et al., 2005; Wright et al., 2015). These research findings were also reflected in this study.

Except for Riley’s adapted reading passage score (47.06%), the students mean scores for emotional regulation were all above 95.00% and all flexible behavior scores were 100%. This means the students did not display any major negative behaviors and overall appeared as content while participating in the CSVM. When external distractors
were present, the students were able to be flexible with their attention most of the time. When converging my observations with the overall mean of flexible attention for Charlie, it became obvious their engagement was lowered because of the numerous times Charlie was distracted by seeing Ms. Lisa and not solely due to other extraneous distractors. The students displayed the most flexible attention during simulations ($M = 91.41$), t-chart practice ($M = 87.50$), and Frayer model practice ($M = 80.57$). It could be inferred from these scores that the students enjoyed the simulations with movement and sounds, as well as when they touched the Apple® iPad® to control the graphic organizers.

According to the three students’ primary teachers, each generally struggled with productivity and independence in their daily academic tasks. When examining the elements of the CSVM, the students were the most productive with t-chart instruction ($M = 88.32$), simulation practice ($M = 82.27$), and educational songs ($M = 78.19$). It could be inferred that the students’ attention was attracted to simple graphic organizers, simulations that involved changing pictures and sounds, and short educational songs presented through engaging videos.

The three students were the most independent with t-chart instruction ($M = 79.06$), applause feedback ($M = 68.77$), cognitive/word map instruction ($M = 63.14$), and simulation instruction ($M = 60.30$). Interestingly, these areas did not involve the students touching the Apple® iPad®, but rather they had to watch the instruction. It could be inferred that the independence scores were lower for the interactive portions because the students depended on verbal prompting and/or physical prompting to answer questions and work on the Apple® iPad®. An example of this is when I would have to assist Charlie with registering their answers due to their sweaty hands. Overall, the students’
independence scores may have been lower due to their educational and/or physical needs and not solely regarding their attention to the CSVM.

Finally, the use of the t-chart instruction had high mean scores for emotional regulation ($M = 100$), productivity ($M = 88.32$), and independence ($M = 79.06$). The t-chart practice sessions also had high emotional regulation ($M = 98.44$) and productivity ($M = 79.71$). It could be concluded that the students engaged with t-chart instruction because they were familiar with this method as I used it often in my class. The students may have also preferred the simplicity of two columns as they are typically presented with two answer choices in daily instruction. Previous research supported the use of t-charts with students with disabilities to show examples and non-examples (Browder et al., 2011), which is how the t-chart was used in this study.

**Implications**

The implications of my research can be explored in three realms. These realms include my (a) personal implications, (b) implications for educators of students with an intellectual disability and autism, and for (c) future research.

**Personal Implications**

The most important implication to me personally was that my students were able to acquire difficult science vocabulary using the CSVM. Through this major implication, I can identify the parts of my study that will continue to inform my practice as an adapted environmental science teacher. These implications include (a) my research methods, (b) unexpected findings, (c) my changed perceptions and lasting experiences resulting from the findings, and (d) sharing and communicating findings with stakeholders.
**Research methods.** When starting my research project, it was difficult for me to differentiate between the use of action research and case study; however, through this process I have learned and noted the differences. As shared by Blichfeldt and Anderson (2006), action research and case study share many qualities such as diversity in theory, diversity in practice, gaining “an understanding of particular phenomena in real-word settings” (para. 7), and a focus on action. However, action research starts with a problem in the researcher’s practice, whereas case study starts with the researcher’s interest (Blichfeldt & Anderson, 2006). Also, action research does not attempt to generalize findings beyond the study setting, case study researchers do seek generalization to other settings or areas (Blichfledt & Anderson, 2006). Based on these similarities and differences, I have gained a deeper understanding of and appreciation for action research because I am able to solve educational problems at the local level (Creswell, 2012; Lodico et al., 2010; Patton, 2002) and implement appropriate actions (Buss & Zambo, 2014).

**Unexpected findings.** My study had two findings that were unexpected: (a) patterns in answering and (b) the adverse effects of the adapted reading passage. The research on the commonness of students with an intellectual disability and autism using patterns for responses is sparse with human subjects (cf. Kangas & Branch, 2008) since Galloway’s 1967 study; however, Bourret, Itwata, Harper, and North (2012) studied five children with autism or other developmental disabilities and found that all the children “showed a pronounced bias by typically selecting the stimulus placed in either left or right positions” (p. 241). While I knew my students had preferences and patterns in their answer choices from observations and discussions with their primary teachers, I had not
previously thought about how they would abandon those patterns. I was very excited to see my students put this effort into looking at and purposefully selecting an answer. I think this unexpected finding will build upon Bourret et al.’s (2012) research and open doors for future research in this area for students with intellectual disability and autism.

I was also surprised how aversive the adapted reading passage was for all three participants. The adapted reading passage came from the curricular series used in all classrooms at our school. I initially thought the students would like the connection to what they see every day; however, the students’ attention was the lowest for all items in CSVM. This finding has personal implications because I have come to realize I need to further evaluate the curriculum we are provided to determine if it is truly a successful method of instruction for our students with an intellectual disability and autism. I am cognizant that action research is not generalizable and there could also be other explanations for why all three students performed poorly when using the adapted reading passages.

**My changed perceptions and lasting experiences.** When I started the CSVM implementation, I did not expect the students to progress so quickly. I initially thought the process would take a month’s worth of CSVM for the students to acquire the photosynthesis vocabulary. The importance of formative assessment in guiding instruction (Kendorski & Fisher, 2018; Taras, 2005) was highlighted through this finding. I also realized more than ever that even though the students may not appear to be engaged in instruction, they may be taking in more than we know. This fact was brought to light by Riley’s performance on the posttest despite their overall lower engagement scores.
Sharing and communicating findings. The findings from this study were shared with the participants’ parents, their primary teachers, and the SCS’s instructional coach. While Peyton’s mother did not respond to my emails, Riley and Charlie’s mothers stayed involved throughout the process. Riley’s mother shared, “Well I have to say that sounds just like [Riley]. [They do] the same things at home to get our attention which often gets [them] put in timeout away from the things [they] enjoy especially [the Apple®] iPad®!” Charlie’s mother shared that it is often difficult to read about them; however, found the pre- and posttest results “very promising.” The three students’ primary teachers were very excited about the results and hope to implement similar instructional methods such as the CSVM. The SCS’s instructional coach noted that the pre- and posttest scores were “very impressive” and wants to learn more about the CSVM.

Implications for Educators of Students with an Intellectual Disability and Autism

While this study had many personal implications, there were also several implications for educators of students with an intellectual disability and autism. This section includes a discussion of using (a) theoretical frameworks to influence practice, (b) CAI components, and (c) future research.

Using theoretical framework to influence practice. The theoretical frameworks included in my study were schema and psycholinguistic theories, dual coding theory, and Gagné’s nine events of instruction. Schema theory influenced the use of graphic organizers and how they helped the students to organize the information presented (Dye, 2000) and develop concepts with examples and nonexamples (Sheridan, 1981) used in the Frayer models and t-charts. Psycholinguistic theory, which provided an explanation for how students comprehend language (Unrau & Alvermann, 2013) influenced the use
of the photosynthesis mnemonic learning strategy. Dual coding theory was used to ensure there was not cognitive overload in the CSVM by using multimodal methods (Kassim, 2018; Sadoski et al., 2012; Thompson 2008; Wright et al., 2015). Finally, Gagné’s nine events of instruction were used to order the elements of the CSVM (Carnahan & Mensch, 2014; Cronjé, 2006; Driscoll, 2000; Gagné & Briggs, 1974; Moallem, 2001; Zhu & St. Amant, 2010). These theoretical frameworks have implications for instructional practices with students with an intellectual disability and autism because they assist the teacher in creating instruction that matches evidence-based practices of special education and vocabulary instruction. These theoretical frameworks are helpful because they give an overall picture of how students organize information and understand language, as well as how teachers can present information to reduce the cognitive load on students with disabilities.

**Using computer-assisted instruction components.** My research and previous research resulted in (a) inferred consequences and (b) positive aspects of the use of CAI with students with an intellectual disability and autism.

**Inferred consequences.** Previous research cautioned that the use of CAI with students with an intellectual disability and autism can impede social skills because the students are encouraged to interact with technology and not people (Moore & Calvert, 2000; Ramdoss, Mulloy, et al., 2011). However, I did not find this caution to be true. Even though I attempted to remain neutral and not involve myself with the students, they still initiated interactions with me. Charlie would ask me questions and talk to me throughout the CSVM. Some examples of this included when Charlie would ask me to tickle them, ask to see Lisa, and look at me while dancing. Peyton would also look at me
and wait for acknowledgement before answering questions, as well as look at me and smile when answering correctly. Riley would seek my attention by swatting at me or throwing their shoes at me. Overall, the use of the CSVM did not seem to impede the students’ use of positive or negative social skills.

Positive aspects of the use of computer-assisted instruction. Previous research on the use of CAI with students with an intellectual disability and autism has found the main benefit included improving active engagement in students with an intellectual disability and autism (Bock & Erickson, 2015; Chen et al., 2019; Moore & Calvert, 2000; Neely et al., 2013; Stasolla et al., 2016). The findings from this study confirmed that the use of CAI with three students with an intellectual disability and autism was successful in improving active engagement. This finding is an important implication for the instruction of students with an intellectual disability and autism because educators can select specific CAI components to meet their students’ specific learning needs and therefore improve instruction.

