Children and Teenagers
ISSN 2576-3709 (Print) ISSN 2576-3717 (Online)
Vol. 3, No. 1, 2020
www.scholink.org/ojs/index.php/ct

Original Paper

Evaluation of an eBook for Oral Health Literacy© to Promote Child Health: Readability, Suitability, Understandability, Actionability, and Gist-Based Message Design

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Received: May 3, 2020 Accepted: May 14, 2020 Online Published: May 20, 2020

doi:10.22158/ct.v3n1p54 URL: http://dx.doi.org/10.22158/ct.v3n1p54

Abstract

The purpose of the study was to evaluate an oral health curriculum called an eBook for Oral Health Literacy© to determine its effectiveness for promoting child health. A secondary purpose was to describe and explain the design characteristics of readability, suitability, understandability, and actionability of the 17 chapters of the eBook. A third purpose was to conduct evaluations on verbatim representations (or literal facts) that are presented in the eBook chapters, including the gist representations that are not explicitly presented but inferred by the reader from the chapter information. Results found that the eBook for Oral Health Literacy© had acceptable, and in many cases, favorable scores, for the five design elements of readability, suitability, understandability, actionability, and gist comprehension. Ongoing dissemination of the eBook for Oral Health Literacy© curriculum has the potential to boost children who are "learning to read" and "reading to learn" about oral health hygiene and nutrition. Future studies should use one or more chapters from the curriculum as an intervention to test this educational premise as an explanatory basis for functional health literacy.

Keywords

child health, oral health literacy, reading, comprehension, readability, suitability, understandability, actionability, verbatim-based representations, gist-based representations, evaluation, eBook, health behavior

1. Introduction

The number one chronic infectious disease among children is dental caries. Pain from tooth decay and gum inflammation keeps children from attending school. School absenteeism due to sick days from dental pain can be detrimental to the academic progress of student learning (Carroll, 2010; Jackson, Van William, Kotch, Pahel, & Yee, 2011). Absenteeism from school means that younger children will not gain the literacy and numeracy skills that advance them successfully through middle school and high school. Youth who graduate from high school increase their average lifespan by six to nine years (Allensworth, Lewallen, Stevenson, & Katz, 2011) and their high risk health behaviors are associated with lower academic achievement (CDC, 2020). Thus, the ability to support children to practice health-related habits increases their chance of academic success and a higher quality of life.

Oral health hygiene is a daily habit that promotes life quality and prevents disease. Research has shown that heart disease, cancer, obesity, diabetes, and Alzheimer's Disease starts in the mouth microbiota (Lu, Xuan, & Wang, 2019; Shoemark & Allen, 2015; Olson, 2015). The mucosal membranes of the mouth, especially the gums surrounding the teeth, are essential environments for a healthy mouth. Dental caries are infections that proliferate when germs are not removed through adequate teeth brushing, flossing, and rinsing with water. The daily intake of healthy foods and beverages with adequate nutrients boosts positive health outcomes for children's teeth, tongue, and gums. Overall body health depends upon an interactive relationship between oral microbiota and gut microbiota by fostering key environments for oral health and gut health (Lu, Xuan, & Wang, 2019).

In keeping with an ecological model of health promotion and disease prevention, a focus on children's health habits at the intrapersonal level must be coordinated by family members at home and by health professionals in school-based health clinics and academic classrooms. Community partnerships that integrate interpersonal and institutional levels of health will build safety nets for children and their families. Policies such as the National Health Education Standards (Joint Committee on National Health Education Standards, 2007) outline what students should "know and be able to do" through eight curriculum statements for health instruction. As such, health educators play key roles in developing the knowledge, attitudes, and skills that children need for practicing daily oral health routines for the prevention of infectious diseases. Health education teachers may not think to cover dental caries as an infectious disease to be prevented and only focus on a healthy smile or time management skills to do personal health routines. However, by incorporating and applying National Health Education Standards 4, 5, and 6 to dental health education, students will be able to *communicate* a healthy smile, demonstrate how to *make a daily decision* for oral health hygiene, and demonstrate how to *set goals* to go to a dentist every six months, respectively.

There is an ongoing need for combining literacy and health into health literacy agendas when educating children and their families. National Health Education Standard 3 focuses on the importance of health

literacy so students "will demonstrate the ability to access valid information, products, and services to enhance health". Health literacy is a requisite skill for making health-related decisions (Paasche-Orlow & Wolf, 2007) and helps to mediate certain health behaviors (Friis, Lasgaard, Rowlands, Osborne, & Maindal, 2016). More recent work in health literacy has focused on certain health conditions or diseases, e.g., diabetes health literacy (Baily, Brega, Crutchfield, Elasy, Herr, Kaphingst et al., 2014); oral health literacy in child caregivers (Baskaradoss, AlThunayan, Alessa, Aolbaidy, Alwakeel et al., 2019); and health literacy of children with asthma (Tzeng, Chiang, Chen, & Gau, 2017).

Health literacy is an all-encompassing concept that has been defined from multiple perspectives for multiple purposes (Allen, Auld, Logan, Henry Montes, & Rosen, 2017; Sorensen, Van den-Broucke, Fullam, Doyle, Pelikan, Slonska, & Brand, 2012). Inadequate to poor health literacy has been associated with "nonadherence to treatment plans, increased health care costs, and greater hospitalization rates" (Ayyaswami, Padmanabhan, Patel, Prabhu, Hansberry, Agarwal, & Magnani, 2019) and reduced "perceptions of health, less utilization of services, and poorer understanding of verbal and written instructions for self-care" (Jackson, Van William, Kotch, Pahel, & Yee, 2011).

Self care is a lifelong goal of health education. Self care self efficacy can be defined as "one's perceived ability to perform relevant self-care activities" (Mak, Law, Woo, Cheung, & Lee, 2009). Eller, Lev, Changrong, and Watkins (2016) found that "self care self efficacy" is the adaptation of the self efficacy concept in the context of self-care. To date, school health education classes have not often focused on the term "self care" with children and youth. By shifting the language of preK-12 health education to "self care" instead of "personal health", a more active engagement may result in child health outcomes due to an implied action of care needed over a lifetime.

