DIGITAL GAME-BASED LANGUAGE LEARNING:

VOCABULARY DEVELOPMENT AMONG YOUNG ENGLISH LANGUAGE LEARNERS

A Dissertation

by

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ABSTRACT

Vocabulary plays a pivotal role in language acquisition. According to Hunt and Beglar (2005, p.2), vocabulary is at “the heart of language comprehension.” It is widely accepted that an increase in vocabulary enhances the natural acquisition of a second language (e.g., Barcroft, 2016; Ellis, 2003). Therefore, it is imperative that the young learners, especially the English language learners, need vocabulary instruction. Moreover, current literature shows that one of the impressive benefits of digital game-based language learning (DGBLL) and technology-mediated language learning is the potential to help the learners’ vocabulary development (Gee, 2007; Prensky, 2007; Reinhardt, 2018). In this three-article dissertation, the researcher explored the connection among DGBLL, technology-mediated language learning, and vocabulary knowledge development for young English language learners (ELLs). In the first article (chapter 2), the researcher explored the theoretical frameworks, features, and measures of the vocabulary development of young ELLs in DGBLL studies. In the second article (chapter 3), the researcher investigated the vocabulary learning experience of the young ELLs in a DGBLL environment as they built their own games based on their understanding of different non-fiction topics. Finally, in the third article (chapter 4), the researcher investigated the vocabulary learning experience of young ELLs in a technology-enhanced writing intervention.

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1. INTRODUCTION*

Children love to play video games. According to the Center on Media and Child Health (2020), young children aged 2 to 4 play for 21 minutes per day, and those aged 5 to 8 play for 42 minutes per day in the United States. Games are fun and engaging because they have elements such as autonomy, playing in groups or individually, visuals and so on that intrinsically motivate children to keep coming back to play. Game play is on the rise for both boys and girls, and statistics show that 99% of boys and 94% of girls play games regularly (Joiner et al., 2011). Also, according to a survey conducted by the Pew Research Center (2015), game play patterns do not vary across racial and ethnic groups. Therefore, it is no wonder that video games have become a lucrative business. Consumers worldwide spent more than $43 billion on game content, hardware, and accessories in 2019 (Entertainment Software Association, 2019). In 2021, there are nearly 221 million players across all ages in the US. 55% of the players mentioned that they played more games during the pandemic, and most players (90%) believe that they will continue playing even after the pandemic is over. 71% of the parents perceived video games as a much-needed break for the children during the pandemic (Entertainment Software Association, 2021). This mass popularity and interest in video games has led researchers and educators to examine how games can be leveraged to facilitate learning and how games can be applicable for language learning.

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Moreover, the 21st century has brought many changes to education worldwide including an increased saturation of technology in every aspect of life and society and an explosion of English language learners (ELLs; Benoit, 2017; Meskill, 2005). The ELL population is increasing and is expected to double by 2050 (Benoit, 2017), and these ELLs will continue to face huge challenges. These ELLS are expected to learn a complex language and keep up with their English-native peers. They are also expected to develop necessary technological skills to meet the technology-oriented competitive global market. In this situation, programs such as the digital game-based language learning may grant the opportunity to stimulate students' language learning as well as prepare them for the technology-oriented future.

In the context of language learning, vocabulary development is critical for young children. Most children learn vocabulary through their interactions with their parents, siblings, relatives, teachers, and peers, often including shared storybook-readings (Beck et al., 2013). Vocabulary knowledge helps young learners with critical literacy skills such as letter-sound knowledge (McDowell et al., 2007), decoding (Hemphill & Tivnan, 2008), and morphological awareness (Bowers et al., 2010). For elementary English language learners (ELLs), lack of second language (L2) vocabulary may impede their reading skill and reading comprehension development of the target language. For example, in the USA, ELLs begin falling behind their peers in vocabulary knowledge and other literacy skills from as early as first grade (Moran & Moir, 2018). Research has highlighted the necessity of repeated exposure to target language vocabulary, explicit instruction on learning strategies, and enough time to learn new words to close the performance gap between the ELLs and their native peers (Ganske, 2018). Therefore, vocabulary knowledge development should be an integral part of every literacy program.

This chapter will include discussion about digital game-based learning (DGBL), digital game-based language learning (DGBLL), how DGBLL interconnects with second language acquisition, different learning theories for vocabulary acquisition, connection between L2 vocabulary learning and DGBLL, and affordances of DGBLL for vocabulary learning.

1.1. Digital Game-Based Learning

Recently, digital game-based learning (DGBL) has received increasing attention among studies conducted on educational technologies (Xu et al., 2018). DGBL includes digital activities which are playful and contain educational objectives (Hung et al. 2018; Ke, 2016). More importantly, DGBL's goal is to help learners reach their maximum potential to learn by assisting them in overcoming roadblocks such as anxiety, low motivation, difficulties in comprehension, and fear of interaction with their peers (Bork, 2012; Hung et al., 2016; Sung & Hwang, 2013; Yang et al., 2016; Yükseltürk et al., 2018).

One of the ways that digital games have been implemented and examined in educational settings is through use of games created by researchers, educators, or companies. Educational games are emerging as a popular area of development, often driven by hope that the entertaining features will motivate learners to learn (Danielsson & Wiberg, 2006; Khalili, 2014). These types of games are usually known as "edutainment." These edutainment games are often associated with a negative connotation due to the many drill-based and poorly designed educational games available on the market (Lim, 2008; Prensky, 2007). A summit on education games sponsored by the Federation of American Scientists (FAS), the Entertainment Software Association, and the National Science Foundation issued a report stating that to reach the maximum potential of educational games to be beneficial for high-impact education, the games must be “built on the science of learning” (FAS, 2007, p.5). Digital games can offer an exploratory environment in which students engage in active, problem-based learning, receive immediate feedback, and create their own pathways to knowledge (FAS, 2007). Some researchers argue that there are commercial entertainment games (not designed for educational purposes) that are already available which exemplify motivating and engaging learning principles (Becker, 2007; Gee, 2007). Becker (2007) also notes that designing games for learning is a big challenge for instructional designers. One of the challenges is that most educational games tend to be “boring” because the adult game designers rarely engage in human-centered design processes such as extensive user testing with the intended audience (Prensky, 2007). Therefore, integrating children’s opinions, interests, identities, and patterns of engagement on game designing can have a positive effect on the way technology is being used for teaching and learning in the classroom (Druin, 2002).

1.2. Digital Game-Based Language Learning

Digital game-based language learning (DGBLL) is DGBL with a specific focus on language learning outcomes (Butler, 2017; Uzun, 2009; Wichadee & Pattanapichet, 2018). Research has shown that learners may benefit from the DGBLL experience because they are learning target language in an interactive manner in a motivating milieu (Xu et al., 2018). Klimova and Kacet (2017) state that DGBLL helps the language learning process by (a) exposing learners to the target language via multimedia (audio, visual, interactive and so on), (b) focusing on specific language learning skills (e.g. vocabulary and grammar), and (c) encouraging interaction, communication, and involvement in language learning.

The use of DGBLL to support English Language Learners (ELLs) is not a new approach to support their language learning. In the past, although some researchers found mixed results (e.g., Jalali & Dousti, 2012; Lucht & Heidig, 2013), many researchers have reported the beneficial effects of DGBLL for improving ELLs' vocabulary knowledge (e.g., Ebrahimzadeh 2017; Jensen 2017), grammar (Cornillie et al. 2017; Mehrpour & Ghayour 2017), pragmatics (e.g., Peterson 2012; Shirazi et al. 2016), writing (Allen et al. 2014; Lin et al. 2018), and speaking (Hwang et al. 2017).

1.3. Second Language Acquisition and DGBLL

The field of second language acquisition (SLA) investigates how second or foreign languages are learned or acquired, in both naturalistic and formal teaching and learning contexts, whether it is technology-mediated or not (Reinhardt, 2018). The findings of SLA research inform second language (L2) teaching and learning practices and vice versa. SLA is an interdisciplinary field, usually related to applied linguistics. SLA emphasizes and adapts theoretical and methodological frameworks from a variety of social sciences and humanities disciplines including psychology, sociology, anthropology, linguistics, modern languages, and the learning sciences. Perhaps partially due to these diverse backgrounds, SLA researchers cannot agree on a single unifying theory about how SLA occurs. Each SLA perspective has ontological aspects, that is, an aligned theory about the meaning of “language” and “learning.” All these perspectives have epistemological and methodological implications to imply a way to understand and a way to explain what exists in the context of SLA (Reinhardt, 2012).

1.4. Learning Theories for Vocabulary Development

One of the commonly studied outcomes in the gaming literature concerns language learning. When looking at specific language skills, many digital game-based learning researchers typically tend to investigate the impact of digital games for vocabulary learning. For example, Hwang and Wang’s (2016) self-developed English learning game helped elementary school students effectively learn vocabulary items with a cloze guiding strategy for drill and practice. In comparison, the teaching and learning of other aspects such as grammar (Castaneda & Cho, 2016), pronunciation (Young & Wang, 2014), speaking (Hwang et al., 2016), and writing (Allen et al., 2014) were less commonly discussed in the identified digital game-based language learning (DGBLL) studies. So far, no studies have been specifically conducted using digital games to improve L2 learners' reading development (Hung et al., 2018). Additionally, the use of digital games for the learning of mixed or integrated skills was found in the previous content analysis conducted by Hung et al. (2018). Most of the studies that investigated vocabulary demonstrated the effectiveness of the digital game-based approach. Less encouraging results were reported in only a few exceptions. An example of the latter is the study by DeHaan et al. (2010) who examined the effects of the interactivity of a music video game on L2 English learners' vocabulary acquisition. The researchers found that the players recalled significantly fewer vocabulary items than their counterparts which authors attributed to split attention or cognitive overload during the gameplay.

The design of any digital game-based learning program or research project must be grounded in theory. Theory provides the rationale through which to explain why and how something happens. While there have been several categorizations proposed for computer assisted language learning (CALL) research, according to SLA theory (e.g., Kern & Warschauer, 2000; Blyth, 2008; Reinhardt, 2012), research usually employs two or three perspectives (Reinhardt, 2018). The researcher was interested in why and how language learning occurs, and specifically why and how certain digital game-based learning programs may or may not facilitate language development. It is also important to mention that vocabulary knowledge development is a complex process and is dependent on many complex interdependent factors. Even though vocabulary instruction based on a range of theoretical frameworks have been used, there is no single theory that can capture the vocabulary knowledge development process in its entirety (Cain & Parilla, 2014). The few learning theories that specifically focus on vocabulary knowledge development in the DGBLL context include schema and psycholinguistic theory, sociocultural and social constructivist theory, dual coding theory, and motivation theory (Alvermann et al., 2013; Moody et al. 2018; Reinders & Wattana, 2012; Reinhardt, 2018; Tracey & Morrow, 2006; Yang et al., 2021).

1.5. Connection between L2 Vocabulary Learning Theories and DGBLL

This section will discuss the major L2 vocabulary theories and will examine them in relation to DGBLL including schema and psycholinguistic theory, social constructivism and sociocultural theories, dual coding theory, and motivation theory. There is no intention to privilege one over the other. Most L2 pedagogical applications reflect several different perspectives, and some principles are common across perspectives, such as attention to input (Reinhardt, 2018). Therefore, it is best for instructors to be aware that a pragmatic, realistic approach based on learners' needs and experiences is more important than adhering to one single perspective.

1.5.1. Schema and Psycholinguistic Theory and DGBLL

According to Gagné and Briggs (1979), there are three classical learning components for schema and psycholinguistic theory, including contiguity, repetition, and reinforcement. Vocabulary learning evolves when associations among different word forms and meanings improve learners' mental lexicon. The associations need to be contiguous and contingent, meaning that different stimuli need to be close in space and time, respectively (Chance, 1994). Repetition points to the fact that the stimulus and the following response must be repeated for learning to be improved. Finally, reinforcement refers to the fact that the learning activity is bolstered through rewards (Case, 1996).

According to Filsecker & Bündgens-Kosten (2012), the implicit pedagogy behind associativist/behaviorist theory tells educators that they need to present information to the learners, give them ample opportunities to practice, and give them precise feedback that reinforces their learning. These approaches were prevalent in the early computer-assisted language learning (CALL) literature, emphasizing teaching language explicitly using a wide range of drill practice, mostly focusing on translation, grammar, and vocabulary (Beatty, 2003). Nowadays, language learning games focus mostly on vocabulary, spelling, and grammar, while translation is considered irrelevant or undesirable in the typical language classroom (Beatty, 2003). These types of games specify a clear reward structure such as points or scores. However, these games are often disconnected from the learning experience. In these games, reinforcement includes drill-and-practice and a heavy emphasis on extrinsic rewards with little student-teacher or student-student interaction and scarce attention to learners' individual differences. Therefore, these types of games are often called "edutainment" (Egenfelst-Nielsen, 2007), mostly because of the lack of teacher involvement and the lack of attention to integrating game mechanics and learning experiences (Ang & Zaphiris, 2006).

An example of a game designed around schema and psycholinguistic perspectives is the web-based game Mingoville (made for language learning for elementary school aged children; Figure 1.1). This digital game is designed around themes and learning activities to increase children's desire to explore and play games (Meyer & Sørensen, 2007).

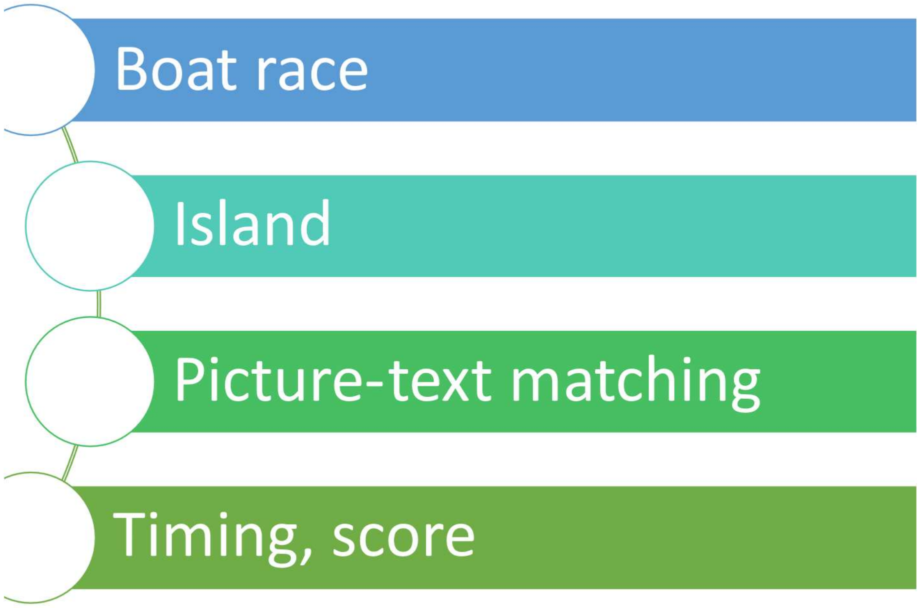

Figure 1.1 Mingoville Features

In *Mingoville*, there are several missions and each mission has content drills and tasks combined with games for development of vocabulary, spelling, grammar, pronunciation, and word recognition. In this game, the player is situated on an island and s/he is surrounded by a boat, a jet, and a helicopter. The boat race is a vocabulary development game. The pictures and text form pairs, where some of the pairs match and some do not. The player controls the boat and the task is to drive the boat around the island for four laps. During these laps, they will come across different text and pictures and the player needs to match the text with the corresponding picture. When they match a pair correctly, they get eight points. The picture-text pairs change their location or a new picture-text displays with the finishing of each lap. After the fourth lap, the game ends and the player gets to know their timing for each lap as well as their score. The player gets the choice to compare their score with other players. In this way, *Mingoville* follows the classic structure of the schema and psycholinguistic theory described above: closeness of space and time between stimuli (text-picture), response (driving a boat around the island for four laps), and reinforcement (score).

1.5.2. Social Constructivism and Sociocultural Theory and DGBLL

Social constructivism and sociocultural theory contend that the knowledge in our mind is a practical construction which is accomplished by individuals as they learn from the context through their interaction with the environment. This knowledge neither relies on any independent, external (i.e., ontological) reality (von Glasersfeld, 1982), nor is it ever found or discovered; but is an active, constructive process (Rorty, 1991). Knowledge is rather an 'adaptive function' which is a set of conceptual structures that are constructed in the face of the individual present experience of a learner (von Glasersfeld, 1982, p. 128).

Following von Glasersfeld and Rorty's work, Savery and Duffy (1996) pointed out three components of social constructivism and sociocultural theory. These are, (a) interaction with the environment leads to comprehension; (b) puzzlement helps the learner to solidify their learning; (c) knowledge is developed through social negotiation and evaluation of individual understanding. They deduced some pedagogical principles, including that educators need to design learning activities which are authentic, challenging, and complex. These activities must incorporate communication among the learners, foster learners' puzzlement, promote learners' comprehension through social interaction with others, and support reflection and ownership of both the problem and its solution (Savery and Duffy, 1996; Filsecker & Bündgens-Kosten, 2012).

According to Filsecker and Bündgens-Kosten (2012), the role of digital games within this framework is to provide a virtual environment where learners can experience a varied and rich learning context. The game presents an information-rich environment in a supportive way so that learners may extract them and form their own hypotheses. Digital games provide complex context with organized learning activities which are authentic and challenging, promoting *puzzlement* for critical thinking, scaffolding, collaboration, and reflection (Hickey et al., 2010; Hickey & Filsecker, 2012). In sociocultural theory, for vocabulary teaching and learning contexts, all learners are active participants in the meaning-making process, and vocabulary instruction is a social dialogue where meanings are constructed through scaffolding and collaboration (Adams, 2006; Moody et al., 2018). Therefore, digital vocabulary games where students work collaboratively to construct definitions of words and participate in discussion together about new vocabulary are based on social constructivism and sociocultural theory. Social constructivist and sociocultural principles can be found in some aspects of the online vocabulary gaming platform called *Flocabulary* which is an online vocabulary gaming platform that consists of educational hip-hop songs, videos, and supplemental activities for kids in grades K-12 (Figure 1.2).

Figure 1.2 Flocabulary – Reprinted from [GwynethJones, 2015]

Flocabulary includes games covering vocabulary, math, language arts, social studies, science, and life skills. Lessons contain music videos and clickable lyrics that can be played at three different speeds. After viewing these as a class or independently, learners can complete the accompanying games, quizzes, reading passages and more. Learners can start a module/unit with a video that introduces the vocabulary they need for a lesson as a scaffolding process. Teachers can decide to play the video for the whole class or let the students watch it individually. At this point, teachers can ask questions or review the newly learned words or have students in pairs or groups to discuss new vocabulary and participate in the process of meaning making. Then teachers can have the learners group up and replay it in discussion mode, giving them opportunities to explore ideas in more depth and learn from one another. This may help them to understand figurative language, word relationships, and nuances in word meanings. Songs for upper elementary kids are more dense, where every rhyme contains some information that they can review afterwards through a variety of activities, including writing their own lyrics. With prompting and support, learners can not only learn vocabulary, but also identify characters, settings, and events in a story, and read and comprehend literature including stories, poems, dramas, and non-fiction texts.

1.5.3. Dual Coding Theory in DGBLL

Dual coding is a concept related to storing information in mind both in linguistic and visual forms (Paivio & Desrochers, 1980). In dual coding theory (DCT), cognition refers to two different subsystems. One is a verbal system that is directly composed of language whereas the nonverbal system processes nonverbal objects and events. Hence, knowledge consists of the use of the verbal and nonverbal systems (Sadoski, 2005; Paivio & Clark, 2006). According to Paivio and Clark (2006), both nonverbal and verbal codes can impact vocabulary recall. They can help to connect a verbal signal with a nonverbal one, for example, a concrete noun with an image. Paivio (2010) reports the positive effects of DCT such as image-word connection on vocabulary knowledge development and word recall. Mayer (1999) highlights the importance of DCT and proposes that educators need to utilize multimodal teaching and learning strategies because in digital contexts words and pictures are used more than just words alone.

According to Nation (2001), DCT can be beneficial to help students learn sight words in a meaningful way. For instance, Kim and Gilman (2008) investigated the effect of text, audio, and graphics on vocabulary learning and found that learners who learned vocabulary items aided by visual texts and graphics excelled in both retrieving and recalling the word forms and their meanings. DCT is especially useful in the contexts of digital games. Digital games can involve learners in learning new words by connecting word forms and meanings successfully using audios, videos, pictures, graphics, and the like, in their virtual world. Therefore, vocabulary learning using DCT in the DGBLL context can be helpful because it gives an opportunity to use “graphic display” with “semantically related vocabulary” (Sadoski, 2005; p. 233).

Figure 1.3 Kahoot – Reprinted from [Alisher, 2018]

For example, in most of the digital games like *Quizlet* or *Kahoot* (Figure 1.3), children experience target words (verbal codes) with flashcards, visuals, audio, and other activities through multimodal platforms. Thus, these games connect the two subsystems (verbal and nonverbal codes) and help the children with word recall.

1.5.4. Motivation theory and DGBLL

Motivation theory focuses on the factors that engage learners in the learning process and help to explain their learning outcomes. Motivation theory relates game-play styles to learning. For example, according to Deci and Ryan (1985), intrinsic motivation is optimized when the individual recognizes that their own capabilities lie within them and others recognize them as useful. Intrinsic motivation is self-regulated and is accomplished for internal, often affective reasons like interest or enjoyment. On the other hand, extrinsic motivation is guided by the more external, utilitarian reasons to motivate a learner. Even though extrinsic motivation can be managed by reward or punishment, it may integrate the sense of competence, autonomy, and social relatedness for a learner (Ryan & Deci, 2000). According to Gee (2003), games are often praised for promising motivation by recognizing competence, giving players a sense of agency and control, and, especially in some multiplayer game designs, functioning as social affinity spaces.

According to Guthrie and Wigfield (2000), vocabulary knowledge development motivation is a multifaceted construct which consists of intrinsic motivation, extrinsic motivation, reading goals, self-efficacy, and social reasons for reading. Motivation theory suggests that if instructors and learners can together set appropriate goals for learners, they will develop a sense of self-efficacy. This self-efficacy will lead the learners to self-regulated learning (Schunk & Swartz, 1993). Thus, self-efficacy and self-regulated learning are two key motivational and cognitive processes that affect vocabulary learning achievement (Schunk & Zimmerman, 2007).

In the context of digital games, structural playable elements such as rules, goals, objectives, outcomes, feedback, conflict, competition, challenge, opposition, representation, and narrative are designed to inspire learners' extrinsic motivation

(Prensky, 2007) and keeps them active in a task (Pivec et al., 2003). In contrast, intrinsic motivation relates to the learner's interests and inner mental fulfillment, which can be interpreted as the enjoyment one experiences, the learning that the game offers, or the feeling of accomplishment one perceives (Figueroa, 2015).

Digital games are reported to be beneficial to motivate children for vocabulary learning. For example, Turgut and Irgin (2009), found that a vocabulary game was helpful for elementary L2 learners as the information was presented both in written and oral form. It motivated the learners to learn unknown words and focus on the characters' speech in the game to win the game. Elements like interactivity, rules, challenge, risk, curiosity, and control motivate the learner to achieve vocabulary learning goals in the game and therefore develop self-efficacy (Rasti-Behbahani, 2021). Moreover, game elements like dialogues, texts, and images appear to be very important to the learner (Turgut & Irgin, 2009). Vocabulary games further motivate them to put more effort into the game through extrinsic motivation and lead them to intrinsic motivation and self-regulated learning by providing feedback such as scores, levels passed, and obtained powers, stars, or medals (Rasti-Bahbahani, 2021).

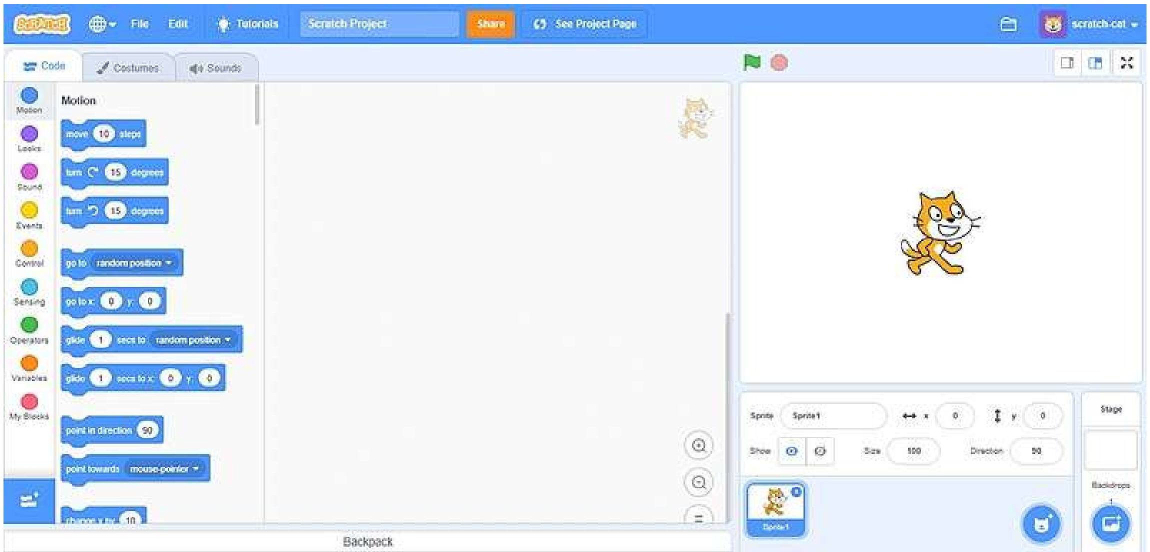

Figure 1.4 Scratch – Reprinted from [Scratch Team, 2019]

An example of motivation theory in the DGBLL setting is the use of *Scratch* (Figure 1.4). With *Scratch* learners can create their own games which others can play. DGBLL experiences can be designed around this tool to emphasize and leverage intrinsic motivation.

1.6. Affordances of DGBLL

Researchers have suggested that, beyond the entertainment value, commercial video games are becoming increasingly complex, challenging, and valuable for learning, as the games place the player into rich learning environments where they are asked to think, problem solve, and collaborate (Gee, 2003; 2012; Shaffer & Gee, 2012; Squire, 2011; Squire et al., 2005). Gamers learn new skills and strategies through different levels that progressively become more difficult, demanding the player to use their knowledge from previous levels to move to the next level in the game (Lim, 2008; Prensky, 2007).

Prensky (2007) recommends that educational curriculum developers should learn from game developers since children are already playing games outside of the classroom and educators may find a way to incorporate these games in a meaningful way for learning. The concept of affordance and the diverse dimensions of affordances of DGBLL compared to the traditional methods of vocabulary instruction below will be discussed in order to understand how to incorporate games in a meaningful way for learning.

The ecological perspective offers the concept of *affordance* to understand how technology-mediated L2 learning actually occurs (Blin, 2016). The concept of affordance, which was first coined by Gibson (1979), refers to the potential for action when an actor and ecological design align together. For example, if the right ecological design is ensured, the affordance of a computer keyboard button is to press it with one's finger. From this perspective, the affordances of DGBLL can be interpreted as emergent phenomena from the interactions between game mechanics and learner.

The ecological perspective is the latest conceptual framework in game-based L2 learning (van Lier 2004; Larsen-Freeman & Cameron, 2008; Reinhardt, 2018). According to this ecological perspective, L2 learning and language development are not only "complex and systemic, but also non-linear and emergent" (Reinhardt, 2018, p. 111). An ecological perspective is directly correlated to learning and learner's understanding of language use (Tomasello, 2003). Here, learning consists of cognitive mechanisms that are domain-specific such as reinforcement, pattern recognition, and statistical learning. While language usage includes cognitive mechanisms just mentioned, the ecological perspective also contends that language learning is emergent and contextual (Reinhardt, 2018).

1.7. Affordances of DGBLL Compared to Traditional Methods of Vocabulary Instruction

Affordances have been conceptualized along multiple dimensions. Cope and Kalantzis (2017) characterized seven categories of affordances of e-learning: the spatial-temporal dimension (ubiquitous learning), epistemic dimension (active knowledge making), discursive dimension (multimodal meaning), evaluative dimension (recursive feedback), social dimension (collaborative intelligence), cognitive dimension (metacognition), and comparative dimension (differential learning). Xiangming and Song (2018) have adopted a broader conceptual framework for affordances consisting of three categories: material, affective, and social. The material affordance category focuses on technology property and individual perceptions; affective affordance refers to the individual user's mental and emotional state about learning engagement; and social affordance category targets collaboration.

Even though all of these above-mentioned researchers provided a detailed account of different dimensions of affordances, they did not focus on the concept of affordance in connection with digital game-based L2 learning. To address this gap, Reinhardt (2018) introduced several dimensions of affordances in the context of DGBLL. Therefore, for the purpose of this dissertation, the researcher will focus on the affordances of DGBLL conceptualized by Reinhardt (2018), which include contextualized language learning, space for sheltered use, goal-oriented learning and feedback, opportunities for languaging and collaboration, means for identity work and play, time and place independent and dependent learning, and extramural autonomous learning.

1.7.1. Contextualized Language Learning

It is evident from research that digital games afford discrete item L2 learning, even though it is still unclear which mechanics, or combination of mechanics, are correlated with it (Reinhardt, 2018). Digital games afford a multimodal combination of visual, audio, and graphic representations of vocabulary contextualized in narratives, with which the user interacts to complete meaningful, goal-oriented tasks. These contextualized combinations of form, meaning, and function allow the player to make and learn associations among them. L2 vocabulary is most effectively remembered in semantically related groupings (Nation, 2001) and L2 learning happens when language is used in meaningful, goal-focused ways (Ellis, 2003). In other words, when it is narrativized. Narrative in games can be embedded stories—or elements of stories such as characters, settings, situations—that can be narrativized by the learner through play (Calleja, 2007; Neville 2010). According to Neville (2010), this "narrativization" process is equivalent to "story mapping" and Calleja (2007) calls this process "alter biography" which may be supported by game-enhanced design.These ideas are based on Gee's (2003; 2014) framework of projective identity exploration.

All the narrative elements in a single game are thematically coherent and integrated, meaning that all the language in the narratives contains interrelated topics, themes, domains, registers, and genres. Purushotma (2008) noted that narrative coherence combined with other mechanics in the digital game *The Sims* affords L2 vocabulary development. In the cases of Dourda et al (2014); Rusmon et al. (2018); and Pu & Zhong (2018), elementary students learned L2 vocabulary by following a storyline and accomplishing all missions in the plot/narrative driven digital games. Most of the objects in the games are commonly identifiable everyday objects, can be explained by clicking or mousing over them, and can be manipulated for different task completion in the game. Dourda et al. (2018) found that authentic and meaningful contextualized material, along with elementary learners' interest in the theme and coherence, contributed to the successful learning of associated vocabulary.

Finally, active engagement seemed to be related to the affordances digital games offer for language learning. Lucht and Heidig (2013) devised a researcher designed game and Pan (2017) used a commercial kinetic game and had elementary learners match vocabulary form to meaning by responding to visual and listening prompts and by matching the response though motion sensing response trackers. In both cases, researchers found that those in the game condition seemed to retain vocabulary knowledge longer than those in the control condition, supposedly because the learners in the experimental group were more engaged and immersed in the game.

1.7.2. Space for Sheltered Use

Different game designs and player configurations can provide space for sheltered practice by restricting with whom or what objects the learner can interact. Many game designs separate play into different areas or phases according to player skill, which aligns to the second language teaching and learning (L2TL) foundation that instruction should be targeted according to the proficiency level in order to be effective, and that lessons should be scaffolded and structured from less to more difficult (e.g., Vygotsky, 1978). During scaffolding, with the guidance of a more knowledgeable peer or teacher, learners could not only perform complex tasks but also learn from the process. Knowledge is shared and negotiated between the learner and the more knowledgeable other. There is also gradual release of scaffolding as the learner develops the ability to take on more agency and autonomy in the learning activity (Reiser & Tabak, 2014). Many games also separate players according to level and allow them to play only up to their level or slightly above their level. In some multiplayer games, the game design allows lower level players to team up with more advanced level players, who can then serve as experts or more capable peers. Moreover, most games incorporate tutorials that are embedded in the game narrative and help the players to familiarize themselves with the objects and rules of the game gradually, scaffolding them into the gameplay. Most game tasks in these games are broken down into manageable sections, and as the player masters them, they become automatized, at which point a new sub-task is added. Tasks are designed so that the desired input is filtered and concentrated, in other words, not randomly or rare as in the real world, but at intervals and in amounts enough to be noticed (Gee, 2003). As they build on one another, mastery experiences lead to a sense of confidence and self-efficacy (Bandura, 1995).

While commercial games may scaffold play, they do not necessarily scaffold play, and they do not necessarily scaffold complexity of language use. Their quality as genuine cultural products and practices is a benefit. However, one potential risk is that the language used in or around the games can be too difficult for some proficiency levels. Learners in these spaces may find the language used along with the interaction and communication with expert peers or native-speaking students to be overwhelming or anxiety-inducing (Reinhardt, 2018). While some heightened emotion may help the learners to notice language use, an overwhelming amount of anxiety may reduce L2 learning, as Second Language Acquisition (SLA) research on affective filters (Krashen, 1985), willingness to communicate (Mcintyre et al., 1998; Reinders & Wattana, 2014), and emotion (De Costa, 2016; Dewaele, 2005) has claimed.

Games may be modified pedagogically to provide a sheltered, low anxiety space for learning while effectively meeting learners' needs. With commercial games, one way to create sheltered space is to manipulate player configurations by modifying the game or by playing it offline only with other learners. For example, Rahmi (2018) modified the action-adventure game *Grand Theft Auto* for elementary students to better match the curricular objectives and learner proficiency levels. Pu and Zhong (2018) reported that a modified augmented reality game significantly improved elementary students' learning interest and reduced their cognitive load during vocabulary development. However, there is still a need for research to explore how game designs can further shelter and scaffold vocabulary development for elementary students.

1.7.3. Goal-Oriented Learning and Feedback

As discussed before, digital games incorporate manageable, scaffolded tasks that are organized gradually into missions and levels. These features not only promote scaffolded mastery learning, but also foster goal-oriented behavior. When a player completes a task successfully, they are rewarded progressively according to the difficulty level of the quest in the form of stars, points, badges, or other game resources and usually leads to another task that builds on the finished one. Purushotma et al. (2009) found that the goal-oriented learning quests in digital games are similar to the authentic, meaningful, and goal-oriented L2 learning tasks proposed by Bygate et al. (2001) and Ellis (2003). These quests are made authentic and meaningful by incorporating features such as narrative, gameplay, and social interconnectedness (Reinhardt, 2018).

Moreover, digital game interfaces provide players with goal-oriented tasks as well as integrate feedback systems that actively and dynamically let the learners assess their progress towards the completion of the task. Well-designed digital games provide feedback in real-time, just when it is needed and just in the right amount. It is individualized or targeted towards the specific learners' needs. It is also instructional and not punitive. In other words, the feedback is constructive and modeled for the learner's improvement. Most vocabulary games use real time, individualised feedback to move to the next segment of the game (Cobb & Horst, 2011; Letchumanan & Hoon, 2012; Lucht & Heidig, 2013; Young & Wang, 2014; Pan, 2017; Elaish et al., 2019). Rusmon et al. (2018) took it one step further and used a multi-sensory approach for feedback where learners not only see the correct answer but also listen to their own pronounced words.

1.7.4. Opportunities for Collaboration and Languaging

Well-designed digital games may afford L2 learning by fostering interactions, communication, and social collaboration with other language learners or native speakers.

This is aligned with the social-collaborative foundation of SLA. Most digital games incorporate meaningful, social language use where rules must be learned, communicated, and negotiated. Moreover, when the game quest requires collaboration, game design ensures interaction among players. Those tasks cannot be completed alone and can be more easily accomplished by delegating the tasks, forcing the learners to take differentiated roles (Reinhardt, 2018). According to Sykes et al. (2010), the jigsaw and information gap in L2 learning tasks helps to further communication and negotiation for meaning which is similar to the cooperative reciprocal quest designs in DGBLL. Researchers such as Cobb and Horst (2011) and Chen and Lee (2018) state that when children play in groups, the game milieu promotes meaningful interaction and negotiation for L2 meaning fostered by their group tasks accomplishments. Also, DGBLL may afford interactive social collaboration mechanics to impact L2 learning outcomes. In DGBLL, affordances for L2 use and learning can appear from different player and game configurations. For example, Piirainen-Marsh and Tainio (2009) showed that opportunities for repetitive exposure to the target words and focus on form emerged for two physically co-present elementary learners who were playing *Final Fantasy X* together and imitating the avatars' voices. Sequences where these players instruct each other and negotiate about successful choices demonstrate not only how they enjoy the game, but also how they learn to manage it through collaborative action involving two co-available languages.

Researchers have deemed the concept of "languaging" to be useful in the context of analyzing language use in games (Swain, 2006; Niu & Li, 2017). Languaging refers to the everyday use of language in social interactions to understand, negotiate meaning, and build relationships. In the context of DGBLL and L2 learning, languaging is more than cooperation. For instance, Zheng et al. (2012) contend that the function of languaging in *World of Warcraft* includes not only strategy building and cooperation, but also collaboration and empathy among the players. Moreover, DGBLL supports learners in accessing forms from meaning, and meanings from forms (Cobb & Horst, 2011), and connects to natural language learning tendency of young children, helps to train their ears, gives lexical access by familiarizing them with the sounding out of words (Rusmon et al., 2018). All of these involve languaging in Swain's (2006) sense when it is externalized and contributes to collective action.