Using special education vocabulary instruction. Out of the three types of evidence-based practices specific to vocabulary instruction, researchers have found that explicit instruction is the most effective for students with an intellectual disability and autism (Archer & Hughes, 2011; Hughes et al., 2017; Kendorski & Fisher, 2018). The specific explicit instruction vocabulary methods that have shown promise for students with disabilities included mnemonics (Haydon et al., 2017) and graphic organizers (Knight et al., 2013; Reutzel & Cooter, 2019). Much of the previous research did not focus on students with more significant IDs; therefore, the findings from this study have
important implications for future research on the types of graphic organizers that are successful specifically with students with more significant IDs.

**Future Research**

As an action researcher, I have completed the first cycle of the action research process. The next step in the action research process is to plan the next cycle of action research (Mertler, 2017). My thoughts about this next cycle of action research include my reflections on my current research which have led me to possible future research topics. These research topics include, but are not limited to, (a) verbal versus nonverbal students, (b) the use of graphic organizers with students with an intellectual disability and autism, (c) the feedback and reward elements of CAI, and (d) patterns in answering.

**Verbal versus nonverbal students.** Throughout the study, I noted the differences between Charlie’s performance and Peyton and Riley’s performances. Through these observations, I began to wonder if Charlie’s performance was so different because they were verbal. A further area of research could be an experimental design comparing how students who are verbal compare with students who are nonverbal when engaging with vocabulary instructional content. In addition, developing methods to collect more accurate data on students who are nonverbal could be conducted.

**Use of graphic organizers with students with an intellectual disability and autism.** This study involved the use of three graphic organizers including t-charts, Frayer models, and cognitive/word maps in conjunction with other CAI components. While the data from this study was promising for the use of t-charts with students with an intellectual disability and autism, the data was not as promising for Frayer models and cognitive/word maps. Further research could be conducted on the use of each type of
graphic organizer, as well as the different structures of cognitive/word maps. The use of graphic organizers with students with an intellectual disability and autism also reveals a paucity of research, however, an important area for future researchers working with this population of students to consider developing.

**Feedback and reward elements of computer-assisted instruction.** Previous research has stressed the importance of immediate, reinforcing feedback that correct errors when instructing students with an intellectual disability and autism (Sigafoos et al., 2014; Weng et al., 2014; Whitby et al., 2012). In this study applause feedback was used for correct responses to questions and incorrect answers were addressed by restating the question. This feedback was received well by the students overall; however, Peyton demonstrated some signs of dislike for the applause by looking around the room when the sound played. Several other studies reported that students with an intellectual disability and autism enjoy embedded extrinsic rewards that catered to the students’ preferences (Constantin et al, 2017; Humphry 2011 as cited in Constantin et al., 2011; Weng et al., 2014). These types of rewards were not used in my study; however, further research on the use of personalized embedded rewards and their effect on the students’ engagement in CSVM could be conducted.

**Patterns in answering.** As stated above, the students abandoned their typical patterns in answering when responding to the formative assessment questions and the posttest questions. While it appeared the students may have abandoned their patterns in answering to make a purposeful attempt at answering, it cannot be concluded that this is what occurred. Current research about students’ locational preferences for answering is sparse and could be further studied.
Limitations

The study method I used was action research, which can result in several study limitations. Limitations in my study included the (a) methodology, (b) qualitative rigor with observations, and (c) picture choice in assessments.

Methodology

Within my action research, there were several limitations presented by this methodology. One of the limitations of this study lies within the participants chosen for the study. These limitations include the (a) generalizability and (b) working with students with an intellectual disability and autism.

Generalizability. The findings from this study are not generalizable due to the use of action research and the small sample size \( n = 3 \); Koshy, 2005; Ruddin, 2006). Action researchers do not seek out to be able to generalize their findings, rather they look to solve a problem within their own setting (Koshy, 2005). While the findings of this study may not be able to be generalized to a larger population, the findings could be applied to new studies and further research within the field (Koshy, 2005). Overall, the findings from this study cannot be generalized to all students with an intellectual disability and autism; however, the findings can produce instructional changes for these three students and others in SCS with similar characteristics.

Students with an intellectual disability and autism. Working with students with an intellectual disability and autism can present many challenges. The first challenge I faced was with Peyton’s absences due to behavioral and physical health concerns. Peyton’s many absences resulted in incomplete data collection because they only completed 10 of 12 modules. Another challenge was working through autistic tendencies...
(Vacca, 2007). For example, Charlie often had to complete scripting before they could continue working. Working through these tendencies also occurred through Riley’s need for attention. The students’ autistic tendencies are challenging because the teacher can never be sure if the students’ reactions are purposeful or part of their autistic tendencies (Vacca, 2007). I had to be very careful in interpreting the students’ actions and be careful not to project what I wanted those actions to mean. A final challenge is the physical skills and attributes to the students’ disabilities. For example, Riley would often have trouble physically controlling his movements to touch the Apple® iPad® and Charlie would often be sweaty as a side effect of medication. These physical factors also had to be interpreted and handled with care. Overall, I had to be very careful not to project my bias and desire for my students to succeed when interpreting the students’ actions.

**Qualitative Rigor with Observations**

A limitation of this study is that the qualitative methods depended solely on observations that I conducted. The students in my study included one verbal student and two nonverbal students, each with a moderate intellectual disability and autism. Due to my students’ cognitive ability levels, I was not able to interview them and had to rely solely on observations. As stated by Mertler (2017), “observations can be extremely useful in certain situations where other forms of data collection simply will not work, such as when teachers want to check for students’ nonverbal reactions to something that is occurring in the classroom” (p. 130). Queirós, Faria, and Almeida (2017) added to this by stating that observations are often “the only way to obtain data in a reliable way” (p. 376).
In addition to the advantages, there are several disadvantages to using observations. Observations require much preparation, are time consuming, and can be difficult to conduct (Mertler, 2017; Queirós et al., 2017). Most importantly, observations depend on the observer remaining impartial (Mertler 2017; Queirós et al., 2017). My attempts to remain impartial included developing an observation protocol to keep my observations focused on the students’ behaviors and conducting member checking with the students’ parents and primary teachers. While I attempted to remain neutral, it was often difficult to determine why the students displayed certain behaviors without being able to directly ask them. Overall, while I was conscious of my biases throughout the observation process, I was not always able to determine the exact reason why something happened because the students could not verbalize why.

**Picture Choice in Assessments**

After examining the students’ answers and reflecting on my choice of picture symbols used, I realized that I should have changed the pictures used with Question 2 of the pre- and posttest. Question 2 asked, “What else does a plant need to live?” Riley first chose the picture on the right depicting a beach scene with an arrow to the sand (see Figure 5.1). I should not have included that picture because of its inclusion of the sun and water. It could be possible that Riley chose this picture based on the sun and water instead of the sand.

I found a similar issue with Question 4 of the pre- and posttest (see Figure 5.2). In this question, I presented a picture of blocks as the center choice. The brightly colored blocks positioned in the center may have drawn the students’ attention away from the sun or sticks. While it cannot be concluded why the students made the answers choices they
did, it taught me that I should have tested for picture preference before creating the pre- and posttest. In the future, I will show students several pictures and see if there is one they select more than others.

Figure 5.1. Question 2 from the pre- and posttest. Picture symbols from SymbolStix®, Copyright 2019, SymbolStix, LLC. All rights reserved. Used with permission.

Figure 5.2. Question 4 from the pre- and posttest. Picture symbols from SymbolStix®, Copyright 2019, SymbolStix, LLC. All rights reserved. Used with permission.
Closing Thoughts

Nationally, students with disabilities have struggled to meet expectations about basic science concepts (Bybee, 1995/2005; NAS, 1996). This struggle was also noted in South Carolina, as well as the local school district and SCS based on SC-Alt scores (SC DOE, 2018a, 2018b; SCS: Sped K-12, 2018). Findings from multiple studies found the importance of using technology with students with disabilities (Braddock et al., 2004; Burgstahler 1994, 2003; Edyburn, 2003; Hasselbring & Williams Glaser, 2000; Kim et al., 2003; Wehmeyer & Smith, 2004). More specifically, the use of CAI was found to close gaps in vocabulary instruction for students with disabilities (Rice & Deshler, 2018). The need for explicit vocabulary instruction to improve overall science instruction for students with disabilities was found by Courtade (2006), Israel et al. (2013), Leddy (2010), Melber (2004), Mutch-Jones et al. (2012), and Villanueva et al. (2012). Based on these findings, the problem addressed in my study was that the students with intellectual disability and autism at SCS had difficulty accessing and retaining grade level science context.