The relationship of health literacy to various health behaviors among young people has recently been investigated (Klinker, Aaby, Ringgaard, Vang Hjort, Hawkins, & Maindal, 2020; Jang & Yoon, 2018; Friis, Lasgaard, Rowlands, Osborne, & Maindal, 2016). Jang and Yoon (2018) analyzed oral health behaviors among elementary students and the relationship of oral health behaviors to oral health literacy and oral health knowledge. Zullig, Ubbes, and Mann (2013) conducted the first quantitative study to examine the relationship between perceived literacy skills and preventive health behaviors and found that middle adolescence was a time when behavioral patterns were becoming established. The Middle School Youth Risk Behavior Survey was used to study the health behaviors of 244 students in seventh and eighth grades. Analysis of variance and Tukey post-hoc analyses indicated that as students' reading abilities and supportive literacy influences declined, students reported significantly fewer dental check-ups and lower sunscreen use ($p<.05$), even after controlling for socioeconomic status. These results suggested that adolescent perceptions of their reading abilities and reading activities are positively associated with health behaviors like oral health. Connecting reading and literacy abilities to health behaviors are important steps forward in health education research.

Eltora, Ghanian, Adams, Born, and Daniels (2014) found that educational materials about trauma prevention and safety education located on the American Association for Surgery of Trauma website did not meet the sixth-grade readability standards that are needed for the public. Hendrickson, Huebner, and Riedy (2016) determined that readability of child health materials for preventive dental care should not exceed the sixth-grade reading level. In the release of the Digital Health Communication Common Agenda 2.0, updates were made to consensus statements for academic, governmental, and technological sectors to advance public health with the plan that people "have access to health information that is timely, credible, and available at the health literacy level of the intended population…to protect or promote individual or population health" (Gold, Auld, Abroms, Smyser, Yom-Tov, & Allegrante, 2019).

eBooks can support children's literacy development through interactive narratives (Thompson Long, Hall, Hogan et al., 2018). Hiniker (2016) highlighted that American children are avid technology users and spend more time using technology than any other activity besides sleeping. The International Literacy Association (2019) advocated for the use of technology by children to strengthen school-home connections and that "meaningful use of high-quality resources is essential in preparing *all* young children for long-term academic success".

1.1 Development of Oral Health Literacy Material

An eBook for Oral Health Literacy© was written from a template designed by Ubbes in 2010 and launched online in 2013 as an academic service learning project in health education and early childhood education for a wide variety of health behaviors (Ubbes & Miami University Libraries, 2013-2020). A slightly enhanced visual-textual design template was employed (Ubbes, Coyle, & Tzoc, 2018) when the project director narrowed the project to focus on oral health, because *Healthy People 2020* (ODPHP, 2020) highlighted that people from two years old into adulthood were not going to the dentist for regular check-ups. Therefore, an eBook was written to improve a leading health indicator Oral Health OH-7, which reads "Increase the proportion of children, adolescents, and adults who used the oral health care system in the past year".

Overall, the eBook for Oral Health Literacy© contains 17 chapters with a focus on five topical themes about oral health: 1) Oral Health Hygiene of Children, 2) Oral Health & Nutrition of Children, 3) Oral Health & Beverages of Children, 4) Oral Health & Medicine Safety, and 5) Dental Health Checkups for Young Boys and Girls. Figure 1 shows a sample chapter cover and a last page template from the eBook for Oral Health Literacy©

Figure 1. Sample Chapter Cover and a Last Page Template from the eBook for Oral Health Literacy©

The eBook for Oral Health Literacy© curriculum is available on the Digital Literacy Partnership website at Miami University (Ubbes, 2020). The key feature of the curriculum is teaching children about health and literacy in tandem while they practice their reading skills and oral health hygiene skills in an integrated way. Full-page photographs show children taking care of their teeth, mouth, and gums supported by skill-based declarative sentences on each page. Each sentence in a chapter describes a child having an intention to act through an action verb, e.g., decision making, goal setting, or communication skills, supported by reasoned actions for doing a variety of oral health habits. The specific self-care behaviors modeled by children in the photograph include teeth brushing, flossing, and rinsing, including how to interact with family, friends, and dental professionals in different sociocultural contexts.

1.2 Readability

A test of readability was first used in health education by Doak, Doak, and Root (1996) to analyze the effectiveness of informational materials. Readability refers to the "reading difficulty of a resource and

uses word and sentence length to determine a score" (Rhee, Von Feldt, Schumacher, & Merkel, 2013). The American Medical Association (AMA) and the National Work Group on Cancer and Health have recommended that health education materials be written at the 5th to 6th reading level to provide an appropriate readability level for readers (Ayyaswami, Padmanabhan, Patel, Prabhu, Hansberry, Agarwal, & Magnani, 2019). Rudd (2020) indicated that "...well over 800 peer-reviewed articles in public health and medical journals attest to the fact that health materials are written at reading grade levels that far exceed the average reading skills of high school graduates. This mismatch between literacy demands and literacy skills limits access to important information as well as to health care and services".

Readability is an important factor to consider in the design and use of health materials because improving readability is a cost-effective way to make the materials more useful to patients. Analyzing the readability of health education materials costs very little time and money and is a very efficient way to maximize the materials distributed to a particular audience (Ayyaswami, Padmanabhan, Patel, Prabhu, Hansberry, Agarwal, & Magnani, 2019).

Several tests are commonly used to calculate readability of written materials. Readability tools measure how hard or easy it is to read educational materials according to grade levels in the United States (Eltorai, Ghanian, Adams, Born, & Daniels, 2014). Examples of measurement tools include the Flesch-Kincaid Grade Level (FKGL) Readability Test, the Fry Readability Formula, and the Simple Measure of Gobbledygook (SMOG) Readability Formula. The Fry Readability Formula was developed by Edward Fry in order to provide a simplistic method for determining a material's reading level to correlate highly with other established readability tests such as the FKGL Readability Test (Fry, 1968). The FKGL Readability Test was developed for the U.S. Navy by Rudolf Flesch (Crosby, 1977) and was used by the U.S. Army to assess military training manuals in the 1970's. Flesch was a linguist who was a strong proponent of plain English in the U.S. and advocated for phonics rather than sight reading to enable students to sound-out unfamiliar words. His co-author, J. Peter Kincaid, was a professor and a scientist for the U.S. military. To estimate reading level for the FKGL Readability Test, a weighted combination of sentences in a passage are counted along with the syllables per word and the words per sentence (Magnuson, Jain, Roomian, Pagni, Tran, & Finkelman, 2020).