1.7.5. Means for Identity Work and Play

Children tend to welcome learning through playing instead of more serious classroom scenarios (Aghlara & Tamjid, 2011). Games create an environment where education is mostly learner-centered, with a good opportunity for socialization when well-designed, and awaken the willingness to win and the desire to compete inside learners (Uzun, 2009). During gameplay, children coordinate and make sense of each others' actions when managing the game (Linderoth & Sjöblom, 2019). They are immersed and involved in the virtual world of game play. Gee (2003) claims that it is this type of involvement that lies at the heart of the learning potential of games. Here, games combine learning by doing and learning and identity where identity is an emergent phenomenon within a complex system which includes goals, perceived action possibilities, self-perceptions, beliefs, emotions, and actions within the social context, domain, culture, and dispositions (Kaplan & Garner, 2017). Games afford players with opportunities to experiment—in a situated and embodied way—with new identities at the intersection of real world and virtual world.

Earlier in this chapter, self-determination theory of motivation was introduced while discussing the motivation theory of learning (Deci & Ryan, 1985) as a way of relating game-play styles to learning styles. Post-structural theories of L2 learner identity (Norton & Gao, 2008) have also been incorporated in the gameful L2 teaching and learning context, specially to analyze and explain learner-player's behavior regarding motivation (Reinhardt, 2018). According to Norton and Gao's (2008) theory of identity investment, part of learner's L2 learning successes are correlated to the commitments learners make because various ascribed and enacted identities and roles are in play into their L2 learning part of their identity. L2 learner-players come from diverse backgrounds and bring numerous histories with them. They take different stances towards gaming and learning practices, gamer and learner identities, gaming content, and discourses. All of these may impact the L2 learning outcome in the DGBLL context. The actions and behaviors incorporating L2 identity into existing identities of the learners is a type of "identity work" (Reinhardt, 2018, p. 130). This identity work may occur through participation in, through, and around games and gaming practices.

Neville (2010) argues that narrative mechanics in some games may afford identity work as players actively learn about experience and interact with different settings, plots, and characters, assembling them into personally meaningful "story maps". The process of composition of these story maps integrates stance taking, potentially mediated by the second language. Collaborative play also incorporates identity investment and negotiation of meaning as learners negotiate their roles and expertise in the gaming context. For example, Piirainen-Marsh and Tainio (2014) used conversation analysis to examine conversation sequences of elementary learners playing *Final Fantasy IX* and *X* for their English vocabulary development. This study displays how group work and the use of external resources like gaming and linguistic knowledge can destabilize epistemic and less vs. more capable peer asymmetries into more complementary relationships and collaborative game-play. In other words, in a multiplayer game where the game design affords to delegate roles or responsibilities, elementary learners' identities may be engaged as they negotiate and take on roles and collaborate with their fellow players.

DGBLL also offers identity play, or the exploration of new identities different from one's own (Gee, 2008). Adventure and role-playing games usually involve building and developing avatars through which the player can have insights about the first, second, and third person point of views. As the game progresses, the player-learner takes stances and shifts among their real- world perspectives, in-game perspective as a player, and the perspectives as an avatar. This dynamism permits identity play and experimentation by fostering perspective taking which may include different gender, orientation, physical appearances, or personality alignment. Therefore, it affords to view a different world through the lens of different stances which may be otherwise unavailable in real world situations. Moreover, since the gaming context offers confidentiality, this identity play can be low stakes for the learners. AlShaiji (2015) claims that teachers can encourage the creativity and imagination of learners by using digital games. Through playing digital games even shy students participate in language learning. Moreover, in simulation games, a player's username and avatar offer them anonymity, where others do not need to know their names or identity outside of the game and cannot know unless the player-learner tells them. In this DGBLL context, the player is valued for their gaming proficiency and knowledge that can contribute to the accomplishment of the game quests. In other words, no one in a simulation gaming context knows or cares about the identity of a player or whether the player is a L2 learner as long as they can contribute to completing the gaming quests. For example, in Dourda et al. (2014), elementary students take the roles of explorers and in Piirainen-Marsh & Tainio (2009), children attempt to retrieve crystals to save the world from an ancient evil behind the sheltered virtual world of role-playing games which proved to be beneficial for their vocabulary knowledge development.

Furthermore, to connect game-play with L2 learning theory and identity in a DGBLL milieu, the identity of a child is of a game user along with being a learner. In usage-based theory of L2 learning, frequency of input is crucial. The more input and repetitions of this input, the more likely s/he is to benefit from it (Ellis, 2003). Gee (2012) asserts that well-designed games will provide exactly this by presenting players or learners with many more instances in a short time than they would see in reality. DGBLL permits learners to understand more complex vocabulary and concepts with animation and sound features as they usually play the same games many times and learn more vocabulary untiringly through this repeated process because their focus is on the message and not on the form (Krashen, 1985; Letchumanan & Hoon, 2012). According to Young and Wang (2014), repeated gameplay is the "driving force" that motivates learners to internalize the target vocabulary knowledge (p. 248).

1.7.6. Time and Place Independent and Dependent Learning

The internet, broadband, or remote server have been developing at a rapid rate and with that, digital games have achieved flexibility of time and place. Today, digital games can be played individually or in a group at any time, from any place in the world. Players can play from anywhere online with others through actions as simple as visiting another's simulated farm in *Farmville* to killing a dungeon monster in *Diablo* in real time and communicating through text and voice chat. In such team-based contexts, interactional language is directive, tactical, and focuses on coordinated actions. This type of interaction is rare in L2 classrooms, but highly authentic.

The place-specific pedagogies reflect the principles of situated (Lave & Wenger, 1991), experiential (Kolb, 1984), and embodied (Stolz, 2015) learning, which state that learning by doing and experiencing an action proves to be effective for learners. Otherwise, learning will be analytic and abstract. DGBLL provides learners opportunities to explore the virtual environment where rich discovering opportunities are available and creating appropriate content for transferring skills into the real world is possible (AlShaiji, 2015). According to Dourda et al. (2014), even a geography bound learning game such as *Whodunit* can provide children with realistic context. Nowadays, researchers are integrating GPS and augmented reality (AR) functionalities along with the mobility affordance of digital games (e.g., *Pokemon)* in L2 vocabulary learning scenarios (Pu & Zhong, 2018; Yunus et al., 2020). Here, the games are layered with vocabulary learning objects in the real world that the learner can see and interact with via the device only at specific physical locations.

According to Rusmon et al. (2018), the contextualized language learning game scenarios provided by the DGBLL context offer the potential to extend and enhance L2 learning time, by making it more varied, even for very young L2 learners. When the elementary learners play for the first time with the time constraints, it is natural for some students not to be able to finish the game. However, through evaluative cycles of scores, points, feedback, and repetitive practice, effective learning occurs (Letchumanan & Hoon, 2012; Rabu & Talib, 2017). Considering the time constraints during game-play, it is important to remember that DGBLL aims at the creation of appealing language learning experiences using the potential of digital games to inspire learners. While it would also be wonderful if learners learn as much language as possible in a certain period of time, there is another goal: to motivate learners more often, and for longer periods of time. Even though it might seem impossible with constraints, researchers have found that a student who may quit after five minutes of traditional learning or feel disengaged, may play and learn for an hour in a game-play milieu (Lucht & Heidig, 2013).

Without time constraints, children do not feel pressured to complete the game within the estimated time as long as they are encouraged to take their time to learn the words (Yunus et al., 2020). However, playing without time constraints on a game that requires many hours may increase the difficulty of establishing the sequences of play significant for both the students and curriculum (Dourda et al., 2014). Dourda et al. (2014) suggest that the most efficient thing may be to let the students play outside the classroom to advance their knowledge. Therefore, it is safe to say that DGBLL develops children's capacities to develop learning skills by providing them with flexibility of time and holding their attention all the time (AlShaiji, 2015).

1.7.7. Autonomous, Extramural Learning

While the development of autonomous, lifelong learning skills are crucial for sustainable L2 learning, they are not usually discussed in L2 learning contexts (Reinhardt. 2018). Most game designers design their games assuming that the game will be played autonomously. Although games are usually designed as self-contained learning objects so that players can learn and play them on their own, some games and several gamers nowadays rely on the external gaming resources available on the Internet. Gamers often communicate with one another, recount gameplay, praise or criticize gaming elements, share resources and informally teach each other. In other words, informal, decentralized gaming learning communities emerge around many games.

In the context of DGBLL, it is imperative to support learner autonomy and self-directed learning practices. L2 learners need to be taught not to rely only on the instructor and formal resources provided to them if they wish to truly become proficient in the L2. Some research shows that extramural, informal gameplay is associated with the development of autonomous learning skills, and that L2 learners who participate in extramural L2 gaming perform better on formal L2 assessments in comparison to the non-gamers (Sylven & Sundqvist, 2012; Jensen, 2017). Moreover, there are numerous resources available online. More than ever before, learners need to be taught explicitly about how to study on their own, where to look for resources, how to become aware of and address their motivations and preferences, and how to realistically set, achieve, and assess learning goals. Above all, L2 learners need to recognize that they need to learn other languages not in order to get good grades or to advance in the world, but because language is the means by which one builds and maintains relationships with each other and understands the world better (Reinhardt, 2018).

1.8. Problem Statement

Considering the above-mentioned affordances of DGBLL for vocabulary development, this dissertation intends to investigate, understand, and explore the DGBLL mediated vocabulary knowledge development. This is a three-article dissertation which includes one literature review and two research studies. In the literature review, the researcher aims to look at the connections between DGBLL and different L2 vocabulary learning theories. In the first research study, the researcher looks at how a DGBLL environment using non-fiction texts may improve ELLs' vocabulary knowledge and reading comprehension. In the second research study, the researcher investigates whether the digital technologies and games used in an intervention are perceived to be beneficial by the ELLs.

1.9. Research Questions

The following questions will be asked in the literature review and two research studies:

1.9.1. Research Questions for Literature Review

1. What theoretical frameworks of L2 vocabulary development are being used in the current research studies to support DGBLL?
2. What features of word knowledge did the researchers examine in these studies?
3. What measures did the researchers use to evaluate the vocabulary knowledge development?

1.9.2. Research Questions for Research Study 1

1. How did participation in the study impact the learners' vocabulary and reading comprehension performance from the pre to post test?
2. What is the learners’ experience about the program?
    a. How are game-based learning experiences, language learning experiences, and affective experiences related?
    b. What are the leverage points in networks of relationships in aspects of learner experiences which can be used to design future DGBLL experiences in the future?
    c. How are learner experiences related to aspects of learning theory in which the program was grounded, and what does this tell us about how different aspects of constructionist theory are related to different aspects of dual coding theory and/or motivation theory?
3. What are the strengths and weaknesses of the program based on learners’ experiences?
    a. How are the strengths and weaknesses related?
    b. What are the leverage points which could be used to address weaknesses?

1.9.3. Research Questions for Research Study 2

1. How did students experience digital technologies for learning new vocabulary?
    a. What were the learners' positive experiences with different digital applications in terms of vocabulary learning?
    b. What aspects of these digital technologies did students find problematic in terms of vocabulary learning?
2. How do the different aspects of learning theory in which the program was grounded connect to vocabulary learning and learners' experiences?
3. How might the problematic aspects of digital technologies be addressed from students' perspectives?

1.10. Significance of the Study

This study may be beneficial to educators as well as for ELLs. This study is helpful for educators as it tries to build a connection between DGBLL and L2 learning theories. This study also tries to provide a framework for a digital game-based learning environment where elementary school aged ELLs can be engaged, interested, and involved to improve their vocabulary knowledge. Moreover, this study describes the benefits of different digital technologies for the ELLs' vocabulary development and suggests how to address weaknesses. To conclude, this study is beneficial for ELLs as it describes digital game-based and digital technology enhanced learning environments displaying how teachers can stimulate the students' interest for developing their vocabulary knowledge.

2. DIGITAL GAME-BASED LANGUAGE LEARNING MEDIATED VOCABULARY KNOWLEDGE DEVELOPMENT FOR ELEMENTARY SCHOOL AGE ENGLISH LANGUAGE LEARNERS: A SYSTEMATIC REVIEW

Since the 1970s, computer games have been a part of the lives of people. Despite their prevalence, they are not without controversy. Researchers and stakeholders such as parents and educators have long debated the merits and demerits of computer games. The chief concerns are the overuse of computer-based games instead of physical or outdoor activities and the violent nature of many games (Anderson, 2004, Anderson & Bushman, 2001). In addition, how digital games impact the attention spans of young learners is a matter of concern for many (Ogletree & Drake, 2007). However, recent research has suggested that computer-based games may support learning, particularly second language (L2) learning outcomes, critical thinking, collaboration, and affective and motivational outcomes (Acquah & Katz, 2020; Connolly et al., 2012; Hainey et al., 2016; Qian & Clark, 2016; Yudintseva, 2015).

One powerful benefit of computer-based games is the potential to support the development of new vocabulary, a critical component of language learning. Knowledge of vocabulary is “the heart of language comprehension” (Hunt & Beglar, 2005, p. 2), meaning that without a sufficient depth and breadth of vocabulary, comprehension and communication are close to impossible (Carter & McCarthy, 2014). A lack of vocabulary knowledge is one of the toughest obstacles for elementary school age English language learners (ELLs) to overcome when trying to master academic content

(Silverman & Hines, 2009). Research has shown that it is necessary for second language (L2) learners to have repeated exposure to the target language words, direct instruction on word learning strategies, and ample time to practice new words to close vocabulary knowledge gap between students (Ganske, 2018)

While an abundance of research exists on the importance of vocabulary in language learning, there is much to learn about the most effective way to increase ELLs' vocabulary knowledge. One possibility is the use of digital game-based language learning (DGBLL), suggested by several researchers (Moreno-Ger et al., 2008; Tsai & Tsai, 2018). For example, Tsai and Tsai (2018), in their meta-analysis, found a large overall effect size for experimental groups playing digital games versus control groups receiving traditional instruction in different conditions for second language vocabulary learning; Peterson's (2010) review study found that second language learners' participation in massively multiplayer online role-playing games provides a valuable opportunity for vocabulary learning. Similarly, Yudintseva's previous content analysis (2015) found that both educational and entertainment games have positive vocabulary learning outcomes for second language learners. However, there are few systematic literature reviews on DGBLL which thoroughly summarize the second language (L2) theoretical frameworks, features, and measures of vocabulary knowledge development in DGBLL studies. Therefore, the research questions for this literature review study are as follows:

1. What theoretical frameworks of L2 vocabulary development are being used in the current research studies to support DGBLL?

2. What features of word knowledge did the researchers examine in these studies?
3. What measures did the researchers use to evaluate the vocabulary knowledge development?

2.1. Different Terminologies

When discussing DGBLL, it is important to understand the differences among the terminologies such as game-based learning (GBL), digital games, digital game-based learning (DGBL), digital game-based language learning (DGBLL), and gamification. GBL involves learning through playing and/or making games including physical or non-digital games (Gee, 2012). A digital game is any game played on a digital device such as a computer, tablet, or mobile device. Digital games are goal-oriented, challenging, promote interactions, and are governed by a set of rules and feedback (Yudintseva, 2015).

According to Prensky (2007), DGBL combines education and games, and uses a digital platform as the medium. DGBL uses game elements to teach a specific skill or achieve a specific learning outcome. It takes the core content and objectives and makes the learning experience fun (Al-Azawi et al., 2016; Findley, 2016). Unlike DGBL, in digital game-based language learning (DGBLL), game elements specifically focus on teaching a language skill or on reaching a specific language learning outcome. DGBLL can create an environment where education is mostly learner-centered, provide opportunities for socialization when well-organized, and can awaken the will to win and competitive desire inside people (Butler 2017; Uzun, 2009; Wichadee & Pattanapichet, 2018).

In contrast to DGBL, gamification is the application of game mechanics in a non-game context to promote desired behavior and learning outcomes (Al-Azawi et al., 2016; Findley, 2016). Gamification uses game elements as rewards for completing existing training modules, whereas game-based learning integrates games with the learning process to teach a specific skill or achieve a learning aim (Nolan & McBride, 2014; Findley, 2016). For this study, focus will be only on digital game-based language learning (DGBLL).

2.2. Digital Game-Based Language Learning for Elementary School Age ELLs

Throughout history, philosophers, educators, and theorists have always emphasized the powerful role of play in a child's development and learning. Children engage in play-based activities which have been considered to be crucial for human development (Bruner, 1983; Ferholt et al., 2015). As children become involved with play-based activities, they become more motivated and their level of engagement is enhanced. DGBLL has the potential to bridge intrinsic motivation with learning outcomes. It can also give students a sense of autonomy over their learning (Hamari et al., 2016; Peterson, 2010; Squire 2008; Wilkinson, 2016). Language learning is more effective when it happens in an authentic context and when learners can be social, two components easily available in the DGBLL milieu (Gee, 2005; Peterson, 2016). Learners entering schools now are considered to be digital natives. Oblinger (2004) calls them the Net Generation. These learners are more inclined to work in teams and expect learning to be fun and engaging. They are also more self-directed and autonomous (Oblinger, 2004). DGBLL can enhance learners' intrinsic motivation to learn due to the game's ability to differentiate and give students a sense of autonomy (Hamari et al., 2016; Wilkinson, 2016).

2.3. Vocabulary Knowledge and its development

Vocabulary knowledge development is considered as a key component of language learning by learners, researchers, and educators. Research into DGBLL-mediated vocabulary learning offers insights into how these games, combined with innovative instructional and learning approaches, affect the development of different aspects of vocabulary knowledge. However, apart from Tsai and Tsai (2018) and Chen, Tseng, and Hsiao (2018), mentioned earlier, there have been no recent reviews focusing on DGBLL and vocabulary learning.

2.3.1. Theories of Vocabulary Development

Although there are numerous theories supporting vocabulary knowledge development, four theories were chosen to guide this study because the International Literacy Association announced these theories as having substantial impact on reading research (Unrau et al., 2013) and they were utilized by prior content analyses (Bowers et al., 2010; Moody et al., 2018). These include social constructivism and sociocultural theories, schema and psycholinguistic theories, dual coding theories, and motivation theory. These theories will be discussed below.

2.3.1.1. Social Constructivism and Sociocultural Theories

A core tenet of both social constructivism and sociocultural theories is that learners construct knowledge by interacting with others during social interactions (Unrau et al., 2013). The construction of meaning, understanding, and reality develops when the more knowledgeable peers or mentors help the learner to comprehend and internalize the social context and its contextual elements such as language and culture. Sociocultural theories are well-known for their Vygotskian concepts, which include the Zone of Proximal Development (ZPD), scaffolding, psychological tools, and inner speech (Vygotsky, 1978; 2012). ZPD refers to the difference between what a child can do alone versus what s/he can do with help from a more expert other. Here, learning must be scaffolded by a more knowledgeable adult or peer. Scaffolding aids learners to speed up the mastery of their psychological tools (i.e., language) and to activate their higher order thinking skills. Researchers have claimed that structured and scaffolded interactions between learners and more knowledgeable mentors help to develop learners' thinking, skills, language knowledge (Wood et al., 1976). Learners initiate these communications as they are dependent on adults and through these interactions learners master the needed skills and achieve self-regulation (Moody et al., 2018).

These theories imply that learners are active agents in the process of meaning-making (Adams, 2006). Therefore, vocabulary instruction should be perceived as a social dialogue through which learners construct meaning through scaffolding and interaction. Therefore, game-based learning activities where students work collaboratively to construct definitions of words and participate in discussions about new vocabulary are rooted in social constructivism and sociocultural theory (Donato, 1994; Swain & Lapkin, 1998).

2.3.1.2. Schema and Psycholinguistic Theories

Schema theory involves the cognitive and conceptual structure and representation of knowledge (Piaget, 1952; Unrau et al., 2013). Schemas can be compared to organizing files in a networked way that allows learners to process, organize, sort, and retrieve information (Anderson, 2004). Activation of schemas helps the learner to understand the information and provides a platform to explain objects and events in a context (Anderson, 2004).

Similarly, psycholinguistic theory proposes that readers do not rely exclusively on textual clues to make meaning, but they predict as they read (Unrau et al., 2013). A reader's background knowledge interacts with conceptual abilities and processing strategies to produce comprehension (Carrell & Eisterheld, 1983). Both schema and psycholinguistic theories demonstrate the active role of learners when constructing meaning and play a role in vocabulary instruction when students are asked to connect new words to synonyms and antonyms, analyze the morphological features of words (Kuo & Anderson, 2006; Rasinski et al., 2017), create concept maps, graphic organizers, and semantic maps (Little & Box, 2011), and use prior knowledge to determine word meanings (Burgoyne et al., 2013)

2.3.1.3. Dual Coding Theory

The basic premise of dual coding theory (DCT) is that the human mind processes environmental stimuli via two mental systems, or *codes* (Sadoski & Paivio, 2004). These codes are verbal or nonverbal. The two independent codes are connected. The verbal code is responsible for processing and representing language, while the nonverbal code does this for nonlinguistic objects and events. In DCT, cognition occurs when representations from both codes become connected. Verbal-only associations result from a failure to concretize the abstract, producing only shallow understandings (Sadoski & Paivio, 2004). In vocabulary instruction, practices emphasizing the concreteness and imageability of words, such as the use of multiple modalities (Dalton & Grisham, 2011) or the elicitation of mental images (Sadoski, 2002), are rooted in DCT.

2.3.1.4. Motivation Theory

Motivation theory, as it pertains to literacy, argues that readers become engaged with a text when it aligns with their goals, desires, and objectives within a particular social milieu (Unrau et al., 2013). Students become intrinsically driven to read when they are curious about the topic of the book or the author, believe in their reading abilities (self-efficacy), are given autonomy in choice of reading material, or are provided with texts of interest (Guthrie et al., 2004). Motivation can also increase through extrinsic means, such as achieving learning goals based on competition (Hodges et al., 2016) or the desire for external rewards or praise (Becker et al., 2010). Vocabulary practices based on motivation theory include the development of word consciousness to enhance student interest (Lane & Allen, 2010), the use of word-learning games (Huang et al., 2014), and technology-based activities (Dalton & Grisham, 2011).

2.3.2. Theories of L2 Vocabulary Development

Wu et al.'s (2012) review study found that game-based learning (GBL) is more likely to yield positive results when game design integrates theoretical frameworks. Young et al. (2012) stated that game designers and researchers need to pay careful attention to contemporary theoretical frameworks when they design and research educational games. Therefore, the present study explores the frameworks used in studies as a variable in relation to DGBLL for vocabulary development. Some prominent frameworks in L2 vocabulary acquisition also include social constructivist and sociocultural theory, schema and psycholinguistic theory, DCT and motivation theories which have been discussed above.

2.3.3. Features of Vocabulary Knowledge

Vocabulary knowledge development is an essential part of L2 teaching and learning (Elgort, 2017; Elgort & Nation, 2010; Henriksen 1999). Nation (2001) outlined three main features of vocabulary knowledge. These are: (1) knowledge of form (spoken, written and word parts), (2) knowledge of meaning (form-meaning mapping, conceptual or referential meaning, and associations), and (3) knowledge of use (grammatical function, collocations, and constraints on use). These features of vocabulary knowledge can be estimated through measures of proficiency in receptive skills (listening or reading) or productive skills (speaking or writing). However, the development of different features of vocabulary knowledge are not identical (Elgort, 2017) and have different paces. They may vary depending on the learning conditions and individual learner characteristics. Therefore, this study attempts to look into what different features of vocabulary knowledge development are being investigated by the researchers.

2.3.4. Measures of Vocabulary Knowledge Development

Vocabulary knowledge development measures may be used to understand a learner's lexicon (how many words they know in L2), or to understand how much they know about one or more features of vocabulary knowledge (Ma, 2009; Nation, 2001; Read, 2000). Vocabulary knowledge measures may focus on receptive knowledge (reading or listening to any text and understanding their meaning) or productive knowledge (retrieval of vocabulary in spoken or written production). Vocabulary measures can be designed online (i.e., with time constraints), or offline (i.e., without time constraints, allowing students to retrieve knowledge). According to Elgort (2017), online measures can better represent functional knowledge needed in real-life language use whereas offline measures can be helpful to assess a learner's capability to use mnemonics, analyze a word's structure, or complete tasks such as guessing or eliminating. These offline measures are often easier to administer and easily available to teachers and researchers (Elgort, 2017). Online measures may include tracking eye-movements while reading, analyzing real time communications, or examining behavioral or linguistic tasks under time pressure, whereas offline measures may include translation or multiple-choice vocabulary tests. Moreover, implicit measures of vocabulary knowledge may be useful to obtain evidence of learning at the early stages of vocabulary development, especially if the learners have low proficiency in the target language (Elgort, 2017)

Vocabulary knowledge may be measured by administering assessments in three settings (i.e., in-context, limited context, out-of context; Elgort, 2017). The target words are presented in isolation for in-context measures (e.g., *LexTALE* by Lemhöfer & Broersma, 2012), in limited contexts (e.g., VST by Nation & Beglar, 2007), or by observation and analyses of linguistic behavior and students' artifacts (i.e., writing samples; Crossley et al., 2012) or online chat (Sauro & Smith, 2010).

2.4. Literature Review Methods

The present study is a systematic literature review. According to Munn et al. (2018), systematic literature review is a research synthesis, conducted by reviewers with specialized skills aiming to produce critically appraised and synthesized results/answers to particular questions. The present systematic review seeks to identify and analyze all available literature on DGBLL for vocabulary development to better understand how DGBLL supports elementary school age ELLs.

2.4.1. Search Procedure and Terms

A search for relevant literature was conducted in ten databases including ACM, Cambridge Core, ERIC (EBSCO), IEEE (Explore), Google Scholar, Science Direct, Ingenta Connect, SpringerLink, Emerald Insight, and ProQuest. Since technology advances at a rapid pace, and this review intends to examine the most recent literature in game-based learning with a focus on vocabulary development, the researcher restricted the year range from 2009 to 2020 using three clusters of keywords. The first cluster included phrases related to digital games such as “educational games" or "digital games" or “digital game-based learning.” Then, the second cluster of keywords was added which is related to vocabulary development to find relevant studies that focus on DGBL and vocabulary development. The keywords included "vocabulary" or "vocabulary development" or "vocabulary instruction" or "vocabulary learning" or "vocabulary teaching" or "vocabulary teaching and learning." To further focus the identified studies on ELLs, a third cluster of keywords were added including "English Language Learners" or "Bilingual Education" or "English as a Second Language" or "second language learning" or "second language instruction" or “ESL” or “ELL.”

2.4.2. Inclusion Criteria

The preliminary search of the ten databases yielded 136,473 papers. To address the primary purpose of this paper, the articles had to (a) be published in the English language; (b) include evidence (quantitative, qualitative, or both) about vocabulary learning in the DGBLL setting; (c) specify information such as theoretical framework, features, and measures in DGBLL setting; (d) include pre-K-5 ELL participants; and (e) be published from January 2009 to January 2020. Then, the researcher screened and marked the titles and abstracts of each article for inclusion/exclusion based on the above criteria. At the end, twenty-two journal articles were identified as meeting the inclusion criteria.

The researcher found 136,473 studies in total which included 133,961 from Google Scholar, 1152 studies from ACM database, 850 from Cambridge Core, 362 from Science Direct, 14 from ERIC(EBSCO), 89 from IEEE (Explore), 21 from SpringerLink, 18 from PsycInfo, 4 from ProQuest, and 2 from Ingenta Connect. Then, the author checked the titles and excluded 136,239 articles based on their irrelevant titles. Then, the remaining 234 papers were uploaded into Rayyan, a free online software designed to assist with the screening process of systematic reviews (Ouzzani et al., 2016). After an automated and manual screening for duplicate records, 119 records were identified as duplicates and were removed from the data set, leaving 115 records for screening.

The researcher then screened the content of the abstracts of 115 records based on the inclusion criteria described above. A total of 39 records were excluded for not including evidence about vocabulary learning in the DGBLL setting and 15 records for not specifying information such as game type and game genre. The researcher excluded an additional 37 records for not including participants in pre-K-5 grade. At the end, 24 studies were selected for full-text analysis. However, upon further inspection, two more studies were excluded from further analysis because two of the studies focused on the use of digital games, one reported only observations and one did not use the digital game for vocabulary development. Figure 2.1 below shows the study selection procedure.

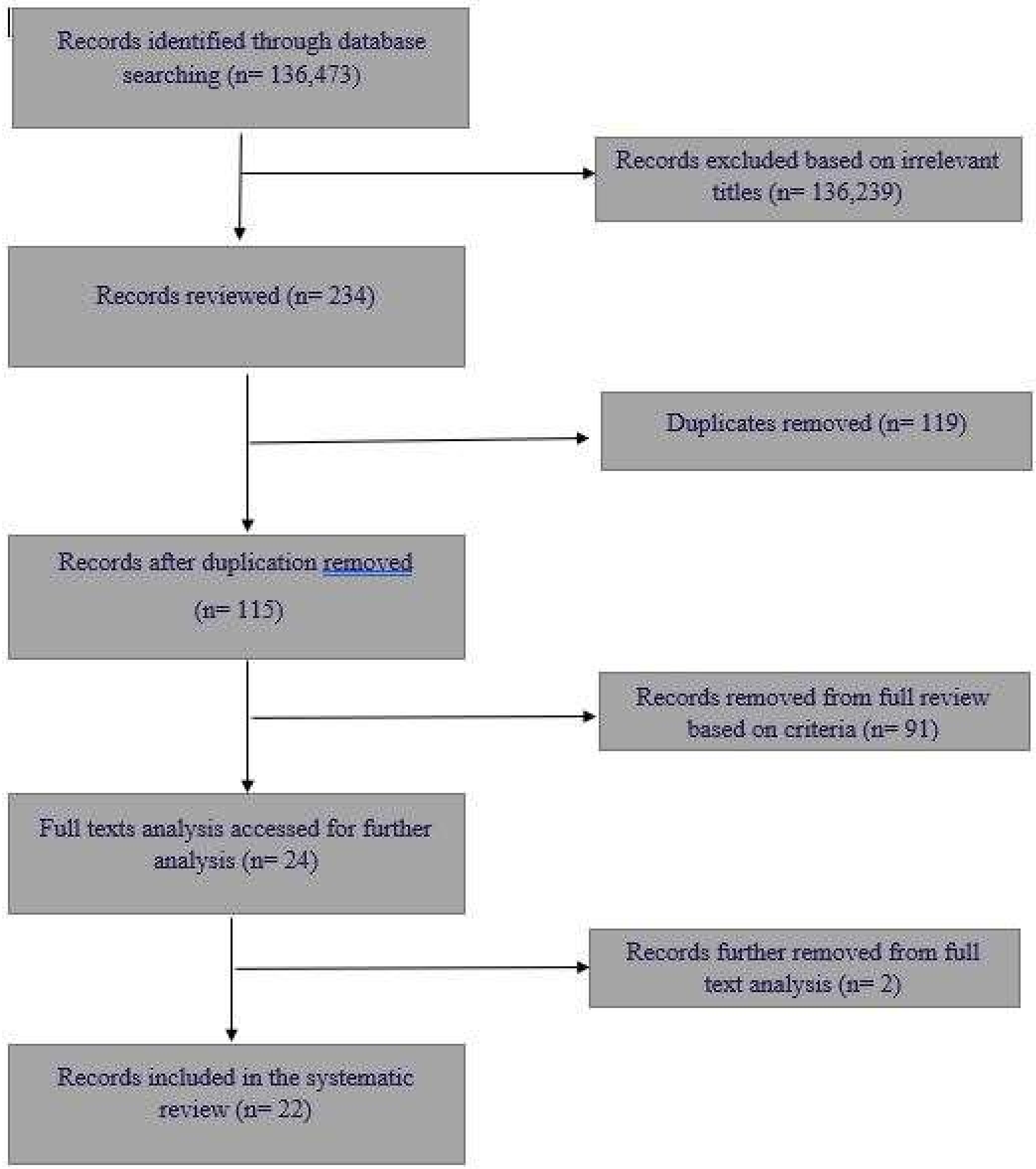

Figure 2.1 Study Selection Procedure

2.4.3. Coding of Papers

Each article was read and coded for the factors related to the research questions, including (1) vocabulary development theories (Unrau et al., 2013), (2) features of vocabulary knowledge development (Elgort, 2017), and (3) measures to assess vocabulary knowledge development (Elgort, 2017). Following Moody et al. (2018), vocabulary development theories were coded based on *why* and *how* it was used in the classroom. For example, playing together in a group was coded within social constructivism and sociocultural theories because here learners were encouraged to work in a collaborative setting to learn the target words. A theory was coded *explicit* if its name was mentioned explicitly in the article, and *implicit* if the theory's name was not mentioned in the article, but enough proof was present that it provided a framework for the practice (Hodges et al., 2016; Moody et al., 2018). Finally, if enough evidence was present, the articles were coded as based on more than one theory (Yang et al., 2018). These studies were further coded (one at a time) to find their features and measures of word knowledge based on the coding themes (see Appendix A for the full list of codes).

2.5. Literature Review Findings

2.5.1. Theories of L2 Vocabulary Development

DCT theory was the most frequent theory that was included in the studies, followed by social constructivism and sociocultural theories, motivation theory, and finally schema and psycholinguistic theory. These findings will be discussed below.

In DGBLL literature, vocabulary knowledge development practices based on DCT were found implicitly in all of the reviewed articles, with only one study naming the theory explicitly. Researchers mentioned presenting new words visually and verbally or by using multiple modalities (AlShaiji, 2015; Chen & Lee, 2018). These researchers also found that digital games encourage learners to connect both forms and meanings successfully as these games use audio, video, pictures, graphics etc. in their virtual worlds. This finding aligns with Vahdat & Rasti-Behbahani (2013), who mentioned that in the DGBLL context, learners are not only provided with the test and definitions of the target words, but they are also assisted by seeing the pictures, images, and graphical displays of the words, which promotes vocabulary knowledge development.

Social constructivism and sociocultural theories were the second most-coded theories. Sixty-seven percent (n=14) of the articles followed social constructivism and sociocultural theories, with only twenty-nine percent (n=4) explicitly mentioning the theory. This finding is expected, as teaching and learning practices have been increasingly emphasizing collaborative learning through social interactions with peers, mentors, and teachers (Akkus et al., 2007). Social constructivism and sociocultural theory help teachers to overcome the old-fashioned notions that vocabulary learning happens only by presenting information about the definitions of the target words while students listen to the information passively. Instead, in the DGBLL context, the students play collaboratively in groups (Chen & Lee, 2018; Cobb & Horst, 2018), follow hints in teams in the gameplay scenarios (Dourda et al., 2014), and engage in social facilitation and learning where the learner displays to others how to play and learn words in different levels of the games as well as observe others' gaming performance (Elaish et al., 2019). All these collaborative scaffolding, social facilitations, and learning go beyond the traditional practice of just recalling meanings. These interactions help the students to fluently access the use of words, understand unknown vocabulary by creating mental connections, and associate unknown words with known words using their imagination (Dourda et al., 2014). This collaborative setting also promotes the desire to try and offers opportunities to students to make mistakes while using words across multiple contexts and leads the learners to have interactions among one another without stress (Young & Wang, 2014).

Motivation theory was the third most coded theory, guiding fifty-five percent (n=12) of the articles implicitly. Features of motivation theory include the use of rewards, competition, and promoting students' interest and autonomy, all of which were found in the reviewed articles. Here, researchers focused on giving extrinsic incentives, such as scores, badges, points, and stars, to motivate players to learn new vocabulary and give immediate feedback in the form of extrinsic incentives (Cobb & Horst, 2011; Dourda et al., 2014; Elaish et al., 2019; Lucht & Heidig, 2013; Pan, 2017).

According to Chomsky (1993), language acquisition is innate and spontaneous; game-based learning provides an opportunity to the learners to learn new words autonomously (Van Eck, 2006). This is the case for DGBLL as well. Researchers repeatedly pointed out the potential of DGBLL for increasing learners' autonomy, providing immediate feedback, and promoting independent learning (Letchumanan & Hoon, 2012; Pu & Zhong, 2018; Sylvén & Sundqvist, 2012; Sundqvist & Sylvén, 2014). The process of completing the game motivated the learners to acquire target vocabulary level by level (Young & Wang, 2014). Research shows that in DGBLL, players attain self-efficacy as they learn by doing. Players also gain experience to give deep meaning to the words and texts they read later, by connecting their gameplay with their learning (Jensen, 2017).

Schema and psycholinguistic theories were found in 50% (n=11) of reviewed articles, with 27% (n= 3) of articles explicitly mentioning the theory. This prominence of the schema and psycholinguistic theories implies that in DGBLL milieu, there is a strong emphasis on the activation of background knowledge, mental mapping and/or sorting of words, and connecting different words with one another (Aghlara & Tamjid, 2011; Lucht & Heidig, 2013; Dourda et al., 2014; Young & Wang, 2014; AlShaiji, 2015; Hwang & Wang, 2016; Elaish et al., 2019; Rabu & Talib, 2017; Tang, 2020). Researchers observed that by using repetition and imitation of target vocabulary and speech during gameplay, the learners showed meticulous attention not only to the linguistic forms of the words, but also to their prosodic qualities as well as semantic meanings (Piirainen-Marsh & Tainio, 2009; Letchumanan & Hoon, 2012; Lucht & Heidig, 2013; Rabu & Talib, 2017; Tang, 2020).