To address this problem, I developed the CSVM using evidence-based special education vocabulary instructional methods through the use of CAI methods. Further research could include verbal versus nonverbal students, the use of graphic organizers with students with an intellectual disability and autism, the feedback and reward elements of CAI, and patterns in answering. Based on my research, developing CAI modules that explicitly teach difficult science vocabulary words through the use of evidence-based special education vocabulary instruction methods can be successful with increasing vocabulary acquisition for students with an intellectual disability and autism. It is
encouraging as an adapted environmental science teacher, that when given the chance and correct tools, students with an intellectual disability and autism can be active participants in the content area of science.
REFERENCES


cognitive and psychological engagement: Validation of the student engagement


vocabulary of high school newcomer English learners. *International Journal of
Bilingual Education and Bilingualism, 20*(3), 252-271.
https://doi.org/10.1080/13670050.2015.1042356

Association for Educational Communications and Technology. (n.d.). Retrieved from
https://www.aect.org/

https://www.attainmentcompany.com/explore-biology

Baltruschat, L., Hasselhorn, M., Tarbox, J., Dixon, D. R., Najdowski, A., Mullins, R. D.,
& Gould, E. (2012). The effects of multiple exemplar training on a working
memory task involving sequential responding in children with autism. *The
Psychological Record, 62*, 549-562. Retrieved from
https://link.springer.com/article/10.1007/BF03395820

discourse for middle and high school students with autism spectrum disorders.
*Intervention in School and Clinic, 53*(3), 292-299.
https://doi.org/10.1177/1053451217736865


263


265


*Educational Communication and Technology, 29*(2), 75-91. Retrieved from https://pdfs.semanticscholar.org/8d32/23ed3c76cc40666ec894b5aca51c4f4028b7e.pdf


https://doi.org/10.1177/002221949002300203


https://doi.org/10.1177/0885728809338714


https://doi.org/10.1016/j.learninstruc.2014.10.005

https://doi.org/10.1007/s10882-011-9259-8


Sage Journals website. (n.d.). http://journals.sagepub.com/home/jst


South Center School: Special education K-12 [MS Word file]. (2018). Retrieved from https://drive.google.com/file/d/1oHupoyXc9Ue6kFyJQXOM6gFxa_KmUaE6/view


https://doi.org/10.1177/004005991204400605


https://doi.org/10.1007/s10763-015-9661-2

https://doi.org/10.1016/j.compedu.2018.03.009


APPENDIX A

CONSENT TO BE A RESEARCH SUBJECT

UNIVERSITY OF SOUTH CAROLINA

CONSENT TO BE A RESEARCH SUBJECT

Study Title: The Implementation of Computer-Assisted Science Vocabulary Modules with Students with Intellectual Disability and Autism: An Action Research Study

KEY INFORMATION ABOUT THIS RESEARCH STUDY:
You are invited for your child to volunteer for a research study conducted by Jamie Taber a Curriculum and Instruction doctoral student with a concentration in Educational Technology, at the University of South Carolina under the direction of Dr. Michael M. Grant (michaelmgrant@sc.edu; 803-777-6176) in the department of Educational Studies. I am the adapted environmental science teacher (AES) at [School Name], I am completing this study as a part of my doctoral requirements at the University of South Carolina. The purpose of this study is to implement and evaluate the academic impact of computer-assisted science vocabulary modules (CSVM) with students who have an intellectual disability and autism in an adapted environmental science class. You are being asked to consent for your child to participate in this study because your child [Child Name], is a grade six through tenth, and receives special education services only for a moderate intellectual disability, autism, and speech/language impairment. This study will take place at [School Name] School District and will involve two students. School’s and individual’s identities will remain strictly anonymous and confidential.

The following is a short summary of this study to help you decide whether to be a part of this study. More detailed information is listed later in this form.

It has been found that students with disabilities often struggle with science concepts because of the advanced vocabulary required. A review of literature provided evidence-based practices for special education vocabulary instruction. These evidence-based practices were applied to the creation of the CSVM. The CSVM will be administered via an Apple® iPad®.

The modules will include elements of the concept of photosynthesis through short videos, simulations, games, etc. There will be approximately three assessment questions at the end of each module. All assessment questions require the student to make a choice out of three possible answers or to touch a model of a plant where requested. Motivating factors that are personalized to your child (e.g. video clips, sound clips, photos, etc.) will be programmed into the CSVM as rewards.

PROCEDURES:
If you agree for your child to participate in this study, he will do the following:
1. Complete one module of the CSVM (approximately five minutes) daily for 27 days.
2. Participate in a pre- and posttest that is made up of 10 questions and will be administered on an Apple® iPad®.

Figure A.1. Consent to be a research subject, page one.
3. The students will be video recorded participating in the assessments and CSVM so that their active engagement in the modules can be measured.

4. Two classroom observations of the students in their homerooms two observations in AES will be conducted so that their engagement in other types of instruction can be measured.

DURATION:
Participation in the study will be approximately eight weeks. The students will be observed in their homerooms and in AES during the two weeks before CSVM implementation. The students will then complete the pretest, participate in 27 five-minute modules, and then complete the posttest.

RISKS/DISCOMFORTS
The activities in the CSVM are intended to be engaging for all students, including those who are diagnosed with intellectual disability and autism. We foresee no risks to subjects beyond those that are normally encountered when completing activities in a classroom.

One discomfort may be the presence of video recording equipment. This equipment will be kept as minimal and unobtrusive as possible. Another discomfort that may occur is the change in the students' schedules when they first start participating in the CSVM. In order to ease this transition, I will complete small, but unrelated, tasks with the students during the two weeks prior to implementation. I will also schedule the CSVM for the same time each day.

BENEFITS:
This study may contribute to a better understanding of best practices in teaching both vocabulary and science concepts to students with intellectual disabilities and autism, as well as features of computer-assisted instruction that improve students' active engagement. Your child may benefit from participating in this study by increasing his conceptual knowledge in the area of science, specifically the concept of photosynthesis.

COSTS:
There will be no costs to you for participating in this study.

PAYMENT TO PARTICIPANTS:
You will not be paid for participating in this study.

VOLUNTARY PARTICIPATION:
Participation in this research study is voluntary. There is not penalty for not participating. Your child is free not to participate by excluding his data or declining to participate in the data collections. He may also stop participating at any time, for any reason without negative consequences. Participants may withdraw from the study at any time without penalty. In the event that you do withdraw from this study, the information you have already provided will be kept in a confidential manner. If you wish to withdraw from the study, please call or email the principal investigator listed on this form.

I have been given a chance to ask questions about this research study. These questions have been answered to my satisfaction. If I have any more questions about my participation in this study, or a study related injury, I am to contact Dr. Michael M. Grant at 803-777-8176 or by email at michaelmgrant@sc.edu.

Questions about your rights as a research subject are to be directed to, Lisa Johnson, Assistant Director, Office of Research Compliance, University of South Carolina, 1600 Hampton Street, Suite 414D, Columbia, SC 29208, phone: (803) 777-6670 or email LisaJ@mailbox.sc.edu.

_____ I do not wish for my child to participate.
_____ I agree for my child to participate in this study. I have been given a copy of this form for my own records.

Figure A.2. Consent to be a research subject, page two.
If you wish to participate, you should sign below.

Parent/Guardian's Signature  Date

Researcher's Signature  Date

My participation has been explained to me, and all my questions have been answered. I am willing to participate.

Print Name of Minor  Age of Minor

Signature of Minor  Date

Figure A.3. Consent to be a research subject, page three.
APPENDIX B

RESEARCH AND INFORMATION SHARING

Figure B.1. Research and data sharing agreement, page one.
Figure B.1. Research and data sharing agreement, page two.
Attachment 1

RESEARCH & INFORMATION USE TERMS AND CONDITIONS

Object: To ensure that a secure method of data use is provided between [redacted] and Requestor and to provide guidelines for conducting research and for the use of information that makes available to Requestor.

Definition: “Information” means the information listed in the Information Sharing Request.

“Requestor” means an individual, company, external entity, party, authorized representative, primary researcher, vendor, organization, or agency with which GCS shares information.

1. Right to Use Information. Requestor may only use the Information for business or research purposes as outlined in this agreement.

1. Return and/or Destruction of Information. Upon termination of this agreement (one calendar year after the effective date), Requestor must either: 1) return all information media to [redacted] and remove all information from Company systems, including, but not limited to, servers, workstations, storage media, and backup media; OR 2) delete and destroy all information from Company systems, including, but not limited to, servers, workstations, storage media, and backup media. Entity shall not retain copies of any data or information received from the District. Entity shall ensure that they dispose of any and all information received from the District in an approved manner that maintains the confidentiality of the contents of such records (e.g., shredding paper records, erasing and reformattting hard drives, erasing and physically destroying any portable electronic devices).

2. In the event Requestor deletes and destroys information, Requestor must certify the removal/destruction of all Information in accordance with the South Carolina Public Records Act.

3. Owned Information.

3.1 [redacted] may, at [redacted] sole discretion, make information available to Requestor for use on Company or personal premises for the completion of Requestor work for [redacted].

3.2 Requestor may modify [redacted] Owned information only after notification and approval in writing by authorized personnel. Variable coding, recoding, and similar data analysis preparation procedures are acceptable without obtaining authorization.


4.1 Requestor will allow only Company employees approved in advance to access information. Requestor shall be solely responsible for due diligence in conducting criminal background checks or any similar security checks on employees who have access to information. Requestor is responsible for properly supervising their employees as it relates to the Requestor’s possession and/or use of Owned Information. In the event of a known or alleged risk or breach, Requestor will provide [redacted] with any information reasonably necessary for [redacted] to evaluate security issues relating to the alleged risk or breach.

4.2 Each party will be solely responsible for the selection, implementation, and maintenance of security procedures and policies that are sufficient to ensure that (a) such party’s use of the information is secure and is used only for authorized purposes, and (b) such party’s business records and data are protected against improper access, use, loss alteration or destruction.

4.3 Any document containing student information from an educational record must be sent out of the district by United States Postal Service certified mail. All emails containing student information from an educational record must be encrypted.


5.1 “Education records” are defined as records that are directly related to a student and maintained by the [redacted] or by a party acting for the [redacted]. “Disclosure” means to permit access to or the release, transfer, or other communication of personally identifiable information contained in education records to any party by any means.