There are some cautions in using readability formulas according to the U.S. Centers for Medicare and Medicaid Services (2020). In their *Toolkit for Making Written Material Clear and Effective*, four cautions are indicated: 1) calculating readability does not mean that the materials are also clear and written effectively; 2) readability formulas vary widely so grade level scores can differ considerably; 3) grade level scores can be over-interpreted for a population; and 4) written passages that are reduced to too low of a grade level may appear choppy and lack cohesion.

1.3 Suitability

A Suitability of Assessment Materials tool was published for the first time in the 2nd edition of the seminal book entitled *Teaching Patients with Low Literacy Skills* (Doak, Doak, & Root, 1996). Suitability measures "how well the material can be understood and accepted by the reader" (Rhee, Von Feldt, Schumacher, & Merkel, 2013). To calculate the suitability of health education materials, the designer and evaluator rate the materials in six different areas (see Methods) to determine which areas need to be improved (Hoffmann & Ladner, 2012). The SAM tool classifies a score of 70-100 percent as superior material, a score of 40-69 percent as adequate material, and a score of 0-39 percent as not suitable material for health education (Doak, Doak, & Root, 1996).

1.4 Understandability

Understandability is an important aspect of educational materials to study because improving a text's understandability will help readers to interpret the message of the materials. Shoemaker, Wolf and Brach (2019) stated that "Patient education materials are *understandable* when consumers of diverse backgrounds and varying levels of health literacy can process and explain key messages".

In order for health education materials to be considered understandable, the Patient Education Materials Assessment Tool (PEMAT) outlines 19 items to be scored. These items demonstrate the purpose, style of language used, organization and layout of the material, and use of visual aids.

2. Purpose of the Study

The purpose of the study was to evaluate an oral health curriculum called an eBook for Oral Health Literacy© to determine its effectiveness for promoting child health. A secondary purpose was to describe and explain the design characteristics of readability, suitability, understandability, and actionability of the 17 chapters of the eBook. A third purpose was to conduct evaluations on *verbatim representations* (or literal facts) that are presented in the eBook chapters, including the *gist representations* that are not explicitly presented but inferred by the reader from the chapter information.

3. Methods

3.1 Procedures

Undergraduate students enrolled in a public health communication course computed the readability scores of the eBook chapters as instructed by the first author. Since the students were instructed how to do readability assessments of health education materials in two different sections of the same course, the readability scores were calculated on an ungraded handout and submitted by at least two different students taking the course. Two evaluators did an independent assessment of the Suitability Assessment of Materials (SAM) for the eBook for Oral Health Literacy©. A third evaluator was added to the research project to ensure internal consistency when conducting the Patient Education Materials Assessment Tool

(PEMAT), which measures understandability and actionability (Shoemaker, Wolf, & Brach, 2014) of the eBook for Oral Health Literacy©.

3.2 Instruments

Three different instruments were used to measure the readability of the eBook for Oral Health Literacy©: 1) a FKGL Readability Test uses a weighted combination of sentences in a passage; syllables per word and words per sentence are counted (Magnuson, Jain, Roomian, Pagni, Tran, & Finkelman, 2020); 2) a Fry Readability Formula uses the average number of sentences and average number of syllables in randomly selected 100 word passages of a reading material. These averages are plotted on the Fry Readability Graph, then the area in which the points fall, determines the grade level at which the material is read (Fry, 1968); and 3) a Simple Measure of Gobbledygook (SMOG) Reading Level is calculated by counting the number of words with 3 or more syllables found in the first 10 sentences, the middle 10 sentences, and the last 10 sentences of a reading material. The square root of the number of words with 3 or more syllables is calculated and added to 3. The SMOG grade level formula is as follows: SMOG grade = 3 + √polysyllable count. SMOG provides a representative score of the tested material as it samples a total of 30 sentences throughout the entire text (McLaughlin, 1969).

Two other instruments were used to measure the suitability, understandability, and actionability of the eBook for Oral Health Literacy©: 1) the Suitability Assessment of Materials (SAM) was employed to evaluate content, literacy demand, graphics, layout and type, learning stimulation and motivation, and cultural appropriateness of the eBook as a whole. Two reviewers scored the eBook in 6 different areas using standards of superior (2 points), adequate (1 point), or not suitable (0 points). All points were totaled then divided by 42 to determine an overall percentage (Doak, Doak, & Root, 1996); 2) the Patient Education Materials Assessment Tool (PEMAT), available online from the Agency for Healthcare Research and Quality, provides a way to evaluate and score educational materials on their ability to be understood by diverse audiences (i.e., understandability) and then be acted upon (i.e., actionability). The PEMAT provides descriptions of 19 items on the topic of understandability and 7 items on the topic of actionability. The scorer can determine if the item is included in the educational text by selecting *Agree* or *Disagree*. One point is given to the text for each *Agree* response. An overall score can then be determined by adding all of the *Agree* points and dividing by 26 to obtain a percentage. A score in the domain of understandability can be determined by adding the *Agree* points for items 1-19 and dividing by 19, and a score in the domain of actionability can be determined by adding the *Agree* points for items 20-26 and dividing by 7.

4. Results

Data for the 17 chapters of the eBook for Oral Health Literacy© are organized below by the four design characteristics (e.g., readability, suitability, understandability, and actionability) and by verbatim-based

versus gist-based message design.

4.1 Readability

Table 1 outlines the number of words, number of sentences, and words per sentence for calculating readability of the 17 chapters of the eBook. The FKGL test indicated that the 17 chapters averaged a reading grade level of 6.5 with an overall range between grades 4.6 and 9.9 depending on the chapter. Calculations using the Fry Reading Level Formula indicated that the eBook chapters averaged a reading grade level of 7.1 with an overall range between grades 4.5 and 10. The Simple Measure of Gobbledygook (SMOG) indicated that the eBook chapters averaged a reading grade level of 5.8 with an overall range between grades 4 and 8.