2.5.2. Features of Word Knowledge

The spoken form (SF) of word knowledge was assessed 8 times, written form (WF) 15 times, form-meaning (FM) making 22 times, semantic and associative dimensions of meaning (SAM) 5 times, and knowledge of use 9 times. This indicates that in DGBLL, form-meaning mapping is the most prevalent feature of vocabulary knowledge development, which aligns with the findings from Elgort (2017). This finding is also aligned with one of the core tenets of vocabulary knowledge development, that vocabulary knowledge requires the ability to connect the word form with its meaning (Nation, 2001; Schmitt, 2008). The written form was the second most assessed feature of vocabulary knowledge development followed by knowledge of use (KoU). KoU consists of grammatical function, collocational knowledge, and constraints on use. More than half of the KoU codes were associated with the feature of collocational aspects of word knowledge, which is a growing area in second language learning research (Schmitt, 2000; Elgort, 2017).

The number of word knowledge features assessed in each study ranged from one to four, with an average of two. Studies that incorporated authentic language use tended to cover more features of word knowledge (e.g., four features: Sylvén & Sundqvist, 2012; Sundqvist & Sylvén, 2014; Cobb & Horst, 2011; three features: Hwang & Wang, 2016, Chen & Lee, 2018). Researchers who assessed four aspects of knowledge also used self-report assessment (Sylvén & Sundqvist, 2012; Sundqvist & Sylvén, 2014) and a series of observational and empirical tests with school children (Cobb & Horst, 2011). Most studies assessed at least two features of word knowledge (n=19), of which WF+FM (54%) is the most prevalent, followed by SF+FM (18%), FM +KoU (9%), WF+KoU (8%), SAM+KoU (7%). The following combinations were recorded for three-feature measures: WF+SF+FM (n= 2), WF+FM+KoU (n=2), WF+SAM+KoU (n=1), FM+SAM+KoU (n=1), WF+FM+SAM (n=1). These results indicate that there is a trend to emphasize written language and form-meaning mapping assessments for vocabulary development, rather than on the semantic and associative meaning of the words, even though semantic and associative meaning is considered as a higher proficiency level of vocabulary development (Barcroft, 2016). Moreover, this trend of emphasizing written form more than the spoken form may indicate the nature of the target language which is the *formal academic register,* because most of the reviewed studies were conducted in a classroom or laboratory setting.

2.5.3. Measures of Vocabulary Development

Sixty percent (n=13) of the articles used productive measures, which was anticipated as there is a tendency to focus on written form aspects of word knowledge. Thirty-two percent (n=7) of the articles used receptive measures, and the remaining 9% (n=2) used the combination of both. In-context measures (n=16) were used more frequently than the out-of-context measures (n=4) or the combination of both in and out-of-context (n=2). Offline (n=9), online (n=7) and a combination of both (n=6) were used fairly equally. In-context measures (71%) were used mostly for evaluating productive knowledge. Researchers used both in-context and out-of-context measures for evaluating receptive knowledge. Productive knowledge was measured offline in eight cases, online in four cases and twice in both online and offline cases. Measures that were used to evaluate receptive knowledge included offline once, online three times, and a combination of both in four articles.

The reported results in the reviewed articles were guided by the analysis of the learners' language data, including test scores, self-reports, analysis of output data, or by the analysis of learners' attitudinal data to DGBLL treatments. Researchers obtained the attitudinal data through questionnaires/surveys or interviews. In regards to the learners' language data, the reported findings were mostly positive (n=20), with no report of negative effects, and only two studies reported no effect. The attitudinal data (n=6) showed overwhelmingly positive (100%) results.

All the studies included different vocabulary learning games for the learners. Apart from vocabulary knowledge development, researchers found that DGBLL helped to teach new skills, for example, active engagement (Hwang & Wang, 2018), collaboration, and interaction (i.e., Dourda et al., 2014; Lucht & Heidig, 2013; Piirainen–Marsh & Tainio, 2009), as the children play, practice, and learn from their peers. This situation is especially beneficial to improve learners' pronunciation and decrease their speaking anxiety because some of the vocabulary games provide them with opportunities to practice speaking in a low-anxiety environment (Young & Wang, 2014).

2.6. Literature Review Discussion and Conclusion

In the present review study, the researcher tried to answer three questions. First of all, the underlying theoretical frameworks of the L2 vocabulary development guiding the DGBLL studies for elementary students was examined. Secondly, the researcher sought to investigate the different features of word knowledge in these studies. Finally, different measures of word knowledge used in these studies were investigated.

Findings showed that in DGBLL, researchers have used four vocabulary knowledge development theories including DCT, social constructivist and sociocultural theories, motivation theory, and schema and psycholinguistic theories explicitly or implicitly. The prominent—but implicit—use of DCT was anticipated, because learners who learn vocabulary items with the help of visual images, icons, texts and graphics, will be proficient in recalling and retrieving target word-forms and their meanings (Sadoski, 2002; Kim & Gilman, 2008). It was also found that social constructivist and sociocultural theories fostered multidimensional collaborative scaffolding (i.e., peer to peer, teacher-learner, game milieu-learner and so on) that goes beyond the mere recollection of the target words. This environment promotes learners' understanding of the precise usage of words, raises their awareness of oral and written word format, and helps them to use the learned words in different contexts, which aligns to the findings of Moody et al. (2018). Moreover, digital games have the potential to create students' intrinsic interest in word-learning, promote autonomy, and self-efficacy (Deci & Ryan, 1985). Finally, in DGBLL for vocabulary knowledge development, there was still a heavy emphasis on using strategies such as drill practice, memorization, imitation, and repetition. This could explain why many researchers use schema and psycholinguistics theories as the guiding theories for their studies. Even though these strategies may play a critical role in word processing, if educators focus only on association (e.g., grouping words by their synonyms and antonyms), it will not lead the learners to a deeper understanding of the words (Stahl & Bravo, 2010). Students need to have ample opportunities to use the words organically, meaningfully, and authentically (Beck et al., 2013).

Regarding the features of word knowledge, this study found that form-meaning mapping and written form were the most prominent features of word knowledge in the DGBLL for vocabulary knowledge development. According to Nation (2007), in order to build a lexicon in a second language, learners need long-term repeated exposure to the target language with opportunities for meaning-focused practice and fluency development. As mentioned above, DGBLL can provide learners with opportunities for meaning-focused practice with long-term repeated exposure to the target language during gameplay. However, little is known about fluency development in the DGBLL setting. Researchers may consider paying attention to fluency development in the DGBLL setting in future studies.

Finally, pertaining to the measures of vocabulary knowledge development, the researcher found that most of the studies typically focused on explicit vocabulary knowledge tests (i.e., pre-test, post-test, and delayed test with word items), conducted either offline or online. Although researchers used both productive and receptive vocabulary measures, it is difficult to predict whether learners will be able to use the newly learned words in real-life contexts since most of the studies were conducted in the classroom or laboratory setting, under a controlled environment. This finding aligns with those of Elgort's (2017) previous content analysis.

These findings indicate two shortcomings of the DGBLL research. First, the DGBLL studies emphasized the target words and ignored pattern recognition (i.e., *bird-birds, eye-eyes* etc.), which is crucial in second language lexicon development. Second, these studies failed to incorporate vocabulary measures that can gauge learners' ability to use the word in an authentic context, in a naturalistic setting. No findings addressed how to develop the functional vocabulary knowledge of the learners. Future research should focus on these aspects of vocabulary knowledge development.

Lastly, this literature review found that DGBLL mediated vocabulary knowledge development is a diverse research arena that incorporates various theoretical perspectives, covers a wide range of features of word knowledge, and uses different measures of vocabulary knowledge development. The identified limitations in this research arena give researchers a set of recommendations for future research in this domain that can further improve the methodology and research design, and make DGBLL mediated vocabulary development studies more robust and effective, as well as more easily applicable to other technology-mediated research contexts.

2.7. Theoretical Framework for Articles 2 and 3

Up until now, this chapter has presented a systematic literature review with an intention to establish connection between DGBLL and vocabulary learning theories. In the final part of this chapter, the theoretical frameworks for article two and three will be discussed. Article two includes constructivism, constructionism, DCT, and motivation theory as its theoretical framework. Article three incorporates constructivism, DCT, and motivation theory as its theoretical framework. Moreover, in both articles two and three students were involved in projects where they create, design, and build artifacts using digital technology.

To understand the research design, which is based on the concept of constructivism and constructionism and ELLs' vocabulary development, the next section is going to delve into constructivism and the subsequent framework of constructionism. The research designs and methods for article 2 and 3 will be discussed in chapter 3 and chapter 4.

2.7.1. Constructivism

Constructivism—or constructivist theory—is grounded in the work of Piaget (1952), Vygotsky (1978), and Bruner (1996) who defined learning as the active construction of knowledge and meaning. In the original formulation (Piaget, 1952) this construction was a purely cognitive process within the minds of individual learners. Vygotsky (1978) and Bruner (1996) expanded constructivist theory to address the constructive interaction between and across individual minds and their social context including peers, more knowledgeable others, tools, languages, and history. Constructivist theory not only sees learning as a generative process, but also sees knowledge as constructed as opposed to discovered or acquired (O'Donnell, 2012). Constructivist researchers today generally define learning as the individual, collaborative, and collective construction of knowledge.

2.7.2. Constructionism

Constructionism—or constructionist theory—expands the constructivist perspective on learning (Papert, 1993). Compared to constructivist theory, constructionism places more emphasis on the art of learning and on the significance of learning through making (Ackermann, 2001). Learning is not only the construction of knowledge, but also the construction of the world in a more literal sense (Donaldson & Bucy, 2016). By constructing artifacts, activities, processes, and other observable things which reflect and embody the meaning, which is simultaneously being constructed, a positive feedback loop emerges: the construction of the thing contributes to the construction of knowledge, which contributes to the construction of the thing, and so on (Kafai, 2006). Learning is inextricable from context and is the result of interactions between learners and features of their environments such as other learners, tools, resources, language, social structures, and so on (Vygotsky, 1978). Thus, the use of external supports are essential in this learning process. Papert's constructionism, in this sense, is considered as more situated and pragmatic than constructivism (Ackermann, 2001).

Constructionist theory provides a set of principles for the design of learning (Donaldson, 2020): **Making**: Learning is most powerful when learners make things of their own design. The constructed artifacts mirror the construction of meaning occurring in the minds of the learners. The artifacts are tangible objects-to-think-with—tools of embodied cognition (Papert & Harel, 1991). **Learner Agency**: The artifacts must be personally meaningful, which depends on some preconditions. The first of these is the agency of the learner. When learners have autonomy and authority over the goals, processes, roles, and nature of the artifacts, those artifacts take on personal significance. Artifacts are embodiments of the meanings the learners have constructed, and the act of constructing meaning involves constructing one's own mind. Therefore, learner agency in constructionist learning leads to ownership and authorship of self (Papert, 1999). **Situating Learners as Designers**: Learners should be situated as designers. As designers on design teams, they engage in negotiation of goals, roles, procedures, tools, and meanings. They collaboratively design, prototype, iterate, and deploy their artifacts in the real world (Donaldson et al., 2020). **Authentic Audience:** Another precondition to meaningfulness of artifacts is the authenticity of the intended use of the artifact. If learners create artifacts which they know will only be seen by their fellow learners and teachers, construction of artifacts is akin to drill-and-practice activities. Learners need to know that the artifacts they are creating will have real-world impact. They need authentic audiences (Glazer, 2015). **Focused Tinkering**: Resnick and Rosenbaum (2013) define tinkering as "a playful, experimental, iterative style of engagement, in which makers are continually reassessing their goals, exploring new paths, and imagining new possibilities" (p. 164). Situating learners as designers fosters a more focused form of tinkering which facilitates development of skills in framing and reflection-in-action. Focused tinkering provides a means of balancing the product-driven activity of artifact construction with the joy and freedom of exploration.

3. ELLS AS GAME DESIGNERS FOR VOCABULARY LEARNING

This chapter includes the background, setting, participants, recruitment, research questions, measures, data collection, and data analysis process of article two.

3.1. Background for Article 2

The idea of children as digital game designers started in the 1970s, but it is far more relevant than ever before, especially in a time when technology is evolving at a faster speed than has ever been foreseen in human history (Khalili, 2014). Software and technology are more readily available these days, and they have become more sophisticated and user-friendly. Free game design programs such as Game Maker, Scratch, and Storytelling Alice are easily available, all of which allow learners to develop and use basic programming skills to be able to create their own projects. Prominent researchers who have implemented game-based learning using these programs in K-12 contexts have found that learners are more motivated and engaged in creating their own projects, collaborating with others, and learning game-designing skills (Kafai & Peppler, 2012; Kelleher & Pausch, 2006; Robertson & Nicholson, 2007; Sheridan, Clark, & Peters, 2009).

English Language Learners (ELLs) are the fastest growing sector of the K-12 school population, and the enrollments are increasing in most parts of the country (Enyinnah, 2014). ELL children are often hard to reach and even more difficult to teach through no fault of their own (Kelley et al., 2010). It is educators' duty to equip ELLs with 21st century skills which generally refers to certain core competencies such as "collaboration, digital literacy, critical thinking, and problem-solving that advocates believe schools need to teach to help students thrive in today's world" (Rich, 2010, p. 7). Educators need to understand that they are training ELLs to excel in future jobs that have not yet been invented, and employers are looking for candidates who can learn on the job and who have a skill-set that includes the three Cs: *creativity*, *communication* and *collaboration* (Rich, 2010). Others such as Thoughtful Learning (2017) have added another C to these three Cs—*critical thinking*—which encompasses information, media, and technology literacies. Statistics show that students who fail to develop necessary skills to reach their potential become disaffected, drop out of school, and settle for low paying jobs or are unemployed because they cannot access the necessary education for success (Calderón, 2007). ELL children as game designers in a digital game-based language learning context could be one strategy that may assist teachers to reach and teach these necessary 21st century skills to ELLs, giving these students greater access to learning and success in life.

In the educational research community, currently there are two approaches to the use of video games as pedagogy. One is games created for learning and the other one is learning through creating games (Khalili, 2014). Games created for learning are the most common in educational research, as well as in practice. This study focuses on the latter approach. Here, the students will be in charge of creating their own video games based on non-fiction texts with which they have no prior knowledge. This provides the opportunity for students to learn about and explore their understanding of the topics while designing their games. The objective of this study was to understand the design and learning processes students followed when placed in a constructivist and constructionist learning environment with available tools to learn new vocabulary while designing their own game. This study also examined student attitudes towards language learning and technology (specifically, making video games) as well as its gains on the learners' vocabulary and reading comprehension after participating in the digital game-based language learning workshop.

3.1.1. ELL Children as Game Designers

Seymour Papert (1993), who is one of the creators of the programming language LOGO, writes about how children interact with the computer and learn math through this programming language. Papert described how children learned how to write commands in LOGO to move a cursor that looks like a turtle on the screen and how to draw a line with the turtle. They learned how to create geometric shapes even though they never learned how to draw different geometric shapes such as a circle or rectangle with explicit instruction. This is an experience for children where each acts as a "builder," which is similar to Jean Piaget's idea where children are "builders of their own intellectual structures" (Papert, 1993, p.7). This is the underlying theory of constructivism which is based on the idea that learners create their own knowledge through their experiences (Piaget, 1964). Papert (1993) takes this idea a notch further, developing the idea of *constructionism,* which argues that learners build their knowledge through creating, constructing, and immersing themselves in an experience. According to constructionism, the children are creating a rectangle through LOGO commands while at the same time, they are building their knowledge about rectangles through this experience.

Kafai (1995) successfully used this idea of constructionism, coined by Papert, to study fourth-grade students making digital games in math lessons using the LOGO programming language. This study—and other studies based on children making digital games (Harel, 1990; Prensky, 2008)—puts a spotlight on the idea of learners as designers of multimedia where students are immersed in a constructivist learning context.

Constructionism views learning as both an internal and external process (Tarman & Baytak, 2012). The internal process includes the active process where the students construct knowledge based on their schema. The external process includes making artifacts which they can share with an authentic audience (Glazer, 2015). Therefore, constructionist perspective can provide a unique lens for language learning since constructing knowledge by making artifacts may help the ELLs to build their cognitive knowledge about language learning skills.

3.1.2. Vocabulary Development, Reading Comprehension, and Digital Games

Vocabulary knowledge development is a necessary part of learning a language since words are the building blocks of a language (Nation, 2001). In fact, vocabulary knowledge is considered to be a major factor behind the achievement of reading comprehension and successful language learning for all learners (Kieffer & Lesaux, 2012; Nation, 2007). Learners develop vocabulary knowledge through systematic teaching of vocabulary as well as through incidental exposure to new words (Zuo &

Yan, 2019). Systematic teaching usually includes targeted vocabulary instruction along with discussion (student-student, student-teacher) and opportunities to learn the words in context (Johnson et al., 2016; Moody et al., 2018), whereas incidental learning of vocabulary involves authentic tasks such as read-alouds, repeated exposures to the text, multimodal platform to make word-form and word-meaning connections (DeVere Wolsey et al., 2015; Hennebry et al., 2017).

In the past decade, researchers have systematically reviewed the potential of using technology to improve learners' vocabulary development and reading comprehension (e.g., Ahmadi & Reza, 2018; Belo et al., 2016; Cheung & Slavin, 2012; Kamil & Chou; 2009; Slavin et al., 2009) In general, their findings suggest the potential for technology to improve reading outcomes. In their meta-analysis, Cheung and Slavin (2012) found that educational technology generally produces a positive effect on reading outcomes including vocabulary development and reading comprehension in comparison to traditional methods. Slavin et al. (2009), in their literature review of reading interventions for elementary students, argue that technology can maximize students' motivation and provide them with metacognitive strategies for reading comprehension, vocabulary development and other reading skills. Kamil and Chou (2009) review the research on effective uses of computers to teach reading comprehension and conclude that technology-enhanced instruction has potential for teaching reading comprehension skills ranging from vocabulary knowledge development to other reading strategies (e.g., decoding, inference, prediction), as well as meta-cognitive abilities.

As mentioned in chapter 1 and 2, researchers have suggested that DGBLL has the potential to increase ELLs' vocabulary knowledge (Moreno-Ger et al., 2008; Tsai & Tsai, 2018). Researchers have also indicated that educational technology such as DGBLL may lead to successful reading comprehension development because DGBLL aligns semiotic interrelationships among multiple sign systems (e.g. words, images, actions and artifacts), semantics, and pragmatics with text-to-self, text-to-text, and text-to-world context in the gaming environment (Lasley, 2017). For example, digital games such as *SimCity* include actions after interacting with an avatar which includes reading dialogue (text-to-text) with other avatars or reading instructions to complete a quest (text-to-world). Sometimes missions or quests present dilemmas that need decision making or problem solving actions such as when to or how to defend oneself against attacks or which objects to select in order to earn rewards (text-to-self). Even though technology-enhanced instruction has been found to be beneficial for both vocabulary development and reading comprehension, and DGBLL has shown promising results for vocabulary development in earlier research, improving reading comprehension via DGBLL has not yet been fully explored.

3.1.3. Scratch Programming

Scratch (https://scratch.mit.edu/) is a platform that has come to prominence in recent years and is considered to be popular among learners. It is a programming platform developed by the MIT (Massachusetts Institute of Technology) media lab. It includes a development environment and a website where the community can host their projects, play games, reuse other programs, and share ideas or suggestions with others

(Moreno-León & Robles, 2015). In this free programming language, students can create their own interactive stories, video games, and animation programming. The instructions (or code pieces) are displayed as puzzle pieces that only fit together if they are syntactically correct (Malan & Leitner, 2007). In general, most of the students (76%) who are exposed to Scratch report to have a positive learning experience (Resnick et al., 2009). Scratch not only provides flexibility to accommodate different types of projects (i.e., video games, interactive stories, animations) along with a multimodal platform, but also allows the learners to express their different learning preferences. It has a positive impact on students' attitude, and leads to better learning outcomes than traditional instruction (Moreno-León & Robles, 2015).

The Scratch usage statistics (Scratch, n.d.) shows that currently there are 87,405,110 projects running and 78,778,255 users on the web which confirms the global nature of the project. Figure 3.1 shows an example of a screenshot of a Scratch project. On the right, the list includes the visual elements used to program the Scratch environment. On the right, the resulting program (above) and the sprites (images used in the program; below).

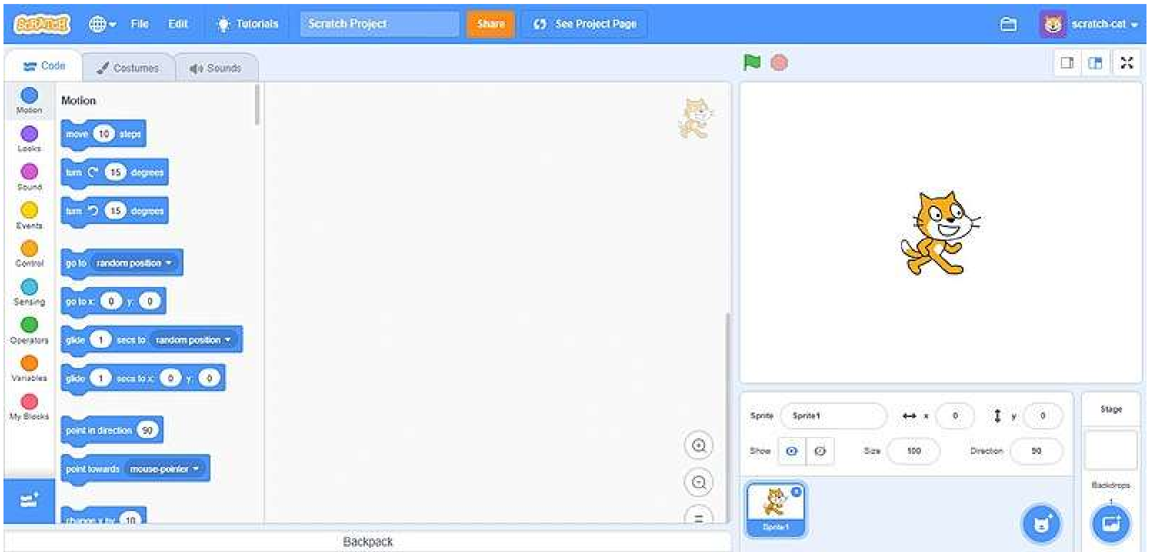

Figure 3.1 Scratch – Reprinted from [Scratch Team, 2019]

3.1.4. Research Gap

Even though researchers have found Scratch to be helpful for accommodating different learning preferences and projects, the benefits of Scratch have not yet been adequately investigated in terms of DGBLL, vocabulary development, and reading comprehension. In a research study conducted by Sourani & Ihmaid (2019), the researchers examined 44 elementary students in terms of the effectiveness of Scratch compared to traditional instruction for vocabulary development. They concluded that the experimental group (22 students) using Scratch programming performed better than the control group (22 students). However, the researchers did not mention how long the treatment lasted or whether the treatment had any impact on students' reading comprehension. Another example of the successful educational use of the Scratch program is the research conducted by Burke and Kafai (2012) running a writing workshop in which students had to create stories using Scratch instead of with pencil and paper. Both students and researchers stated that the overall experience had been very motivating and positive, not only for improving digital literacy, but also for improving the learners' writing skill development through digital storytelling. However, they did not provide any information about how the students chose new vocabulary within their story retellings. Therefore, more research is needed linking the DGBLL and generative platforms, such as Scratch, in terms of vocabulary development and reading comprehension.

3.1.4.1. Project Overview

This project included: (1) development of a game-based literacy curriculum focusing on developing both lower-level and higher-level processes that are aligned with the Common Core Standards, and an (2) implementation of the game-based literacy workshop, using concept-based instruction so participants can actively use language skills for game-based activities. The curriculum was designed by the researcher, where in each session students read a non-fiction text, learned new vocabulary, and designed games based on their reading using Scratch. The instructors read the non-fiction text to the students, discussed difficult and/or new words when necessary, and demonstrated how to design a game. This direct instruction regarding new words may lead to successful vocabulary knowledge development (Lesaux et al., 2014). During designing the game sessions, the students worked in groups. The sessions were conducted online, and the participants remained at their respective homes. They participated in both video and audio chat. The instructor used video format via Zoom. Students were immersed in an environment where they were involved in digital game-based language learning.

Students participated in a game-based language learning workshop that aimed to improve their vocabulary and reading comprehension through developing video games. The workshop consisted of eight 50-minute online sessions over eight weeks. Prior to the workshop and again after the workshop, the students were assessed for reading comprehension and vocabulary development. They also completed a pre and post survey about their confidence and interest in language learning, game making, and game playing experience. After the conclusion of the program, participants were invited for interviews by the researcher. These interviews were conducted via Zoom, with only audio being recorded for transcription.

During the DGBLL workshop, students were immersed in the constructionist learning environment which may lead to incidental vocabulary development. Based on the non-fiction text discussed by the instructor, they constructed their own game in Scratch which might lead to embodied cognition (Papert & Harel, 1991). The students were situated as game designers (Donaldson et al., 2020), and the final artifacts (digital games) were personally meaningful to the students since they have learners' agency resulting in embodiment of the knowledge that learners have constructed (Papert, 1999). The students also shared their final artifacts with their peers and instructors for feedback which provided them with authentic audiences (Glazer, 2015). During this whole process, students went back and forth between their non-fiction texts and their game multitude of times to remember the facts to embed in their games or to add details to their games or to visualize the facts in the games or to connect the games with what they read in the non-fiction topic, which could lead to incidental learning of vocabulary (DeVere-Wolsey et al., 2015). This also gives the students ample opportunities for focused tinkering (Resnick & Rosenbaum, 2013) where they reassess their game-making strategies and information from the non-fiction text to design their game.

3.1.4.2. Setting

The 50-minute online sessions included interactive guided learning. All interactions were verbal. The 50-minute class sessions included game designing activities and discussions. The students were grouped by the facilitator during the game designing sessions. Each group worked in Zoom breakout rooms. Even though they brainstormed together, the games were designed individually. The facilitator rotated in the group breakout rooms to observe and give feedback. Between sessions, the groups worked in Google documents and in the Scratch platform asynchronously.

3.1.4.3. Participants

Thirteen elementary school age (9-13 years old) learners participated in this study. Participants were second generation Bangladeshi American ELL students. All of the students speak Bengali at home. From a needs-based analysis with parents, the researcher found that these students had beginner to intermediate level proficiency in Bengali and are struggling readers in English and have low English vocabulary knowledge. All participants had computer and internet access at home. None of the learners had prior experience with the game designing platform Scratch. The workshop was designed to increase the participants' vocabulary knowledge and reading comprehension skills in non-fiction texts, as well as increase their knowledge about computer animation, programming, and game designing.

3.1.4.4. Recruitment

The study investigated participants from a specific community (Bangladesh) living in the US, who are elementary school age English learners. Participants were recruited from mailing lists of Bangladesh student associations at a major US research university. Parents received a study invitation and the informed parental consent form via Email.

3.1.4.5. Instructors

There were two doctoral students on hand during the workshops, one male and one female. The female instructor was a doctoral student in English as a Second Language (ESL) education and had five years of teaching experience. The major purpose of this study was to look at the learners' language learning experience during the DGBLL program using Scratch. As the primary researcher's background was not in computer science or programming language, the researcher included another doctoral student from computer science and engineering as a Scratch troubleshooter and programming mentor for the students (the male doctoral student). He also assisted in reviewing the students' created artifacts. Both of these instructors were proficient in Scratch programming and led the students through an introductory/review lesson of the software, creating different pages and levels in the game, and building documentation features of the game. Also, both the researcher and the Scratch mentor provided feedback on the non-fiction content present within the games and how well the students themselves were able to explain and understand the non-fiction concepts they studied. The doctoral student from computer science and engineering was also proficient in Adobe Illustrator. He led a lesson on creating sprites, which was an assortment of various character images, ranging from people to animals to alphabet letters stored within the Scratch website; users could click on these sprites and import them into their projects. He also demonstrated how to incorporate readily available images online to students' artifacts. Using the help of a Scratch mentor is similar to utilizing an interpretive community (Fish, 1980), which refers to a group that shares strategies and influences the shape of what was being read and interpreted instead of only relying on textbook-based definitions. With the help of the Scratch mentor, the researcher would be able to get scientific interpretation of the non-fiction texts as well as get insights about how to incorporate Scratch programming into the DGBLL curriculum to better meet the needs of the students.

3.1.4.6. Research Questions for study 1

The research questions for this study were as follows

1. What were the gains of the participants in terms of vocabulary and reading comprehension performance from the pre to posttest?
2. What was the learners' experience in the program?
    a. How were game-based learning experiences, language learning experiences, and affective experiences related?

   b. What were the leverage points in networks of relationships regarding aspects of learner experiences which can be used to design DGBLL experiences in the future?
   c. How were learner experiences related to aspects of learning theory in which the program was grounded, and what does this tell us about how different aspects of constructionist theory are related to different aspects of dual coding theory and/or motivation theory?
3. What were the strengths and weaknesses of the program, based on learners' experiences?
   a. How were the strengths and weaknesses of the DGBLL program related?
   b. What were the leverage points which could be used to address weaknesses?

3.1.5. Measures for Article 2

This was a convergent mixed methods case study based on an eight-week game-designing and language learning workshop. Measures for this study included game-design journals, pre and post vocabulary and reading comprehension tests, semi-structured interviews, and pre- and post- workshop surveys which are described in the data collection section below.

3.1.5.1. Data Collection

According to Maxwell (2005), data triangulation is a strategy for validity testing. Triangulation refers to the collection of information of various types from different sources to gain a better understanding of the explanations and interpretations of the collected data (Fielding & Fielding, 1986). This research study used multiple data sources to collect data to gain an understanding of learners' experiences and strategies as they make their digital games. This included the students' game-design journals, pre- and post- surveys, student interviews, and games that students created. Data collection took place over eight weeks of the game-design workshop.

3.1.5.1.1. Game Design Journals

Each student received a game design journal in each lesson in Google slides where they could note new vocabulary, facts from reading, or brainstorm their game-design ideas. Game design journals might be helpful to the students for thinking through their ideas, collecting their data, and observing the progression of their ideas (Khalili, 2014). Students were not required to take notes, nor were they given any specific prompts to write about in their journals; rather, the journals were available to them to use as needed. The journals were primarily used for brainstorming and note taking. The game design journal prompt is added in Appendix B.

3.1.5.1.2. Pre and Post Vocabulary and Reading Comprehension Assessment

The reading comprehension tests were aligned to the lexile band of 2nd graders (420L-650L). Common core lexile bands were designed to ensure that students comprehend texts of increasing complexity as they moved through each grade level (Total Reader, n.d.). The lexile bands communicated what was expected of students in each grade level and helped to ensure that students would be college and career ready when they graduate high school. There were also researcher-designed pre- and post-vocabulary tests to measure vocabulary achievement. Fifty percent of the questions were the same on the pre- and post-tests, and the other fifty percent were new questions grounded in the contextual learning during the DGBLL workshop. The vocabulary tests included targeted vocabulary included in the intervention regarding the non-fiction concepts (e.g., authors' purpose, context clues, using diagrams to clarify a text).

Non-standardized assessments were used in pretesting and posttesting for various reasons. First of all, standardized assessments are designed to measure growth over a year or more. Therefore, the effects of an eight-week long workshop may not be reflected on standardized tests. Second, the researcher wanted to see the impact of the DGBLL workshop on the acquisition of specific vocabulary words and non-fiction concepts. This was the reason why the researcher used non-standardized, researcher-designed pre-tests and post-tests. However, to minimize the concern regarding the reliability of the tests, the researcher calculated the reliability coefficients for the pre- and post-tests using Cronbach's alpha. The reliability coefficients for the vocabulary development and reading comprehension for pretests are 0.68 and 0.63. The reliability coefficients for the vocabulary development and reading comprehension for post tests are 0.72 and 0.83. According to Nunnally (1978), if the coefficients were over 0.6, the tests were acceptable, and if the coefficients were over 0.7, the test items are highly reliable. Therefore, the coefficients indicate high reliability of the test items (Nunnally, 1978). All the pre-tests and post-tests are included in appendix A.

3.1.5.1.3. Semi-Structured Interviews

At the end of the workshop, students participated in semi-structured interviews. These interviews were conducted in Zoom, with only audio being recorded for transcription. These interviews were conducted to understand the overall experience of the learners. Maxwell (2005) states that verbatim transcripts are a must if researchers want to collect detailed and enriched data to test validity for the research questions. Therefore, all the interviews with the students were audio recorded and then transcribed verbatim. Finally, during the interviews, the researchers used a semi-structured interview protocol to guide their questions to the students. The interview protocol is added in Appendix B.

3.1.5.1.4. Pre- and Post-workshop Surveys

The students were given a pre- and a post-workshop survey. The pre-workshop survey included 5-point Likert scale (1 being “not at all" and 5 being “definitely”) sentences regarding the students’ technology proficiency and attitudes regarding the game designing and playing (See Appendix A). These survey instruments were a modified version of the TOSRA: Test of Science Related Attitudes (Fraser, 1981). This assessment is widely used in the STEM research and has been recognized as a valid instrument (Fraser, 1979; Khalili, 2014). The reason for using it was because this study attempted to explore the students’ attitudes towards the technology of game designing.

3.1.5.2. Data Analysis

This was a convergent mixed-methods case study. In a convergent mixed-methods research design, both qualitative and quantitative data were collected more or less simultaneously, and both data sets are analyzed and compared to understand the research problem (Creswell, 2008; Merriam, 2016). A case-study is an in-depth description and analysis of a bounded system (Merriam, 2016). Yin (2014) observes that case study is particularly useful when it is difficult to separate a phenomenon's variables from their contexts. The argument for using a mixed methods research design was that combining both quantitative and qualitative methods would provide a more complete look at the research problem than any one single method, especially since each method had some limitations (Creswell, 2008; Greene, 2007). According to Reichardt and Cook (1979), mixed methods provide opportunities to use the most appropriate methods to be used in the research design. This method not only allows researchers to mix both qualitative and quantitative processes, but also combines the various approaches of research at multiple levels, such as methodology, philosophy, theoretical backgrounds, and values, and acknowledges the fact that multitude forms of knowledge exist in the real world (Greene, 2007). According to Grene (2007), mixed-methods study is a way of thinking which engages dialogue between this diversity in order to gain a better understanding of the social inquiry at hand. These different analytical approaches will allow for methodological triangulation (Maxwell, 2005).

In this study, data were analyzed using both quantitative and qualitative research methods. The pre- and post-workshop vocabulary and reading comprehension assessments were analyzed quantitatively using paired *t*-test statistical analysis to determine how the participation in the study impacts the learners' vocabulary and reading comprehension performance from pre- to post-test. This was done using STATA.

For qualitative data coding, researchers used the MAXQDA Analytics Pro qualitative analysis software. The unit of analysis (Creswell, 2016) was the network representing the relationships among codes found from coding of all qualitative data, and because this was network analysis, the unit of observation (Lavrakas, 2008) was a dyad consisting of two nodes (codes) and their relationship (Hanneman & Riddle, 2005; Wäsche et al., 2017). Each node represents a code which consists of a sentence. Each sentence was coded according to multiple codes in the codebook when appropriate. All the qualitative data were coded in-vivo for emergent codes (Corbin & Strauss, 2015). Moreover, coding was conducted according to *a priori* categories based on the theories in which this study is grounded (Thornberg, 2012).

The next step was to conduct axial coding, which is a process of analyzing codes in terms of relationships among codes (Corbin & Strauss, 2015). Axial coding was conducted in MAXQDA Analytics Pro to relate the data together to reveal relationships between codes, which was organized according to categories and subcategories (Kuckartz & Rädiker, 2019). The initial codebook included a category for theory with sub-categories related to motivation theory, constructionist theory, and dual coding theory, as well as categories for game-based learning experience, affective experience, language learning experience in terms of vocabulary development and reading comprehension, and research design strengths and challenges as perceived by the learners. The initial codebook is included in the Appendix D (Figure D1).

Then the researcher cleaned the codebook, deleting the codes that occurred only once since they cannot be used in a pattern (Donaldson, 2019). The researcher also merged codes if they were two versions of the same idea - to avoid redundancy (Kuckartz & Rädiker, 2019). If a code occurred too many times, the researcher split the code in multiple codes to provide greater depth of understanding (Kuckartz & Rädiker, 2019). After this, the researcher ended with 57 codes.

MAXQDA was used to code, organize, and structure data (Chi, 1997). The researcher negotiated the codes, categories, and subcategories with an expert regularly to minimize the coder's bias. However, there might still be a concern about whether a single data collector can "interpret the same data and record exactly the same value for the same variable each time these data are collected?" (McHugh, 2012, p. 277). To respond to this concern, the researcher conducted an intra-rater reliability test (Brennan & Prediger, 1981) where 20% of the data was coded twice by the researcher. For this reliability test, the coder coded 20% of the transcripts and made a copy of the project file. Then, the researcher stripped all the codes from the copied file, leaving the coding categories intact. After that, the researcher coded those transcripts again from scratch and ran an intra-rater reliability test in MAXQDA (Kuckartz & Rädiker, 2019) to determine Kappa values (Brennan & Prediger, 1981). These Kappa values indicated the degree to which the first round of coding matches the second round. Using the scale for strength of agreement developed by Landis and Koch (1977), Kappa values (less than 0=poor; .01-.20=slight; .21-.40=fair; .41-.60=moderate; .61-.80=substantial; .80-1=nearly perfect) determined whether to proceed to the next step. The researcher ran the intra-rater reliability test and found the Kappa value to be 0.64 indicating substantial reliability of the coder (Brennan & Prediger, 1981).