Page 3 of 15

Research and Data Sharing Agreement (RDSA) – Revised February 2017

Figure B.3. Research and data sharing agreement, page three.
5.2 FERPA specifically addresses disclosure of education records to contractors, consultants, volunteers and service providers who are not employees of an educational agency or institution. FERPA states that those individuals may have access to records if they 1) perform an institutional service or function for which the agency or institution would otherwise use employees; and 2) are under the direct control of the agency or institution with respect to the use and maintenance of education records.

5.3 Requester provides one or more services for the [blank] that it would otherwise provide for itself by employees. Requester would have “legitimate educational interests” in the information disclosed if the services were performed by employees. Requestor is under the direct control of the educational agency or institution with respect to the use and maintenance of information from education records.

5.4 Requestor may use the information disclosed only for the purposes for which the disclosure was made and may not re-disclose the information to any other party without prior written consent of the parent/guardian or eligible student, except as authorized by FERPA. Any information disclosed to a third party, including information from a [blank], must be destroyed in accordance with the South Carolina Public Records Act once the information is no longer needed for its permitted use.

5.5 Requestor shall not disclose "directory information" concerning any student unless the disclosure is in connection with the services agreed to in Attachment 2 [RESEARCH & INFORMATION SHARING APPLICATION]

5.6 Requestor shall not release or otherwise reveal, directly or indirectly, information to any individual, agency, entity, or third party not included in this Agreement unless specifically authorized by District. Requester shall not use information shared under this Agreement for any reason other than in furtherance of the specific purpose of its relationship with District. Should Entity receive a court order or lawfully issued subpoena seeking the release of such data or information, Entity shall provide immediate notification to District of its receipt of such court order or lawfully issued subpoena and shall immediately provide District with a copy of such court order or lawfully issued subpoena prior to releasing the requested data or information, if allowed by law or judicial and/or administrative order.

DISCLAIMER OF WARRANTIES. NEITHER PARTY MAKES ANY WARRANTIES, EXPRESS OR IMPLIED, CONCERNING ANY SUBJECT MATTER OF THIS AGREEMENT, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

LIMITATION OF LIABILITY.

7.1 EXCEPT WITH RESPECT TO A PARTY’S CONFIDENTIALITY OBLIGATIONS UNDER THIS AGREEMENT, IN NO EVENT WILL EITHER PARTY BE LIABLE TO THE OTHER PARTY FOR ANY SPECIAL, INDIRECT, INCIDENTAL, PUNITIVE OR CONSEQUENTIAL DAMAGES (INCLUDING LOSS OF USE, DATA, BUSINESS OR PROFITS) ARISING OUT OF OR IN CONNECTION WITH THIS AGREEMENT, INCLUDING WITHOUT LIMITATION, ANY DAMAGES RESULTING FROM ANY DELAY, OMISSION OR ERROR IN THE ELECTRONIC TRANSMISSION OR RECEIPT OF DATA PURSUANT TO THIS AGREEMENT, WHETHER SUCH LIABILITY ARIED FROM ANY CLAIM BASED UPON CONTRACT, WARRANTY, TORT (INCLUDING NEGLIGENCE), PRODUCT LIABILITY OR OTHERWISE, AND WHETHER OR NOT A PARTY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH LOSS OR DAMAGE.

7.2 THE FOREGOING LIMITATION SHALL NOT RELEASE REQUESTOR FROM, OR RELIEVE REQUESTOR OF, ANY LEGAL RESPONSIBILITY MAY HAVE OR LIABILITY REQUESTOR MAY INCUR TO ANY THIRD PARTY, NOR DOES IT CREATE ANY OBLIGATION ON THE PART OF DISTRICT TO DEFEND, INDEMNIFY, OR OTHERWISE HOLD HARMLESS REQUESTOR FROM ANY LEGAL OBLIGATION OR LIABILITY TO A THIRD PARTY.

Confidentiality.

8.1 [blank] possesses records constituting "confidential information" that are protected from disclosure by law. If Requestor has access to, has custody of, or creates legally protected confidential information on behalf of [blank], the course of providing goods or services to the [blank] Requestor shall not knowingly disclose, and shall use its best efforts not to allow to be disclosed, such information except as directed by the [blank] in accordance with the provisions of the law protecting the information. Examples of such information include, but are necessarily limited to, all employment related records required by law, employee personal health or insurance information, attorney-client

Research and Data Sharing Agreement (RDSA) – Revised February 2017

Page 4 of 15
privileged information, trade secrets, procurement related information, land acquisition information, and in general any record the District is permitted to exempt from disclosure pursuant to the South Carolina Freedom of Information Act ("FOIA") or similar provisions of other State or Federal laws.

8.2 The parties acknowledge that by reason of their relationship to each other hereunder, each will have access to certain information and/or certain information and materials concerning the others technology, products, and or information that is confidential and of substantial value to that party, which value would be impaired if such information were disclosed to third parties ("Confidential Information"). Should such Confidential Information be orally or visually disclosed, the disclosing party shall identify and summarize the disclosed information in writing within five (5) days of disclosure. Each party agrees that it will not use or disclose in any way for its own account, except as provided herein, nor disclose to any third party, any such Confidential Information revealed to it by the other party. Each party will take every reasonable precaution to protect the confidentiality of such Confidential Information. Upon request by the receiving party, the disclosing party shall advise whether or not it considers any particular information or materials to be Confidential Information. The receiving party acknowledges that unauthorized use or disclosure thereof could cause the disclosing party irreparable harm that could not be compensated by monetary damages. Accordingly each party agrees that the other will be entitled to seek injunctive and preliminary relief to remedy any actual or threatened unauthorized use or disclosure of such other party’s Confidential Information. The receiving party’s obligation of confidentiality shall not apply to information that (a) is already known to the receiving party or is publicly available at the time of disclosure; (b) is disclosed to the receiving party by a third party who is not in breach of an obligation of confidentiality to the party to this agreement which is claiming a proprietary right in such information; or (c) becomes publicly available after disclosure through no fault of the receiving party.

8.3 Entity shall immediately report to District any suspected breach of confidentiality or information or a violation of any term of this Agreement and take immediate steps to limit and mitigate such security breach to the extent possible. Entity agrees that any breach of the confidentiality obligation not forth in the contract may, at District’s discretion, result in cancellation of further consideration for contract award and the eligibility for Entity to receive any information from District for a period of not less than five (5) years. In addition, Entity agrees to indemnify and hold the District harmless for any loss, cost, damage or expense suffered by District, including but not limited to the cost of notification of affected persons, as a direct result of the unauthorized disclosure of education records.

9. Term, Termination and Survival. This Agreement will remain in effect until terminated by either party. Either party may terminate this agreement for convenience by providing not less than one (1) day prior written notice, which notice will specify the effective date of termination. Either party may also terminate this Agreement immediately upon the other party’s breach of this Agreement. Upon the effective date of termination, all research and accompanying activities and information sharing as outlined in this agreement involving the district and the requestor will cease.

10. MISCELLANEOUS

10.1 Severability. If for any reason a court of competent jurisdiction finds any provision or portion of this Agreement to be unenforceable, that provision of the Agreement will be enforced to the maximum extent permissible so as to effect the intent of the parties, and the remainder of this Agreement will continue in full force and effect.

10.2 Waiver. The failure of any party to enforce any of the provisions of this Agreement will not be construed to be a waiver of the right of such party thereafter to enforce such provisions.

10.3 Assignment. Neither party may assign this Agreement, in whole or in part, without the other party’s prior written consent. Any attempt to assign this Agreement, without such consent, will be null and of no effect. Subject to the foregoing, this Agreement is for the benefit of and will be binding upon the parties’ respective successors and permitted assigns.

10.4 Force Majeure. Neither party will be liable for any failure to perform its obligations in connection with any Transaction or any Document if such failure results from any act of God or other cause beyond such party’s reasonable control (including, without limitation, any mechanical, electronic or communications failure) which prevents such party from transmitting or receiving any information or documents.

10.5 Dispute Resolution. Governing Law: The terms of this Agreement shall be interpreted according to and enforced under the laws of the State of South Carolina. The parties agree that any judicial proceeding filed by the parties regarding this Agreement will take place in [Redacted] County, South Carolina.

[Redacted] Research and Data Sharing Agreement (RDSA) - Revised February 2017
Legal and Ethical Protocols for Researchers. Research shall conform to federal regulations and sound educational research practice that ensures negligible risks for those involved and family/pupil privacy and protection rights. To this end, the originator of the request shall have the qualifications necessary for conducting research in a school system and submit to any requirements (e.g., South Carolina Law Enforcement Division check) to perform tasks described as an educational researcher. The requestor should be familiar with the following laws and principles.

- Family Educational Rights and Privacy Act (FERPA)
- Protection of Pupil Rights Amendment (PPRA)
- Office for Human Protection - Federal Policy for the Protection of Human Subjects
- American Psychological Association's Ethical Principles of Psychologists and Code of Conduct

Although case-by-case, district approval shall be granted until specified data collection has concluded (seeAttachment 2 - “Project Start and End Dates”) OR for a maximum of one-year from the approval letter's date, whichever comes first. After one-year the researcher must submit for approval a request for extension to continue conducting research or sharing information. For any research extending beyond one school year, the researcher shall submit an annual progress report along with a request for extension.

District approval does not constitute approval for the study to be conducted in any specific school. The district’s research representative will obtain approval of the principal(s) prior to approving the agreement. If students participate, copies of all approved and completed informed consent forms shall be stored by the requestor for district review upon request. No student, employee, or other personally identifiable information shall be reported in any median or manner. Confidentiality of all information shall be observed. The privacy and rights of individuals and schools shall be respected.