Table 1. Evaluation of the eBook for Oral Health Literacy© for Readability

Chapters	Total Words	Total Sentences	Total Words per Sentence	FKGL	Fry	SMOG
Chapter 1	195	11	16.9	5.9	5.5	5.0
Chapter 2	223	12	17.8	6.2	5.5	6.0
Chapter 3	197	12	15.6	7.0	6.0	6.0
Chapter 4	195	11	17.0	4.6	6.0	7.0
Chapter 5	168	11	14.7	4.7	6.0	4.0
Chapter 6	156	12	13.0	5.9	10.0	6.6
Chapter 7	200	12	15.8	7.9	9.0	6.3
Chapter 8	199	12	16.0	6.5	6.0	6.6
Chapter 9	183	12	14.5	5.2	7.5	5.0
Chapter 10	200	11	17.4	7.3	7.0	5.0
Chapter 11	207	11	18.0	7.2	7.0	6.7
Chapter 12	174	10	16.2	8.1	9.0	7.2
Chapter 13	160	12	12.7	7.2	9.0	5.0
Chapter 14	176	9	18.6	5.3	6.0	4.0
Chapter 15	176	9	18.6	5.3	6.0	4.0
Chapter 16	152	12	11.7	5.7	4.5	6.6
Chapter 17	225	13	17.3	9.9	10.0	7.9
Averages	**187**	**11**	**16.0**	**6.5**	**7.1**	**5.8**

Key: FKGL = Flesch-Kincaid Grade Level Readability; Fry = Fry Readability Formula; SMOG = Simple Measure of Gobbledygook Readability

4.2 Suitability

Table 2 shows the eBook results for six different categories of the Suitability Assessment of Materials (SAM) Evaluation. In the area of *content*, the eBook received a score of 83 percent. In the area of *literacy demand*, the eBook received a score of 90 percent. In the area of *graphics*, the eBook received a score of 100 percent. In the area of *layout and type*, the eBook received a score 83 percent. In the area of *learning stimulation and motivation*, the eBook received a score of 100 percent. In the area of *cultural appropriateness*, the eBook received a score of 83 percent. Overall, the scores in the six categories ranged from 83 to 100 percent. When the scores of each area were averaged together, an overall score of 91 percent out of 100 resulted, which indicated a superior material.

Table 2. Evaluation of the eBook for Oral Health Literacy© Using the Suitability Assessment of Materials

Suitability Categories (n = 6)	**Scores***
1. Content	0.83
2. Literacy Demand	0.90
3. Graphics	1.00
4. Layout and Type	0.83
5. Learning Stimulation and Motivation	1.00
6. Cultural Appropriateness	0.83
Total Percentage of Suitability	**91% out of 100%**

*Maximum score of 1

4.3 Understandability

The Patient Education Materials Assessment Tool (PEMAT) indicated a score of 94 percent in the domain of understandability. This indicated that 94 percent of the objectives comprising an "understandable" material were met by the eBook. Shoemaker, Wolf, and Brach (2014) define an *understandable* text as one in which "consumers of diverse backgrounds and varying levels of health literacy can process and explain key messages". The list below shows the key messages of the 17 chapters of the eBook for Oral Health Literacy©. The topics, concepts, and underlined skills in the eBook chapter summaries show key vocabulary that is read by children when interacting with each of the 10 pages in a chapter for a total of 170 pages of content:

Chapter 1: Setting Dental Hygiene Goals for Healthy Teeth

Learn how to set dental hygiene goals for healthy teeth by brushing every morning and night, buying toothpaste with fluoride, flossing regularly, and visiting your dentist to ensure a healthy smile.

Chapter 2. Making Decisions to Have Fun with my Oral Health

Learn how to make decisions for brushing your teeth, tongue, and gums every morning and night while singing songs for 2 minutes to ensure a proper cleaning.

Chapter 3. Taking Action and Making Decisions to Have Healthy Teeth

Learn how to take action for oral health by making decisions to brush your teeth, eat healthy fruits and vegetables, and floss away leftover food to prevent plaque buildup on your teeth. Other healthy decisions include buying oral health products with your parents at the grocery store and practicing oral hygiene habits with your family at home.

Chapter 4. Setting Daily Goals to Rinse My Mouth

Learn how to set a goal to rinse your mouth with water and mouthwash for a fresh breath and clean teeth.

Chapter 5. Setting Food Goals for Healthy Teeth

Learn how to set goals for healthy teeth by eating foods rich in calcium and fiber, brushing after snacks and meals, and visiting with your dentist every 6 months. Other oral health goals include buying floss and toothpaste at the grocery store and following healthy role models from your parents at home.

Chapter 6. Decisions to Keep My Teeth Healthy and Strong

Learn how to make decisions to keep your teeth healthy and strong by eating healthy snacks and drinking healthy beverages with your friends at school and your family at home.

Chapter 7. Deciding to Improve My Dental Health by Drinking More Water

Learn how to make decisions to improve your dental health by drinking more water to clean your teeth and to prevent cavities and dry mouth.

Chapter 8. Deciding to Drink Milk for Healthy Teeth

Learn how to make healthy decisions for your teeth by drinking milk at breakfast, lunch, and dinner and not drinking sugary beverages. Learn the many benefits of drinking milk to improve your oral health.

Chapter 9. Setting Beverage Goals for Healthy Teeth (African American)

Learn how to set beverage goals for healthy teeth by choosing nutritious food and beverages when eating alone and with your family and friends.

Chapter 10. Setting Beverage Goals for Healthy Teeth (Latin American)

Learn how to set beverage goals for healthy teeth by choosing nutritious food and beverage when eating alone and with your family and friends.

Chapter 11. Coping with the Stress of Dental Pain

Learn how to set a goal to cope with the stress of dental pain by always brushing, flossing, and scheduling a dental appointment for pain management.

Chapter 12. Communicating How to Take Medicine Safely with a Trusted Adult

Learn how to communicate with your words and actions when taking medicine given to you from trusted adults such as your dentist, doctor, and parents.

Chapter 13. Deciding to Follow Rules for Taking Medicine

Learn how to make decisions to follow safety rules when taking medicine by first talking with your doctor, dentist, trusted adults, and other health professionals.