To answer research questions 2 and 3, the researcher conducted semantic network analysis (Donaldson & Allen-Handy, 2020). Semantic network analysis is the use of network analytic techniques on multiple paired associations based on their linguistic connections and semantic proximity within the cognitive schema (Doerfel, 1998; Krippendorff, 2004). Taken together, these associations represent the meaning inherent in the data. (e.g., Doerfel, 1998; Donaldson & Allen-Handy, 2020).

The first step of semantic network analysis was to calculate the code co-occurrence correlations for all pairs of codes within each category, as well as pairs across multiple categories. It is important to note that the unit of analysis is a semantic network which consisted of all significantly correlated nodes, and the unit of observation in semantic network analysis is a node (Krippendorff, 2004) which in this study is a code (not a coded segment). Each code consists of multiple coded segments.

Correlations were calculated using Pearson Product-Moment Correlation (Freedman et al., 2007) in MAXQDA Analytics Pro to identify significant correlations between each code and other codes within each coding category. These correlations indicated how likely a code is to appear within proximity of another code. These correlations were exported as symmetrical correlation matrices in MS Excel format constructed at the $p<0.05$, $p<0.01$, and $p<0.001$ confidence levels. After creating correlation matrices, the next step was to use the results of these correlation matrices to make semantic network maps. The researcher used UCINET/NetDraw network analysis software to analyze the relationships among categories (Corbin & Strauss, 2015). These maps visually expressed the multiple networked connections in the correlated data, and then each map was analyzed to determine which patterns were meaningful from a theoretical perspective (Corbin & Strauss, 2015). The researcher also used the Girvan-

Newman algorithm to apply cluster analysis to the semantic network maps (Girvan & Newman, 2002). Cluster analysis indicated the property of two vertices that are both neighbors of the same third vertex having a heightened probability of also being neighbors of one another. In other words, it was analogous to two friends of a person having a heightened probability of knowing each other than two people chosen at random from a population, considering the common acquaintance with that person.

To answer the second research question, clustered semantic network maps of learner experiences in terms of affect, game-based learning, and language learning were used to identify how various aspects of learners' experiences were related. After that, betweenness measures of centrality were used to identify leverage points (Freeman, 1977). Betweenness measures of centrality was defined as the number of shortest paths that run through a vertex/node in a network map. These measures of centrality identified leverage points which indicated the places to intervene in a network map where a relatively small change in one part of a system can lead to relatively big changes in the whole system (Lam et al., 2021; Meadows 1999). Leverage points could be used to design more powerful DGBLL experiences in the future.

Finally, to answer the third research question, clustered semantic network maps of strengths and weaknesses of the design were used to identify the relationships between design strengths and weaknesses. Betweenness centrality measures were calculated in NetDraw, and node (code) sizes will indicate the level of betweenness. Nodes with higher betweenness centrality measures helped to identify leverage points by which particular strengths can be used to address weaknesses. Clustered semantic network maps of student experiences in relation to elements of the theories in which the program was grounded were used to determine the relationships between elements within each theory and elements across theories. Betweenness measures in these semantic network maps were used to identify leverage points in each theory which could provide insights to strengthen the other theories.

3.2. Findings and Discussion

3.2.1. Quantitative Findings

To answer the research question 1, "*What are the gains of the participants in terms of vocabulary and reading comprehension performance from the pre to post test?,"* the researcher started by identifying the null and research hypothesis. The null hypothesis is that there is no difference in vocabulary performance scores between the pre and post vocabulary test, while the research hypothesis is that there will be a difference in vocabulary performance scores between the pre and post tests, in favor of the post-test scores.

Since this study is using the same subjects before and after the workshop, the researcher first planned to use a paired sample t-test. However, the researcher wanted to make sure all assumptions were met in the vocabulary data. The researcher wanted to test if the sample scores were normally distributed. Since this study includes a small sample, a Shapiro-Wilks test was conducted to see if the data were normally distributed (see Appendix E: Figure E1). The Shapiro-Wilks test shows that the pre and posttest vocabulary scores were normally distributed with a p-value of 0.18 and 0.16 ($p>0.05$).

As the test scores met the assumption of normality, the researcher ran the paired sample t-test on the pre and pre and post vocabulary test scores (See Appendix E: Figure E2. Looking at the means, it is evident that the post mean score (3.35) is higher than the pre mean score 2.08). It means that the students had a gain in their post vocabulary scores compared to their pre vocabulary scores. The mean difference is 1.28 with a standard deviation of 1.08. The obtained t-value is 4.25 and the p-value includes 0.001 ($p<0.05$). Therefore, the null hypothesis is rejected and the research hypothesis is accepted. It means that there is a statistically significant gain between the two mean scores of 1.28 (95% CI, 0.62 to 1.93), $t(12) = 4.25$, $p<0.05$

Similar to the vocabulary performance score, the researcher also wanted to see whether there was any significant difference in the reading comprehension score from pre to post test. The researcher ran the Shapiro-Wilks test to check the normality assumption (see Appendix E: Figure E3). Shapiro-Wilks test displays that the pre-test was normally distributed with a p-value of 0.98 ($p>0.05$) for the pretest and 0.99 for the post test.

Since the test scores met the assumption of normality, the researcher ran the paired sample t-test on the pre and pre and post reading comprehension mean scores. Looking at the means, it can be seen that the post mean score (3.28) is higher than the pre mean score (2.24). It means that the students had a gain in their post vocabulary scores compared to their pre vocabulary scores (See Appendix E: Figure E4). The mean difference is 1.03 with a standard deviation of 0.81. The obtained t-value is 4.58 and the p-value is 0.0006 ($p<0.05$). Therefore, the researcher rejects the null hypothesis and accepts the research hypothesis. It means that there is a statistically significant gain between the two mean scores of 1.03 (95% CI, 0.54 to 1.53), t(12) = 4.58, $p<0.05$.

Moreover, the researcher looked at participants' individual mean scores from pre to post test. Overall all the students had vocabulary gains (Figure 3.2) except for one student (Student 1).

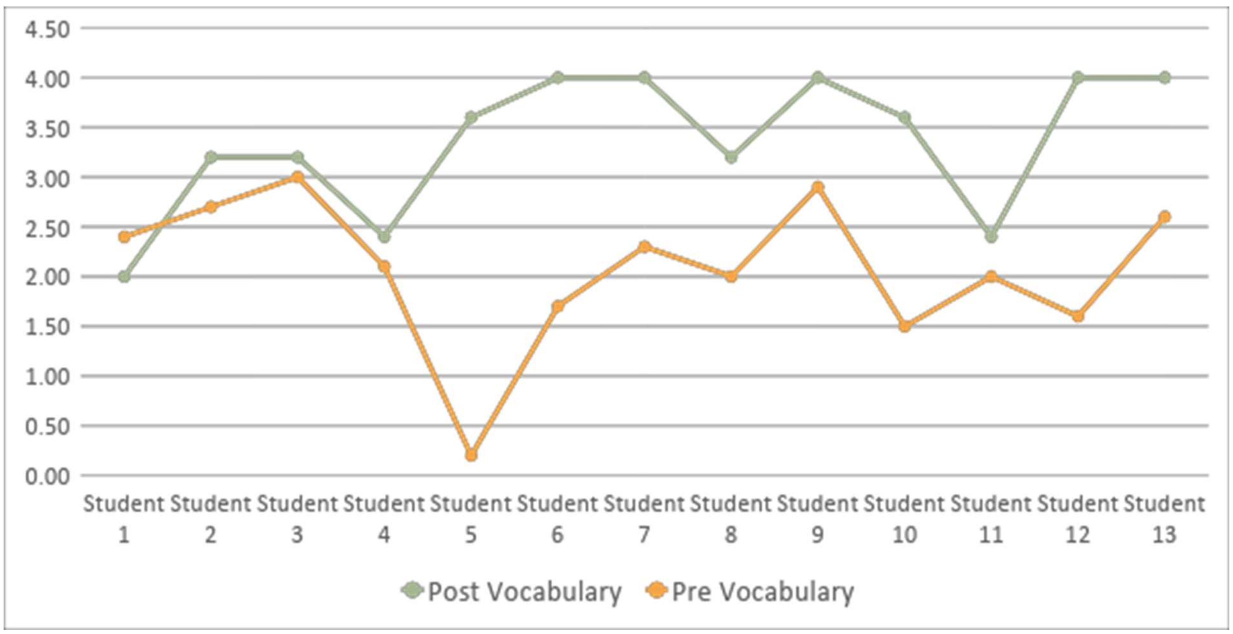

Figure 3.2 Vocabulary Scores by Student

Looking at the reading comprehension mean scores from pre to post test, the researcher found that overall, all the students made progress except for students 1 and 3 (Figure 3.3).

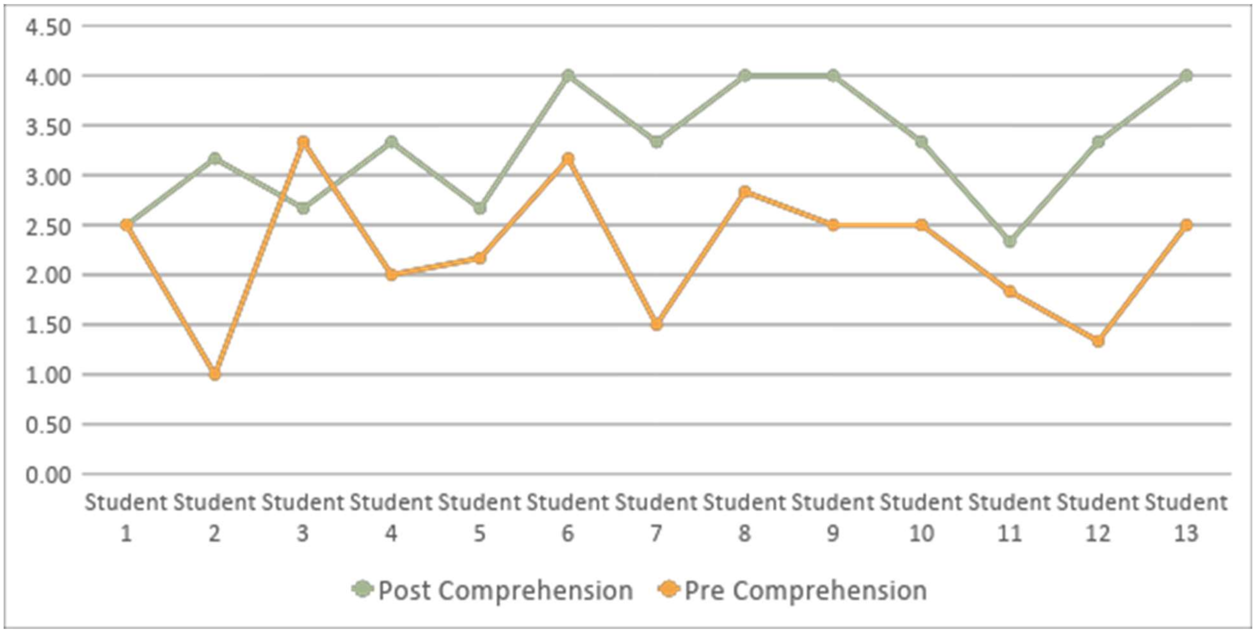

Figure 3.3 Reading Comprehension Scores by Student

To find out more about the gains of students' performance from the pre to post test, the researcher looked at the understanding level of the students based on the students' responses to the test items. The responses of the students were scored based on the continuous variables of "complete understanding," "almost understanding," "incomplete/vague understanding," and "misunderstanding." In the case of vocabulary pre and post tests, it was found that there was an increase of "complete understanding" (28.2% to 65%), and a decrease in "almost understanding" (65.5% to 7.5%), "incomplete/vague understanding" (58.3% to 15%), and "misunderstanding" (40% to 6.67%; see Appendix E: Figure E5). Similar to the vocabulary tests, in the case of reading comprehension pre and post tests, it was found that there were an increase of "complete understanding" (22% to 78%), and a decrease in "almost understanding" (85.5% to 14.4%), "incomplete/vague understanding" (69.4% to 13.9%) and "misunderstanding" (50% to 0%; see Appendix E: Figure E6). Last but not least, looking at the mean scores of the repeated test items in the vocabulary tests, it was found that there was a gain in the mean scores from the pre to post test (Figure 3.4). Similar to the vocabulary test, in the reading comprehension test items, there were gains in the mean scores from the pre to post tests (Figure 3.5) for the same concepts. All the mean score differences for the repeated vocabulary items came out to be statistically significant (Appendix E: Figure E10). All the mean scores differences for the same concept items in the reading comprehension pre and posttest came out to be statistically significant as well (Appendix E: Figure E11).

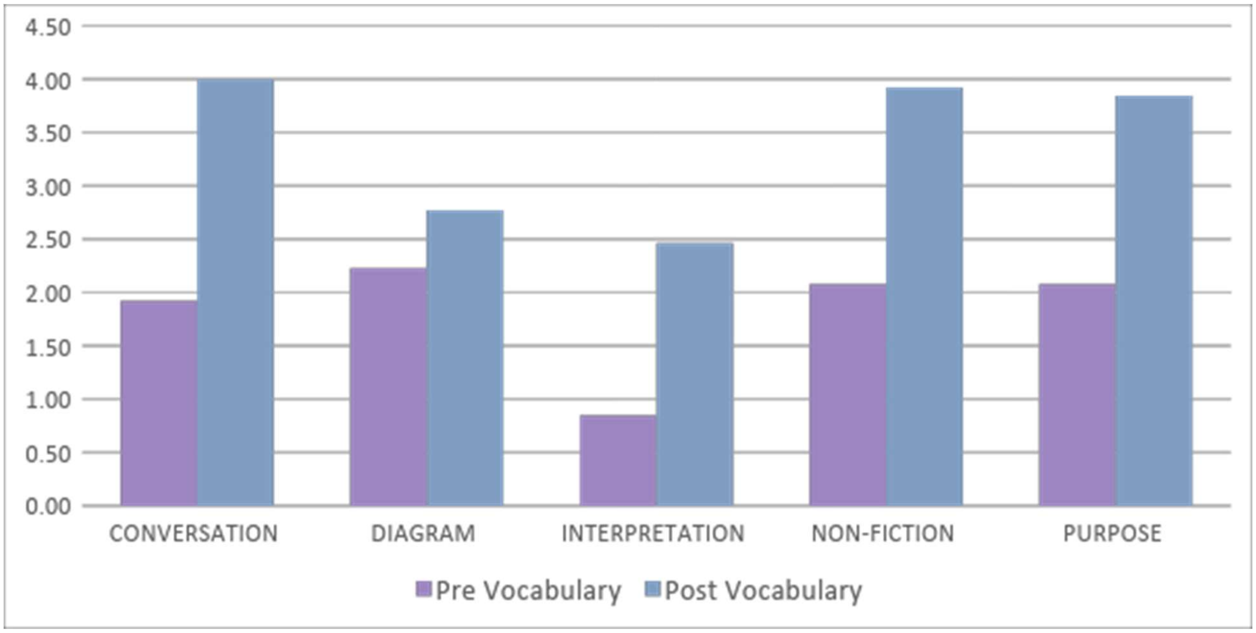

Figure 3.4 Pre and Post Vocabulary Items (Repeated)

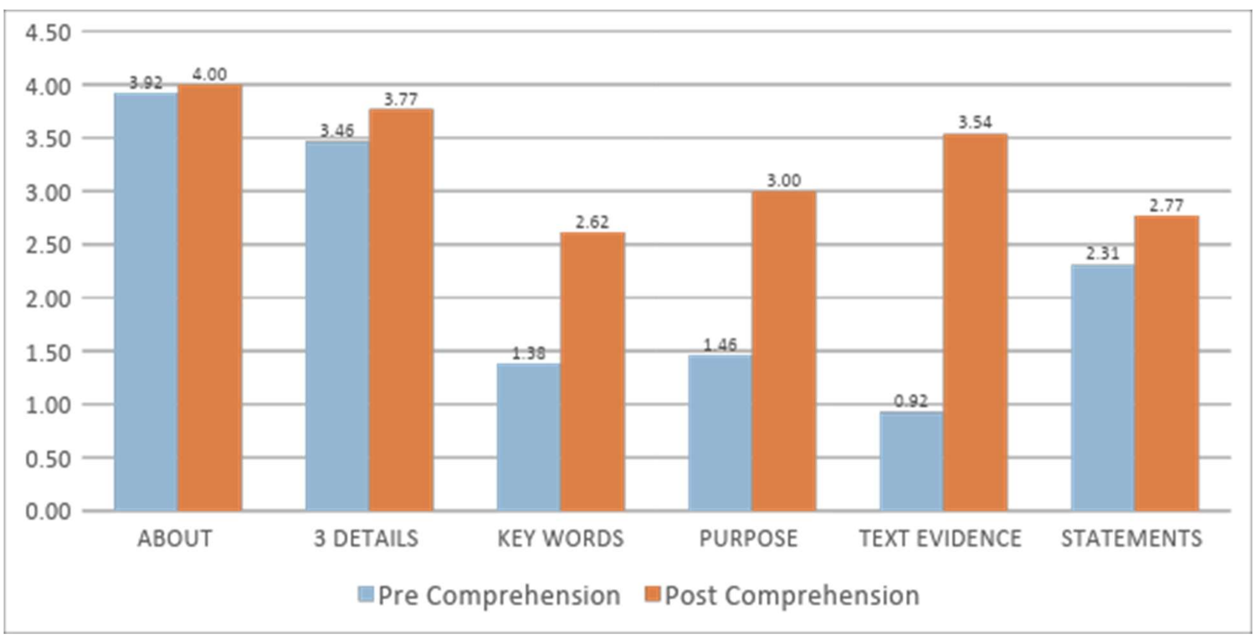

Figure 3.5 Pre and Post Comprehension Items

3.2.2. Discussion of Gains from Pretest to Posttest

There were statistically significant gains from pre to post tests in both cases of vocabulary development and reading comprehension. From the Cronbach's alpha coefficients, the researcher also found that the assessment items have medium to high reliability. The students' responses in the pre- and post-tests in both the vocabulary and reading comprehension show that there is an increase in the "complete understanding" and a decrease in the "almost understanding," "incomplete/vague understanding," and "misunderstanding." Moreover, there was a gain in the mean scores of the repeated test items in the pre and post vocabulary and reading comprehension tests. Since the researcher did not have a control group for this study, these gains cannot be attributed solely to the DGBLL workshop. However, several aspects of workshop such as making a digital game (Papert & Harel, 1991), learners' agency (Papert, 1999), authentic audience (Glazer, 2015), tinkering (Resnick & Rosenbaum, 2013), or intrinsic motivation (Deci & Ryan, 1985) may have contributed to this gain.

3.2.3. Qualitative Findings

The researcher analyzed the qualitative data using semantic network analysis using MAXQDA Analytics Pro and UCINET/NetDraw softwares to explore the learners' experiences and the strengths and weaknesses of the DGBLL workshop. The first phase was conducted in MAXQDA, starting with in-vivo coding for emergent codes (Corbin & Strauss, 2015) and coding according to *a priori* categories based on theories (Thornberg, 2012). This resulted in the initial codebook. After cleaning the codebook, the data were coded again and the intra-rater reliability test was calculated. The Kappa value was found to be 0.64 indicating substantial reliability (Brennan & Prediger, 1981).

To answer the second and third research questions, in the second phase the researcher conducted axial coding using Pearson's correlations, semantic network maps, and cluster analysis. In the first step the researcher ran Pearson's correlations for all pairs of codes within each category as well as across multiple categories. Then, to conduct the semantic network analysis, the researcher input the correlation matrices in the UCINET/NetDraw software to analyze and visualize the multiple networked connections among the correlated data through the semantic network maps (Doerfel, 1998; Krippendorff, 2004) and cluster analysis using the Girvan-Newman algorithm (Girvan & Newman, 2002). These clusters represent the codes that appear to be connected together based on their strong associations. They were also often found to be discussed together by multiple participants. Using the betweenness of centrality measures, the researcher also identified leverage points when necessary. A leverage point identifies a code which is so important in a network map that if it changes, it may affect the whole network (Lam et al., 2021; Meadows 1999).

3.2.3.1. Findings for Research Question 2

To answer the research question 2a "*How are game-based learning experiences, language learning experiences, and affective experiences related?*" a three-cluster semantic network map (Q= 0.23) was generated using the categories "game-based learning experience" (GBL), "language learning experience" (LL), and "affective experience" (AFF) using the Girvan-Newman algorithm (Girvan & Newman, 2002) in the analysis software. The network map was created using the correlation matrix at the *p*<0.001 confidence level (Figure 3.6). The clusters are described below with their zoomed-in images with labels.

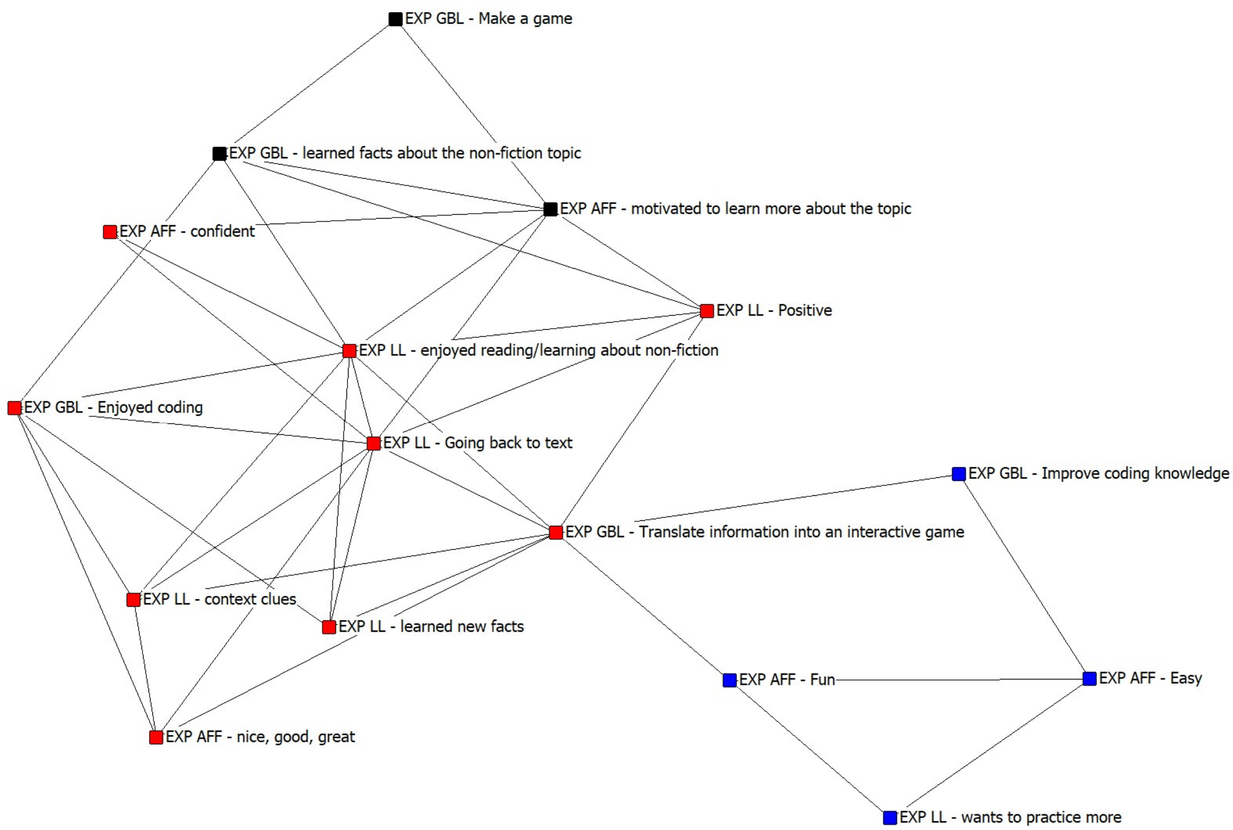

Figure 3.6 GBL vs LL vs AFF

The ***reading-application*** cluster (red cluster in Figure 3.7) includes the LL experiences codes of *enjoyed reading/learning about nonfiction, positive, going back to text, learned new facts*, and *context clues,* related to students' AFF experience code of *confident.* This cluster also includes GBL experience codes of *enjoyed coding* and *translate information into an interactive game.*

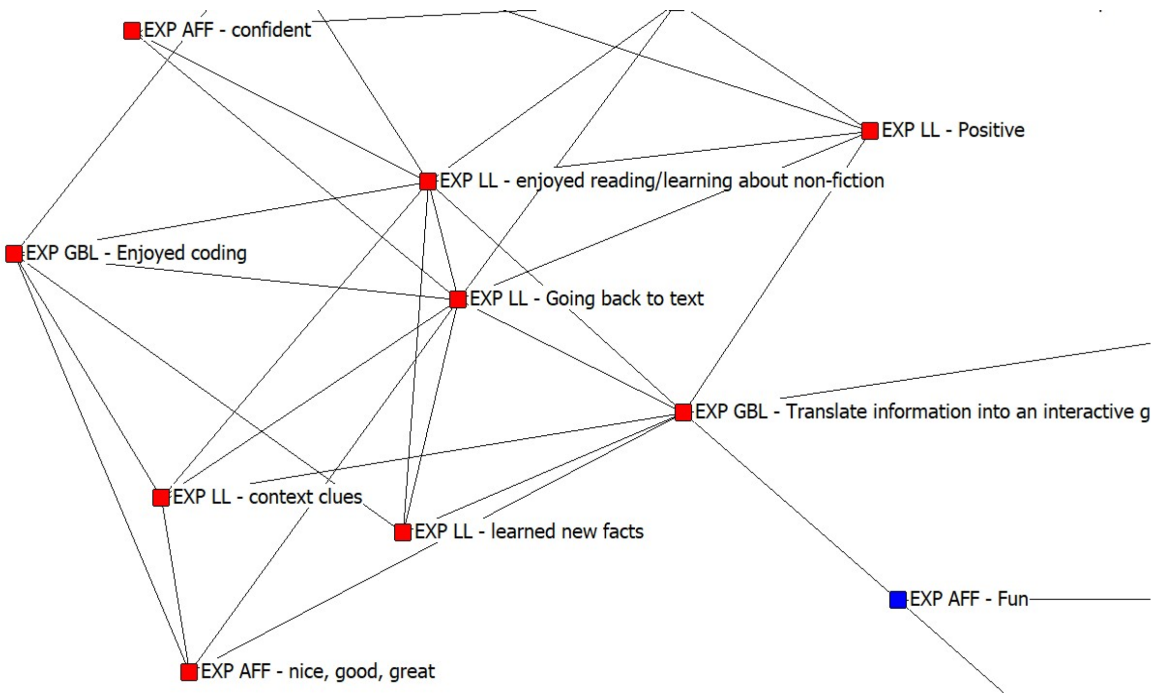

Figure 3.7 Reading-Application Cluster

The ***fun-coding*** cluster (blue cluster in Figure 3.8) includes the AFF codes of *fun* and *easy,* as well as a GBL code of *improve coding knowledge* and *wants to practice more*.

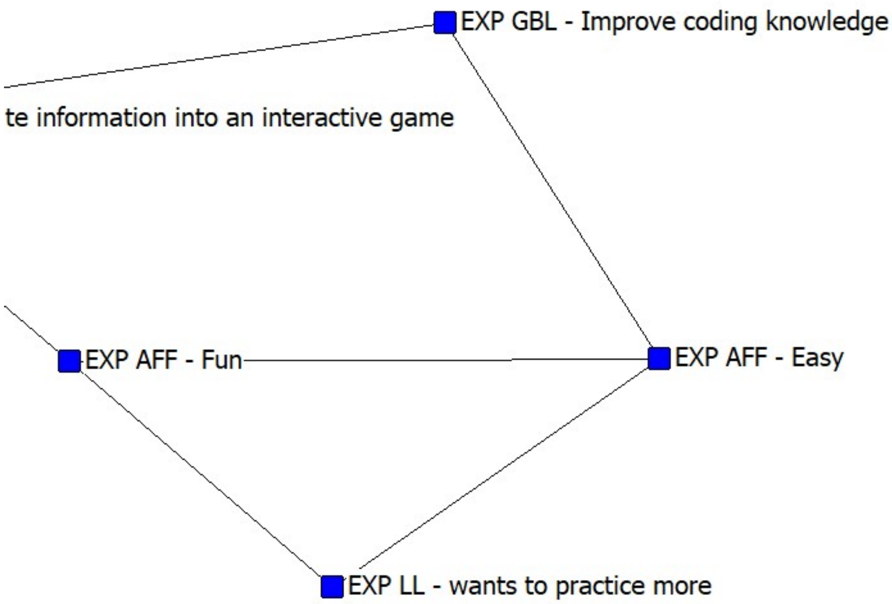

Figure 3.8 Fun-Coding Cluster

The ***game-making-learning*** cluster (black cluster in Figure 3.9) in black includes two GBL experiences of *making a game* and *learned facts about the non-fiction topic*, and an affective experience—*motivated to learn more about the topic*.

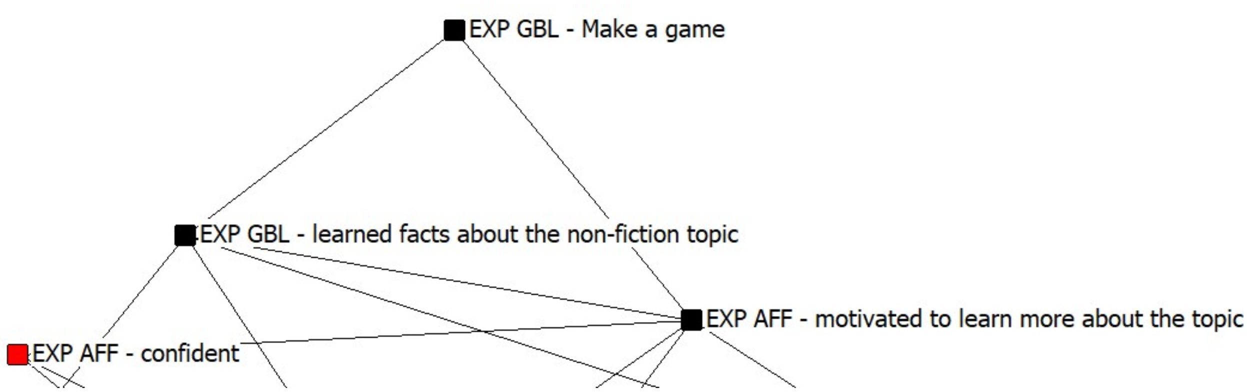

Figure 3.9 Game-Making-Learning Cluster

To answer the question 2b, "*What are the leverage points in networks of relationships regarding aspects of learner experiences which can be used to design DGBLL experiences in the future?*," the researcher calculated the betweenness measures of centrality of nodes within the categories of GBL, LL, and AFF (see Appendix E: Figure E7) to see which nodes hold the most importance in the network map in terms of connecting two or more other nodes. The most prominent leverage point was found to be the GBL experience code of *translate information into an interactive game* (the largest node in Figure 3.10 - betweenness centrality value 46.5). Some other leverage points are LL experience codes of *going back to text* (betweenness value 14.67) and *enjoyed reading/learning about nonfiction* (betweenness value 16.83) and the AFF code of *fun* (betweenness value 18.00).

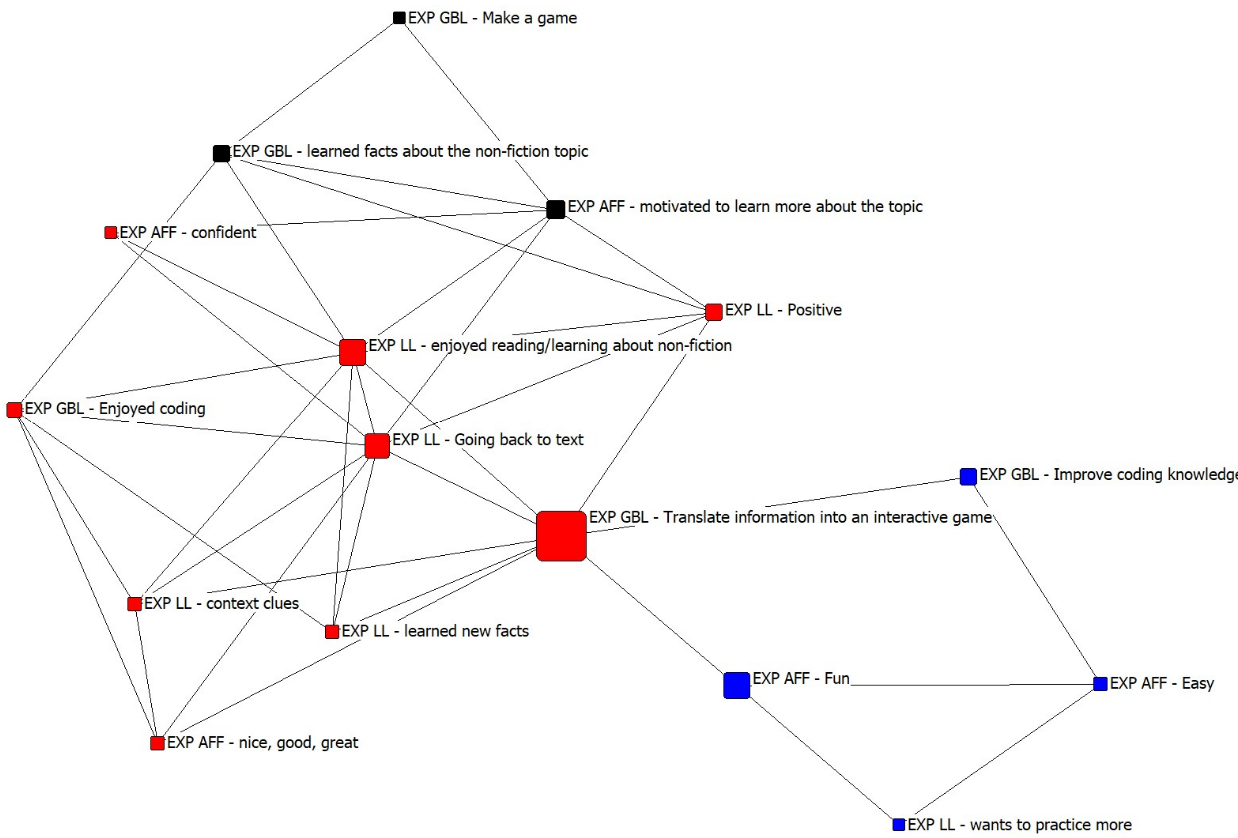

Figure 3.10 Learners' Experience - GBL vs LL vs AFF (Leverage Points)

To answer the research question 2c, "*How are learner experiences related to aspects of learning theories in which the program was grounded, and what does this tell us about how different aspects of constructionist theory are related to different aspects of dual coding theory and/or motivation theory?*" a three-clustered semantic network map was generated in the analysis software using the codes for the categories "constructionist theory," "dual-coding theory," and "motivation theory" (Figure 3.11). Using the Girvan-Newman algorithm (Girvan & Newman, 2002), the researcher identified a three-cluster semantic map (Q = 0.22) using the correlation matrix at the

$p<0.001$ level. All the clusters with their zoomed-in images with labels are described below.