When conducting research in schools, individuals shall abide by standards of professional conduct and dress. Failure to do so will cause for immediate termination of the study and revocation of research approval.

Upon conclusion of the research, a copy of the final report will be submitted at no charge to the Director of Accountability and Quality Assurance. A copy of the final report must be submitted within six months of final presentation, publication, etc. However, if a more formal report is to be released (dissertation, thesis, book, journal article, etc.), the author shall provide a formal copy at no charge. The researcher agrees to release this report for internal use as long as no compensation.

The researcher agrees to present at no charge his/her results to the district's management team and provide personal feedback and a workshop to principals and others interested in the study's results, upon request.
Figure B.7. Research and data sharing agreement, page seven.
F. FERPA PII Studies Exception (Check the ONE that applies to your study.)

- Developing, validating, or administering predictive tests,
- Administering student aid programs,
- Improving instruction, or
- Other, specify:


H. Study’s Duration - Project Start and End Dates: October 1, 2019 – April 27, 2020

I. Justification of information sharing - This study will implement and evaluate computer-assisted science vocabulary modules (CSVM) with students with intellectual disability and autism (IDA). This study may contribute to the educational advancement because, if successful, it will provide a method that can be applied to all contexts for instruction of students with severe intellectual disabilities.

J. Brief summary of literature review.

In order to evaluate the implementation of CSVM, it is imperative to understand the theoretical underpinnings of vocabulary instruction, science vocabulary instruction for students with IDA, CAI in special education, and active engagement in students with IDA. First, the theoretical understandings of vocabulary instruction can assist teachers in developing strong lessons that meet their specific learning needs. Schema theory and psycholinguistic theories, which are constructivist, explain that comprehension is based on prior knowledge/schemas and components of language. A promising theory to use for students with IDA is dual coding theory because it involves the use of nonverbal information as well as verbal information. Students with IDA often respond well to the use of images, sounds, etc. that allow them to use dual processes to code the information they are learning. A final theory to use to plan instruction is Gagné’s nine events of instruction which provides a set of procedures to organize lessons.

Explicit instruction of science vocabulary is vital for students’ overall science literacy. Science vocabulary terms are considered tier three words and require explicit instruction, which in an ERF of special education vocabulary instruction. Explicit instruction is a direct teaching method using systematic and scaffolded instruction. There is a total of 16 elements and six teaching functions of explicit instruction. Explicit instruction strategies include keyword mnemonic strategy, picture matching, and graphic organizers. Specific graphic organizers which are effective with students with IDA include cognitive/word mapping, Frayer models, and t-charts. Vocabulary instruction can be assessed through formative assessments such as CIM and teacher-created assessments.

CAI is beneficial to the education of students with IDA because the teacher can customize learning to the specific needs of the students. The multimodal focus of CAI lends itself well to vocabulary instruction and allows students with IDA to receive visual representations that they need to be successful in learning new words. Difficulties associated with CAI may include the time to create, teacher knowledge of the technology tools, the lack of social interaction for students with autism, and the inappropriate use of feedback. Overall, the benefits to CAI instruction with students with IDA for vocabulary acquisition far outweigh any negative aspects.

A final area of importance in instruction of students with IDA is active engagement. The definition of active engagement for students with ASD is based on the five factors of active engagement which include emotional regulation, class participation, social connectedness, initiating communication, and flexibility. CAI has been shown to have a positive influence on active engagement. Active engagement of students with IDA can be assessed using the CMAE.

K. What procedures will be used in the District?

The innovation in this study will be CSVM that are teacher created. These CSVM have not been used in the classroom previously. Vocabulary terms will be targeted in the modules because several researchers have found that learning science vocabulary has helped to close the gap in science instruction and increase the students’ participation in inquiry-based activities for students with learning disabilities (Brewer et al., 2012; Fincham, Brewster, Sperney, & Dibiane, 2012; Kennedy & Thie, 2012; Kennedy, Rodgers, Ronig, Lloyd, & Brownell, 2017). Computer-assisted instructional modules, including interactive portions, will be used because students with disabilities are able to better access science curriculum through repetitive games integrated in the curriculum due to controlled feedback (Marino et al., 2014; Marino et al., 2013; National Research Council, 2011).

[Research and Data Sharing Agreement (RDSA) – Revised February 2017]

Figure B.8. Research and data sharing agreement, page eight.
The specific topic that will be addressed in the innovation is photosynthesis. The main ideas that will be explored in the CSVM are: (1) plants perform photosynthesis, (2) plants make food out of sunlight, CO₂, and water/H₂O, (3) plants need sunlight to make food and grow, and (4) photosynthesis is a chemical reaction (Bauman, 2018). This section will address the (a) theoretical influences, (b) description of the CSVM, and (c) stages of implementation.

The three participants will work each day individually with the instructor to complete the CSVM. The participants will come to the adapted environmental science room, or another quiet location, for approximately 15 minutes each day to complete their module. The participants will complete the modules individually so that all distractions of group work are removed; however, they will also participate in the CSVM that their entire class participates in weekly so that any differences in engagement can be noted. It should be noted that the students attend my adapted environmental science class one weekly and spend a majority of their day with their homeroom teachers and paraprofessionals.

The CSVM will be an interactive digital slideshow that the student could complete without assistant. The CSVM will be completed either on a laptop computer or by using the Doceri app (SP Controls, 2018) on an Apple® iPad®. The Doceri app allows the contents of the laptop to be projected onto an Apple® iPad® screen and manipulated via the Apple® iPad®. The first part of each CSVM will include instruction, where the student engages in learning activities by advancing slides, watching the videos, or clicking where requested. The second part of the CSVM will be an interactive, formative assessment section where the student actively engages by answering questions, completing graphic organizers or models, filling-in-the-blanks, etc. Each learning section of the module will last approximately five minutes, unless it is a few minutes longer due to the inclusion of a video. The interactive or assessment part of the modules will depend on the students’ response times. Overall, the CSVM will be designed using research-based (a) computer-assisted instruction features, (b) vocabulary strategies, and (c) special education instruction strategies (see Table 2.2).

<table>
<thead>
<tr>
<th>ERP Area</th>
<th>Specific Strategy</th>
<th>Description</th>
<th>Innovation Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer-assisted instruction</td>
<td>Feedback</td>
<td>• Extrinsic rewards (Constantin et al., 2017; Weng et al., 2014)</td>
<td>- The student answers correctly and a 10 second clip of their favorite cartoon, song, etc. is presented</td>
</tr>
<tr>
<td>Feature</td>
<td></td>
<td>• Video or song clips</td>
<td>- A student answers correctly and a bright flashing star with a preferred sound is presented</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Immediate feedback that provides reinforcement and error correction</td>
<td>- The student answers incorrectly and is provided with the correct answer and another opportunity to answer correctly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Sigafous et al., 2014; Weng et al., 2014)</td>
<td></td>
</tr>
<tr>
<td>Computer-assisted</td>
<td>Attention-Getting</td>
<td>• Sound or action to elicit student’s visual attention (Moore &amp; Calvès, 2005)</td>
<td>- There will be dedicated sound for clicking to go to the next page, correct answers, incorrect answers, etc.</td>
</tr>
<tr>
<td>instruction feature</td>
<td>Features</td>
<td>• Video for sequences of actions (Israel et al., 2013)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Actions will be used to introduce pictures, terms, etc.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Videos showing the process of photosynthesis and growth will be used</td>
<td></td>
</tr>
<tr>
<td>Vocabulary Strategy</td>
<td>Mnemonic</td>
<td>• Assist participants in remember definition (Haydon et al., 2017; Stevenson et al., 2016)</td>
<td>- A mnemonic will be created for photosynthesis using a sun with a camera (photo = light) and two trees with puzzle pieces in between (synthesis = putting together)</td>
</tr>
</tbody>
</table>

Figure B.9. Research and data sharing agreement, page nine.
<table>
<thead>
<tr>
<th>EBP Area</th>
<th>Specific Strategy</th>
<th>Description</th>
<th>Innovation Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vocabulary</td>
<td>Picture Matching</td>
<td>• Students match a photo, picture symbol, or other visual representation with the written word (Harmon &amp; Wood, 2018)</td>
<td>• Picture matching will be used during the interactive portions of each module as a formative assessment tool</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>T-Chart</td>
<td>• Used to show examples and non-examples (Broader et al., 2011)</td>
<td>• A t-chart will be used to label what is used in photosynthesis and what is not used. The students will watch the t-chart being completed during the instruction section and complete it during the interactive sections</td>
</tr>
<tr>
<td>Special Education EBP</td>
<td>Explicit instruction</td>
<td>• The intentional focus of instruction on the targeted vocabulary words (Wanzek, 2014)</td>
<td>• Each vocabulary term will have a dedicated module with specific strategies planned for that word’s instruction</td>
</tr>
<tr>
<td>Special Education EBP</td>
<td>Constant-Time Delay</td>
<td>• The constant time delay will start with an initial zero delay so that there is immediate reinforcement and errorless instruction and will be followed by a five second delay in subsequent questions (Broader et al., 2012; Hsu et al., 2013; Lee &amp; Vail, 2005; Knight et al., 2015)</td>
<td>• Implemented in the interactive portions of the CSVM when the students are required to answer questions/completed activities</td>
</tr>
</tbody>
</table>

L. What is the type of data you are requesting (check all that apply)?

X New Data (surveys, interviews, observations, etc.)