Chapter 14. Setting Goals for Going to the Dentist (Boys)

Learn how to set a goal to go to the dentist for a 6-month check up on your mouth, teeth, and gums. Other healthy goals include brushing daily for fresh breath and clean teeth.

Chapter 15. Setting Goals for Going to the Dentist (Girls)

Learn how to set a goal to go to the dentist for a 6-month check up on your mouth, teeth, and gums. Other healthy goals include brushing daily for fresh breath and clean teeth.

Chapter 16. Communicating Through My Smile and Teeth at A Very Young Age

Learn how to communicate through your smile and teeth at a very young age by recognizing early signs of tooth growth and practicing healthy habits with family members.

Chapter 17. Communicating with Health Professionals About My Child's Oral Health Care

Learn how to communicate and advocate for your child's oral health by recognizing early signs of tooth growth, establishing a positive relationship with your child's dentist, and identifying possible dangers and risks for your child's oral health.

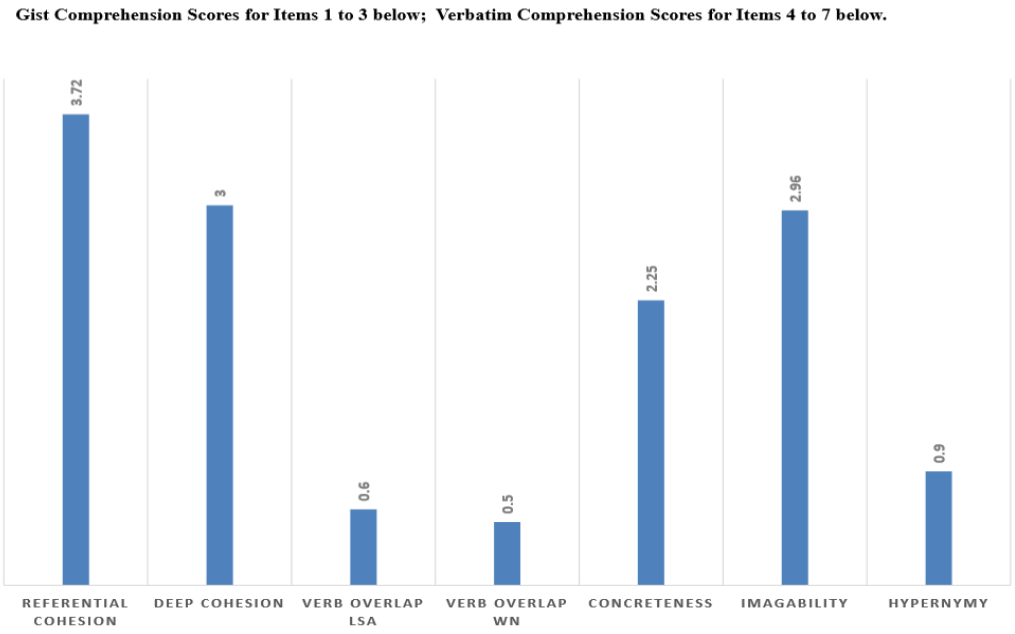
4.4 Actionability

The Patient Education Materials Assessment Tool (PEMAT) indicated a score of 80 percent in the domain of actionability. This means that 80 percent of the objectives comprising an "actionable" material were met by the eBook. Shoemaker, Wolf, and Brach (2014) defined an *actionable* text as one in which "consumers of diverse backgrounds and varying levels of health literacy can identify what they can do based on the information presented".

4.5 Verbatim-Based versus Gist-Based Message Design

A Coh-Metrix protocol was used to analyze the eBook for Oral Health Literacy© for verbatim-based versus gist-based message design. A Gist Inference Score (GIS) was calculated in order to determine if the messages in the chapters were written to embrace verbatim memory with exact numbers, words, and pictures or to embrace gist memory with an implied meaning of the messages (Lloyd & Reyna, 2001), The eBook earned a Gist Inference Score (GIS) of 0.10, which is slightly above average. Gist is defined as the likelihood that a text will yield appropriate inferences about its bottom-line meaning in contrast to its exact literal meaning. A GIS is a metric in the Coh-Metrix protocol that determines whether the material leads to verbatim memory or gist memory (Reyna, 2020) or the more-valued gist comprehension when the health information is complex (Wolfe, Reyna, Widmer, Cedillos, Fisher, Brust-Renck, & Weil, 2015). The underlying intent is to help people to explain the gist of oral health information, which may help them to make better health decisions.

The eBook scored high on coherence and interconnectivity of actions. Figure 2 shows an analysis of other Coh-Metrix components expressed in Z scores. Since the eBook chapters were written to be highly concrete and didactic through the use of declarative sentences, young readers will likely form age-appropriate understanding through verbatim representations found in the words and pictures on each page. Message designers should also build the potential to form gist representations through the health education materials. Gist comprehension scores are shown from left to right for the first three items in Figure 2; verbatim comprehension scores make up the next four items.



*Gist Scores = Referential Cohesion, Deep Cohesion, and Verb Overlap- LSA.

**Verbatim Scores = Verb Overlap-WN, Concreteness, Imageability, and Hypernymy

Figure 2. Gist Comprehension* versus Verbatim Comprehension Scores for the eBook**

In the case of the eBook, the textual messages scored the highest on referential cohesion (3.72) and deep cohesion (3.0), which suggests that readers are very likely to comprehend the text and make appropriate gist inferences. Another gist score, Verb Overlap LSA (0.6), is slightly greater than the verbatim score found within the Verb Overlap WordNet (0.5) suggesting that readers will also make gist inferences about the actions in the chapters. Verb Overlap indicates the repetition of the lexical verb patterns in the sentences. However, on the right side of Figure 2 indicated by verbatim scores, the eBook is also quite high on Concreteness (2.25), Imageability (2.96), and Hypernymy (0.9), but not as high as the gist scores on the left side of Figure 2. These high Z scores lower the GIS score considerably, which may be suboptimal for adult readers, but likely helpful to children (Ubbes & Wolfe, 2019).