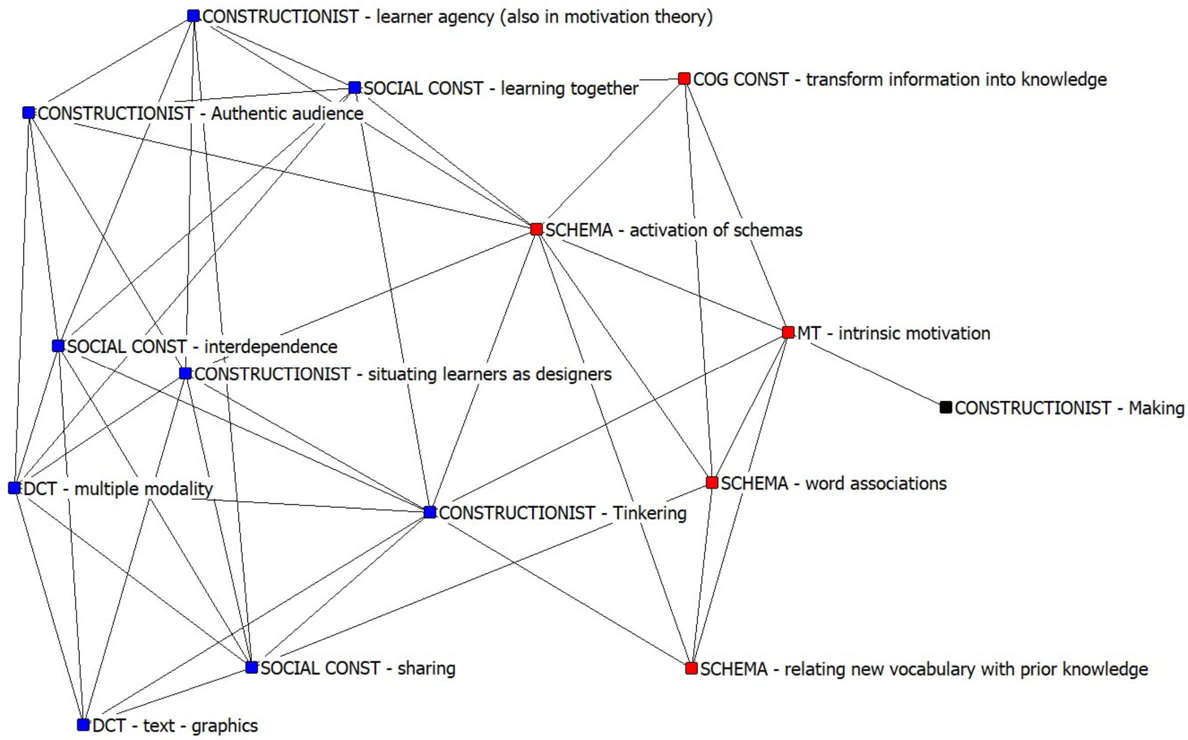

Figure 3.11 Learning Theories

The ***construction-together*** cluster (blue cluster in Figure 3.12) includes codes of *learner agency, authentic audience, situating learners as designers,* and *tinkering* from the constructionist theory, codes of *learning together, interdependence,* and *sharing* from constructivist theory, and codes from dual coding theory including *multiple modality* and *text-graphics.*

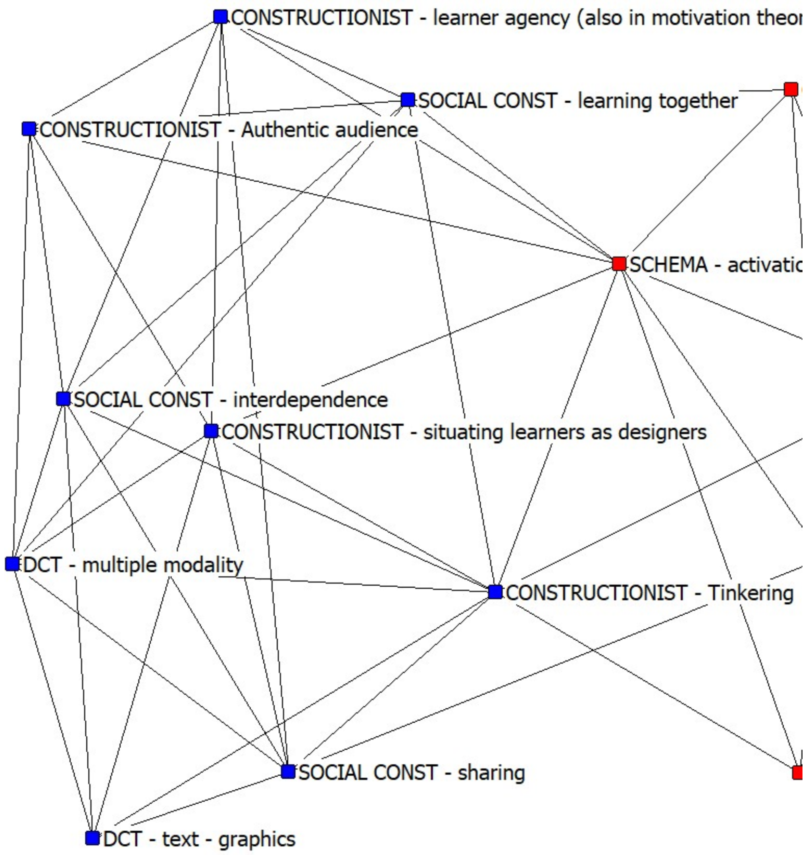

Figure 3.12 Construction Together Cluster

The ***schema-construction*** cluster (red cluster in Figure 3.13) includes the schema theory codes of *activation of schemas, relating new vocabulary with prior knowledge,* and *word associations,* the cognitive constructivist code of *transform information into knowledge,* and *intrinsic motivation* from motivation theory. The black node (Figure 3.13) represents one code of *making* from constructionist theory (according to Girvan-Newman analysis [Girvan & Newman, 2002], it is "clustered" on its own, but has a significant relationship to the red cluster).

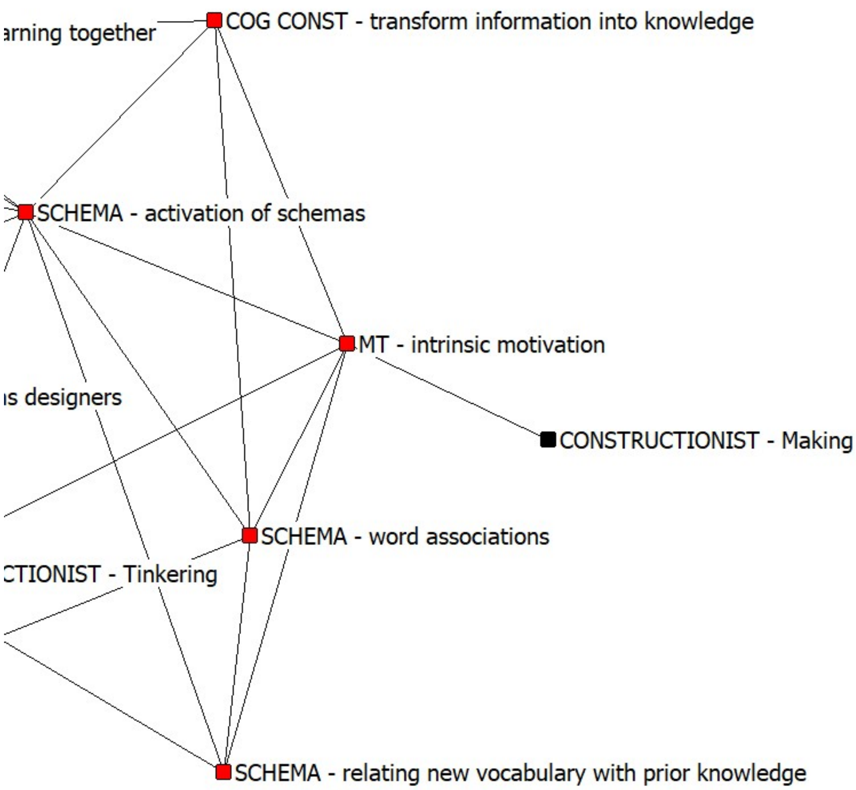

Figure 3.13 Schema-Construction Cluster

The researcher also ran the betweenness measures of centrality (Figure 3.14) and re-sized the nodes by betweenness (see Appendix E: Figure E8) to discover the leverage points among the learning theories and found three leverage points. These include the constructionist theory code of *tinkering* (the largest blue node in Figure 3.14- betweenness centrality measure of 15.80), the motivation theory code of *intrinsic motivation* (large node on the right side of the red cluster - betweenness value 14.06), and the schema theory code of *activation of schemas* (large red node in the center of the map - betweenness value 14.97).

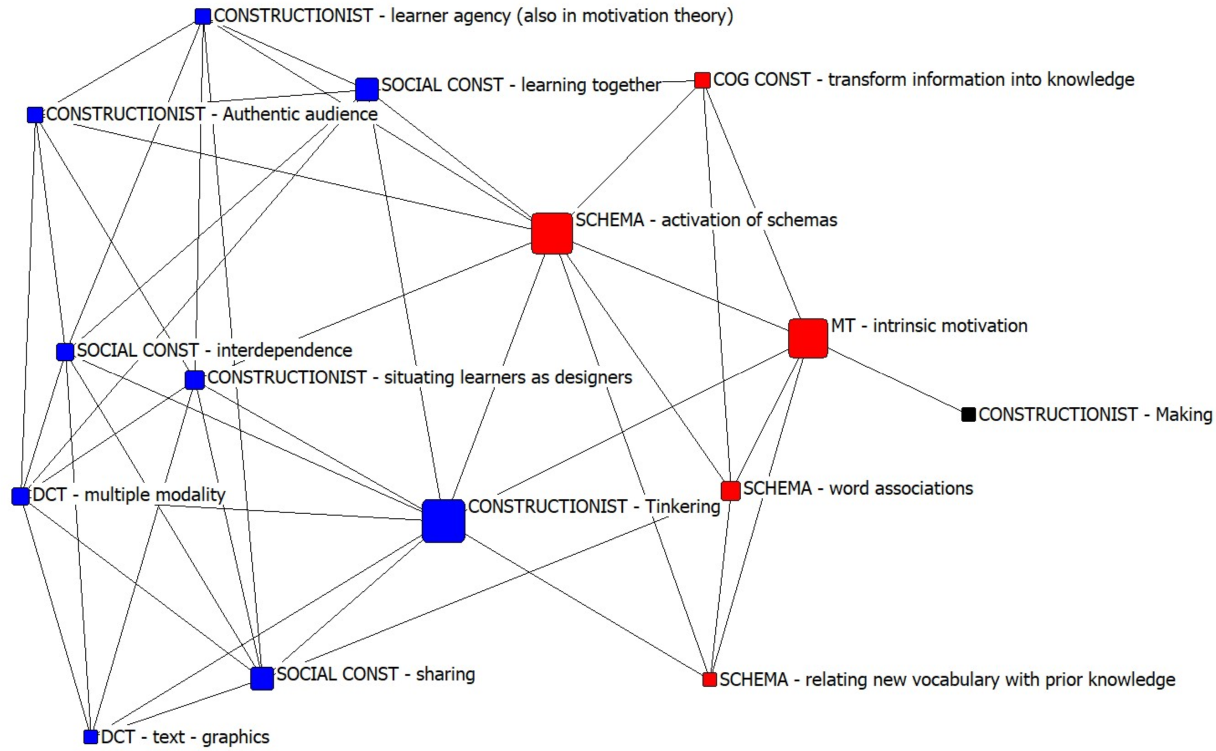

Figure 3.14 Learning Theories (Leverage Points)

3.2.3.2. Discussion of Findings for Research Question 2

Findings related to research questions 2a and 2b display the interconnection among the learners' experiences in terms of game-based learning, language learning, and students' affective experiences (Figure 3.6). The ***reading-application*** cluster (red cluster in Figure 3.7) shows us that the students have *enjoyed reading/learning about non-fiction texts, learned new facts,* and went *back to texts* and these language learning experiences have helped them to apply their knowledge as they *translate information into an interactive game.* Moreover, they feel *confident,* and *nice, good, great* about this experience overall. This aligns with the affordance of providing space for sheltered vocabulary learning where the DGBLL experience has helped the ELLs to apply their knowledge in a low-anxiety environment with the students feeling *positive* and *confident* (Pu and Zhong, 2018; Rahmi, 2018).

The ***fun-coding*** cluster (blue cluster in Figure 3.8) displays that the students have a *fun* and *easy* experience in the game-based learning environment. They want to *improve their coding knowledge* and they *want to practice more.* This aligns with the concept of intrinsic motivation where the learner is self-regulated and motivated to practice for their own skill development due to the affective reasons such as interest or enjoyment (Deci & Ryan, 1985). The ***game-making-learning*** cluster (black cluster in Figure 3.9) reinforces this idea of intrinsic motivation as the students mention that they are *motivated to learn more about the non-fiction topic.*

Findings from the research question 2b (Figure 3.10) shows the leverage points in the semantic map interconnecting game-based learning, language learning, and students' affective experience. One important point to note here is that the most important leverage point among the experiences is *translating information from the nonfiction text into an interactive game.* This leverage point allows us to assume that DGBLL experience may provide the unique affordance of contextualized language learning where the students use the language in a meaningful, goal-focused way (Ellis, 2003; Reinhardt, 2018). Contextualization is known to be one of the most effective methods of L2 vocabulary learning as it helps the learners to remember the vocabulary in semantically related groupings (Nation, 2001). This DGBLL experience also provided the students with space for sheltered use where the students progress through steps

(Reiser & Tabak, 2014; Vygotsky, 1978). For example, thinking about the leverage points from Figure 3.10 (*translating information from the nonfiction text, enjoyed reading/learning about non-fiction,* and *fun)* closely, it includes the whole cycle of the workshop where the students first read the non-fiction text, jotted down the facts from their reading along with newly learned vocabulary, designed their game around the facts, went back to the text if necessary, coded and built their game, and enjoyed the whole process. Therefore, if researchers want to design a more powerful DGBLL workshop in future, educators are well-advised to design generative learning experiences in which students translate information into knowledge by constructing meaningful representations in the DGBLL context. Furthermore, educators should design these learning experiences such that they include opportunities for reading. Finally, educators can leverage the affordance of DGBLL to facilitate positive affective experiences (fun) but must take care not to lose the fun, for instance by placing too much emphasis on the pedagogical goals and learning outcomes.

Findings related to research question 2c reveal that aspects of constructionist theory are closely related to aspects of the L2 vocabulary learning theories of social constructivist theory, schema theory, dual coding theory, and motivation theory. The ***construction-together*** cluster (blue cluster in Figure 3.12) shows that several aspects of constructionist theory—including focused tinkering, authentic audience, and situating learners as designers—are connected to aspects of interdependence and learning together from social constructivist theory. This aligns with the connection between the DGBLL and social constructivist theory of vocabulary learning as it emphasizes the DGBLL affordance of opportunities for collaboration (Reinhardt, 2018; Sykes et al., 2010). This affordance is based on the social-collaborative foundation of SLA which emphasizes aspects of collaboration, cooperation, empathy, and critical thinking (Hickey, Filsecker, & Kwon, 2010; Hickey & Filsecker, 2012). Moreover, in this cluster, the above-mentioned constructionist theory and constructivist theory are also connected with multiple modality and text-graphics connection of dual coding theory of vocabulary learning.

The ***schema-construction*** cluster (red cluster in Figure 3.13) shows that the code of *activation of schemas* is connected to the codes of *relating new vocabulary with prior knowledge,* and *word associations*. This aligns with the schema theory of vocabulary learning which contends that connecting new words with prior knowledge and making word associations helps the learners to activate their schema which in turn, results in their vocabulary learning (Chance, 1994; Rasinski et al., 2017). Even though the black node of *making* is not a cluster, it is an important node to create the dyad with the code of *intrinsic motivation.* Without this node, the semantic map becomes weak. This dyad suggests that the DGBLL context may have the potential for promoting intrinsic motivation.

Moreover, if we take the construction-together cluster (blue cluster in Figure 3.12) and the schema-construction cluster (red cluster in Figure 3.13), the blue cluster includes all the nodes that points to the active, external learning by making artifacts whereas the red cluster includes all the nodes that points to the internal, cognitive process of knowledge construction. This aligns with the feature of constructionist theory where the learners make artifacts (in this case, digital games) and these artifacts mirror the embodied cognition of learners' minds (Papert & Harel, 1991). This external and internal process simultaneously helps the learner with knowledge construction (in this case, vocabulary learning).

Furthermore, the three leverage points in Figure 3.14 also reveal that the DGBLL environment may provide opportunities for focused tinkering (Resnick & Rosenbaum, 2013) which helps the learners to immerse themselves in an "experimental, iterative style of engagement" (p. 164), promote intrinsic motivation (Deci & Ryan, 1985), and activate their schemas for vocabulary knowledge development (Anderson, 2004).

3.2.3.3. Findings for Research Question 3

To answer the research question 3a, "*How are the strengths and weaknesses of the DGBLL program related?,"* a clustered semantic network map was generated in the analysis software using the codes for the categories "design strengths" and "design challenges." Using the Girvan-Newman algorithm (Girvan & Newman, 2002), a three-cluster semantic map ($Q = 0.34$) was constructed using the correlation matrix at the $p<0.05$ level (Figure 3.15).

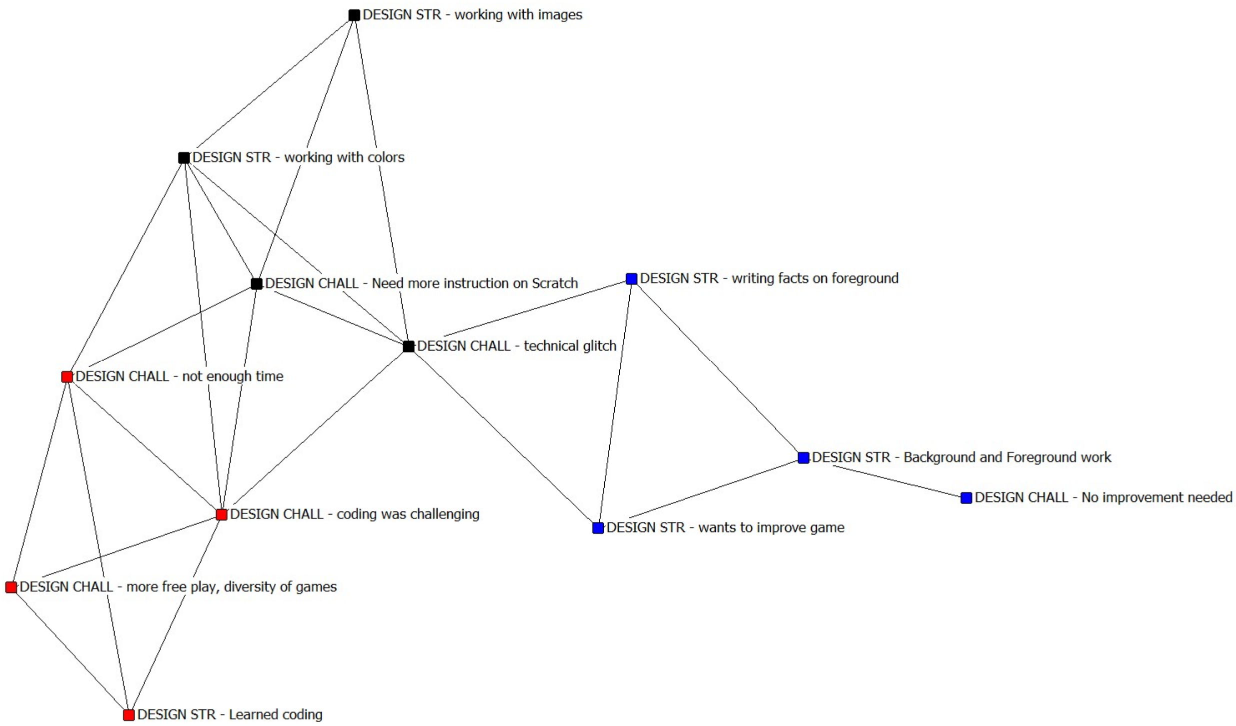

Figure 3.15 Design Strength vs Challenges

The ***instructions-glitch*** cluster (black cluster in Figure 3.16) includes the codes of *technical glitch* and *need more instruction on Scratch* from the category "design challenges," and codes of *working with colors* and *working with images* from the category of "design strengths."

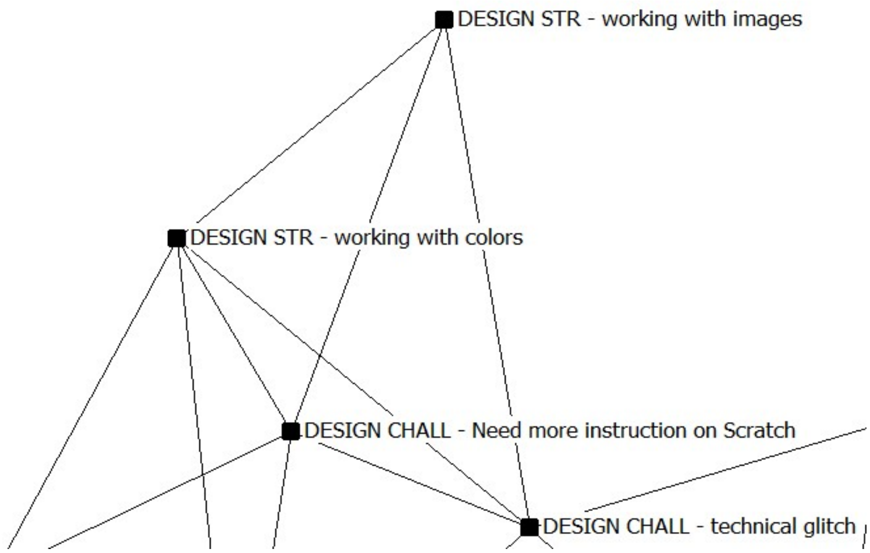

Figure 3.16 Instructions-Glitch Cluster

The ***coding-time*** cluster (red cluster in Figure 3.17) includes the codes of *coding was challenging, not enough time,* and *more free play/diversity of games* from the category design challenges and a code of *learned coding* from the category “design strength.”

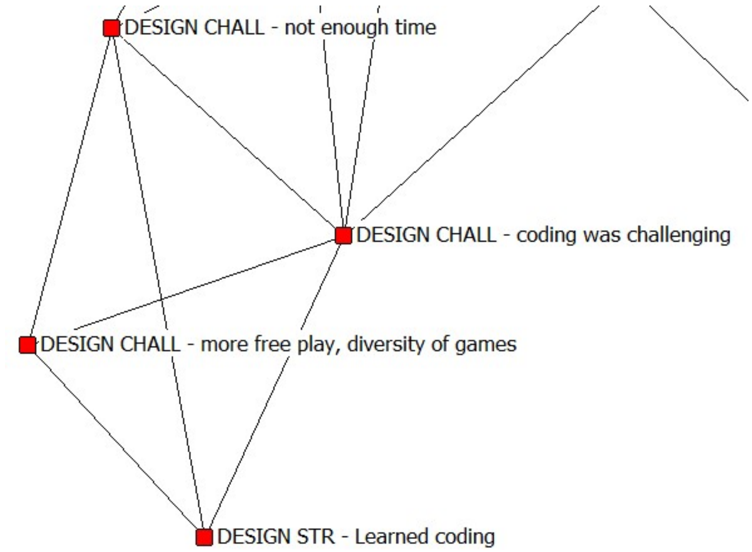

Figure 3.17 Coding-Time Cluster

The ***foreground-background*** cluster (blue cluster in Figure 3.18) includes three codes of *wants to improve game, background and foreground work,* and *writing facts on foreground* from the category "design strengths" and a code of *no improvement needed* from the category of "design challenges."

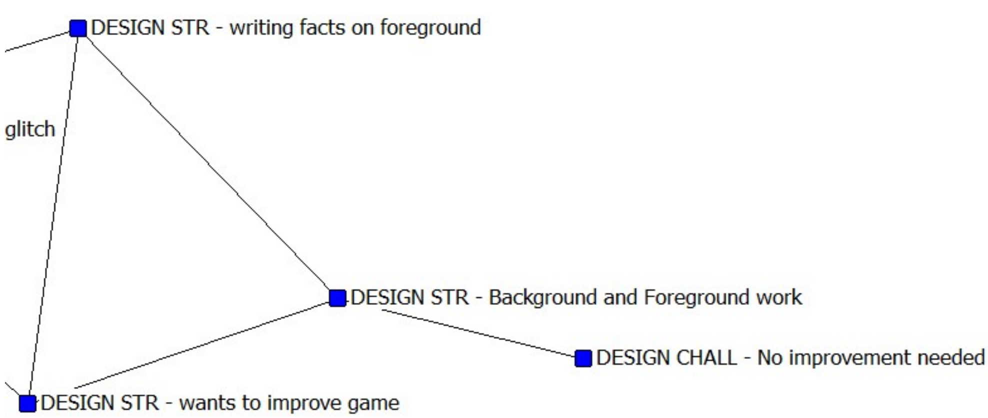

Figure 3.18 Foreground-Background Cluster

To answer the research question 3b "*What were the leverage points which could be used to address weaknesses?,*" the researcher calculated the betweenness measures of centrality to find out the leverage points to address the design challenges (see Appendix E: Figure E9). There were two prominent leverage points: *technical glitch* (large black node in the center of Figure 3.19 - betweenness centrality value 28.73) and *coding was challenging* (large red node - betweenness value 14.87) from the category "design challenges."

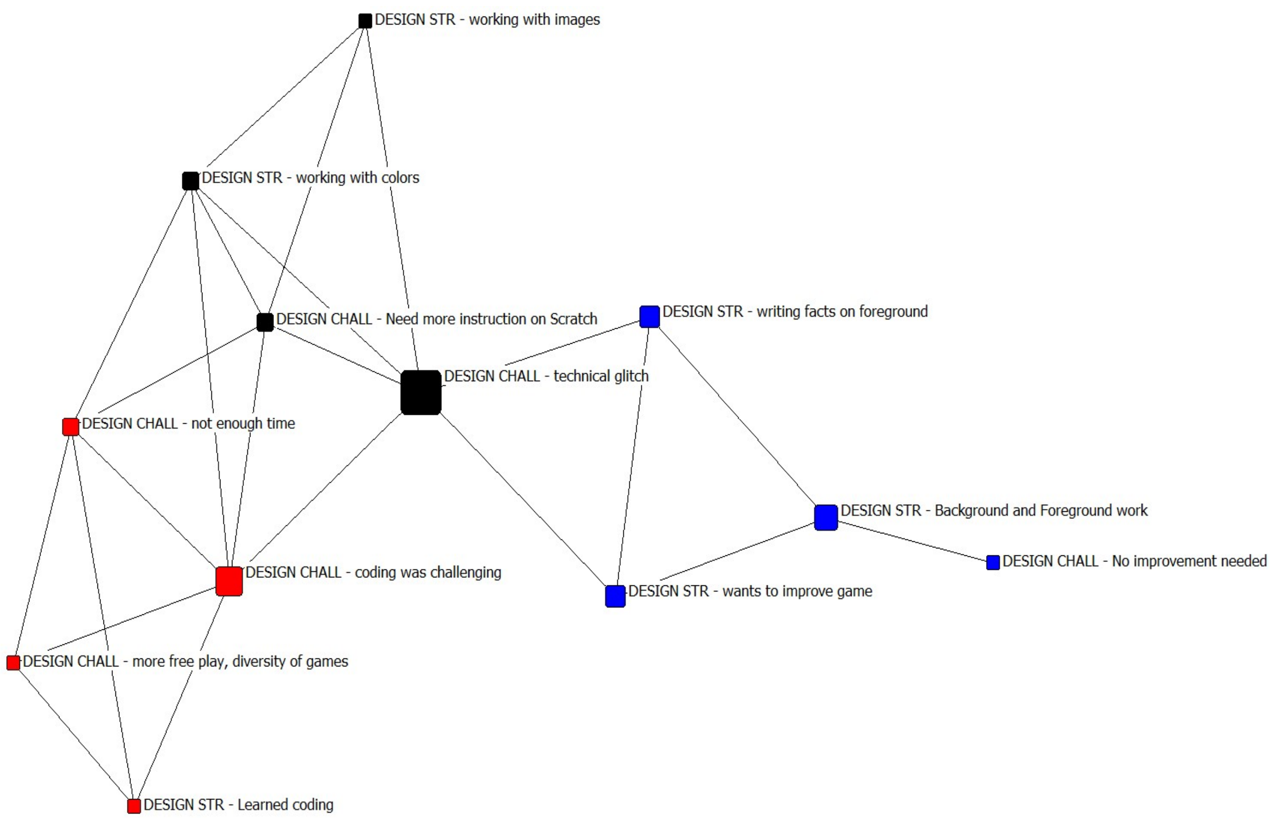

Figure 3.19 Design Strengths and Design Challenges (Leverage Points)

3.2.3.4. Discussions of Findings for Research Question 3

From the findings of the research questions 3a and 3b, we can see the connections between the design strengths and challenges of the DGBLL workshop. The ***instructions-glitch*** cluster (black cluster in Figure 3.16) shows that the "design strengths" of *working with images* and *working with colors* is connected to the "design challenges" of *technical glitch* and *need more instruction on Scratch.* Therefore, to design a more powerful DGBLL experience in future, the curriculum developers should pay more attention to ensuring the stability of internet and technical issues as well as provide ample instruction on Scratch.

Moreover, from the ***coding-time*** cluster (red cluster in Figure 3.17), it is evident that learning to code the game is connected to the "design challenges" of *coding was challenging, not enough time,* and *more free play/diversity of game.* Connecting this finding to the above-mentioned ***instructions-glitch*** cluster (black cluster in Figure 3.16), it is safe to assume that even though these students enjoyed working with colors and images, they would prefer more time to develop their skill in coding for better designing their game. Furthermore, the ***foreground-background*** cluster (blue cluster in Figure 3.18) shows that there is no improvement suggested by the data when it comes to the "design strengths" of *wants to improve game, background and foreground work,* and *writing facts on foreground.*

Last but not least, from the findings of research question 3b, the two prominent design challenges that the learner faced were *technical glitches* and *coding was* *challenging* (Figure 3.19). Looking at the coded segments, participants mentioned ensuring stable internet connection and "internet" when discussing the technical glitches. One participant mentioned that her computer was restarted every now and then. Another student mentioned not being able to share her screen in the ZOOM sessions during their sharing time. Because these are significant leverage points (high betweenness centrality values), addressing these issues in the future can be expected to improve the learning experience. Another design challenge that the researcher found from the leverage points was that *coding was challenging* which is connected to lack of time, not enough instruction on Scratch, and not enough free play. Therefore, to address this design challenge in future, instructors should not only give ample time and instruction on Scratch, but also make sure that the students have more autonomy for free play (Sylven & Sundqvist, 2012; Jensen, 2017) and are provided with a diversity of games.

3.3. Article 2 Conclusion

Findings from this study of DGBLL for L2 vocabulary learning shows that there were gains from pre to post-tests in both vocabulary learning and reading comprehension. However, because this study did not have a control group, these gains cannot be ascribed to the DGBLL workshop entirely. This study also finds that DGBLL contexts have the potential to provide students with low-anxiety environments for the facilitation of vocabulary development (Pu & Zhong, 2018; Rahmi, 2018). Moreover, DGBLL contexts may promote intrinsic motivation for the learners and provide them with the opportunity to contextualized language learning where vocabulary is learned through narrative in the gaming context. Furthermore, the DGBLL context of this study provided students with opportunities to collaborate and share ideas with each other. This experience gave them an opportunity for focused tinkering which may lead to vocabulary learning. The findings suggest that educators should design more generative learning environments for the learners in future.

4. TECHNOLOGY-ENHANCED WRITING INTERVENTION FOR ELLS' VOCABULARY DEVELOPMENT

4.1. Background for Article 3

4.1.1. Project Overview

Study 2 investigated a writing intervention called *Ready, Set, Write!* (RSW), which was designed based on constructivism. In RSW, students were provided with daily opportunities to actively discover, use, and apply new words within writing.

Vocabulary development is a key component in language acquisition. It is widely accepted that an increase in vocabulary enhances the natural acquisition of a second language (Barcroft 2004; Ellis 1995). Vocabulary can be learned either implicitly, from contexts such as reading (DeVere-Wolsey et al., 2015; Krashen 1985; Sternberg 1987), or explicitly, through repetition, associational learning strategies or imagery mediation techniques (Ellis 1995; Moody et al., 2018). However, vocabulary instruction is often neglected in the early elementary grades (Wanzek, 2014; Wright & Neuman, 2014).

The beneficial connection between reading and vocabulary development has been widely investigated by researchers, who assert that reading development can lead to vocabulary development (Nagy et al. 1985). Writing with attention to vocabulary development is also considered to be a tool for L2 development, because L2 writers often struggle with limited vocabulary or with vocabulary that have been only partially learned (Nation, 2001). In spite of the fact that vocabulary development is important for L2 writing performance, L2 writing researchers have offered little information about L2 writing instructors' practices aside from the consistent finding that a greater vocabulary diversity is associated with stronger L2 writing performance (Engbar, 1995; Grant & Ginther, 2000, Johnson et al., 2016).

In recent years, researchers have also investigated how technology can increase students' knowledge and application of vocabulary within writing. Technology such as *Popplet* encourages students to to map their ideas through brainstorming ideas, keywords, and phrases in small bubbles. Students can drag and drop their ideas later or make connections among different ideas from the context (Kervin & Mantei, 2016) and/or display their ideas and thoughts by incorporating sensory detail, visualization, and sequencing (Sessions & Lang, 2016). In a study by Mills and Unsworth (2017), students were asked to animate a character's emotions. By first animating on an iPad, students gained a greater understanding of the feelings of their characters. This allowed students to write with more specific emotion words and synonyms of those words when describing characters in written form.

Because vocabulary development has potential for L2 writing improvement, technology can serve a multi-faceted purpose when learning new words in context during writing development. Researchers have reported that technology that helps students with transcription and spelling may contribute to encouraging students to use less familiar vocabulary words that students would not otherwise try during paper and pencil compositions (Bourke & Adams, 2010; Kim & Schatschneider, 2017). Moreover, students' interactions with technology may also improve the use of new words during writing. In two studies with older students, technology was preferred to traditional paper-and-pencil transcription when learning new vocabulary (Ou Yang & Wu, 2015; Lu, 2008).

Despite having potential, technology, vocabulary development, and writing are rarely investigated in the elementary grades. The gap in research targeting elementary school age writers is identified in a review of the research on writing in young bilingual learners (Williams, & Lowrance-Faulaber, 2019), where the researchers found a paucity of studies between 2000 and 2017 about elementary school age writing programs. Williams and Beam (2019), in their meta-analysis on technology and writing, found that only three studies focused on elementary aged students. In the first study, the researcher investigated how 8-year-old children make connections among the written texts, images, music etc. as they create digital and multimodal texts (Mills, 2011). In the second study, Kervin and Mantei (2016) examined one third-grade student's process-writing approach to complete a writing project using a series of iPad applications including *Popplet* for planning, *instaGrok* as search engine to gather information, *Google images* for pictures, *Tellagami* for creating avatar, *Book Creator* for typing, *Reflector* for receiving peer feedback, and *iBooks* for publishing. The third study, conducted by Yamac and Ulusoy (2016), investigated the advantages of digital storytelling to develop third-grade students' writing skills. The students built a storyboard and wrote their draft using multimodal resources such as images, videos, and so on from the Internet and shared their stories with their peers using the website *PhotoStory.* The researchers described that even the reluctant students showed enthusiasm during the digital storytelling process. However, none of the studies investigated or reported any vocabulary improvement of the learners. They did not provide any information about how the technology-enhanced writing exercises may have contributed to students' word choices or whether technologies encouraged them to learn and/or use new vocabulary. Moreover, all of these studies included third-grade students, who are on the outer edge of what is typically considered to be "early literacy." Ultimately, despite the findings by Williams and Beam (2019) that suggests students' overall writing quality improves when technology is successfully implemented, the research linking vocabulary to a technology enhanced writing intervention is inadequate and there is a need for further research in this area. Therefore, the purpose of this study is to investigate what digital applications the students experienced to be beneficial for vocabulary development in a technology-enhanced writing intervention.

4.1.2. Setting

RSW was conducted at three different elementary schools (School A, School B, and School C) over the course of two years. The first year was referred to as Cohort One (2017-18) and the second year was referred to as Cohort Two (2018-19). All schools were part of one district in the southwestern U.S. This district includes approximately 16,000 students per year, which was the largest student enrollment in the county. According to the district demographic data, there were 18.4% African American students, 57.4% Hispanic, 21.9% White, and 2.4% other students. 75% of the students were recognized as economically disadvantaged, 24.2% were ELLs and 9.5 % were special education students. This district was selected by the research team for its literacy intervention needs. Cohort One and Cohort Two together included 101 students, with 90 of them identified as ELLs. For the purpose of this study, the researcher only focused on the 90 ELLs, and the sample demographics are given in the participants section below.

4.1.3. Recruitment

RSW schools' recruitment was completed in the summer before Cohort One began. In the first step, graduate research assistants e-mailed the principals of several elementary schools which were deemed as in need of literacy intervention by district personnel. Graduate research assistants also went to each school and distributed flyers to encourage the school administration to be interested in the project. Two schools were recruited through these means. After that, the research team sent another round of e-mails to the school principals. At this point, two more principals expressed their interest to participate in the project. Next, the research team met with the principals of these four schools and recruited schools A, B, and C based on their similar demographics.

Schools A, B, and C were assigned to one of the three conditions: a) RSW Technology (RSW-T), b) RSW Writing Workshop (RSW-WW), and c) Control. These three conditions are described in the *intervention* section below. These assignments differed from Cohort One to Cohort Two. The intervention occurred after school at the relevant school campus two days a week, for 85 minutes per day, for a total of 10 weeks. The intervention for Cohort One started in late Fall of 2017 and finished in mid-spring of 2018. The intervention of Cohort Two began in early fall of 2018 and ended in winter of 2018. Differences in the start and end dates of each cohort can be attributed to logistical issues, such as recruitment of schools and students, during the first year of the project.

4.1.4. Participants

Research team members requested the principals of each school to distribute flyers to all second-grade students who tested below Level 2 on district standardized reading assessments, such as the Developmental Reading Assessment (DRA), which assesses students' reading engagement, oral reading fluency, and comprehension (Beaver & Carter, 2019). Then the interested families completed an application which was reviewed by the research team. After that, the interested families attended an introductory meeting where they were provided with information about RSW, signed consent forms, and completed other required paperwork. The same procedures were followed for recruitment in both Cohort One and Cohort Two.

After the collection of all consent forms, a total of 101 second-grade students consented to participate, 90 of whom were ELL students and therefore included in this substudy. All of them were admitted to participate in the RSW program. Of the 90 ELL students, 62.2% (n=56) were male, and 37.8% (n=34) were female students. Special education students encompassed 8.9% (n=8) of the ELL participants (90). A Transitional Bilingual Early Exit Program was maintained in schools from which the ELLs were recruited. In these schools, students received the majority of instruction in the primary language for two to five years, with the goal of becoming competent readers, speakers, listeners, and writers in English.

Overall, 37.8% (n=34) of participants engaged in the RSW-T intervention, 30% (n=27) in the RSW-WW intervention, and 32.2% (n=29) in the Control group. Specific demographics can be seen in Table 4.1.