X Existing Data (PowerSchool, test data fields, etc.)
<table>
<thead>
<tr>
<th>Who is requesting the data?</th>
<th>How and from whom will the data be collected? (e.g., surveys, focus groups, interviews and/or data provided)</th>
<th>BE SPECIFIC, what data are requested?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jamie Taber, Requestor</td>
<td>Review of records provided</td>
<td>IEP, Psychological Evaluations, ISP(s) (if applicable), demographic data in permanent records for participants in the study. This information will be used only to program the CSVM for the student's specific needs related to their disabilities and/or behavior needs. Demographic data will only be used to report the grade level, age of the student, and disability classification.</td>
</tr>
<tr>
<td>Jamie Taber, Requestor</td>
<td>Pre- and Posttest, administered by Jamie Taber</td>
<td>The pre- and posttest and formative assessments will be scored by creating a summed score, or counting how many questions were answered correctly out of the ten questions (Creswell, 2012). I will calculate a percentage correct from the summed score. After the students are administered the posttest, difference scores will be calculated by subtracting the pretest score from the posttest score to achieve a net difference (Creswell, 2012). The formative assessment summed scores will include scores for the individual module (three questions per module) and all the CSVM together (a total of 81 questions). Measures of central tendency (mean) will be used to show the average amount of times the student was correct on the first or second attempt or required the extra assistance in the third attempt for the formative assessment (Creswell, 2012; Mertler, 2017; Trista, 2012). The formative assessment scores and the number of attempts to obtain a correct answer will also be calculated with measures of dispersion (range and standard deviation) in order to find what may be different about the scores (Mertler, 2017; Trista, 2012).</td>
</tr>
<tr>
<td>Jamie Taber, Requestor</td>
<td>Formative Assessments, administered by Jamie Taber</td>
<td></td>
</tr>
</tbody>
</table>
| Jamie Taber, Requestor   | Researcher's Journal, compiled by Jamie Taber                                                  | Narrative data will be collected via my researcher’s journal. This narrative data may include the students’ interactions with the CSVM change over time, details about the students’ days (e.g., change in mood, had a major schedule change, did not sleep the previous night, etc.), major events that may happen during implementation (e.g., fire drill), observational notes that are not related to the CMME (e.g., the home room teacher used a different reward system), and/or notes about the research procedures used (Bogdan & Biklen, 2007). The narrative data collected will be analyzed using inductive analysis. Inductive analysis can be defined as “a systematic procedure for analyzing qualitative data in which the analysis is likely to be guided by specific evaluation objects” (Thomas, 2006, p. 238). The purpose of inductive analysis is to condense data into smaller parts and create themes from these parts (Leahy & Currahbeutel, 2007; Mertler, 2017; Thomas, 2006). The qualitative data from my researcher’s journal entries will be analyzed by (a) organizing and preparing the data, (b) coding the data, (c)
M. ALL studies possess a level of disruption to the district/school, what is the study’s impact on instructional and human resources at the district/schools (total time required of all participants including pre-visits, etc.)?

Participation in the study will be approximately 20 weeks. The students will be observed in their homes and in adapted environmental science during the two weeks before C SVM implementation. The students will then complete the pretest, participate in 27 five-minute modules (approximately 2 per week), and then complete the posttest. I will arrange a time with the students’ home room teachers so that participation in the study does not remove the student from any other core instruction periods. For example, the students may complete the modules with me during their recreation/leisure time.

N. What are the potential risks and benefits to the participants?

The activities in the C SVM are intended to be engaging for all students, including those who are diagnosed with intellectual disability and autism. We foresee no risks to subjects beyond those that are normally encountered when completing activities in a classroom.

One discomfort may be the presence of video recording equipment. This equipment will be kept as minimal and unobtrusive as possible; however, video recording is important to this study. Video recording is needed to complete member checking, which must be completed with the students’ parents due to the students’ intellectual disabilities. It is also important because the researcher needs to be able to review the sessions to pick up on subtle actions the students may make to record behavioral trends during the implementation. Another discomfort that may occur is in the change in the students’ schedules when they first start participating in the C SVM. In order to ease this transition, I will complete small, but unrelated, tasks with the students during the two weeks prior to implementation. I will also schedule the C SVM for the same time each day.

O. How and to whom will results/data be reported?

Sharing the findings of an action research project is what “helps bridge the divide between research and application (Merler, 2017, p. 259). I can share the findings both informally and formally in the local, regional, and/or national contexts.
Before I share my research, all information about teachers and students will be protected following the alternative approach to confidentiality that provides "guidelines to reduce the uncertainty surrounding the use of detailed data that might lead to deductive disclosure" (Kaiser, 2005, para. 23), or when the descriptions of the participants make them identifiable. These guidelines will include a consideration of the audience to which I will present my findings and will consider my participants as part of the audience (Kaiser, 2009). The alternative approach is important to my study because I will not be able to guarantee confidentiality when I present the information at WC because everyone knows all the students so well; however, I can better guarantee confidentiality when presenting to anyone outside of the school (Kaiser, 2009). I will also protect the participants' identities by using pseudonyms (Wiles, Cone, Hough, & Charles, 2008). Finally, during the informed consent process, I will discuss my possible audiences and my confidentiality process with the students' parents so that they understand how I will protect their identities and the identities of the students (Kaiser, 2009).

I plan to share my results with the parents of the participants, as well as other professionals. First, I will create a presentation about my action research project which includes the background information, purpose of my study, a description of the methodology I used, the findings, the conclusions I reached, an action plan, and questions and answers (Merler, 2017). I will share my presentation with the participants' parents via a Google Classroom link so they can be comfortable with what I present to others. I will ask the parents if they feel any of the information I have in my presentation could lead to the breach of confidentiality of their children. After I edit the presentation and it is approved by the parents, I will share my results with other professionals.

A presentation will also be shared with both the science and special education departments in GCSD. The presentation will include my findings, as well as a how-to session, so teachers can create similar modules. This presentation will also be shared at GCSD’s summer academy professional development sessions, the Upstate Technology Conference, South Carolina EdTech conference, and South Carolina’s Science PLUS Institute where I provide science professional development for special education teachers. I will also locate national forums, such as the Association for Educational Communications and Technology (AECT website, 2019), the National Association of Special Education Teachers (NASET website, 2007), the Council for Exceptional Children (Council for Exceptional Children Website, 2017), the Journal of Special Education Technology (JSET Journals Website, n.d.), and other science, special education, or technology associations, in order to further share the findings of my research. At the conclusion of each presentation, I will provide attendees with a Google Classroom link. Through the Google Classroom, I will create an interactive area where teachers who use the CSMV in their classrooms can provide feedback. I can edit and improve my modules based on this input and republish them to the teachers in the group, as well as continue in reflection about my work. By engaging in this collaborative and reflective practice, I will be able to give more meaning to my practice, as well as a heightened level of empowerment (Merler, 2017, p. 276) to myself and other teachers.

P. What types of materials will participants receive/use (attach one copy of each survey, test validation info, informed consent form(s), etc.?)
   a. Informed Consent
   b. Pre- and Posttest delivered via Apple® iPad®
   c. Formative Assessments (1 question per module) delivered via Apple® iPad®
   d. Classroom Measure of Active Engagement Observation Protocol—completed by Jamie Taber after review of videotaped daily observations
   e. CSMV—computer-assisted instruction designed on Microsoft® PowerPoint® and delivered via Apple® iPad® (examples attached)

Q. What method do you prefer used to safeguard delivery of the data to you (vendor/company)? Include any security controls in the delivery or transmission of the information.

   Data will not need to be delivered to me as I can access the data in the students' files at [REDACTED].

R. What technical, physical, and administrative safeguards will be used to maintain the data in a secure manner during access to the data?

   The data will be stored in a locked cabinet in my locked office. I will also password protect the folder on my laptop, which is also password protected. When reviewing EEP data and other demographic information, there will be no copies or notes made. I will only take mental notes of the information in order to design features in the CSMV. I will also have one form which contains the true identities of the students and homeroom teachers matched to their pseudonyms. This form will be locked in the filing cabinet and will be destroyed poststudy.
S. When (actual date) and how will all data be destroyed?

All data will be destroyed on or before December 31, 2020, after permission is received from . All videos will be deleted permanently from the SD card and/or computer. The researcher’s journal and pseudonym matching form will be shredded at the conclusion of the study. Any and all other identifying information will be permanently deleted from the computer or will be shredded.

NOTES: When dealing with student information and records which include unique identifying number, social security numbers, student addresses and/or names, the Family Educational Rights and Privacy Act (FERPA, 20 U.S.C. § 1232g) requires steps be taken to protect that information. The annual FERPA OPT OUT procedure is run before sharing information. This is done before, or in conjunction with, any additional opt out or consent. Also, this process is provided in order to control for any conflicts between consent forms. Please note: Under Federal and state law personal identifying information (PII) individuals retain a right to seek remedy. There are remedies under the law for the resident, student (over 18), or parent if this information is not protected and is breached.

Please Note: PII - Under Section 16-13-530 of the South Carolina legislature, “personal identifying information” (PII) is composed of the first name or its initial; the last name; and one or more of the following:
- Social Security number;
- Driver’s license number or state identification card number issued instead of a driver’s license;
- Financial account number, or credit card or debit card number in combination with any required security code, access code, or password that would permit access to a resident's financial account;
- Other numbers or information which may be used to access a person’s financial accounts or numbers or information issued by a governmental or regulatory entity that uniquely will identify an individual.

The above definition only holds when elements are “neither encrypted nor redacted.”

District FERPA compliant security controls state: When transferring student information and any other confidential data, the data will be compressed or zipped, encrypted and password protected. The minimum requirements are as follows. AES, 256 bits, strong password (min 8 characters, no dictionary word, a mixture of uppercase/lowercase, numbers, special characters). The password will not be communicated in email.