Research conducted within the framework of fuzzy trace theory and its central concept of gist (Reyna, 2020) indicates a developmental trend from verbatim informational processing to gist information processing in message design. Thus, there are sound theoretical reasons to believe that a text with a GIS profile of 0.10 is ideal for children when comprehending health-related information. Further empirical research is needed on whether children have enough background knowledge about oral health so that they can "get the gist" (Reyna, 2020) of the different chapters making up the eBook for Oral Health Literacy©. Reyna (2020) also claimed that "The uptake of a message depends not just on what is said but what is heard".

5. Discussion

The eBook for Oral Health Literacy© takes a multimodal, multisensory, and multidisciplinary approach to skill development (Ubbes, Coyle, & Tzoc, 2018). The International Literacy Association (2019) states that "According to the multimodal perspective, children make meaning using multiple modes (texts, pictures, words, gestures, movements, or production of artifacts), and all these modes complement one another as children seek to interpret their world and convey their understanding". Recent eye movement research by Pellicer-Sánchez, Tragant, Conklin, Rodgers, Serrano, and Llanes (2020) showed that the presence of audio in reading-while-listening conditions allowed children to look at images in a text more and that children who increased processing time on images was positively related to their reading comprehension. This seems extremely useful for the eBook for Oral Health Literacy© as explained below.

The eBook for Oral Health Literacy© is written in first person narrative with one "reasoned action step" stated on each page in the implied voice and actions of a child. A large photograph on each page shows the actions of a child performing a series of oral hygiene behaviors supported by a sentence beneath the photo as a written caption. When a reader clicks on the auditory icon on each page, the sentence is narrated aloud by a child's voice. When reading along with the narrated scripts, children simultaneously learn to read vocabulary words and phrases while viewing photographs that show a child doing an oral health action in different situations at home, at school, or in a dental clinic. For example, child-centric photographs show what health behaviors are being encouraged by the picture and the lexical script such as: 1) brushing teeth, tongue, and gums; 2) flossing teeth; 3) eating fresh fruits and vegetables; 4) drinking healthy beverages; and 5) going to the dentist every 6 months.

A unique design contribution of the eBook for Oral Health Literacy© is the co-development of reading skills and health-related skills for children who are in elementary school. One of the goals of the eBook curriculum is to advance the U.S. *Healthy People 2020* Objective 5.3.1. for Adolescent Health that is focused on reading skills: to increase the proportion of 4th grade students whose reading skills are at or above the proficient achievement level for their grade. However, in order to determine if the curriculum

contributes to reading outcomes in general, and to health literacy outcomes specifically, we first needed to evaluate the characteristics of the eBook curriculum for readability, actionability, suitability, understandability, and gist versus verbatim comprehension.

5.1 Readability

In this study, three different types of readability tests were used to determine an overall average grade level of 6.5 for the 17 chapters, (i.e., FKGL 6.5, Fry 7.1, and SMOG 5.8). In the eBook design, oral health hygiene is explained through vocabulary words with two-syllables (e.g., brushing, toothbrush) and three-syllables (e.g., infection, appointment). Owing to the fact that reading comprehension of material is improved by the practice of vocabulary and fluency (Pikulski & Chard, 2005; Varlas, 2013; Rasinski, Rupley, Paige, & Nichols, 2016), the more that children are exposed to the eBook and listen to the stories being read, the more potential they have in gaining further understanding of the chapters, including the pronunciation of vocabulary words with visual and auditory cues. This assumption that the eBook can lead to an improvement of health-related skills and behaviors for oral health literacy still needs to be tested.

5.2 Understandability

The PEMAT was used to evaluate the entire eBook curriculum beyond the readability assessments. Zuzelo (2019) suggested that "While readability is an important measure, the…PEMAT...ensur[es] the educational materials satisfy the informational needs of diverse learners, specifically those with a wide range of literacy abilities and challenges". In order to improve understandability in the eBook for Oral Health Literacy©, six children were recruited at the end of the design phase to make an audio recording while reading a chapter of the eBook. The children read aloud with prosody (intonation and expression) using fluency (speed) to enhance the understandability (comprehension) of the materials. If children are able to read aloud with prosody and fluency, the cognitive load of the reading material on memory is reduced. When children have a low cognitive load, comprehension of the material increases. The use of children's voices enhances and primes the readers' identification with how to do the oral health behaviors in the child-centric photographs. Presenting contextual information in practical situations such as teeth brushing at home with a sibling or shopping for toothpaste with a parent in a grocery store primes children's identification with how to do a variety of oral health behaviors, e.g., brushing, flossing, and rinsing (Hawkins, 2008).

Skill development is a vital component of any health education curriculum. According to the National Health Education Standards (Joint Committee on National Health Education Standards, 2007), students in prekindergarten to 12th grade should "know and be able to do" many cognitive skills related to their health status. Ubbes (2008) describes cognitive thinking skills as habits of mind "that young people learn in order to successfully demonstrate habits of health" or health behaviors (p. 54). In the current project, the eBook for Oral Health Literacy© curriculum addresses the cognitive skills of decision making, goal

setting, and communicating when practicing oral health hygiene and nutrition. Those three skills align to the National Health Education Standards 5, 6, and 4, respectively.

Each of the 17 chapters in the eBook focuses on one of the cognitive skills for 10 pages; the cognitive skill is highlighted as a lexical pattern by an underlined verb. For example, in Chapter 2, students learn how to make decisions for brushing their teeth, tongue, and gums every morning and night while singing songs for 2 minutes to ensure a proper cleaning. Therefore, the word "decide" is underlined in each sentence to emphasize the cognitive skill development that is needed in order to practice brushing for good oral health. Please revisit the prior list to see the topics and concepts by themes for the 17 Chapters, including the underlined cognitive skill that is needed in order for children to take action and do the oral health behavior.