Table 4.1 Demographics

	Year 1		Year 2		
	Number	Percent	Number	Percent	Total
Gender					
Female	34	64.2%	0	0%	34
Male	19	35.8%	37	100%	56
Group					
Control	18	34%	12	32.4%	30
RSW-WW	15	28.3%	12	32.4%	27
RSW-T	20	37.7%	13	35.2%	33

4.1.5. Intervention

In each cohort, School A, B, and C were assigned to one of three conditions: a) Technology, b) Traditional, and c) Control. The experimental groups were Technology and Traditional, and these groups received the intervention in the fall of each year. The Control group was provided with the same intervention as the Technology group each spring, after posttesting had been completed.

The intervention curriculum was designed by two highly experienced and state certified teachers, who worked as the graduate research assistants for the project. Teachers for the intervention were graduate research assistants and trained undergraduate elementary education majors. Objectives for the curriculum were derived from the state standards, and focused on the composition of narrative writing samples, as well as the development of vocabulary, handwriting, spelling, and grammar. The narrative genre was chosen because: a) it is taught in all grade levels, b) it is often covered on standardized writing assessments, c) many students struggle with writing narrative stories, and d) narrative samples have been found to be helpful for vocabulary knowledge development than other genres (Danzak, 2011; Olinghouse & Wilson, 2012).

During the intervention, students worked in small-group centers for 35-40 minutes to develop their literacy skills including vocabulary, handwriting, spelling, and grammar. All the activities in centers were scaffolded by RSW instructors and undergraduate student assistants. Students worked in groups of three in these centers. They rotated among three centers: a) vocabulary, b) handwriting, and c) spelling and/or grammar, for approximately 12-15 minutes per center. Center instruction included mini-lessons on previously mentioned literacy skills. Then the students worked in pairs as well as individually. The center instruction consisted of features of constructivism such as, experimenting together, collaborating with others, and learning while playing games and interacting with others to develop students' vocabulary knowledge, spelling, grammar, and handwriting.

As mentioned earlier, each day the intervention lasted for 35-40 minutes. Vocabulary development instruction was incorporated into the writing workshop instruction. Each lesson included 15-minutes of mini-lesson, and 25-minutes of independent narrative writing practice. Instruction on writing followed the Writing Workshop Model, developed by Calkins (2005) and involved five stages: a) prewriting, b) drafting, c) revising, d) editing, e) publishing. Vocabulary instruction was incorporated into the mini-lessons and independent writing practice in various ways in each stage of writing. First, when the targeted vocabulary was used in the mentor texts they were specifically pointed out and referenced. During the whole class instruction, teacher modeling time, and student-teacher conference during independent writing practice, teachers would encourage the students to replace the basic words (e.g., surprised) with a higher-level word (e.g., shocked). During the teacher modeling, the teacher would give examples and discuss how this change was made. These instructions scaffolded the students to utilize these techniques independently and would potentially facilitate the acquisition of new vocabulary (Williams, 2018). During the editing and revising stage of writing, peers would look at each others' writings, discuss, and focus on using higher level vocabulary words. During this discussion, they would turn and talk which may lead to the meaningful use of low- and high-frequency words (Johnson et al., 2016). Last but not least, even at the publishing stage, teachers would praise the writings of the students who used higher-level vocabulary words.

For the vocabulary instruction, RSW-T groups used the digital game named Quizlet in iPad where they practiced vocabulary through cloze passages, played flashcards, and competed against the clock with their peers.This includes all the necessary instruction for vocabulary learning through systematic instruction including direct instruction, word-learning through word-associations, form-meaning connection and student interaction (Lesaux et al. 2014) In the RSW-WW group, vocabulary was practiced through the traditional paper-and-pencil instruction. Everyday during the intervention, students in both RSW-T and RSW-WW groups received instruction regarding a series of higher-level words for their vocabulary knowledge development.

The RSW-T group had also incorporated different technologies during the different stages of writing instruction which might lead to incidental learning of vocabulary. These included *Popplet* for brainstorming and storybuilding, *Book Creator* for typing, *Toontastic* and *Educreations* for visualization, and *Google Docs* and *Google Classroom* for drafting, editing, and publishing. Even though there is not adequate research in this area, researchers suggest that integrating technology into writing instruction may be beneficial for both vocabulary and writing development (Williams & Beams, 2019). First, technologies such as *Popplet* and *Book Creator* may support students to brainstorm, build the story structure, and allow them to incorporate their vocabulary knowledge into their writing (Kervin & Mantei, 2016). Next, applications such as *Toontastic* and *Educreations* may benefit students to visualize the topic and setting of their writing, help them to add details to their writing, and thus, help them to incorporate new vocabulary in their writing (Sessions et al., 2016). Finally, using composition and word processing technologies such as *Google Docs* and *Google Classroom* during the drafting, editing, and publishing stages may be beneficial for the students to integrate low and high frequency words into their writings (Johnson et al., 2016).

4.1.6. Research Questions for Article 3

Earlier research has suggested that repeated practice and exposure to new words have the potential for vocabulary development (DeVere-Wolsey et al., 2015; Zhong, 2018). Research has also suggested that technology-enhanced instruction can be beneficial for the development of both vocabulary and writing skills. However, this avenue has not been adequately explored in the elementary grades (e.g., Williams & Beam, 2019; Williams, & Lowrance-Faulaber, 2019). The present study attempts to fill the research gap by examining the following questions:

1. How did students experience digital technologies for learning new vocabulary?
    a. What were the learners' positive experiences with different digital applications in terms of vocabulary learning?
    b. What aspects of these digital technologies did students find problematic in terms of vocabulary learning?
2. How do the different aspects of learning theory in which the program was grounded connect to vocabulary learning and learners' experiences?
3. How might the problematic aspects of digital technologies be addressed from students' perspectives?

4.1.7. Data Sources for Article 3

This was a qualitative study. The data included 62 (27-interviews from 2017-18, and 35-interviews from 2018-19) semi-structured interviews with ELL students after the intervention. The interviews were conducted to learn about the participants' perceptions about the digital applications and their language learning experience.

4.1.7.1. Semi-Structured Interviews

At the end of the 10-week intervention, students participated in semi-structured interviews. These interviews were conducted face-to-face. These were group interviews with about five students per group. There were 62 students' interviews in total. For the sake of data analysis, the researcher created separate files for individual students. The anonymous students' interviews were not included. After that, the researcher had 54 interviews of ELL students. Of the 54 interviews, 26 students belonged to the technology group, and 28 students belonged to the control group. However, these 28 students were interviewed after they received the technology workshop and therefore their interviews were included in the data analysis.

Only audio was recorded for transcription. The students were asked to name their favorite application that they used during the intervention, clarify why it is their favorite, which applications they would prefer not to use in future, and what suggestions they have for the application designers. Maxwell (2005) states that verbatim transcripts are a must if researchers want to collect detailed and enriched data to test validity for the research questions. Therefore, all the interviews with the students were audio recorded and then transcribed verbatim. Finally, during the interviews, the researchers used templates to guide their questions to the students. The interview protocol is attached in Appendix B.

4.1.7.2. Data Analysis

This study used semantic network analysis of coded qualitative data (Donaldson, 2019; Hunzaker & Valentino, 2019). The first step for the data analysis was coding the data. For coding the data, the researcher used the MAXQDA Analytics Pro qualitative analysis software and built a comprehensive codebook (Creswell, 2016). In network analysis, the unit of analysis (Creswell, 2016) is the network of all correlated nodes. The unit of observation (Lavrakas, 2008) is a dyad, a unit containing two nodes and the relationship (a.k.a. tie/edge) between the two nodes. For instance, in social network analysis, a node represents an individual about whom the data is collected, and the unit of observation is two individuals and their relationships (Hanneman & Riddle, 2005; Wäsche et al., 2017). In this study, a node represents a code (not an individual participant), and the unit of observation is a dyad made of two codes and their relationship. Each node represents a code which consists of an interaction block in which the interviewer and one interviewee discuss one question (usually regarding one technology or activity), thereby reducing multiple identical comments of similar nature by one individual regarding one specific technology in one coded segment. Each paragraph can be coded according to multiple codes in multiple categories in the codebook when appropriate.

All the interview data were coded in-vivo indicating the codes that are the exact words used by the participants (Creswell, 2016), as well as coding for emergent themes

(Corbin & Strauss, 2015) and coding according to *a priori* categories guided by the theories in which this study was grounded (Thornberg, 2012). The initial codebook consisted of a category for theory with sub-categories related to motivation theory, dual coding theory, and constructivist theory, as well as categories for technologies used and types of activities in which students participated (e.g., drafting, visualization, typing, story building, adding details and so on). There was also a category for affect, divided into very positive affect (e.g., liking something very much, excitement), slightly positive affect, slightly negative affect (e.g., boredom, disinterest), and very negative affect as codes. The researcher coded all the data using the emergent, *a priori,* and axial coding processes within the categories needed for answering the research questions. The initial codebook is included in Appendix D (Figure D2).

To address the validity issue and researcher bias, the researcher enlisted the help of an experienced researcher with expertise in qualitative coding in MAXQDA to discuss and negotiate the codes, which was organized according to categories and subcategories, on a regular basis to minimize coder's bias (Chi, 1997). For example, under the category of "Theory," the researcher and the external experienced researcher negotiated a subcategory for *Dual Coding Theory*, under which there are *a priori* codes for "word-form and word-meaning connection," and "multimodal information presentation." Moreover, McHugh (2012) poses the question "With a single data collector the question is this: presented with exactly the same situation and phenomenon, will an individual interpret data the same and record exactly the same value for the variable each time these data are collected?" (p. 277). To minimize this concern, the researcher also conducted an intra-rater (as opposed to inter-rater) reliability test in MAXQDA (there was only one researcher involved in coding the data, therefore inter-rater reliability testing was not possible). After coding 20% of the transcripts, the researcher copied the project file. In the copied file, the researcher deleted all the coding, with coding categories left intact. Then the researcher coded those 20% of the transcriptions again and conducted an intra-rater reliability test to determine Kappa (Brennan & Prediger, 1981) values - the degree to which the first round of coding matches the second round of coding. The researcher used Landis and Koch's (1977) scale to determine strength of agreement in the coding rounds. Kappa values less than 0 = poor; 0.01-0.20 = slightly acceptable, 0.21-0.40 = fair, 0.41 -0.60 = moderate; 0.61-0.80 = substantial; 0.80-1 = nearly perfect. After cleaning the codebook, the intra-rater reliability test was calculated and the Kappa value was found to be 0.78, indicating substantial reliability (Brennan & Prediger, 1981).

After coding, the researcher cleaned up the codebook. Semantic network analysis identifies patterns and relationships among the codes and therefore codes which occurred only once could not be used in a pattern and needed to be deleted (Donaldson, 2019). The researcher merged any codes that could be merged together when the two codes were similar in content or can be combined under one merged code name (Kuckartz & Rädiker, 2019). Also, when any code occurred too many times, this was an indication that the code was too broad, and therefore the researcher scrutinized all the coded segments within the code to determine whether it was necessary to split the code into multiple codes to provide greater depth of understanding (Kuckartz & Rädiker, 2019). After this process, the researcher ended with 69 codes.

Next, MAXQDA was used to understand the relationships between codes via axial coding (Kuckartz & Rädiker, 2019). Axial coding is an analytic process to reveal the relationships among codes (Corbin & Strauss. 2015), which was done through the use of Pearson's correlation, semantic network analysis, and cluster analysis. The first step in the axial coding is to calculate the code co-occurrence correlations using Pearson's Product-Moment Correlation (Freedman et al., 2007). Pearson's correlations among the different codes were calculated in MAXQDA. The correlations were conducted for all pairs of codes within each category, as well as pairs across multiple categories. These correlations indicated how likely a code is to appear within proximity of another code. The researcher exported these correlations as MS Excel files as symmetrical correlations matrices. These matrices were created for co-occurrence of codes with each of the categories (e.g., digital applications, students' affect, learning theory, suggestions), with matrices constructed at the $p<0.05$, $p<0.01$, and $p<0.001$ confidence levels.

Then, the researcher ran a semantic network analysis (Hunzaker & Valentino, 2019; Krippendorff, 2004) to answer research questions 1 and 2. Semantic network analysis is the use of network analytic techniques on multiple paired associations based on their linguistic connections and semantic proximity within the cognitive schema (Doerfel, 1998; Krippendorff, 2004). Taken together, these associations represent the meaning inherent in the data. (e.g., Doerfel, 1998; Donaldson & Allen-Handy, 2020).

The unit of analysis is the semantic network map which consists of all significantly correlated nodes, and the unit of observation was a node (Krippendorff, 2004) which in this study was a code (rather than a coded segment).

To conduct the semantic network analysis, the results from the correlation matrices were used in UCINET and NetDraw software to create semantic network maps and to analyze the relationships among codes (Corbin & Strauss, 2015). The maps helped the researcher to visualize the pattern and explain the correlations among the networked data. The Girvan-Newman algorithm was also used to apply cluster analysis to the semantic network maps for better understanding the patterns (Girvan & Newman, 2002). The cluster analysis shows the closely related codes based on their strong association. They were also often found to be discussed together by multiple participants. In some cases, the researcher has also identified the leverage points (Freeman, 1977) by using the betweenness measures of centrality. A leverage point indicates a code which is so important in a network map that if it changes, it may affect the whole network (Lam et al., 2021; Meadows 1999).

4.1.7.2.1. Analysis for Research Question 1

To answer the research question one, *How did students experience digital technologies for learning new vocabulary?,* the researcher analyzed semantic network maps with Girvan-Newman clusters (Girvan & Newman, 2002). These maps visually represented the interconnected and interdependent aspects of learner experiences in relation to their use of digital applications during learning activities which promote vocabulary development.

For research question 1a, "*What are the learners' experiences with different digital applications in terms of vocabulary learning?*," the researcher looked at the semantic map using the categories Technologies, Students' Affect, Vocabulary Learning Experience, and Activity to interpret the connection between different digital applications in terms of vocabulary learning. These categories were necessary because the researcher was interested in the interdependent aspects of positive student experiences within the context of specific learning activities using specific digital tools.

For research question 1b, "*What aspects of these digital technologies did students find problematic in terms of vocabulary learning?*," the researcher analyzed the semantic map using the categories Digital Applications, Students' Affect and Activity to understand the relationship between negative learner experiences and specific learning activities related to vocabulary development in which they used specific digital technologies.

4.1.7.2.2. Analysis for Research Question 2

For research question two, "*How do the different aspects of learning theory in which the program was grounded connect to vocabulary learning and learners' experiences?*," the researcher analyzed the semantic network maps using the categories Theory, Students' Affect, Activity, and Technologies. The researcher used these categories to understand and interpret the connections between different learning theories and learners' experiences within the context of using specific digital tools to engage in specific learning activities related to vocabulary development.

4.1.7.2.3. Analysis for Research Question 3

For research question three, "*How might the problematic aspects of digital technologies be addressed from a student perspective?*," the researcher analyzed the semantic map using the categories Suggestion, Activity, and Tool to understand the relationship between learners' experience with digital applications and specific learning activities and their suggestions for improving either the technologies or the use of those technologies within the learning context.

The whole process is displayed in Figure 4.1.

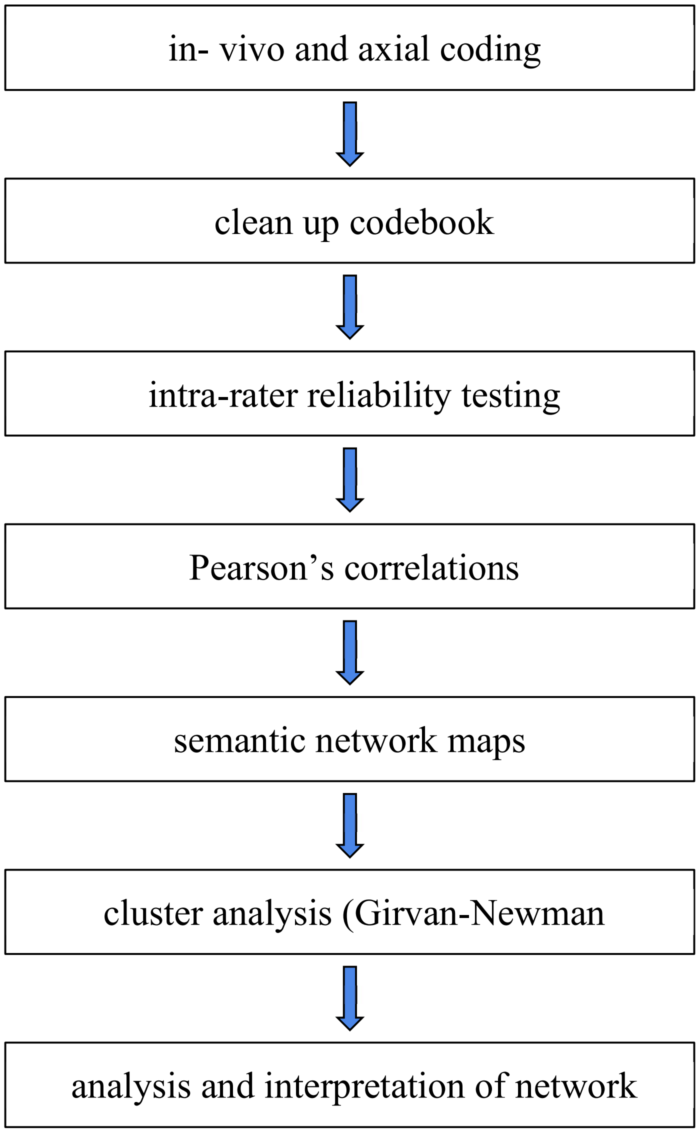

Figure 4.1 Data Analysis Process for Article 3

4.2. Findings and Discussion

4.2.1. Findings for Research Question 1

To answer the research question 1a and 1b, *“What were the learners’ experiences with different digital applications in terms of vocabulary learning?”* and “*What aspects of these digital technologies did students find problematic in terms of vocabulary learning?,”* the researcher generated a semantic network map in the analysis software using the categories “technologies,” “students affective experience,” “vocabulary learning experience,” and “activity” to understand the interdependent aspects of student experiences (both positive and negative) in terms of vocabulary learning. Using the Girvan-Newman algorithm (Girvan & Newman, 2002), the researcher constructed a four-cluster semantic map (Q= 0.52) using the correlation matrix at the level of $p<0.05$ (Figure 4.2).

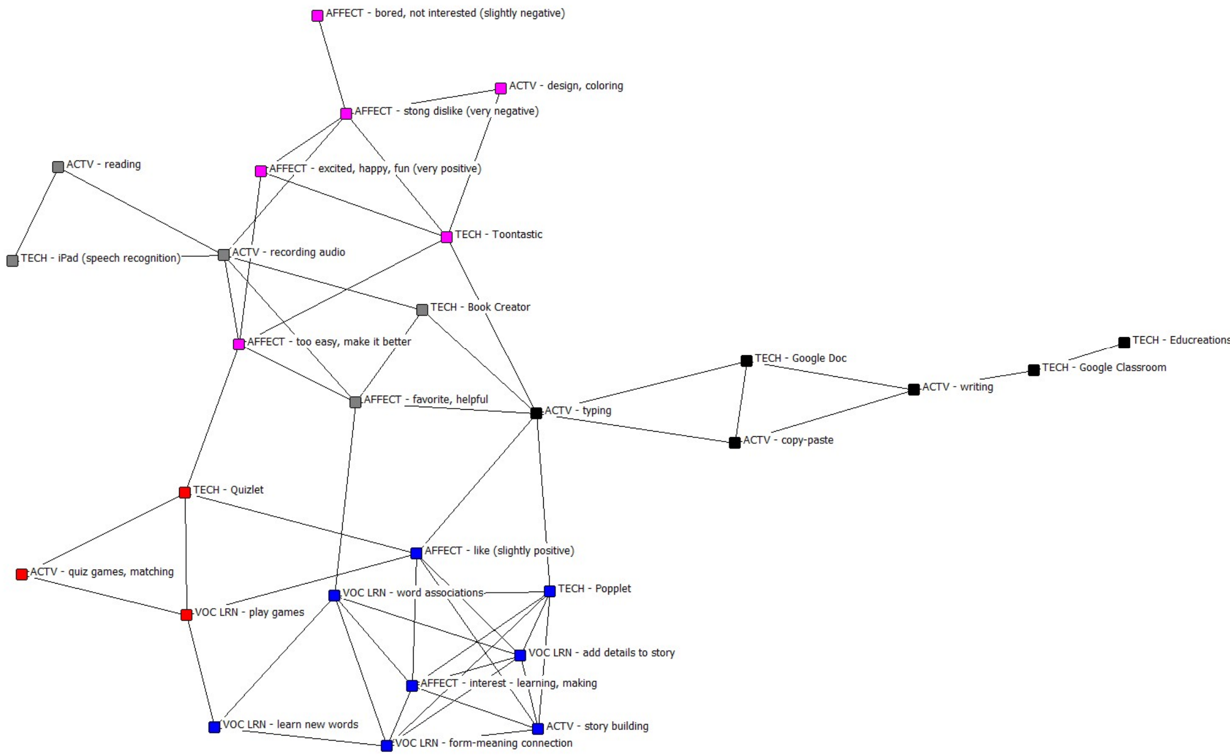

Figure 4.2 Students' Affect vs Technology vs Activity Map vs Vocabulary

The ***generative*** cluster (blue cluster in Figure 4.2, enlarged in Figure 4.3) includes one code of *story building* from the category of "activity," one code of *Popplet* from the category of "Technologies," four codes of *word associations, add details to story, form-meaning connection,* and *learn new words* from the category of "vocabulary learning experience" and three codes of *favorite, too easy/make it better,* and *very positive* from the category "students' affect."

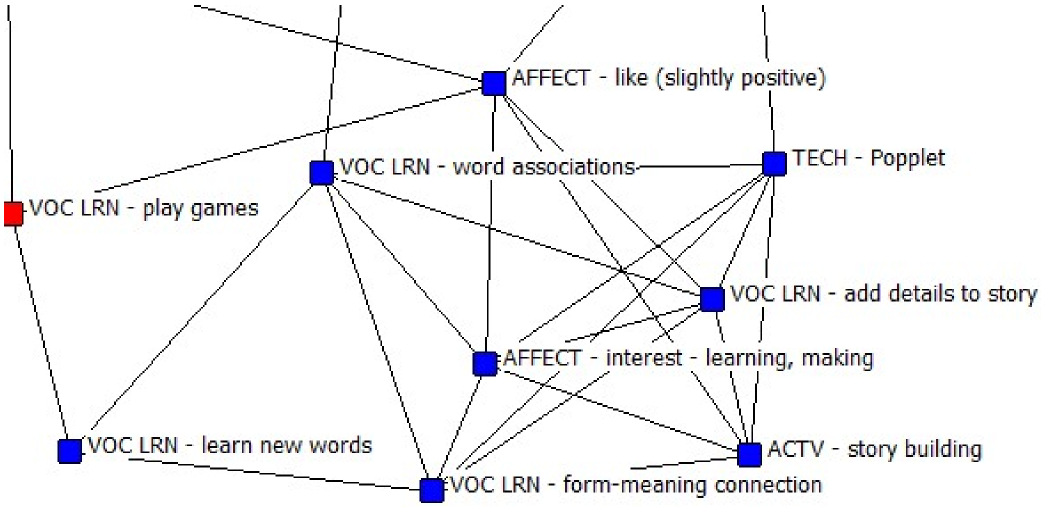

Figure 4.3 Generative Cluster

The ***type-write*** cluster (black cluster in Figure 4.4) includes three codes of *typing, copy-paste,* and *writing* from the category of 'Activity," and three codes of *Google Doc, Google Classroom,* and *Educreations* from the category "technologies." However, no code from the categories of "students' affect" or "vocabulary learning experience" were associated with this cluster.

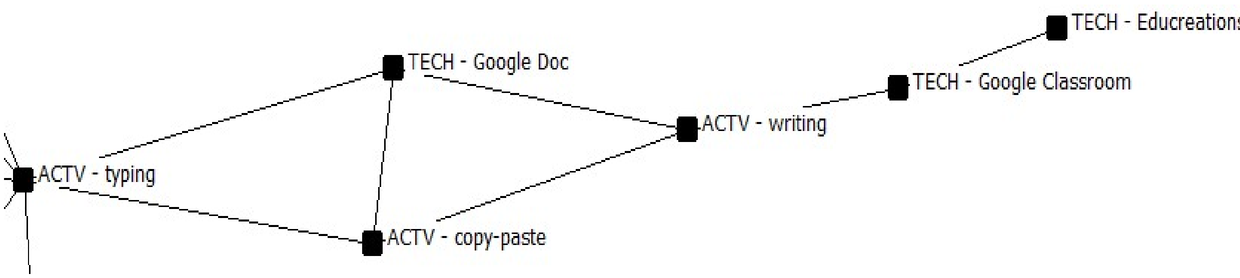

Figure 4.4 Type-Write Cluster

The ***read-speak*** cluster (gray cluster in Figure 4.5) includes two codes of *reading* and *recording audio* from the category "activity," two codes of *iPad (speech recognition)* and *Book Creator* from the category "technologies," and one code of *favorite, helpful* from the category of "students' affect".

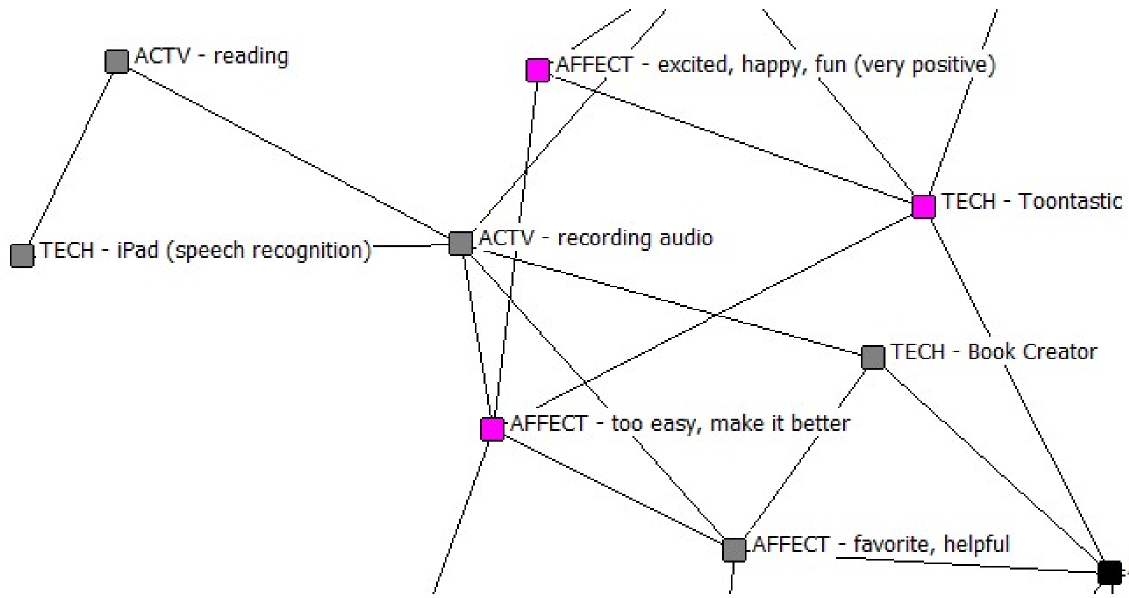

Figure 4.5 Read-Speak Cluster (Gray)

The ***design*** cluster (pink cluster in Figure 4.6) includes one code of *design, coloring* from the category of "activity," four codes of *slightly negative, strong dislike, very positive,* and *too easy, make it better* from the category of "students' affect," and a code of *Toontastic* from the category of "Technologies."

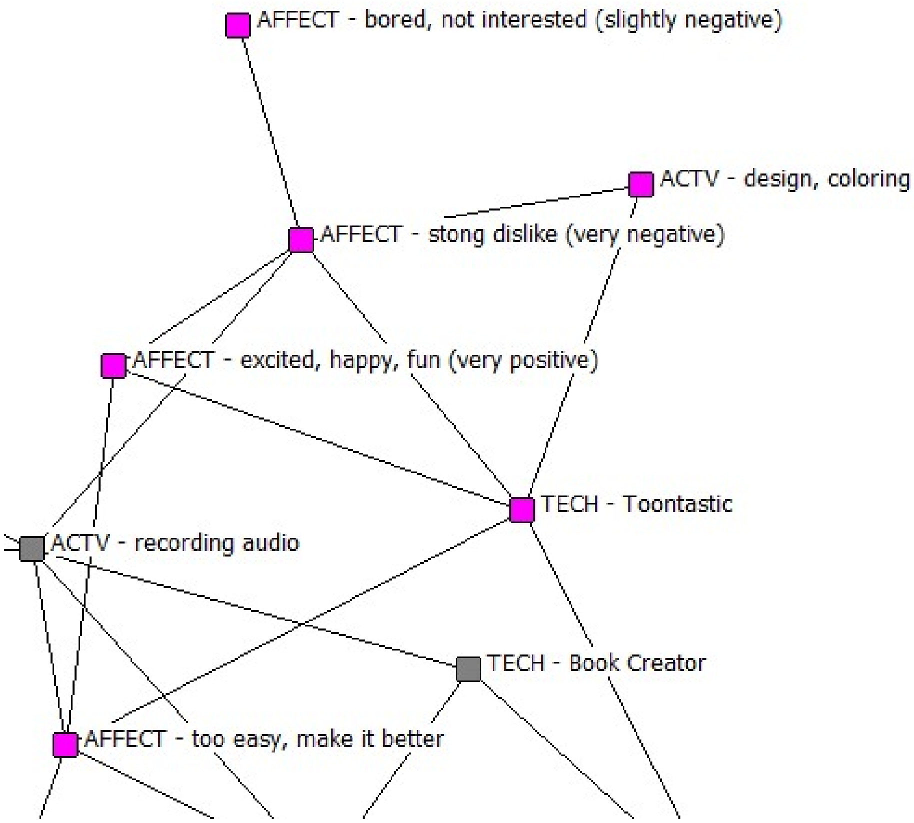

Figure 4.6 Design Cluster

The ***quiz-match*** game cluster (red cluster in Figure 4.7) includes one code of *quiz games, matching* from the category of "activity," one code of *play games* from the category of "vocabulary learning experience," and one code of *Quizlet* from the category of "technologies."

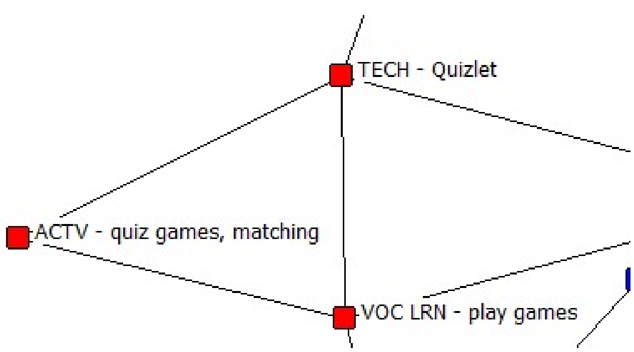

Figure 4.7 Quiz-Match Cluster

4.2.2. Discussion of Findings for Research Question 1

Findings related to research questions 1a and 1b display the interconnections among students' experience regarding the digital technologies for learning new vocabulary. As shown in Figure 4.2, the ***generative*** cluster (Figure 4.3) and the ***read-speak*** cluster (Figure 4.5) hold the positive affective experiences of the learners in terms of vocabulary learning. The ***generative*** cluster (blue) includes students' affective experience such as *like (slightly positive)* and students' *interest* in learning and making as they build their stories using *Popplet.* Popplet appears to be connected to vocabulary learning experiences of *learning new words, form-meaning connections, adding details to story, word associations.* This finding aligns with the findings of Kervin & Mantei (2016) suggesting that Popplet encourages students to learn vocabulary by providing them with opportunities to incorporate details into their story structure. This will also help the students to bolster their vocabulary knowledge of connecting the word forms with their meanings and making word associations. The ***read-speak*** cluster (gray) includes the code of *reading* and *recording audio* to be connected with the technology *iPad (speech recognition)* but does not include any students' affect. The "activity" codes *recording audio* as well as *reading* are connected with the student affect *favorite, helpful* and the technology *Book Creator.* This indicates that the students considered the Book Creator app to be their favorite app and found this app to be helpful while audio recording their story as it helps the students to "make books while recording" themselves as one student mentioned in the interview. This may help the students learn vocabulary implicitly from context as they make their story (DeVere-Wolsey et al., 2015; Krashen 1985; Sternberg 1987).

The ***design*** cluster (pink cluster in Figure 4.6) is associated with the negative student experiences in terms of vocabulary learning within the writing intervention. The design cluster displays that the code of *Toontastic* is connected to the "students' affective experience" of *strong dislike* and *boredom.* Students also associate this technology of Toontastic to be *too easy* and the designers need to *make it better.* However, few students find it to be *fun* and exciting. Even though some researchers see potential of Toontastic for visualization and setting of the story for writing, which could help students to incorporate new vocabulary in their writing (Sessions et al., 2016), this study's findings indicate that this technology might need improvement and/or curriculum designers need to implement more rigorous learning task designs to improve the learning experience.

The ***type-write*** cluster (black cluster in Figure 4.4) and the ***quiz-match*** cluster (red cluster in Figure 4.7) appear not to be related to positive or negative learners' experience in terms of vocabulary learning. The ***type-write*** cluster shows the connections among the "activities" of *typing, writing,* and *copy-pasting* to be connected to *Google Docs. Writing* code is also connected to the technology codes of *Google Classroom* and *Educreations.* This cluster does not include any affect or vocabulary learning experience. Previous research has shown that *Google Docs* can be beneficial for composing and word processing during the writing phases of drafting, editing, and publishing and may help the students to include high and low frequency words in their writing (Johnson et al., 2016), whereas *Educreations* has the potential to aid the students in visualizing their story and adding new vocabulary in their writing (Sessions et al., 2016). However, even though this study's findings show connections among the *writing*, *typing*, and *copy-pasting* skills with *Google Docs* and *writing* with *Google Classroom* and *Educreations,* this study's findings do not indicate any connection between writing and vocabulary learning experiences. Last but not least, the ***quiz-match*** cluster (red cluster in Figure 4.7) shows connections among the codes of *Quizlet, quiz games,* and "vocabulary learning experience" of *playing games.* However, this cluster does not include any students' affective experience. This explicit vocabulary learning experience through playing games may lead to vocabulary knowledge development (Lesaux et al., 2014). This finding also aligns with the unique affordance of autonomy of game-based learning for L2 vocabulary development where the learner gradually, through practice and scaffolding (Vygotsky, 1978), develops autonomous vocabulary learning skills such as word-associations and form-meaning connections without depending on the instructor (Sylven & Sundqvist, 2012; Jensen, 2017).

4.2.3. Findings for Research Question 2

To answer the research question 2, "*How do the different aspects of learning theory in which the program was grounded connect to vocabulary learning and learners' experiences?"* a six-cluster semantic network map (Q= 0.43 - Figure 4.8) was constructed using the Girvan- Newman algorithm (Girvan & Newman, 2002). The map was generated in the analysis software using the correlation matrix at the confidence level of $p<0.01$ using the categories "theories," "students' affect," "activity," "technologies," and "vocabulary learning experience" to explore the connections among different learning theories in which this study was grounded and learners' experiences. The researcher also calculated the betweenness measures of centrality in this semantic network map to identify the leverage points. These different clusters are described below along with their zoomed-in images.

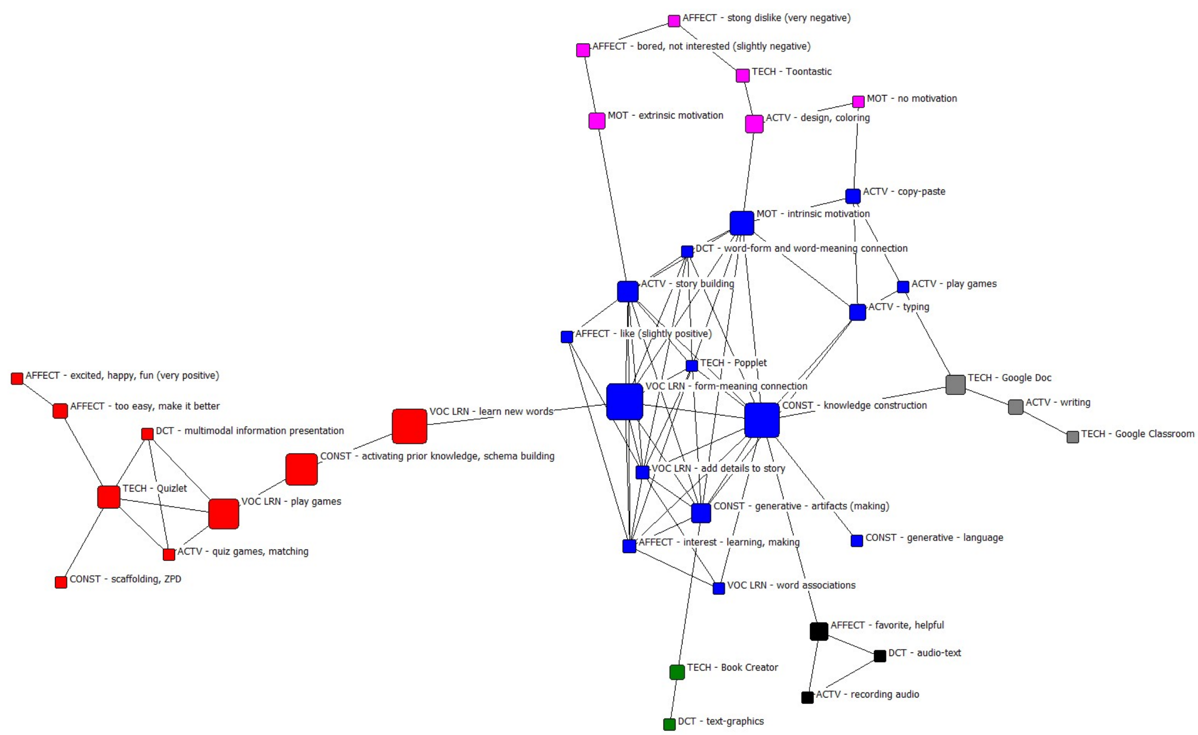

Figure 4.8 Theory vs Affect vs Vocabulary Learning vs Activity Map

The ***knowledge construction*** cluster (blue cluster in Figure 4.8 - enlarged in Figure 4.9) includes three codes of *knowledge construction, generative language,* and *generative artifacts (making)* from the subcategory of "constructivist theory," one code of *intrinsic motivation* from the subcategory of "motivation theory," and one code of *word-form and word-meaning connection* from the subcategory of "dual-coding theory." This cluster also includes four codes of *story building, copy-paste, play games,* and *typing* from the category of "activity," three codes of *form-meaning connection, add details to story,* and *word associations* from the category of "vocabulary learning experience," and two codes of *slightly positive,* and *interest-learning, making* from the category of "students' affect," and a code of *Popplet* from the category of "technologies." The two prominent leverage points in this cluster are the codes *knowledge construction* (betweenness value 238.94) and *form-meaning connection* (betweenness value 254.32).