Page 14 of 15

Research and Data Sharing Agreement (RDSA) – Revised February 2017

Figure B.14. Research and data sharing agreement, page 14.
The researcher must destroy PII data collected within the designated protocol of the district-approved study, the researcher must complete a SC Department of Archives and History Division of Archives & Records Management Report on Records Destroyed (see below) and submit to Maria Beltran (beltran@greenville.k12.sc.us) in the Office of Information Assurance for approval, prior to destroying. Data may not be destroyed until the research requestor has received written approval from the Office of Information Assurance.

**SC Department of Archives Report of Records Destroyed**

<table>
<thead>
<tr>
<th>SC Department of Archives and History Division of Archives &amp; Records Management Report on Records Destroyed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Name of Requester: Jamie Taber</td>
</tr>
<tr>
<td>2. RDSA Title: Implementation and Evaluation of Computer-Assisted Science Vocabulary Modules with Students with Intellectual Disability and Autism: An Action Research Study</td>
</tr>
<tr>
<td>3. Current Date (M/D/YYYY):</td>
</tr>
<tr>
<td>4. Data Destruction Date from Section 5 (M/D/YYYY): Example: 6/3/2020</td>
</tr>
</tbody>
</table>

5. The records listed below have been disposed of in accordance with provisions of the Public Records Act, Code of Laws of South Carolina, 1976,Sections 30-1-10 through 30-1-140, as amended, and approved Records Retention Schedule.

**Signature of Record Officer’s or Representative:**

<table>
<thead>
<tr>
<th>Record</th>
<th>PII Data</th>
<th>Format</th>
<th>Destruction Method</th>
<th>Actual Date of Destruction (M/D/YYYY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example: Student Survey</td>
<td>Example: Student name, school name, gender, ethnicity</td>
<td>Example: Paper</td>
<td>Example: Shredded</td>
<td>Example: 6/19/2020</td>
</tr>
<tr>
<td>Pseudonym matching form</td>
<td>Student’s name and identifying information (school, grade, gender, disability classification, and ethnicity), homeroom teacher’s name</td>
<td>Paper</td>
<td>Shredded</td>
<td></td>
</tr>
<tr>
<td>Observation videos</td>
<td>Students’ faces/identity while completing the CSVM</td>
<td>Video File</td>
<td>Permanently deleted from computer and SD card</td>
<td></td>
</tr>
<tr>
<td>Researcher’s Journal</td>
<td>All notes about the study, may include notes from parents such as medication changes, etc.</td>
<td>Paper</td>
<td>Shredded</td>
<td></td>
</tr>
</tbody>
</table>

Page 15 of 15

Research and Data Sharing Agreement (RDSCA) – Revised February 2017

Figure B.15. Research and data sharing agreement, page 15.
July 29, 2019

Dr. Mason Gary, Deputy Superintendent
Dr. Jason McCreary, Director of Accountability and Quality Assurance
Dr. Spencer Benham, Head of Information Security, Lead IS Administrator

Dear Drs. Gary, McCreary, and Benham:

I am writing in support of Ms. Jamie Taber to conduct action research within
Schools. As her dissertation chair, I have worked closely with Ms.
Taber since she began our program approximately two years to design a rigorous study
that will positively impact her students, school, and district. Her proposed study
entitled "Implementation and Evaluation of Computer-Assisted Science Vocabulary
Modules with Students with Intellectual Disability and Autism: An Action Research
Study" has been successfully defended to our four-member faculty research committee
in August 2019 and approved for data collection beginning January 2020. We have
determined that her research complies with professional research ethics with children.

In addition, Ms. Taber’s proposed study (#Pro000091580) has been reviewed by the
University of South Carolina Institutional Review Board for Human Research in July
2019, and this office has determined that this study is not Human Subjects Research,
which follows the federal definition with everyday classroom instruction, small samples,
and non-generalizable findings. The Office of Research Compliance is an administrative
office that supports the University of South Carolina Institutional Review Board. If you
have questions regarding the review, please contact Lisa Johnson at
lisaj@mailbox.sc.edu or (803) 777-6670.

If I can provide you any additional information or answer any additional questions,
please contact me by email at michaelmgrant@sc.edu or by phone at (803)777-6476.

Sincerely,

Michael M. Grant, Ph.D.
Associate Professor & Programs Chair
Wardlaw College - 820 Main Street - Columbia, South Carolina 29201 - 803-777-6985 - sc.edu
APPENDIX C

INSTITUTIONAL REVIEW BOARD APPROVAL

Figure C.1. Institutional review board approval.
## APPENDIX D

PRE- AND POSTTEST QUESTIONS AND ANSWERS AND SCORESHEET

Correct answers are highlighted in blue. All answers will include a picture symbol.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer 1</th>
<th>Answer 2</th>
<th>Answer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>What does a plant need to live?</td>
<td>Rocks</td>
<td>Sunlight</td>
<td>Animals</td>
</tr>
<tr>
<td>What else does a plant need to live?</td>
<td><strong>Water</strong></td>
<td>Sand</td>
<td>Sticks</td>
</tr>
<tr>
<td>What type of air does a plant need?</td>
<td>Oxygen</td>
<td>Cold</td>
<td><strong>Carbon Dioxide</strong></td>
</tr>
<tr>
<td>What does a plant need to make food?</td>
<td>Sunlight</td>
<td>Blocks</td>
<td>Sticks</td>
</tr>
<tr>
<td>What is photosynthesis?</td>
<td>A type of exercise</td>
<td>Using light to put together food</td>
<td>Drawing a picture</td>
</tr>
<tr>
<td>A chemical reaction is when two things are...</td>
<td>Converted into one thing</td>
<td>Exercising</td>
<td>Running Fast</td>
</tr>
<tr>
<td>Which picture shows photosynthesis?</td>
<td><img src="image" alt="Blue Sun" /></td>
<td><img src="image" alt="Drawing" /></td>
<td><img src="image" alt="Asparagus" /></td>
</tr>
<tr>
<td>What does a plant need to grow?</td>
<td>Animals</td>
<td>Rocks</td>
<td>Energy</td>
</tr>
<tr>
<td>How does a plant make food?</td>
<td>Growth</td>
<td>Photosynthesis</td>
<td>Jumping</td>
</tr>
<tr>
<td>What part of the plant is the food made in?</td>
<td>Rocks</td>
<td>Stem</td>
<td>Leaf</td>
</tr>
</tbody>
</table>

Figure D.1. Pre- and posttest questions and answers.
Pre- and Posttest Score Sheet

Student’s Name

Pretest

<table>
<thead>
<tr>
<th>Question</th>
<th>Student’s Answer</th>
<th>Correct Answer</th>
<th>+/-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Posttest

<table>
<thead>
<tr>
<th>Question</th>
<th>Student’s Answer</th>
<th>Correct Answer</th>
<th>+/-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## APPENDIX E

FORMATIVE ASSESSMENT QUESTIONS AND SCORESHEET

<table>
<thead>
<tr>
<th>Topic</th>
<th>Question 1 &amp; Answers</th>
<th>Question 2 &amp; Answers</th>
<th>Question 3 &amp; Answers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Photosynthesis</td>
<td><strong>What does a plant need to put together food?</strong></td>
<td><strong>What is photosynthesis?</strong></td>
<td>Which picture shows how we can remember what photosynthesis means?</td>
</tr>
<tr>
<td></td>
<td>Rocks Light Animals</td>
<td>Using rocks to make food</td>
<td>Using light to make food Using animals to make food [see choices below]</td>
</tr>
<tr>
<td>2 Plant</td>
<td><strong>What part of a plant holds it up?</strong></td>
<td><strong>What color are most plants?</strong></td>
<td>Which picture shows a plant? [see choices below]</td>
</tr>
<tr>
<td></td>
<td>Stem Flower Rock</td>
<td>Red Blue Green</td>
<td></td>
</tr>
<tr>
<td>3 Growth</td>
<td><strong>If something grows it gets...</strong></td>
<td><strong>What does a plant need to grow?</strong></td>
<td>Which picture shows something growing? [see choices below]</td>
</tr>
<tr>
<td></td>
<td>Smaller Bigger Stays the same</td>
<td>Sand Sunlight Sticks</td>
<td></td>
</tr>
<tr>
<td>4 Chloroplast</td>
<td><strong>The organelle in a plant is called...</strong></td>
<td><strong>What does chloroplast do?</strong></td>
<td>Chloroplast is in the...</td>
</tr>
<tr>
<td></td>
<td>chloroplast Crayon Leaf</td>
<td>Grow Photosynthesis Jump</td>
<td>Leaf Stem Roots</td>
</tr>
<tr>
<td>5 Plant Review</td>
<td><strong>What is photosynthesis?</strong></td>
<td><strong>What does chloroplast do?</strong></td>
<td>Which picture shows a leaf? [see choices below]</td>
</tr>
<tr>
<td></td>
<td>Using rocks to make food</td>
<td>Grow</td>
<td></td>
</tr>
</tbody>
</table>

Figure E.1. Formative assessment questions and answers, page one.
## Figure E.2. Formative assessment questions and answers, page two.