5.3 Actionability

Studying the actionability of educational materials is important in order to write materials that teach readers how to perform the health behavior or take action for their health. Shoemaker, Wolf & Brach (2019) stated that "Patient education materials are actionable when consumers of diverse backgrounds and varying levels of health literacy can identify what they can do based on the information presented". The Theory of Reasoned Action dictates that actions that individuals take are influenced both by the information given about the behavior and the beliefs that individuals hold about that behavior (Fishbein & Ajzen, 2011). Each chapter of the eBook is written based on the three types of salient beliefs in the Theory of Reasoned Action in order to improve their actionability. Each chapter includes the same sequence of a self efficacy belief (n = 1), health outcome beliefs (n = 3), normative beliefs (n = 3), another self efficacy belief (n = 1), and interactive health literacy (n = 1) (Ubbes, Coyle, & Tzoc, 2018). The self efficacy beliefs in the eBook present "I believe" statements in order to model strong self-care self-efficacy beliefs to the children. If children take on and embody these strong self-care self-efficacy beliefs, they will have greater confidence that they can perform the oral health behavior and making the demonstrated behavior more actionable (Eller, Lev, Changrong, & Watkins, 2016).

The health outcome beliefs in the eBook inform readers of the positive effects that result when performing the demonstrated health behaviors. The expected outcome that one holds about a behavior has a strong influence on the individual's attitude toward that behavior. If one perceives that there are more positive outcomes than negative outcomes, that individual is more likely to take action to perform the behavior (Fishbein & Ajzen, 2011).

The normative beliefs in the eBook demonstrate that children can practice the targeted health behaviors with their peers, family members, or dental professionals. By presenting a targeted health behavior as one that is socially normative and acceptable, the behavior is reinforced for the child, making it more actionable. Using normative beliefs to encourage children to practice positive health behaviors can prove to be effective, because children tend to conform highly to practices which they consider to be the norm

(Quilliam, McKay, Lapinski, Viken, Plasencia, Wang, & Fraser, 2018).

As previously shown in Figure 1, interactive health literacy initiates feedback through reading participation when the reader is asked "How about you? Can you set goals for going to the dentist too?" Higher interactive health literacy has been correlated with increased ability to perform self care behaviors (van der Heide, Heijmans, Schuit, Uiters & Rademakers, 2015), so the use of several interactive health literacy statements in the eBook can lead to greater actionability.

Design characteristics of written educational materials also require careful decisions around content, format, layout, language, legibility, and illustrations (Griffin, McKenna, & Tooth, 2002). Learners "require accurate, balanced, and comprehensive information if they are to make informed choices, participate in decision making about their health and take responsibility for their own well-being" (Griffin, McKenna, & Tooth, 2002, p. 176). Comprehension of health information also contributes greatly to material effectiveness.

5.4 Comprehension

The eBook for Oral Health Literacy© has a focused goal of building reading fluency and comprehension in tandem with skill development in health literacy. Comprehension is a key concept in a few definitions of health literacy in childhood (Bröder, Okan, Bauer, Bruland, Schlupp et al., 2017). For example, the National Health Education Standards for preschool to grade 12 (Joint Committee on National Health Education Standards, 1995) were the first to define health literacy as "the capacity of an individual to obtain, interpret, and understand basic health information and services and the competence to use such information and services in ways which are health-enhancing". Later, the Patient Protection and Affordable Care Act of 2010, Title V, defined health literacy as "the degree to which an individual has the capacity to obtain, communicate, process, and understand basic health information and services to make appropriate health decisions" (CDC, 2020).

When children are learning to read, literacy research indicates that fluency and vocabulary are the two main steps to reading comprehension (or understanding what is read). Pikulski and Chard (2005) indicated that fluency is a bridge between decoding and reading comprehension. Varlas (2013) claimed that "Academic vocabulary is one of the strongest indicators of how well students will learn subject area content". In the eBook chapters, many vocabulary words are used to build functional knowledge for knowing how to practice oral health hygiene, how to set a goal to go to a dental appointment, and how to make food and beverage decisions for oral health.

In the eBook for Oral Health Literacy©, fluency is enhanced by multimodal cues that are heard and read. Fluency involves the rhythmic and auditory aspects of the reading pace and can be improved by practice (Rasinski, Rupley, Paige & Nichols, 2016). Each chapter of the eBook is read aloud through an audible narration by a child's voice to encourage modeling of fluent reading to a child peer. Each text is also "read" in visual form through the words and lexical patterns that are underlined in each sentence to

support skill development. Each page also uses photographs showing children modeling the intended behavior. Bandura (1975, p. 187) stated that "when a model is provided, patterns of behavior are rapidly acquired in large segments or in their entirety". Hence, we hope that children are able to learn "how to read" and then "read to learn" when, why, with whom, and where to brush their teeth through multiple patterns and cues provided by the eBook design.

Another key aspect of fluency is the ability to read textual material with flow and prosody. Prosody is the expression given to the meaning of the words as one reads…and the continuity that is modeled when polysyllabic vocabulary words are pronounced and articulated. When child peers serve as role models and are able to read polysyllabic words with fluency and prosody as narrators, this can support less experienced readers to gain practice and to improve. Through repetition and increased exposure to oral health vocabulary and word patterns, children can also benefit when more difficult vocabulary words are encountered. Increased reading fluency can then free up cognitive load which is the memory needed for comprehending what was read. Because we envision children and their parent caregivers (or teachers) reading along with the audible narration on the ten pages of each eBook chapter, the opportunities for word cuing and vocabulary support for children can occur in real time as needed.

6. Strengths

By design, the eBook for Oral Health Literacy© enables children to practice literacy skills and oral health behaviors at home, especially when children are absent from school and unable to experience their academic curriculum in the classroom. Framing the eBook for Oral Health Literacy© as a co-curricular approach helps to bolster the health-related and literacy-related challenges associated with missed school attendance, which can be a significant detriment to the academic progress of student learning (Carroll, 2010; Jackson, Van William, Kotch, Pahel, & Yee, 2011). Children also miss portions of their academic lessons when parents take their child to dental appointments during the school day. During this lost school time, one chapter of the eBook can provide a brief health literacy intervention during the travel time to and from the community dental clinic. With an internet connection on a smartphone or mobile device in the car, children can read along with one chapter and then read another chapter when they transition from the car into the dental waiting room or vice versa.