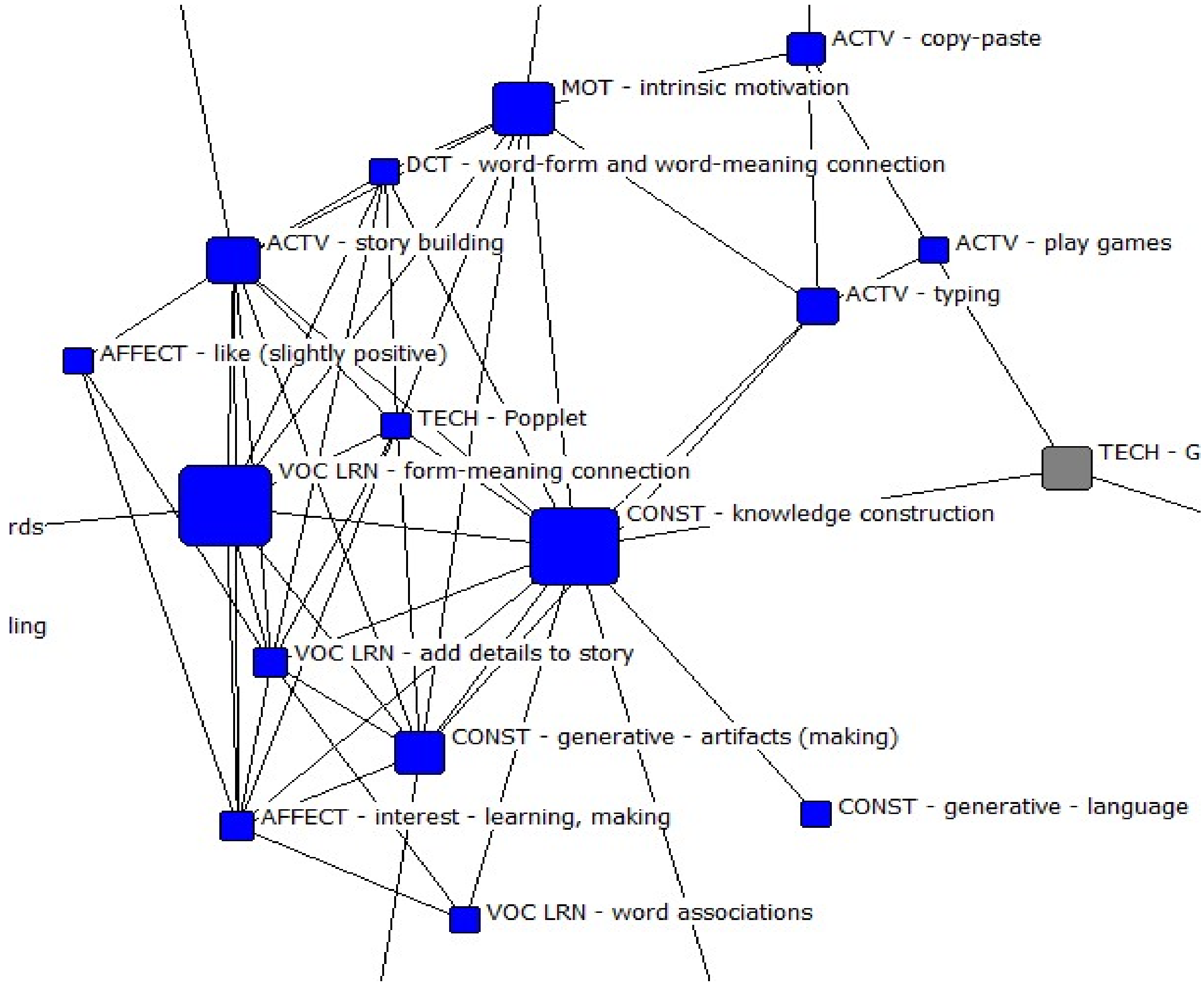

Figure 4.9 Knowledge Construction Cluster

The ***game-quiz*** cluster (red cluster in Figure 4.10) consists of one code of *quiz game, matching* from the category of "activity," one code of *multimodal information presentation* from the subcategory of "dual coding theory," two codes of *play games* and *learn new words* from the category of "vocabulary learning experiences," two codes of *scaffolding, ZPD* and *activating prior knowledge, schema building* from the category of "constructivist theory," and a code of "*Quizlet*" from the category of "technologies."

The three prominent leverage points in this cluster are *play games* (betweenness value 186.00)*, activating prior knowledge* (betweenness value 210.00)*,* and *learn new words* (betweenness value 232.00).

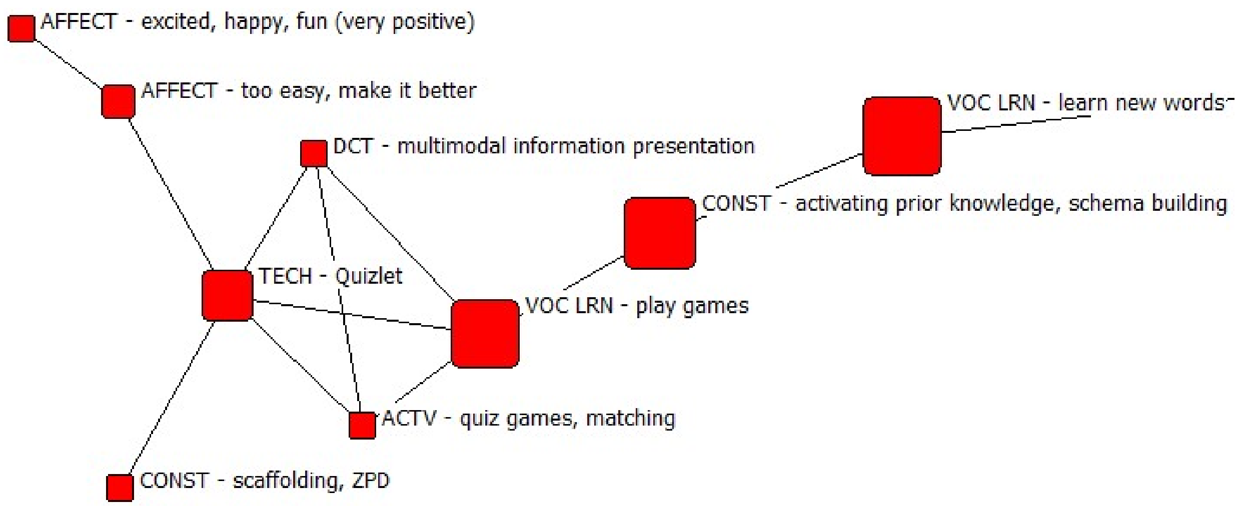

Figure 4.10 Game-Quiz Cluster

The ***extrinsic-negative*** cluster (pink cluster in Figure 4.11) consists of two codes of *extrinsic motivation* and *no motivation* from the subcategory "motivation theory," two codes of *very negative* and *slightly negative* from the category of "students' affect," one code of *design, coloring* from the category of "activity," and one code of "Toontastic" from the category of "technologies." This one and subsequent clusters had no distinct leverage points.

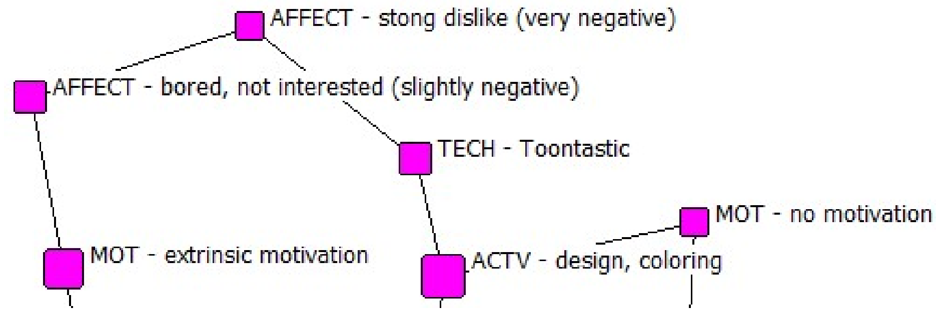

Figure 4.11 Extrinsic-Negative Cluster

The ***writing*** cluster (gray cluster in Figure 4.12) includes a code of *writing* from the category of "activity," and two codes of *Google Doc* and *Google Classroom* from the category of "technologies."

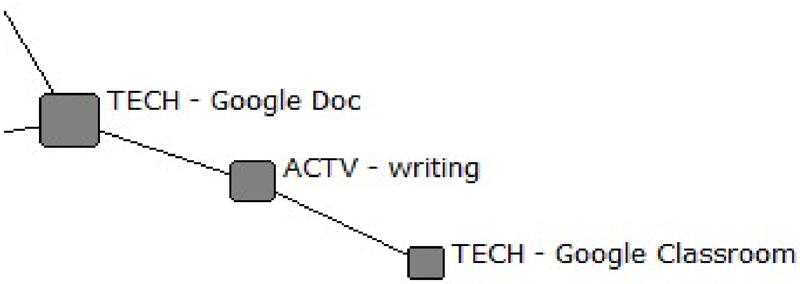

Figure 4.12 Writing Cluster

The ***auditory*** cluster (black cluster in Figure 4.13) consists of a code of *recording audio* from the category of "activity," a code of *audio-text* from the subcategory of "dual-coding theory," and a code of *favorite, helpful* from the category of "students' affect." The green ***book-text-graphics*** cluster (green cluster in Figure 4.13) includes a code of *Book Creator* from the category of "technologies," and a code of *text-graphics* from the subcategory of "dual-coding theory."

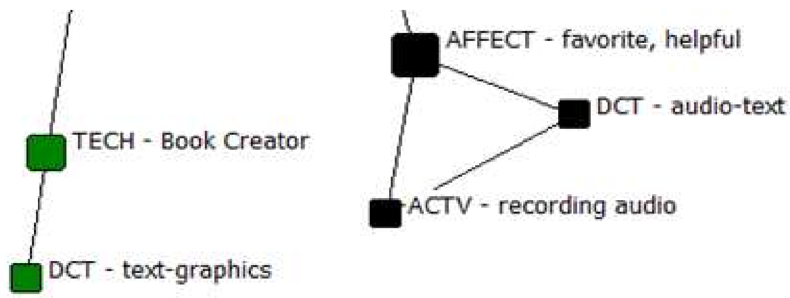

Figure 4.13 Auditory and Book-Text-Graphics Clusters

4.2.4. Discussion of Findings for Research Question 2

Findings from research question two (Figure 4.8) reveals the connections among the different learning theories that this study is based on including constructivist theory, dual coding theory, and motivation theory and learners' experience in terms of vocabulary learning. The ***knowledge construction*** cluster (blue cluster in Figure 4.9) reveals two leverage points including *knowledge construction* and *intrinsic motivation* from the subcategories of "constructivist theory," and "motivation theory," and another leverage point of *form-meaning connection* from the category of "vocabulary learning experience." All these theories are connected to the digital application *Popplet* which is also connected to the "activity" of *story building*. Students feel *slightly positive* and have *interest* in *learning, making* artifacts in *Popplet* (Figure 4.9). This aligns with the constructivist theory which views learning both as a generative process as well as a cognitive process in which knowledge is constructed (Bruner, 1996; Vygotsky, 1978) for vocabulary development. Generative technologies such as *Popplet* which allow students to innovate upon it without any gate-keeping may bring positive impact on affect and vocabulary learning of the students (Grisham & Smetana, 2011) while motivating the students intrinsically (Deci & Ryan, 1985).

The ***game-quiz*** cluster (red cluster in Figure 4.10) shows two leverage points including *play games* and *learn new words* from the category of "vocabulary learning experience" and a code of *activating prior knowledge, schema building* from the subcategory of "constructivism" (Piaget, 1952, 1964). This ***game-quiz*** cluster is connected to the ***knowledge construction*** cluster by the one code of *form meaning connection.* This suggests that playing games may contribute to activating the prior knowledge and/or schema building of the students which may lead to learning new words, form-meaning connection, and ultimately to knowledge construction for vocabulary knowledge development. This aligns with the schema theory of vocabulary learning which suggests that vocabulary learning evolves as the learners make connections among different word forms and meaning (Chance, 1994). This cluster also includes one code of *Quizlet* from "technologies" category, and is connected to two codes of *very positive,* and *too easy* from the "students' affect" category. *Quizlet* is also connected with one code of *multimodal information presentation* from "dual coding theory," one code of *scaffolding* from "constructivist theory," one code of *quiz games, matching,* and a code of *play games.* This indicates that students had a very positive attitude towards the *Quizlet* app even though some of them found it to be too easy, and therefore the app designers or curriculum designers need to make it more rigorous. *Quizlet* provides the students with opportunities to play quiz games by presenting information in a multimodal form including audio, text, videos, images and so on. This aligns with the feature of dual coding theory of vocabulary learning in the DGBLL context which contends that digital games may be helpful for learners' vocabulary development as they help the learners to use "graphic display" with "semantically related vocabulary" (Sadoski, 2005; p. 233). *Quizlet* is also connected to *scaffolding* indicating that the application may help the students to move from easy to harder vocabulary words (Vygotsky, 1978) and may help the learners to develop more agency and autonomy in the learning activity (Reiser & Tabak, 2014).

The ***extrinsic-negative*** cluster (pink cluster in Figure 4.11) shows that the code *extrinsic motivation* is connected to the "students' affect" of *bored, not interested (slightly negative),* which in turn, is connected to *strong dislike (very negative)* with *Toontastic. Toontastic* is also connected to the "activity" of *design, coloring* which is connected to *no motivation.* This suggests that students perceived *Toontastic* to be not engaging enough. Some of the students perceived it to be "not fun" and "boring." The *design, coloring* activities were not motivating to most students. There were a few students who completed the activities in *Toontastic* because of the extrinsic motivation as it lets the students "choose a color," or "make a person," or "puts name on it (character)." This resonates with the idea that too much emphasis on extrinsic motivation and lack of teacher-student and student-student interaction may create a disconnect between the technology and learning experience (Egenfelst-Nielsen, 2007). However, other studies indicate that *Toontastic* was beneficial in developing young students' writing & creativity skills (Galván et al., 2020) and digital story creation skill (Das, 2012; Laidlaw & Wong, 2016). It is possible that the students in this study did not like the particular feature of *design, coloring* or it may be the case that digitally-mediated language learning experiences using this app were not implemented optimally in the curriculum.

The ***writing*** cluster **(**gray cluster in Figure 4.12) shows that both *Google Doc* and *Google Classroom* are connected to *writing.* This cluster does not include any students' affective experience or learning theory. However, this cluster is connected to the ***knowledge construction*** cluster (Figure 4.9) with two codes of *play games* and *knowledge construction* through the code of *Google Doc.* After playing games in the brainstorming phase, the students may have used *Google Doc* and *Google Classroom* to write down their stories in their drafting, editing, and publishing phases which may have led to their knowledge construction (Johnson et al., 2016).

Last but not least, the ***auditory*** and the ***book-text-graphics*** clusters (Figure 4.13) shows that the code of *audio-text* from dual-coding theory is connected to the activity of *recording audio* and students' affect of *favorite, helpful.* Figure 4.5 shows that recording audio is connected to *iPad (Speech recognition)* and *Book Creator* as well. The ***book-text-graphics*** cluster shows the connection between the codes of *Book Creator* and *text-graphics*. This suggests that *Book Creator* may promote vocabulary learning by providing a multimodal platform where students can record audio and write their stories and therefore can connect the multimodal platforms of audio-texts and text-graphics as well as incorporate new words into their writing (Kervin & Mantei, 2016).

4.2.5. Findings for Research Question 3

To answer the research question 3, *"How might the problematic aspects of digital technologies be addressed from students' perspectives?,"* a five-cluster semantic network map (Q= 0.68; Figure 4.14) was generated in the analysis software using the Girvan-Newman algorithm (Girvan & Newman, 2002) with the categories of "technologies," "suggestions," "students' affect," and "activity" using the correlated code matrix at the level of $p<0.01$ level. Different clusters are described below with their zoomed-in images. Betweenness centrality measures were calculated for this map as well, but because there was a narrow range of betweenness measures, no distinct leverage points could be identified.

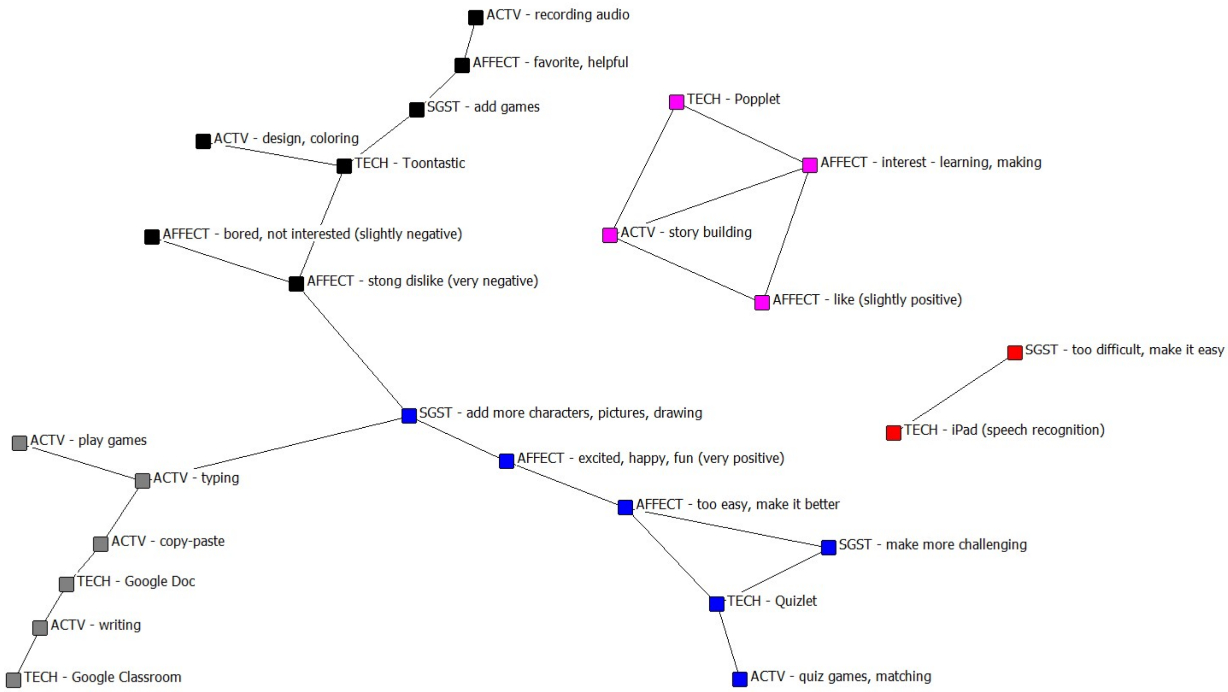

Figure 4.14 Technologies vs Suggestions vs Students' Affect vs Activity

The ***bored-dislike-design*** cluster (black cluster in Figure 4.15) includes one code of *Toontastic* from the category of "technologies," three codes of *slightly negative, very negative* and *favorite, helpful* from the category of "students' affect," two codes of *recording audio,* and *design, coloring* from the category of "activity," and a code of *add games* from the category of "suggestions."

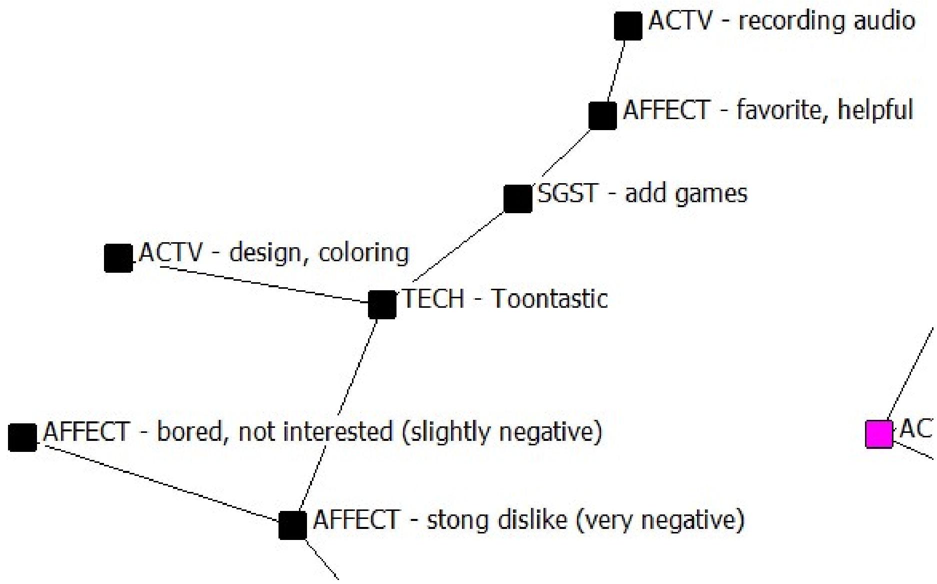

Figure 4.15 Bored-Dislike-Design Cluster

The ***easy-fun*** cluster (blue cluster in Figure 4.16) includes two codes from the category of "students' affect" including *very positive* and *too easy, make it better,* two codes from the category of "suggestions" including *add more characters, pictures, drawing,* and *make more challenging,* one code from the category of "technologies" namely, *Quizlet,* and one code from the category of "activity" namely, *quiz games, matching.*

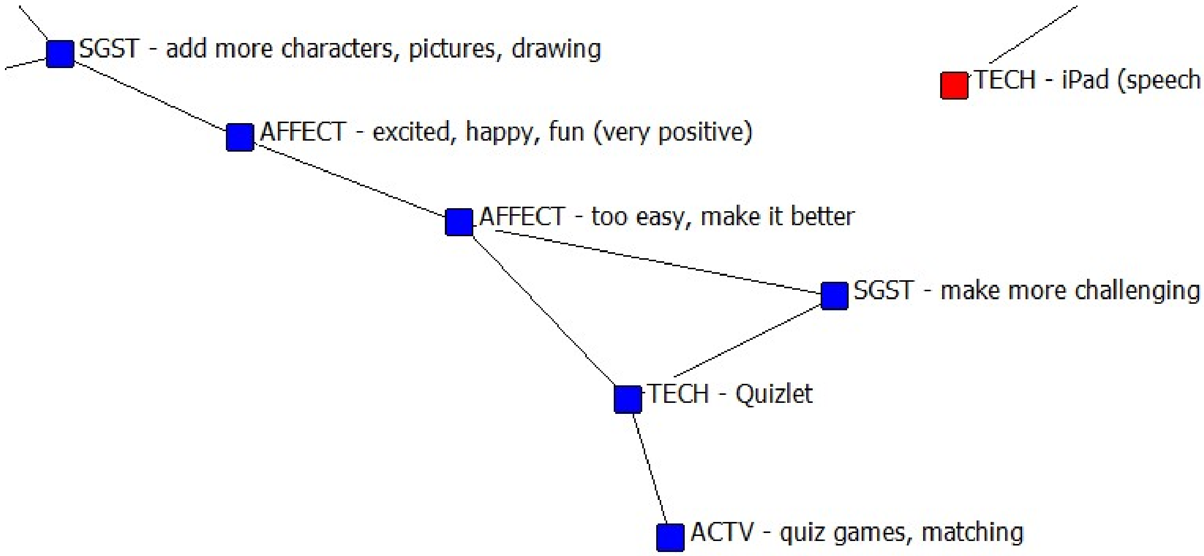

Figure 4.16 Easy-Fun Cluster

The ***document-play*** cluster (gray cluster in Figure 4.17) includes four codes of *typing, copy-paste, writing,* and *play games* from the category of "activity," and two codes of *Google Doc* and *Google Classroom* from the category of "technologies." This cluster does not include any code from the categories of "suggestions" or "students' affect."

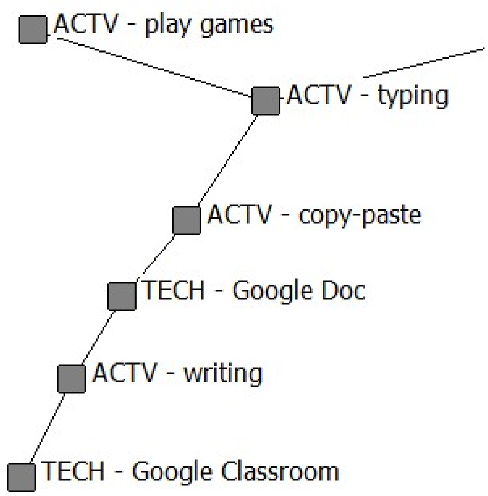

Figure 4.17 Document-Play Cluster

The ***like-learning*** cluster (pink cluster in Figure 4.18) consists of two codes of *like (slightly positive)* and *interest-learning, making* from the category of "students' affect," one code of *story building* from the category of "activity," and one code of *Popplet* from the category of "technologies."

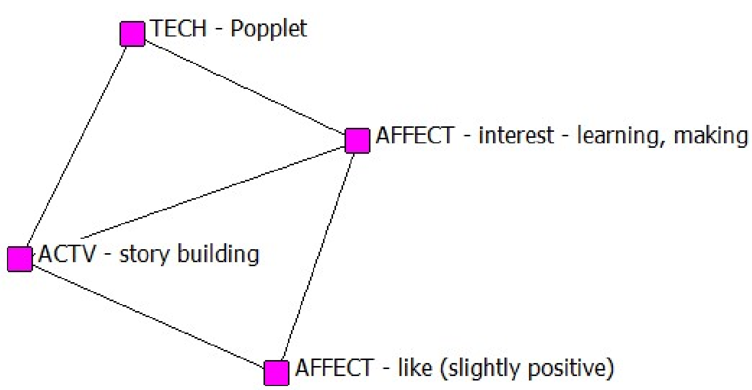

Figure 4.18 Like-Learning Cluster

The ***difficult*** cluster (red cluster in Figure 4.19) includes one code of *too difficult, make it easy* from the category "suggestions," and one code of *iPad (Speech Recognition)* from the category of "technologies."

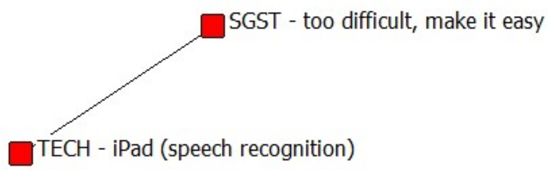

Figure 4.19 Difficult Cluster

The implications of these findings regarding student's positive and negative language learning experiences, connections between these experiences and aspects of learning theories, and data-grounded suggestions for improvement of digitally-mediated vocabulary learning experiences within a writing intervention will be discussed in the following section.

4.2.6. Discussion of Findings for Research Question 3

Findings from research question three (Figure 4.14) shows connections between the problematic aspects of digital technologies and students' suggestions for improvements. The ***bored-dislike-design*** cluster (black cluster in Figure 4.15) shows that the code *Toontastic* is connected to the codes of *design, coloring, strong dislike,* and *add games.* The code of *strong dislike* is also connected with the code of *bored, not interested (slightly negative).* The code of *adding games* is also connected with *favorite, helpful,* which is connected with *recording audio.* This suggests that students associated the *Toontastic* app with strong dislike, especially in terms of the activity *design, coloring*. They suggested *adding games* to this application. However, a few students found the *recording audio* aspect to be helpful even though they suggested adding games as well. As mentioned earlier, other researchers have suggested that the *Toontastic* app may have potential to help students with visualization and incorporating new words in writing (Sessions et al., 2016). *Toontastic* has also been found to have potential for promoting creativity and digital storytelling skills (Das, 2012; Galván et al., 2020; Laidlaw & Wong, 2016). Despite the beneficial findings by other researchers, in this study, students reported finding *Toontastic* helpful only for recording audio. This finding may be attributed to the fact that this study did not incorporate all features of *Toontastic* for story creation; instead, this study only used the visualization and audio recording features of this app.

The ***easy-fun*** cluster (blue cluster in Figure 4.16) shows that the codes of *too easy, make it better, Quizlet,* and *make more challenging* are connected with each other. *Quizlet* is also connected with *quiz games, matching.* The code of *too easy, make it better* is also connected to the code of *excited, happy, fun* which is connected to *add more characters, pictures, drawing.* This suggests that the *Quizlet* app is associated with quiz games and matching activities. Some students perceive this app to be too easy even though some students have very positive experiences with it. Students who perceived it to be too easy wanted the app designers and curriculum designers to make it more challenging, whereas students who were excited to use this app wanted to add more activities or functionality involving characters, pictures, and drawings. This is an interesting finding because it is in stark contrast to the ***bored-design-dislike*** cluster where the students mention that the app *Toontastic* has characters, colors and pictures in it and they suggest adding more games to it. In the case of *Quizlet,* which has games, students feel the necessity to add a variety of characters, colors, and drawing. Therefore, it is safe to assume that there should be balance between generative design activities and gaming activities. Constructionist theory (Papert & Harel, 1991) suggests that a happy medium could be provided by letting students design their own game.

The ***document-play*** cluster (gray cluster in Figure 4.17) includes four "activity" codes of *play games*, *typing, copy-paste,* and *writing.* It also includes two "technologies" codes of *Google Classroom* and *Google Doc.* As mentioned above during our discussion for research question one, *Google Classroom* and *Google Doc* may have the potential to solidify students' ideas for story writing and typing after their brainstorming session (Johnson et al., 2016). However, this cluster does not include students' affective experience or any suggestion for improvement.

The ***like-learning*** cluster (pink cluster in Figure 4.18) includes three codes of *Popplet, story building,* and *interest-learning, making*, all connected to one another. The codes of *story building,* and *interest-learning, making* are also connected to the code of *like (slightly positive).* This suggests that students perceive this app as interesting for learning and creating artifacts as well as for story building. While discussing research question 1, the researcher mentioned how *Popplet* is connected to *learning new words, form-meaning connections,* and *word associations* as well (Figure 4.3). These findings suggest that *Popplet* may have the potential for learners' vocabulary development through word-associations, form-meaning connections, and incorporating new words while adding details to their story (Kervin & Mantei, 2016). Last but not least, the ***difficult*** cluster connects only two codes of *ipad (speech recognition)* and *too difficult, make it easy* to each other. This cluster does not include any suggestions or students' affective experience. While using *Google Docs*, the students were encouraged to use the in-built speech recognition app of iPad if they had difficulty in typing or had low proficiency in spelling. However, the students found this app to be too difficult and not user friendly. The students mentioned that this app could not "hear right" or "didn't tell the words I [student] was saying," meaning that the app could not recognize the words the students were saying. The app developers should resolve these issues, and curriculum designers could modify the learning experiences such that the speech recognition plays a less prominent role.

4.3. Article 3 Conclusion

To conclude, the findings in this study are threefold. Firstly, this study attempts to show the interconnections between learners' experience with technologies and vocabulary learning during a writing intervention. Findings suggest that learners may have positive experiences with some digital applications, while some digital applications may evoke negative emotions for learners and that these affective experiences are interdependent with technologies, learning activities, and aspects of vocabulary learning theories. For example, students perceive digital applications such as *Popplet* helpful for incorporating new words in their writing, and *Book Creator* for learning contextual vocabulary, whereas they associate dislike and boredom with the application *Toontastic* even though other researchers found it to be helpful for vocabulary learning during writing (Sessions et al., 2016). Secondly, this study demonstrates the importance of understanding the complexity of learning (Nasir et al., 2021) and the intricate connections among different learning theories, technologies, and vocabulary learning experiences of the learners. This study reaffirms that learning is both a generative and a cognitive process where knowledge is constructed (Bruner, 1996; Vygotsky, 1978) and suggests that generative technologies such as *Popplet* may bring positive impact on students' vocabulary learning experience while promoting their intrinsic motivation. Moreover, applications like *Quizlet* or *Book Creator* may be beneficial for learners to interconnect between the multimodal forms (i.e., audio, video, images) and semantically connected words. Lastly, this study attempted to address the problematic aspects of technology from the students' perspectives and made suggestions: 1) for the app developers to improve the technologies in future, and 2) for curriculum designers to develop powerful digitally-mediated language learning experiences for the learners. Educators need to keep in mind that each digital technology has its own set of unique affordances. However, educators should explore the less obvious affordances of the technologies they use. For instance, the most obvious affordance of quiz technologies is for educators to develop multi-modal quizzes which students answer. This could lead to extrinsic motivations (e.g., points), and may fail to facilitate student development of intrinsic motivation and learner agency. However, the designers of learning experience could leverage the less obvious affordances, for instance by having groups of students construct their own multi-modal quizzes which their peers in other groups could take. In other words, learning theories should help educators and researchers identify the less obvious affordances in order to develop digitally-mediated language learning activities which are generative while also developing learner agency and intrinsic motivation.

5. CONCLUSIONS

Current research studies show that different theoretical frameworks may offer different skill development and most research studies are guided by a combination of theoretical frameworks (Donato, 1994; Moody et al, 2018; Swain & Lapkin, 1998). Findings from article one showed that in the research studies focusing on DGBLL context for vocabulary development also tend to incorporate several vocabulary development theories including dual coding theory, social constructivist theory, motivation theory, and schema and psycholinguistic theory. The use of dual coding theory is prevalent in DGBLL research as it focuses our attention on the importance of helping students construct understanding of new vocabulary words through multiple modalities such as pictures, audio, video and so on (Sadoski, 2002; Kim & Gilman, 2008). Constructivist theory promotes social collaborative learning through digitally mediated scaffolding (Donato, 1994; Swain & Lapkin, 1998; Vygotsky, 1978). Motivation theory contends that the DGBLL milieu has the potential to increase students' intrinsic motivation in word-learning while promoting self-regulation, autonomy, and self-efficacy (Deci & Ryan, 1985). Finally, many researchers have used schema and psycholinguistic theories as the guiding theories for their studies. Only focusing on the schema and psycholinguistic theory, however, may lead some researchers to heavy emphasis on drill practice, memorization, and repetition which may not aid the learners in deeper understanding of the words (Stahl & Bravo, 2010).

Current research studies also show that grounding research studies on different theoretical frameworks may offer different skill development. Most research studies are guided by a combination of theoretical frameworks (Moody et al., 2018). Based on the above-mentioned findings from article one, the researcher designed the study for article two, heavily grounded in the theoretical frameworks of dual coding theory (Paivio & Desrochers, 1980), motivation theory (Deci & Ryan, 1985), and constructivist theory (Piaget, 1952). The researcher also took the constructivist approach one notch further and used constructionist theory (Papert, 1993) by designing learning experiences in which the learners designed their own game instead of just playing games.

Findings from article two show that after the eight-week DGBLL workshop where the students designed their own games, there are statistically significant gains in vocabulary development and reading comprehension. However, since the researcher did not have a control group, these gains cannot be attributed to the DGBLL workshop entirely. The DGBLL experience afforded the learners with a space for sheltered vocabulary learning which is low-anxiety inducing for the students (Pu and Zhong, 2018; Rahmi, 2018). The DGBLL environment also helped the learners with contextual L2 vocabulary learning in a goal-oriented, meaning focused way (Ellis, 2003; Reinhardt, 2018) in a social-collaborative environment (Hickey et al., 2010; Hickey & Filsecker, 2012). Moreover, this study also found that educators could design generative learning experiences where learners have the opportunity to transform the learned information into knowledge by constructing meaningful embodiments of their cognition in the DGBLL context.

Article three is not focused on a DGBLL context, but rather on technology-mediated vocabulary learning during a writing intervention. This study is also heavily grounded in the theoretical frameworks complemented by the findings of article one. Article three is grounded in motivation theory (Deci & Ryan, 1985), dual coding theory (Paivio & Desrochers, 1980), and constructivist theory (Piaget, 1952).

Article three findings show that students had a positive attitude towards some digital applications for vocabulary development whereas some digital applications evoked negative emotions for the learners. Moreover, this study showed the interconnections among different learning theories, technologies, and vocabulary learning experiences of the students. The findings suggested that generative technologies, if grounded in theory, have the potential to help the learners with knowledge construction (Bruner, 1996; Vygotsky, 1978).