<table>
<thead>
<tr>
<th>6</th>
<th>Sunlight, Energy, &amp; Sugar</th>
<th>Sugar gives plants...</th>
<th>Energy is the ability to do...</th>
<th>Sunlight helps a plant make...</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exercise</td>
<td>Exercise</td>
<td>Exercise</td>
<td>Food</td>
</tr>
<tr>
<td></td>
<td>Rocks</td>
<td>Work</td>
<td>Exercise</td>
<td>Toys</td>
</tr>
<tr>
<td></td>
<td>Energy</td>
<td>Light</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Convert</td>
<td>Convert means something...</td>
<td>Plants convert light, water, and CO₂ into...</td>
<td>Which picture shows convert?</td>
</tr>
<tr>
<td></td>
<td>Stays the same</td>
<td>Rocks</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Changes</td>
<td>Animals</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rolls</td>
<td>Food</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Chemical Reaction</td>
<td>A chemical reaction is when two things are...</td>
<td>Photosynthesis is a...</td>
<td>Which picture shows a chemical reaction?</td>
</tr>
<tr>
<td></td>
<td>exercising</td>
<td>Fast animal</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>converted into one thing running fast</td>
<td>Big car</td>
<td>(see choices below)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>chemical reaction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Carbon Dioxide &amp; Oxygen</td>
<td>People breathe in...</td>
<td>Plants take in...</td>
<td>Plants give out...</td>
</tr>
<tr>
<td></td>
<td>Carbon Dioxide – CO₂</td>
<td>Oxygen – O₂</td>
<td></td>
<td>Oxygen – O₂</td>
</tr>
<tr>
<td></td>
<td>Oxygen – O₂</td>
<td>Carbon Dioxide – CO₂</td>
<td></td>
<td>Carbon Dioxide – CO₂</td>
</tr>
<tr>
<td></td>
<td>Water – H₂O</td>
<td>Water – H₂O</td>
<td></td>
<td>Water – H₂O</td>
</tr>
<tr>
<td>10</td>
<td>Review</td>
<td>Photosynthesis is...</td>
<td>Plants convert light, water, and CO₂ into...</td>
<td>What type of air do plants need?</td>
</tr>
<tr>
<td></td>
<td>Exercise</td>
<td>Rocks Water</td>
<td></td>
<td>Carbon Dioxide – CO₂</td>
</tr>
<tr>
<td></td>
<td>A chemical reaction</td>
<td>Food</td>
<td></td>
<td>Oxygen – O₂</td>
</tr>
<tr>
<td></td>
<td>Running fast</td>
<td></td>
<td></td>
<td>Water – H₂O</td>
</tr>
<tr>
<td></td>
<td>Photosynthesis - mnemonic (repeat of module 1)</td>
<td>What does a plant need to put together food?</td>
<td>What is photosynthesis?</td>
<td>Which picture shows how we can remember what photosynthesis means?</td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------------</td>
<td>---------------------------------------------</td>
<td>-------------------------------</td>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td>11</td>
<td>Rocks, Light, Animals</td>
<td>Using <strong>rocks</strong> to make food</td>
<td>Using <strong>light</strong> to make food Using <strong>animals</strong> to make food</td>
<td>[see choices below]</td>
</tr>
<tr>
<td>12</td>
<td>Photosynthesis - song</td>
<td><strong>Photosynthesis makes ___ for plants.</strong></td>
<td><strong>Photosynthesis happens in...</strong></td>
<td><strong>Putting together light, CO₂, and water to make food is called...</strong></td>
</tr>
<tr>
<td></td>
<td>Chairs: Food, Roots</td>
<td>Plants</td>
<td>Animals</td>
<td>Rocks</td>
</tr>
<tr>
<td>13</td>
<td>Photosynthesis - model</td>
<td><strong>Touch the leaf.</strong></td>
<td><strong>Touch the sunlight.</strong></td>
<td><strong>Touch the water.</strong></td>
</tr>
<tr>
<td></td>
<td>Students will touch the correct part of the photosynthesis model.</td>
<td>Students will touch the correct part of the photosynthesis model.</td>
<td>Students will touch the correct part of the photosynthesis model.</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Photosynthesis - simulation</td>
<td><strong>Touch where the plant makes its food.</strong></td>
<td><strong>Touch what the plant needs to make food.</strong></td>
<td><strong>Touch another thing the plant needs to make food.</strong></td>
</tr>
<tr>
<td></td>
<td>The student touches the leaf.</td>
<td>The student touches CO₂, water, or sun.</td>
<td>The student touches CO₂, water, or sun.</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Photosynthesis - review</td>
<td><strong>Photosynthesis makes ___ for plants.</strong></td>
<td><strong>What is photosynthesis?</strong></td>
<td><strong>Which picture shows how we can remember what photosynthesis means?</strong></td>
</tr>
<tr>
<td></td>
<td>Chairs: Food, Roots</td>
<td>Using <strong>rocks</strong> to make food</td>
<td>Using <strong>light</strong> to make food Using <strong>animals</strong> to make food</td>
<td>[see choices below]</td>
</tr>
</tbody>
</table>
Figure E.4. Picture choices for formative assessment answers.

Figure E.5. Sample of formative assessment recording sheet.
### Classroom Measure of Active Engagement Observation Protocol

#### Classroom Measure of Active Engagement (CMAE):

**Recording Sheet**

<table>
<thead>
<tr>
<th>Factor/ Descriptor &amp; Data</th>
<th>Anecdotal Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emotional Regulation</strong></td>
<td></td>
</tr>
<tr>
<td>Emotional Regulation:</td>
<td></td>
</tr>
<tr>
<td>Record begin/end times for duration</td>
<td>Instruction</td>
</tr>
<tr>
<td>Instruction</td>
<td>Assessment</td>
</tr>
</tbody>
</table>

#### Classroom Participation

<table>
<thead>
<tr>
<th>Productivity:</th>
<th>Instruction</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record begin/end times for duration</td>
<td>Instruction</td>
<td>Assessment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Independence:</th>
<th>Instruction</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record begin/end times for duration</td>
<td>Instruction</td>
<td>Assessment</td>
</tr>
</tbody>
</table>

**Anecdotal Notes Codes**

- CSVM Features/Action
- WV = watching educational video
- WS = watching simulation
- D s = D s CTD
- S s = S s CTD
- FB = Feedback
- S = Sound
- T = Transition
- M = Motion/Animation
- ASS = Able to Advance Slide
- CA = Cannot Advance Slide
- AQ = Answering Questions

**Color Codes**

- Blue = Description of Activities
- Red = Reflective Notes

---

Figure F.1. Classroom measure of active engagement observation protocol, page one.
### Social Connectedness

<table>
<thead>
<tr>
<th>Responding:</th>
<th>Instruction</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record + for responds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– for does not respond</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Initiating Communication

<table>
<thead>
<tr>
<th>Directed Communication:</th>
<th>Instruction</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record a tally of occurrences</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Accidental Notes Codes

- CSV: Features/Action
  - WV = watching educational video
  - WS = watching simulation
  - S+ = S+ CTD
  - S- = S- CTD
  - FB = Feedback
  - S = Sound
  - T = Transition
  - M = Motion/Animation
  - AS = Able to Advance Slide
  - CA = Cannot Advance Slide
  - AQ = Answering Questions
  - CR = Clicking Where Requested
  - RSC = Reward: Song Clip
  - RSV = Reward: Video Clip
  - RO = Reward: Other

### Behavior/Engagement

- V = Verbal Sound
- VS = Verbal Speech
- G = Gesture
- FE = Facial Expression
- SI = Stimming
- E = Echolalia
- EI = Elapement
- P = Perseverates
- PO = Preoccupied

### Color Codes

- Blue = Description of Activities
- Red = Reflective Notes

Figure F.2. Classroom measure of active engagement observation protocol, page two.
<table>
<thead>
<tr>
<th>Generative Language: Record tally of occurrences</th>
<th>Instruction</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction</td>
<td>Assessment</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flexible Behavior: Record + for exhibits - for does not exhibit</th>
<th>Instruction</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction</td>
<td>Assessment</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flexible Attention: Record + for exhibits - for does not exhibit</th>
<th>Instruction</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction</td>
<td>Assessment</td>
<td></td>
</tr>
</tbody>
</table>

**Anecdotal Notes Codes**
- **CSVM Features/Action**
  - WV = watching educational video
  - WS = watching simulation
  - G:G = G:G CTD
  - G:G = G:G CTD
  - FB = Feedback
  - S = Sound
  - T = Transition
  - M = Motion/Animation
  - AS = Able to Advance Slide
  - CA = Cannot Advance Slide
  - AQ = Answering Questions
  - CR = Clicking Where Requested
  - RSC = Reward: Song Clip
  - RSV = Reward: Video Clip
  - RO = Reward: Other

**Behavior/Engagement**
- N = Negative
- P = Positive
- NR = No Reaction
- V = Verbal Sound
- VS = Verbal Speech
- G = Gesture
- FE = Facial Expression
- St = Stimming
- E = Echolalia
- El = Elopement
- P = Perseverates
- PO = Preoccupied

**Color Codes**
- Blue = Description of Activities
- Red = Reflective Notes

---


Figure F.3. Classroom measure of active engagement observation protocol, page three.
APPENDIX G

LINK TO TABLE G.1

Table G.1. Formative Assessment Questions, Type of Questions, and Students' Scores can be found at:

https://docs.google.com/document/d/17bTiTkI5cDbyyRPOKQUCMFMPYDS2JHgq4BmHFLnL1bc/edit?usp=sharing
APPENDIX H

LINK TO TABLE H.1

Table H.1. *Summary of Classroom Measure of Active Engagement Findings* can be found at:

https://docs.google.com/spreadsheets/d/1KmIyP9C8L1OyqwKftvw8AV2FaIxxE-yTdz6B7qgRIGE/edit?usp=sharing