School-based health clinics can also give students convenient access to dental care "on campus" for teeth cleaning, filling caries, and/or applying fluoride varnish on developing teeth. With the potential for lost time from the academic curriculum, school-based health clinics (e.g., dental, medical, and eye) become incredible child-centered opportunities for health literacy interventions. *Healthy People 2020* objectives for Oral Health 9.2 state that Americans need to "increase the proportion of school-based health centers with an oral health component that includes dental care". Even if a school-based health center is not part of a school district, mobile vans converted to dental clinics on wheels can support children who do not

have a dental home and who have not seen a dentist in the last six months. Both site-based and mobile-based dental clinics are curriculum venues for the eBook for Oral Health Literacy©.

Another strength of the eBook is the intentional design of visual textual gestural material so that children will be more motivated as they "read to learn" about oral health practices and habits. The self-paced design of the eBook is sequentially organized in a pattern for multimodal learning: visual, auditory, tactile, and kinesthetic movement sequences, which primes the human senses to process and attend to information. The multisensory "workout" or "training" for children include eye tracking for reading pictures and words and ear training to hear words being read with rhythmical fluency and prosody (meaningful expression). There are two possibilities with the latter. The first possibility is that our technology-assisted reading builds sight learning and sound learning. When the reader listens quietly to the ten sentences of a chapter being read by the narrator, one level of fluency instruction is met because fluency refers to the accuracy and automaticity rate of reading (Kuhn, Schwanenflugel, & Meisinger, 2010). Reading fluency by the narrator through a role modeling process can help children learn polysyllabic words related to oral health and dental care. The second possibility is that children can also read aloud with the narrator using a paired reading response. Oral reading fluency is associated with the overall reading skills of elementary children (Roehrig, Petscher, Nettles, Hudson, & Torgesen, 2008). When children read texts accurately with fluency, their working memory no longer has to focus on decoding the words and can begin to process the text for meaning (Perfetti, 1985). Prior research has demonstrated strong correlations between oral reading fluency and reading comprehension, ranging from .67 (Good, Simmons, & Kame'enui, 2001) to .76 (Roberts, Good, & Corcoran, 2005) for students in grades one to three.

7. Limitations

One limitation of the eBook for Oral Health Literacy© is the potential that overuse of digital reading material could lead to developmental delays in children who may be exposed to excessive screen time (Madigan, McArthur, Anhorn, Eirich & Christakis, 2020). Developmental delays could occur if children do not spend the necessary time needed to practice their oral language skills, increase their reading fluency skills, and/or act on their motor movement skills after viewing and listening to the digital materials. However, developmental delays may be reduced if the digital material being viewed contains educational content, or if children view the material with a caregiver and are exposed to digital literacy materials at a later age (Madigan, McArthur, Anhorn, Eirich, & Christakis, 2020). When children "read to learn" about oral health and nutrition habits with a caregiver, the next step is to cue children to practice the skills demonstrated in the eBook in order to develop body language postures, gestures, and actions for daily oral health hygiene. Hence, parental support and supervision are essential in the effective implementation of the eBook chapters.

Another limitation of the eBook for Oral Health Literacy© could be the speed at which the material is advanced on the screen from page-to-page. Even though the design of each chapter has only 10 pages guided by a narrated voice that reads the script out loud to the children, the reading pace should ideally be controlled by the children when they are ready to click on the arrow to advance the next page. When children are able to moderate the pace of the story, they can focus their attention on both the pictures and the written text. For example, some children may like to study the photographs while being read to by the narrator whereas some children may like to read the words aloud while the narrator is silent. More advanced children can be cued to read aloud in tandem with the narrator to practice reading fluency and prosody (expression) skills. Any of these reading options are available (but not explicit in the material design), so parental guidance is needed. Parents, caregivers, and educators who understand the developmental needs of children will be able to scaffold the interactions that children have with the digital material so that the children remain challenged and engaged in improving their oral health literacy skills and especially their oral health hygiene behaviors for many years to come.

8. Implications for Public Health Education

Our current social marketing project called “Reading for a Healthy Smile” hypothesizes that health-related reading materials can have reciprocal effects for children and their caregivers as a form of interactive health literacy. Dentists who are upstream influencers, and teachers and parents who are midstream influencers on children, are critical access points for the dissemination and use of the eBook chapters with children who are in the downstream position of the campaign. Future research needs to address the concepts of “self care self efficacy” or “intentions to act” for improving oral health behaviors of children when they read chapters from the eBook for Oral Health Literacy© as an educational intervention in school-based health clinics and community-based dental clinics. In addition, research is needed on the role of parents in the oral health hygiene practices of children and whether reading materials for health literacy can enhance parent-child communication at home. Parent-child communication that is developed routinely through oral language, written language, and body language interactions are critical for understanding how a variety of health behaviors, especially oral health habits, develop across the lifespan.

9. Conclusion

The curriculum purpose of the eBook for Oral Health Literacy© is to help children “learn to read” through an integrative oral, written, and body language approach while practicing oral health literacy skills as they “read to learn” health. Children benefit from all forms of language and literacy strategies as they form functional (essential) knowledge in health. Children will first learn how to read, then they use reading as a way to learn about more topics, concepts, and skills in health (Ubbes, 1999). To demonstrate

health literacy, children will also need explicit and consistent practice time to do health-related skills and behaviors to improve their health status and quality of life.

There is educational value in evaluating the readability, suitability, understandability, and actionability characteristics of health literacy materials for children, including whether curriculum cohesion results in verbatim comprehension leading to the preferred gist comprehension. Our evaluated eBook for Oral Health Literacy© has filled the gap of providing multisensory and multimodal materials for children who are learning to read while also learning to manage their oral health hygiene habits in their daily lives. Our digital material provides photographic narratives that are read to children with visual, textual, and gestural instructions for self-care routines in oral health and nutrition. Our 17 chapters contain 10 pages each and take approximately one-minute to read, forming a lexical pattern of reasoned actions for health through visual, textual, and gestural cues to action.

We found that the eBook for Oral Health Literacy© had acceptable, and in many cases, favorable scores, for the five design elements of readability, suitability, understandability, actionability, and gist comprehension. Ongoing dissemination of the eBook for Oral Health Literacy© curriculum has the potential to boost children who are "learning to read" and "reading to learn" about oral health hygiene and nutrition. Future studies should use one or more chapters from the curriculum as an intervention to test this educational premise as an explanatory basis for functional health literacy.

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