The findings that both articles two and three share in common is that both of them are grounded in theoretical foundations that promote vocabulary learning including constructivist/constructionist theory, dual coding theory, and motivation theory. Moreover, the findings from both of the studies show that generative technologies (i.e. Scratch, Popplet) may have the potential to lead to knowledge construction and vocabulary knowledge development while promoting the learners' autonomy (Sylven & Sundqvist, 2012; Jensen, 2017) and intrinsic motivation (Deci & Ryan, 1985). Both articles can help us understand DGBLL and technology-facilitated learning environments in much greater depth because the interdependencies of theoretical frameworks, learning experiences, and affective experiences are the primary focus of analysis. More research like this is needed to explore the ways in which everything is connected and interdependent (aspects of theory, affect, learning experiences, and technologies).

These three articles provided insights regarding DGBLL and digitally-mediated contexts for vocabulary learning. Article one provided guidelines for using multiple vocabulary learning theories for DGBLL contexts. Article two contributes to understanding DGBLL in comparison to the technology-mediated language learning in article three.

Educators' changing roles in K-12 settings are intertwined with their relationships to technology in the classroom. In general, teachers do not have many opportunities to participate significantly in the design and/or testing of technologies in the classroom. Most of the time they are not even trained with the skills or background to change, modify, or create technologies for their own classrooms. Therefore, they select and contextualize technologies. Even in those cases, however, teachers usually use general-purpose desktop publishing and office tools to create and remix multimedia such as powerpoint or short video clips. These tools, although effective to some extent, only support mundane or commonplace activities (Hoadley & Uttamchandani, 2021). On the other hand, from article two and article three findings, it is apparent that educators can use more generative technologies for L2 vocabulary knowledge development so that students develop learner agency and autonomy. Therefore, teacher training in generative technologies is an absolute necessity. Educators should design these vocabulary learning opportunities such that they include reading (article two) and writing (article three) activities. They should design generative learning experiences where learners have the opportunity to transform the learned information into knowledge by constructing meaningful embodiments of their cognition in the DGBLL context (Papert, 1993). Moreover, educators could incorporate the unique affordances of DGBLL to promote positive affective experiences for the learners. Educators should keep in mind that each technology has its own unique affordances and ground their practice in learning theories to identify the less obvious affordances to develop learner agency and intrinsic motivation as opposed to teacher dependency and extrinsic motivation. Each technology has its own unique affordances and grounding their practice in learning theories can help them identify the less obvious affordances (Becker & Riel. 2000; Fishman & Pinkard, 2001; Hoadley & Uttanchandani, 2021). Educators should also think about the interdependencies between aspects of theory, affect, learning experience, and technology. Educators can use more generative technologies for L2 vocabulary knowledge development so that students develop learner agency and autonomy (Sylven & Sundqvist, 2012; Jensen, 2017).

Understandably, there are differing viewpoints regarding pedagogical priorities, and how the instructor adapts and deploys the technology (Becker & Riel. 2000; Fishman & Pinkard, 2001). Technology can be perceived as “freeing up” for a teacher where it enables the teacher to engage in the facilitative and scaffolding work that only the teacher can do, or to provide the teacher with more time for curriculum design work (Hoadley & Uttanchandani, 2021, p.17). On the flip side, technology can be perceived as a "replacing" agent for the teacher where technology may create disruption and may not be helpful for students' learning at all (Hoadley & Uttanchandani, 2021, p.17). Therefore, for more constructivist and generative learning in the classroom, technology needs to be "teacher empowering," rather than "teacher proof" (Hoadley & Uttanchandani, 2021, p.17; Robinson, 1991). However, at the same time, curriculum designers need to make the learning tasks more rigorous so that the students do not get bored. One strategy is to engage the teachers in the curation, revising, reviewing, and development process of digital tools, which may help to close the gap between the curriculum developers and technology designers (Ravitz & Hoadley, 2005).

Limitations and Future Studies

The three articles resulted in significant findings. However, article two had a small sample size (13 participants). Data collected from this small sample size cannot perfectly represent the DGBLL workshop experience for vocabulary learning. Also, since this study did not have a control group, the researcher could not attribute the gains from pre to post test in vocabulary development and reading comprehension to the DGBLL workshop. However, the findings in this study provided transferable insights into the DGBLL context. Moreover, article three had a different pre-test than the post-tests. Therefore, we could not look at the gains of the students' vocabulary learning. Article three did not have in-depth individual interviews with each student, so there was less robust depth of data than desirable. Future research should focus on long-term data collection and implementation of the research design with multiple data sources for the triangulation of the data.

Most qualitative research has issues with researcher bias (Creswell & Poth, 2016). To address this, the researcher acknowledged the issue, ran intra-rater reliability tests, and tried to reflect critically through all the stages of analysis and interpretation.

Furthermore, the workshop in article two only lasted for eight weeks and the intervention in article three lasted for ten weeks. More time and progression through time in a longitudinal study could provide more in-depth findings regarding DGBLL and digitally mediated-language learning contexts.

Finally, since the articles included qualitative studies, generalizability is not a feasible goal. Also, because the articles rely mostly on the qualitative methodologies, even though replicability of protocol and procedures may be possible, replicability of findings are not possible. Therefore, future research should focus on long-term data collection and implementation of the research design with multiple data sources for the triangulation of the data. Lastly, future researchers should focus on grounding their research on theoretical frameworks to design more powerful learning experiences for the learners.

The strength of this dissertation lies in the innovative use of network analysis in DGBLL and technology-facilitated vocabulary learning research which provide insights into the relationships between aspects of theory, affect, learning experiences, and technologies.

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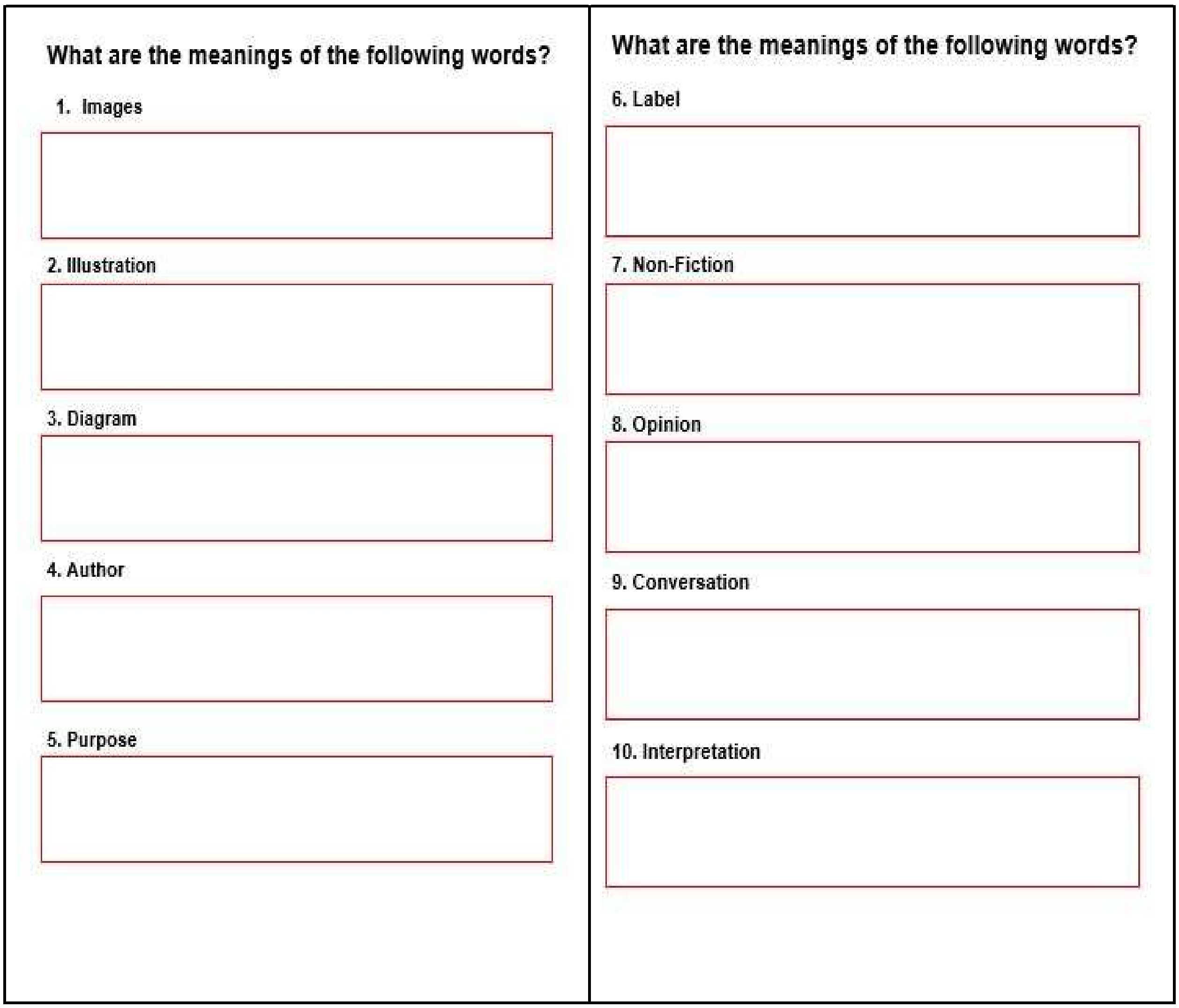
APPENDIX A

PRE AND POST TESTS



What are the meanings of the following words?

1. Images

2. Illustration

3. Diagram

4. Author

5. Purpose

What are the meanings of the following words?

6. Label

7. Non-Fiction

8. Opinion

9. Conversation

10. Interpretation

Figure A1. Vocabulary Development Pre-test

The Grand Canyon

One of the most famous national park of America is the Grand Canyon. Every year about five million people visit this place.

This Grand Canyon was created out of the Colorado River. It is 277 miles long, 18 miles wide, and one mile deep. Over 17 million years, the Colorado River has been eroding the canyon. This erosion has resulted in layers of beautifully colored rock.

Native Americans have lived in this canyon areas for thousands of years. The first of the native people to live in the Grand Canyon were the Ancient Puenloans. Today, Hualupai and Navajo tribes still live in this area.

Figure A2: Reading Comprehension Test (Part 1)

Answer the following Questions

1. What is this passage “the Grand Canyon” about?
2. What are the three details of this passage that support the main topic?
3. Which of the following details could the author add to their passage?
   a. There are many caves inside the canyon.
   b. We should wear boots if we want to hike in Grand Canyon.
   c. Horseshoe Bend was created by Colorado river in the Grand Canyon
   d. Flagstaff airport is very close to the Grand Canyon.

4. What are some key words that help you to understand author’s purpose?

Figure A3: Reading Comprehension Test (Part 2)

5. What is the author trying to explain in this passage? What is the author describing in this passage?

6. Give two evidences from the passage that help you understand the author's purpose. (What is the setting of the passage? Did the main topic and details help you to understand the passage?)

7. Which of the following statement would you agree with?

a. You should go camping to the Grand Canyon.

b. The Grand Canyon is a wonderful place to visit.

c. If you go to Texas, you should visit Austin.

d. It is best to visit the Grand Canyon when you grow up.

Figure A4: Reading Comprehension Pre-Test (Part 3)

What are the meanings of the following words?

1. Analyze
2. Biography
3. Definition
4. Synonym
5. Purpose

What are the meanings of the following words?

6. Detail
7. Non-Fiction
8. Diagram
9. Conversation
10. Interpretation

Figure A5: Vocabulary Development Post-Test

Are School Uniforms Best?

Everyday students confront many things that may distract them from focusing on their education. Some of these distractions include technology, fashionable attires, and peer pressure. School uniforms may be helpful to reduce distraction about the clothing.

Uniforms help the students to not get distracted from their study. When everyone looks identical, they will not be distracted by attires.

Moreover, school uniforms may help the parents to save money. If everyone wears same clothing, parents will not have pressure to buy expensive clothing for their children.

Furthermore, school uniforms help the students look professional for future jobs and careers. This will help them to maintain dress codes which is a requirement for many jobs nowadays.

Therefore, school uniforms help to remove many distractions regarding clothing. Uniforms are also helpful to save money. Lastly, uniforms help the students to be prepared for their future jobs and career.

Figure A6: Reading Comprehension Post-Test (Part 1)

Answer the following Questions

1. What is this passage “the Grand Canyon” about?
2. What are the three details of this passage that support the main topic?
3. Which of the following details could the author add to their passage?
   a. School uniforms are cool.
   b. School uniforms is helpful to save time.
   c. Places to buy school uniforms.
   d. Black, blue, oranges should be the colors of school uniforms.

4. What are some key words that help you to understand author’s purpose?

Figure A7: Reading Comprehension Post-Test (Part 2)

5. What is the author trying to explain in this passage? What is the author describing in this passage?

6. Give two evidences from the passage that help you understand the author's purpose. (What is the setting of the passage? Did the main topic and details help you to understand the passage?)

7. Which of the following statement would you agree with?

a. School uniforms may cost a lot of money.

b. School uniforms are not comfortable at all.

c. School uniforms do not look professional.

d. School uniforms help students to save their time to get ready.

Figure A8: Reading Comprehension Post-Test (Part 3)

APPENDIX B

JOURNAL PROMPT AND INTERVIEW PROTOCOL

Please write about your game-design today

	What is working well?	Needs Improvement
Player role/character		
Game goals/rules Is it clear what you are supposed to do? What ways could the goals/rules work better?		
Challenges Which part was too hard/boring/easy/just right?		
Language Do you understand the words/language/story? Did you learn a new word?What was it? Can you write a sentence with it?		
Style		

What images/color choices work well?		

Figure B1: Game-Design Journal Prompt

Interview Protocol for Study 1

1. What did you think about the program?
2. How did you feel about making the games?
3. What was your game about?
4. What did you like about working on your game in Scratch?
5. How do you think your game turned out?
6. What steps did you follow to make your game after reading a nonfiction text?
7. How did you work with any other students on your game?
8. Do you think you will show your video game to other people?
9. Would you be interested in designing video games about other stories?
10. Do you feel more confident about reading non-fiction texts now (after this program)?
11. Do you feel more confident about learning new words?

Interview Protocol for Study 2

1. Tell me about your favorite app used in the program. Why was it your favorite?

2. Tell me about the app you do not want to use again? Why wouldn't you want to use it again?
3. So, if you get a chance to talk to the programmer who created this app, what suggestions would you give them? How can they make it better?
4. So which app helps you to be a better writer? How did it help you?

APPENDIX C

SURVEY INSTRUMENT

Pre-Survey

1. I enjoy making video games very much
2. I am pretty good at making video games.
3. I think making video games is a boring activity.
4. I think I am pretty good at making video games.
5. I think making video games is an important activity.
6. I would describe making video games as very interesting.
7. Making video games is an activity that I can't do very well.
8. Making video games is fun to do.

Post- Survey

1. I think I am up to the difficulty of this task
2. I probably won't manage to do this task
3. I feel under pressure to do this task well
4. After reading the instructions, this task seemed very interesting to me.
5. I am eager to see how I will perform in this task
6. For tasks like this, I do not need a reward, they are lots of fun anyway.
7. It would be embarrassing to fail at this task
8. I think everyone could do well in this task
9. If I can do this task, I will feel proud of myself
10. I would work on this task even in my free time.

APPENDIX D

INITIAL CODEBOOKS

Category	Sub-Category	Code
Theory	Motivation Theory (MT)	MT - extrinsic motivation
		MT - intrinsic motivation
	Constructionist Theory	CONSTRUCTIONIST - Authentic audience
		CONSTRUCTIONIST - situating learners as designers
		CONSTRUCTIONIST - learner agency (also in motivation theory)
		CONSTRUCTIONIST - Tinkering
		CONSTRUCTIONIST - Making
	Dual Coding Theory (DCT)	DCT - graphics - audio
		DCT - text - audio
		DCT - text - graphics
		DCT - multiple modality
Game-Based Learning Experience (EXP GBL)		EXP GBL - Make a game
		EXP GBL - Enjoyed coding
		EXP GBL - learned facts about the non-fiction topic
		EXP GBL - Translate information into an interactive game

		EXP GBL - Making digital artifact
		EXP GBL - Improve coding knowledge
Affective Experience (EXP AFF)		EXP AFF - confident
		EXP AFF - Fun
		EXP AFF - boring
		EXP AFF - Difficult
		EXP AFF - nice, good, great
		EXP AFF - Just right
		EXP AFF - motivated to learn more about the topic
		EXP AFF - Easy
		EXP AFF - exciting, amazing
Design Challenges		DESIGN CHALL - more free play, diversity of games
		DESIGN CHALL - technical glitch
		DESIGN CHALL - Need more instruction on Scratch
		DESIGN CHALL - coding was challenging
		DESIGN CHALL - not enough time
		DESIGN CHALL - Want more complexity

		DESIGN CHALL - no reflection
		DESIGN CHALL - No improvement needed
Language Learning Experience (EXP LL)		EXP LL - enjoyed reading/learning about non-fiction
		EXP LL - learned new facts
		EXP LL - Positive
		EXP LL - context clues
		EXP LL - New words learned
		EXP LL - Going back to text
		EXP LL - wants to practice more
		EXP LL - Can make a sentence
		EXP LL - Wants to learn more new words
		EXP LL - Didn't learn new word
Design Strengths		DESIGN STR - Learned coding
		DESIGN STR - writing facts on foreground
		DESIGN STR - working with colors
		DESIGN STR - wants to improve game
		DESIGN STR - working with images

		DESIGN STR - Background and Foreground work
Gains	Vocabulary Gain (Gain_VOC)	Gain_VOC - Low
		Gain_VOC - Medium
		Gain_VOC - High
	Reading Comprehension Gain (Gain_COMP)	Gain_COMP - Low
		Gain_COMP - Medium
		Gain_COMP - High
	Overall Gain (Gain_Overall)	Gain_Overall - Low
		Gain_Overall - Medium
		Gain_Overall - High

Figure D1: Initial Codebook for Research Study 1

Category	Sub-Category	Code
Suggestions (SGST)		SGST - make more challenging
		SGST - add games
		SGST - improve interface
		SGST - add more characters, pictures, drawing
Activity (ACTV)		ACTV - reading
		ACTV - play games

		ACTV - quiz games, matching
		ACTV - typing
		ACTV - recording audio
		ACTV - writing
		ACTV - story building
		ACTV - design, coloring
Theory	Motivation Theory (MOT)	MOT - extrinsic motivation
		MOT - intrinsic motivation
		MOT - no motivation
	Dual Coding Theory (DCT)	DCT - word-form and word-meaning connection
		DCT - multimodal information presentation
	Constructivist Theory (CONST)	CONST - knowledge construction
		CONST - scaffolding, ZPD
		CONST - activating prior knowledge, schema building
		CONST - generative - language
		CONST - generative - artifacts (making)
Students' Affect		AFFECT - excited, happy, fun (very positive)
		AFFECT - too easy, make it better

		AFFECT - strong dislike (very negative)
		AFFECT - bored, not interested (slightly negative)
		AFFECT - favorite AFFECT - don't want to use in the future
		AFFECT - interest - learning, making
		AFFECT - like (slightly positive)
Technologies (TECH)		TECH - Google Doc
		TECH - iPad (speech recognition)
		TECH - Educreations
		TECH - Quizlet
		TECH - Popplet
		TECH - Popplet
		TECH - Book Creator
		TECH - Google Classroom
		TECH - Toontastic

Figure D2: Initial Codebook for Research Study 2

APPENDIX E

ARTICLE 2 FIGURES

```
. swilk PRE POST

                   Shapiro-Wilk W test for normal data

    Variable |        Obs       W           V         z       Prob>z
-------------+------------------------------------------------------
         PRE |         13    0.90956      1.593     0.912    0.18086
        POST |         13    0.90709      1.637     0.965    0.16728
```

Figure E1: Shapiro-Wilk Test for Vocabulary Performance

```
. ttest POST == PRE

Paired t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. err.   Std. dev.   [95% conf. interval]
---------+--------------------------------------------------------------------
    POST |      13    3.353846    .1950067    .7031067    2.928963    3.778729
     PRE |      13    2.076923    .2054245    .7406684    1.629342    2.524505
---------+--------------------------------------------------------------------
    diff |      13    1.276923    .2998191    1.081013    .6236733    1.930173
------------------------------------------------------------------------------
     mean(diff) = mean(POST - PRE)                                t =   4.2590
 H0: mean(diff) = 0                              Degrees of freedom =       12

 Ha: mean(diff) < 0           Ha: mean(diff) != 0           Ha: mean(diff) > 0
 Pr(T < t) = 0.9994         Pr(|T| > |t|) = 0.0011          Pr(T > t) = 0.0006
```

Figure E2: Paired Sample T-Test for Vocabulary Performance

```
. swilk Post Pre

                   Shapiro-Wilk W test for normal data

    Variable |        Obs       W           V         z       Prob>z
-------------+------------------------------------------------------
        Post |         13    0.98529      0.259    -2.645    0.99592
         Pre |         13    0.98027      0.348    -2.070    0.98080
```

Figure E3: Shapiro-Wilk Test for Reading Comprehension

```
. . ttest Post == Pre

Paired t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. err.   Std. dev.   [95% conf. interval]
---------+--------------------------------------------------------------------
    Post |      13    3.282051    .1670771     .602405    2.918022    3.646081
     Pre |      13     2.24359    .1930186    .6959386    1.823038    2.664141
---------+--------------------------------------------------------------------
    diff |      13    1.038462    .2265763    .8169326    .5447941    1.532129
------------------------------------------------------------------------------
     mean(diff) = mean(Post - Pre)                                t =   4.5833
 H0: mean(diff) = 0                              Degrees of freedom =       12

 Ha: mean(diff) < 0           Ha: mean(diff) != 0           Ha: mean(diff) > 0
 Pr(T < t) = 0.9997         Pr(|T| > |t|) = 0.0006          Pr(T > t) = 0.0003
```

Figure E4: Paired Sample T- Test for Reading Comprehension

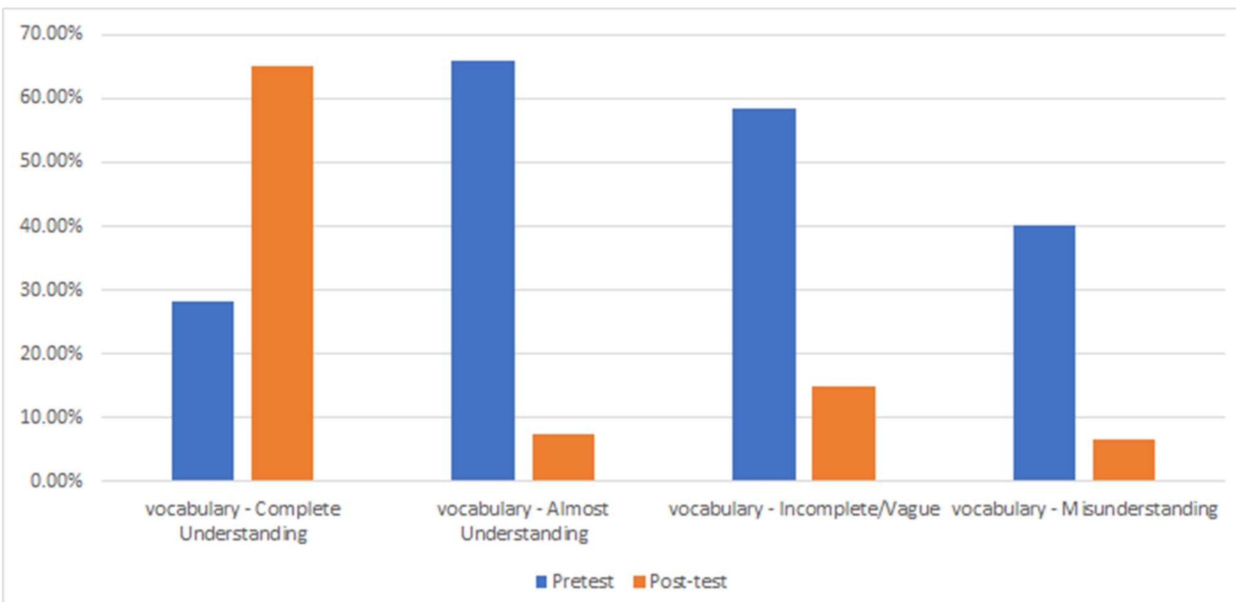


Figure E5: Change in Students' Understanding Level of Vocabulary Items

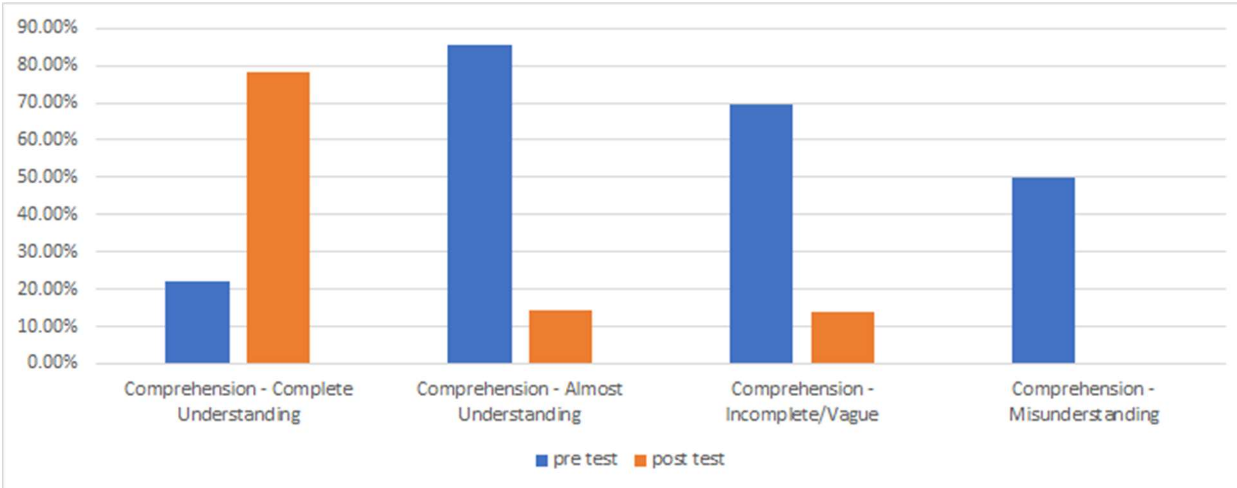


Figure E6: Change in Students' Understanding Level of Reading Comprehension Items

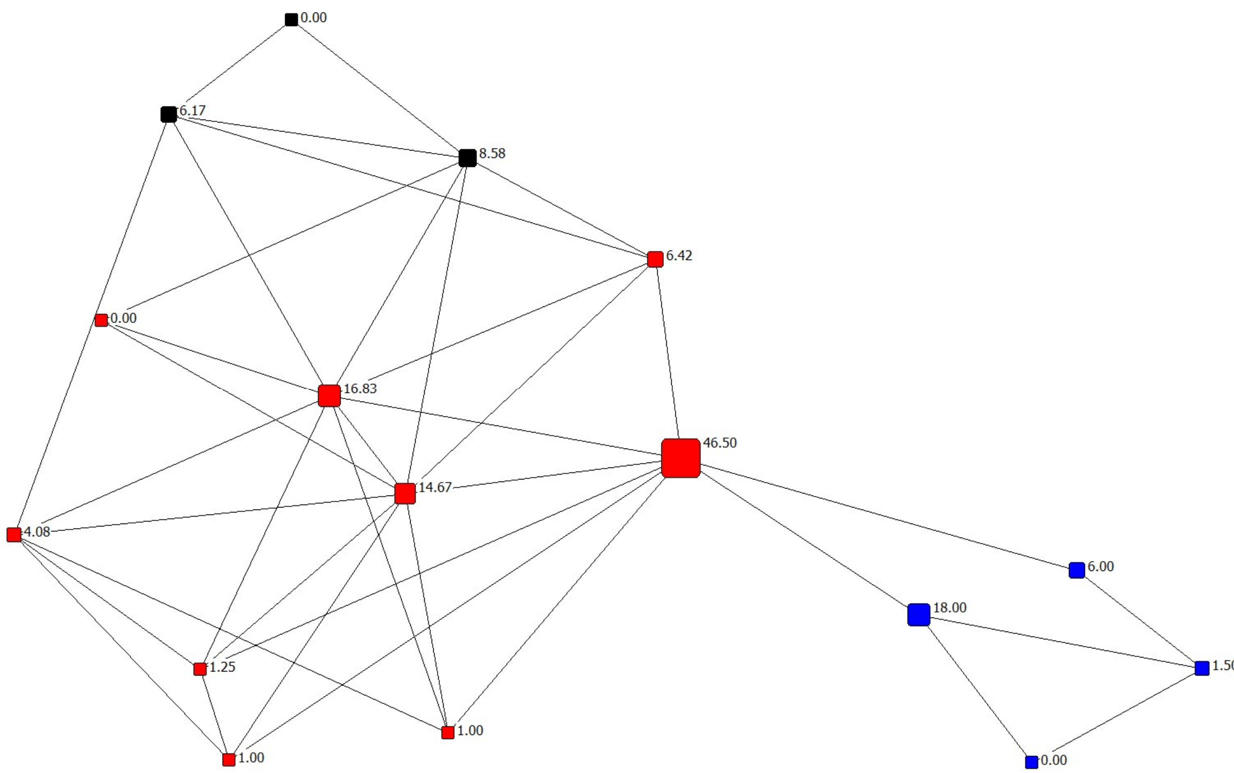


Figure E7: Betweenness Values in the GBL, LL, and AFF Network Map

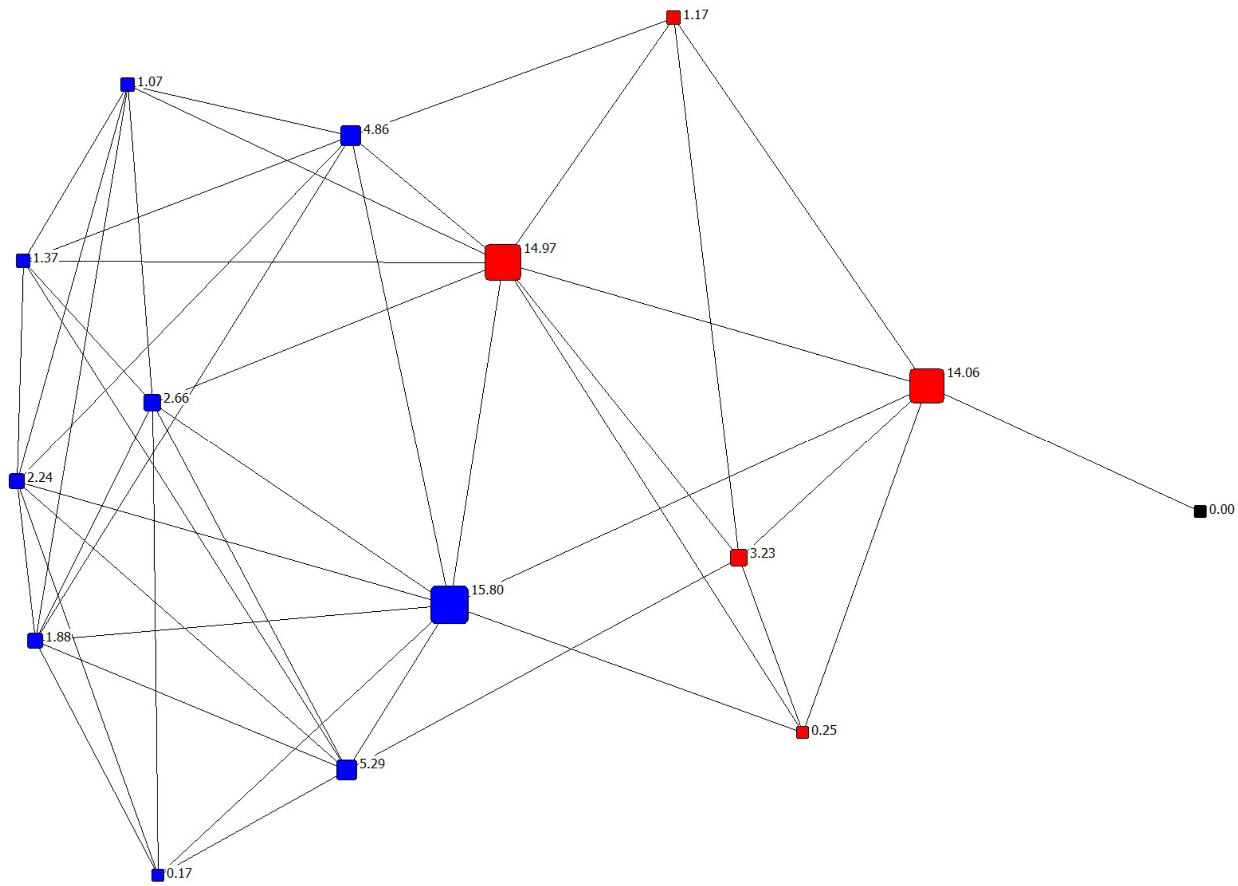


Figure E8: Betweenness Values in the Learning Theories Network Map

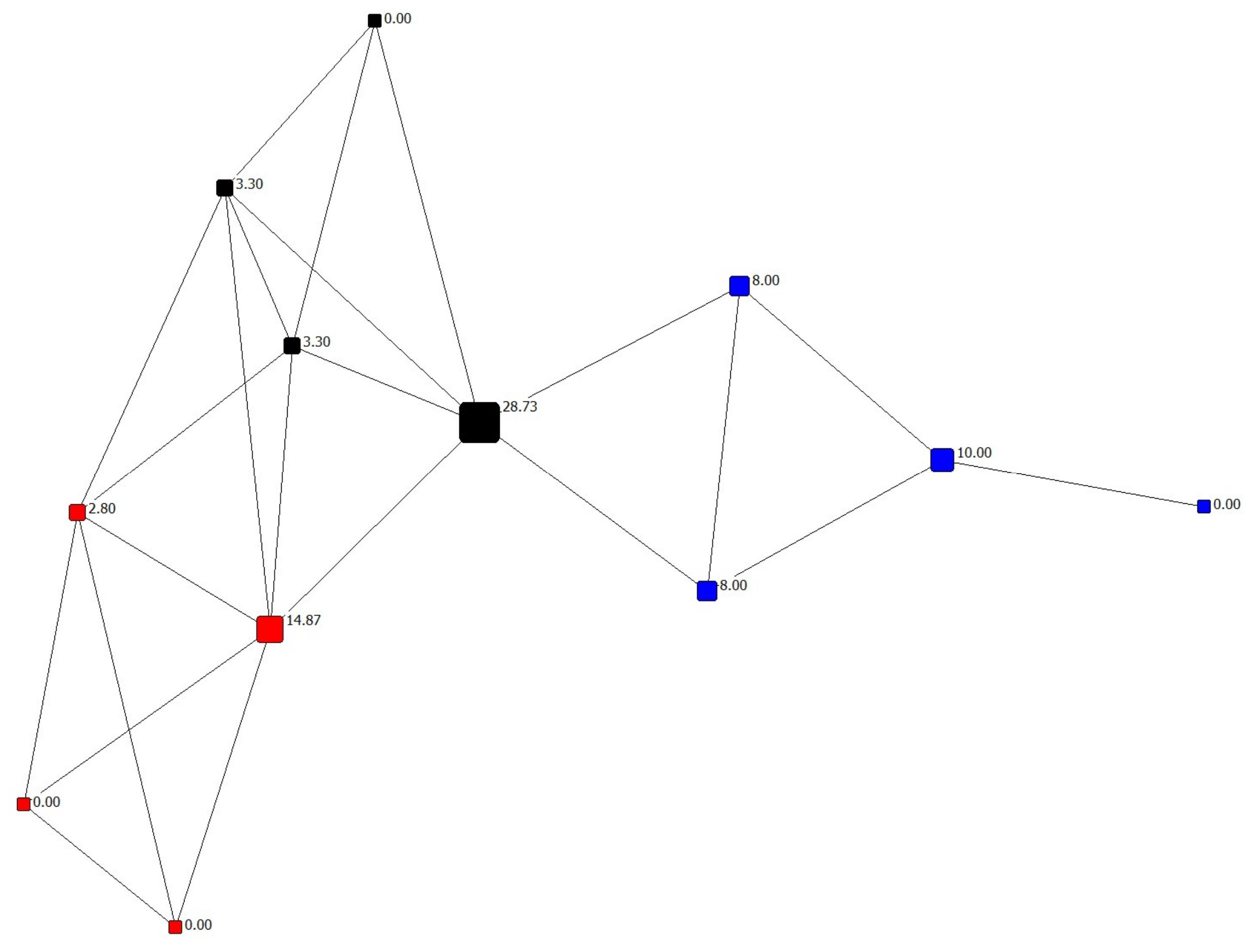


Figure E9: Betweenness Values in the Design Strengths and Challenges Network Map

. ci variance, sd

Variable	Obs	Std. dev.	[95% conf.	interval]
A	2	1.47	0.66	46.86
B	2	0.38	0.17	12.15
C	2	1.14	0.51	36.45
D	2	1.31	0.58	41.66
E	2	1.25	0.56	39.92

.

Figure E10: Vocabulary Items- Mean Scores Differences (Repeated)

```
. ci variance, sd
```

Variable	Obs	Std. dev.	[95% conf.	interval]
A	2	0.05	0.02	1.72
B	2	0.22	0.10	6.94
C	2	0.87	0.39	27.77
D	2	1.09	0.49	34.71
E	2	1.85	0.82	59.00
F	2	0.28	0.12	8.85

Figure E11: Reading Comprehension Items- Mean Scores Differences (Same Concepts)